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Children's drawings: Evidence-based research and practice

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Children's drawings: Evidence-based research and practice

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Editorial: Children's drawings: evidence-based research and practice

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Editorial on the Research Topic
Children's drawings: evidence-based research and practice

Drawing is one of the few surviving forms of human expression from prehistoric times (Lange-Küttner, 2020). It is also considered an enjoyable, playful, and entertaining activity for children and represents an important means of non-verbal communication for them (Longobardi et al., 2022). For this reason, children's drawings have attracted the interest of professionals working with children. The developmental psychologists Piaget and Inhelder (1956) used the technical details of drawings to decipher children's space concepts, while Goodenough (1926) counted details and found them to correlate with IQ. Psychoanalysts have tried to interpret children's psychological dynamics through the graphic characteristics and symbolic contents of their drawings (Kramer, 1979). In general, it is believed that drawing can be a window into the child's inner world, allowing to capture feelings, representations, and perceptions related to a specific topic of investigation (Bozzato et al., 2021; Kallitsoglou et al., 2022). Therefore, it is considered that through drawing, the child does not represent a realistic copy of the external world but rather what they feel, think, and know about the surrounding reality (Quaglia et al., 2015).

Although interest in children's drawings has existed since the 19th century, research on the development of drawing and its potential is more recent. There is a need to increase scientific inquiry into the potential applications of children's drawings in prevention, assessment, and treatment interventions in various developmental contexts. Although research has moved in this direction, more work is still needed, particularly to overcome the various methodological limitations that characterize the current literature.

This Research Topic collected 17 publications from different cultural contexts, 14 of which are research articles. Each of these publications has the merit of increasing our knowledge of the potential and reliability of analyzing children's drawings, both as a research tool and for assessing children's psychological adjustment.

Drawing as a tool for assessing a child's knowledge, attitudes, and beliefs

Two studies address the use of drawings for assessing children's attitudes and knowledge about Research Topics. The study by Brechet et al. sought to examine the development of children's knowledge of the brain and its functioning. Data from a sample of more than 250 French elementary school students showed that their drawings tended to reflect their current knowledge of how the 'black box' of the brain works. Graphical indicators of knowledge about brain functioning became more frequent with age. These data are important because they underscore the usefulness of drawings in assessing children's metacognitive knowledge and remind us of the importance of neuroeducation in elementary school. Profice et al. used the design to examine the effectiveness of an environmental education program (BioBrasil) implemented with adolescents to develop their knowledge and attitudes about nature. The authors found that direct contact with nature favors consolidation of knowledge and greater closeness to the natural environment visited. They also seem to suggest that drawing is a valuable tool for understanding adolescents' attitudes toward nature.

Drawing as a tool to investigate the child's representations

Some research has used drawing to examine children's representations of social phenomena, activities, and the physical contexts in which they are embedded, primarily the school environment. Marengo et al. conducted an interesting mixed-methods study using interviews and drawings to analyze descriptions of bullying among more than 600 elementary school children. Interestingly, the experience of being involved in bullying, whether as a victim, bully, or as a bully and victim simultaneously, was reflected in the children's drawings when they depicted the concept of bullying. In addition, the authors pointed out that interviews provide a more comprehensive and general insight into children's portrayal of bullying, while the drawings illustrate children's personal experiences of bullying.

In another Italian study, Berti and Cigala proposed a new instrument to assess children's representation of the preschool environment: DRAW.IN.G. (DRAWing and Interview Grid). The instrument consists of five main dimensions of children's representations of the educational environment—physical, behavioral, relational, emotional, and motivational—in 18 macro-categories and 90 categories that make up the scoring grid. This study involved 262 Italian pre-school children who were asked to draw their favorite place at school. Although validation studies indicate the potential of this method, some critical aspects have emerged that the authors urge us to consider.

In Germany, Rott et al. proposed the development of the Draw a Mathematics Classroom test in order to assess elementary students' representations of their mathematics lessons in classrooms. The authors focused on developing and validating coding of the data with low-inference categories. The results confirm the reliability and validity of the methodological approach. The students' drawings suggest that almost half of the participating students perceived their lessons to be teacher centered.

Moreover, Hatisaru, who is interested in the graphic representation of mathematics, proposed a new framework, the legitimacy code theory (LCT), to critically analyze drawing-based research in mathematics education. The author conducted two studies in Ankara, Turkey, involving primary and middle school students. Overall, both studies emphasized the students' perceptions of mathematical content, discipline-related issues, and attitudes toward mathematics and mathematicians. The application of the LCT provides a framework for analyzing and understanding the knowledge produced through drawing-based research in mathematics education.

Drawing as a tool for investigating children's emotional experience and psychological and relational wellbeing

One of the major uses of drawing is as a tool for assessing the psychological and relational wellbeing of children and adolescents. In clinical and legal settings, the Family Drawing test is among the most widely used projective tests for assessing the quality of a child's family relationships with a scoring system for assessing attachment (Kallitsoglou et al., 2022). In their opinion paper, Pace et al. discussed the strengths and weaknesses of the Family Drawing test with such an attachment-based coding system. The authors discussed salient aspects such as the test's psychometric validity and its use in different cultural contexts while also offering important insights for future research.

Di Norcia et al. used the Pictorial Assessment of Interpersonal Relationships (PAIR) to investigate the quality of the teacher–pupil relationship and school adjustment in primary school students. The authors asked children to draw two situations in which they were involved with a teacher: one situation characterized by distress and the other by wellbeing. Amongst the many results, the authors identified that the authority of the teacher, of which the pictorial valorization is an index, is internalized even by the youngest children and does not vary in a stressful situation vs. a wellbeing situation.

Also addressing the school context is the Italian contribution of La Grutta et al., who recruited some 1,700 primary and secondary school children. The authors used the "Drawn Stories Technique" and the "Classroom Drawing" to assess children's emotional state within the class group and their scholastic integration in an educational context. The authors found some significant age and gender differences. Furthermore, they recommended the use of the drawing technique to facilitate dialogue with children, modulate didactical materials, and detect and prevent some problems in group class functioning.

Two Italian studies focused on analyzing the emotional experiences of children and adolescents during the COVID-19 pandemic through drawing. Cornaggia et al. surveyed a small sample of 18 elementary school children and asked them to draw three moments: "Before" the pandemic and "During" and "After" the lockdown. According to the authors, it appeared that the children felt sufficiently capable of coping with the situation, as evidenced by the fact that they included themselves in the drawings and indicated many details of their houses in the "During" drawings. However, a sense of loneliness and lack of friends also emerged from the representations, as evidenced by the fact that the children depicted significantly more friends in the drawings that concerned the future.

In the second study, Capurso et al. recruited 900 children and preadolescents (aged 7–13) who were asked to draw a moment in their lives during lockdown. The authors reported a detailed qualitative and quantitative analysis that yielded interesting data. According to the authors, children coped with the lockdown through play, screen use, and technology use. However, the high incidence of lack of self-expression found among preschoolers may indicate how enforced solitude and lack of direct physical contact with others affected their self-perception.

Considering the impact that adverse developmental experiences can have on the psychological development of individuals, Ballús et al. sought to investigate whether graphic emotional indicators were expressed in drawings of the projective Draw-a-Person test made by children in dangerous or neglectful situations. The results of this Spanish study, conducted on children and pre-adolescents, show a high frequency of graphic indicators that are often associated in the literature with experiences of abuse and maltreatment. According to the authors, this is an important finding because it would support the usefulness of drawing human figures in identifying children at risk of victimization.

Drawing as a learning strategy

In Estonia, Tolsberg et al. have revealed some evidence of the effectiveness of the "Learning with Understanding" program that instructs teachers to help children to develop metacognitive awareness of learning strategies, including drawing, in order to better process study material. Drawing is therefore considered a constructive learning strategy. The authors suggested the importance of the use of schematic drawings in learning processes and provided important evidence on the usefulness of drawings in training programs for teachers.

The role of possible cultural influences

One of the long-standing questions related to research in the field of children's drawings is the possible influence of the cultural environment. The work by Restoy et al., which attempts to analyze possible cultural influences on the self-portraits of children and adolescents, is very interesting in particular. For the study, 958 self-portraits of children aged 2 to 15 years from 35 different countries on five continents were used. The authors found the existence of cultural variations in the self-portrait patterns. In addition, they found how age and physical vs. sociocultural context may influence self-portrait drawing. In particular, they found an influence of the physical and socio-cultural contexts through the level of urbanization and the degree of individualism of the countries, which affected the complexity, content, and representation of human figures in the observed drawings.

Children's drawings: a look at developmental processes and research methodology

Research on children's drawings, however, is not limited to the extent to which drawing may be an expression of a child's mental state, perceptions, or world knowledge. More research is needed on the developmental processes of drawing as a process, i.e., the cognitive factors underlying the capacity for visually realistic representation. Lange-Küttner and Vinueza Chavez have made an interesting empirical contribution in this direction to the Research Topic. Through an innovative experimental design, using real spatial models and recording the drawings online, the authors aimed to test whether a negative space drawing technique could help children to draw in perspective. In a sample of five age groups from 5 up to 12 years plus adults, the negative space technique was understood and used only from the age of 9. This work makes a valuable contribution to the long-standing debate in developmental psychology about intellectual and visual realism in children's drawings and to the object- and space-based distinction of attention in cognitive psychology.

From a methodological perspective, the contribution of Jensen et al. shows the importance of using new technologies in the analysis of drawings. They scanned children's drawings and fed them into a machine learning algorithm that would classify selected drawing features into classes. To compare, human evaluations were collected. The authors pointed out that machine and human metrics capture different aspects of the structure of drawings and are both independently useful for evaluating and predicting participants' drawing characteristics.

In addition, Beltzung et al. presented a detailed literature review of deep learning applied to the study of drawings and provided a list of drawing datasets relevant to deep learning approaches. The authors aimed to offer an overview of how deep learning has been and can be used to improve our understanding of drawing behavior. The authors pointed out that both traditional and comparative cognitive methods used in psychology to analyze drawings rely on the subjective interpretation of the experimenter, which can limit the reproducibility of the results. According to the authors, deep learning could contribute to solving this problem.

To summarize, the research and theoretical contributions assembled in this Research Topic demonstrate the potential of children's drawings as a research and assessment tool for children and adolescents. However, much research is still needed to understand the cognitive and neurobiological factors underlying the development of child drawing and to explore its applicability in a variety of assessment and research contexts in the field of developmental psychology. Future research may increasingly face the development of new artificial intelligence (AI) technologies to develop new analytical tools.

Moreover, there is still a need to overcome and clarify the limitations that currently impact empirical research on children's drawings. These include the psychometric properties of instruments used for the quantitative analysis of drawings, the role of the developmental level of graphic ability, the influence of cultural variables, and the generalizability of results. It is our hope that this Research Topic will encourage researchers to improve the quality of research in this area and further investigate the development of drawing and its potential in assessment, prevention, and treatment interventions, as well as an investigative tool in empirical and experimental research.

Author contributions

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

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Learner-generated drawing as a learning strategy. The effect of teacher-guided intervention program "Learning with Understanding" on composing drawings in math word problems in the primary grades

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The study aimed to examine the possibility of teaching primary school students a learner-generated drawing strategy, among other constructivist learning strategies. The teacher-guided program "Learning with Understanding" began by discussing the broader topics of the learning process, followed by teaching specific strategies, and ended with an overview of all strategies and reflective discussions. During 18 program lessons, primary school teachers taught, practiced, and raised metacognitive awareness of three learning strategies—elaboration of new information with familiar material and daily practice, organization of material into categories and elaboration, and organization of information through drawing. This study examined composing drawings for math word problems before and after the program. The sample consisted of second- and fourth-grade students from eight Estonian schools. The intervention group included 110 students from second grade and 80 students from fourth grade. The control group consisted of 121 second-grade students, and 82 fourth-grade students. Before and after the intervention, students had to solve two math word problems and compose a drawing, if needed. The results showed that before the intervention, neither the control group nor the intervention group students drew almost any drawings. However, after the intervention, both the control group and the intervention group students started to draw more drawings. Also, the intervention group students composed both more drawings and more schematic drawings. The effect of the intervention was visible at both grade levels. Comparing the correctness of answers with the drawing type showed that the fourth grade obtained significantly more correct answers when no drawings were made, while in the second grade, students had fewer correct answers when they had not compiled a drawing. Thus, we showed that even very young students could learn to compose schematic drawings; however, drawings alone may not be of help to solve the problem.

KEYWORDS

composing drawings, learning strategy, math problem solving, intervention, primary grades

Introduction

The characteristics and developmental peculiarities of children's drawings have been studied for many years (e.g., Barnes, 1892; Cox, 2005). Drawings have been used not only to examine children's general ability level, emotional, and family problems (e.g., Campbell and Bond, 2017; Ivens, 2021), but also to discover children's science conceptions (e.g., Vosniadou and Brewer, 1992; Kikas, 2000), learning (Hsieh and Tsai, 2016), and math (Hatisaru, 2020). Additionally, drawings are also valuable visual learning aids (Mayer, 2017). While drawings have been used to illustrate texts or represent scientific ideas for a long time, the usefulness of constructing drawings as a learning strategy besides learning from drawings has been acknowledged only recently (Van Meter and Garner, 2005; Schmidgall et al., 2019; Ainsworth et al., 2020). Also, the advantages of self-generated drawings have been found only in certain conditions—for schematic drawings, when students have a certain level of knowledge and cognitive skills, and have been taught to compose useful drawings and been supported in their application (Hegarty and Kozhevnikov, 1999; Terwel et al., 2009; Ainsworth et al., 2020).

Although many studies have examined relations between generating drawings and learning, some areas need further investigation. Many interventions use composing drawings in specific subjects like math (Hegarty and Kozhevnikov, 1999; Van Garderen and Scheuermann, 2014) or science (Tippett, 2016). Strategies learnt in one area may be difficult to generalize to other areas. Generating drawings is useful in learning different subjects and it is valuable to use it in different lessons. Moreover, it is only one helpful strategy among several others that students can use and should be taught. Teaching various learning strategies and their application in different lessons allows talking about learning process, reasons why some strategies are useful for learning, what is needed to be successful in applying each strategy etc. It means supporting metacognitive knowledge of learning strategies and skills in their application, which importance has been well documented (Dignath et al., 2008; Fiorella and Zhang, 2018). So far, little attention has been paid to supporting students' metacognitive knowledge and skills during the process of generating drawings. Lastly, teachers tend to have misconceptions regarding generating drawings and this may inhibit them in supporting students' knowledge and skills of constructive learning strategies (Dignath and Büttner, 2018; Glogger-Frey et al., 2018). Thus, it is important to educate teachers in this process.

Our study aimed to examine the possibility to teach primary school students learner-generated drawing strategy among other constructivist learning strategies. The "Learning with Understanding" intervention program was designed to help primary school teachers teach, practice and raise metacognitive awareness of three learning strategies—elaboration of new information with familiar material and daily practice, organization of material into categories and elaboration and organization of information with drawing. While the effects of the program for supporting elaboration and organization strategies represented fourth grade students (Kikas et al., 2021), the aim of this study was to examine the effects of intervention on second- and fourth-grade students' skills in composing drawings for math word problems.

Learner-generated drawing as a constructive learning strategy

Drawings are configurations of symbols, images or concrete objects standing for some other entity that constitutes a constructive learning strategy if generated to achieve a learning goal (Van Meter and Garner, 2005; Chi, 2009; Fagnant and Vlassis, 2013; Tippett, 2016; Brod, 2020). For generating drawings, students must first select critical information from the text for processing in their working memory. Next, they mentally organize the verbal elements into a coherent verbal representation that is used to support the construction of the drawing, at the same time integrating given information with the students' existing knowledge from their long-term memory. Finally, learners convert their mental model into a representative drawing on paper that may also include verbal signs (Van Meter and Garner, 2005; Tippett, 2016; Fiorella and Zhang, 2018). Generating is useful for learning drawings and presumes good metacognitive skills as the cognitive processes of selecting, organizing, and integrating occur recursively and should be guided by self-monitoring and self-regulation (Fiorella and Zhang, 2018).

Drawings and other visual aids are—like words—mediators of knowledge. They are generalizations that help comprehend new material but students also have to learn their meaning (Vygotsky, 1997; Prain and Tytler, 2012). In line with differentiation of everyday and scientific concepts (Vygotsky, 1997), drawings can be divided into pictorial and schematic. Everyday concepts are acquired *via* individual sensory experiences, and similarly, children are used to draw what they see. Everyday concepts are generalizations of personal experiences, and children's pictorial drawings represent the overall situation and emphasize the visual appearance of objects, but also include what they know (Cox, 2005). Scientific concepts do not directly refer to objects, but rather to other concepts; they are generalizations about generalizations, in which perceptual features are recombined into new, supposedly more-informative and abstract structures. Likewise, drawings as ameans of a learning strategy—schematic drawings—are generalizations of what has to be learnt, they include abstractions, non-perceptible features and bring out the main idea of the text or the problem (Fiorella and Zhang, 2018).

Acquiring everyday concepts is quite an easy process. Children also compose pictorial drawings at a young age (Cox, 2005). In contrast, learners have difficulties with comprehending scientific concepts, and form misconceptions (Kikas, 2003). Studies have indicated to misconceptions regarding drawings and other visual aids (Stylianou, 2020). For example, students may interpret graphs as iconic, similarly to interpreting picture reading (Leinhardt et al., 1990). These misconceptions may inhibit students' own creation of schematic drawings. Independently, young students and those with lower abilities do not construct or only rarely construct schematic drawings (Hegarty and Kozhevnikov, 1999; Van Garderen and Montague, 2003; Fiorella and Zhang, 2018). Besides misconceptions and drawing skills, starting to compose schematic drawings may increase the cognitive load and result in utilization deficiency and reduced performance (Leutner et al., 2009; Clerc et al., 2014). If the activity of drawing is too demanding, the cognitive capacities are required for composing the drawing and thus are no longer available for information processing. Low metacognitive skills also prevent generating useful drawings (Rellensmann et al., 2016; Fiorella and Zhang, 2018).

Meta-analyses have confirmed advantages of using and generating drawings over passive learning strategies. Learner-generated drawing has been shown to be a more effective learning strategy than verbalizing or guess-and-test strategies (Hembree, 1992) and reading or using text-focused strategies (Fiorella and Zhang, 2018). However, when comparing generated and readymade illustrations, the effects of drawing are mixed and depend on the quality of drawing and amount of teacher support (Fiorella and Zhang, 2018).

Applying learner-generated drawing in solving math word problems

Math word problems are a subcategory of word problems in which one or more quantitative relationships are described and a numerical answer is required (Van Essen and Hamaker, 1990). Word problems are used in math education starting from first grades as they integrate school math with students' real life experiences (e.g., Van de Weijer-Bergsma and Van der Ven, 2021). However, these are not simple calculation tasks instructed by words, but presume conceptualizing the problem, planning a solution, searching for strategies etc. (Van Garderen and Montague, 2003). Problem solving models have identify two phases: problem representation and problem execution (Krawec, 2014). Problem representation requires a learner to transform linguistic and numerical information into representations that show how the problem information is related. This helps to select appropriate mathematical algorithms and to perform the appropriate calculations (problem execution phase). Composing drawings (also diagrams, representations; see Stylianou, 2020) may be helpful in the problem representation phase (Van Garderen and Scheuermann, 2014). Learner-generated drawing is a tool for analyzing the problem and finding the solution (Van Essen and Hamaker, 1990). Schematic drawings represent the problem's main data and the mathematical relationships between them; these may include both physical features, abstract spatial relationships, and also words (Hegarty and Kozhevnikov, 1999; Fiorella and Zhang, 2018). Good problem solvers compose general schematic drawings of the problem that enhance comprehension (Van Garderen and Montague, 2003; Krawec, 2014).

Studies support the usefulness of constructing drawings by students, but in certain conditions. For instance, it has been shown that the use of schematic representations is positively, whereas the use of pictorial representations is negatively related to success in math problem solving (Hegarty and Kozhevnikov, 1999; Van Garderen and Montague, 2003; Edens and Potter, 2007; Rellensmann et al., 2016). Students' spontaneous diagram use in math word problem solving is also influenced by problem type (Fagnant and Vlassis, 2013) and cultural context (see New Zealand vs. Japan, Uesaka et al., 2007). Studies have indicated that drawing accuracy is related to problem solving performance (Rellensmann et al., 2016), but not always (Van Essen and Hamaker, 1990). Drawings are supportive if students accurately depict the structural relations and processes described in the text or problem.

Interventions supporting learner-generated drawing strategy

Students need help in learning to use and understand the usefulness of constructive learning strategies, including generating drawings (Terwel et al., 2009; Tippett, 2016; Fiorella and Zhang, 2018; Ainsworth et al., 2020; Van Meter and Stepanik, 2020). While some researchers have emphasized the importance of teaching students specific schemas for specific tasks (Fagnant and Vlassis, 2013), it is now more widely accepted that students should be taught different types of schemas that may be used for solving various problems (Fiorella and Zhang, 2018). Multiple studies have referred to the importance of metacognitive awareness of learning strategies, including generating drawings (Dignath et al., 2008; Fiorella and Zhang, 2018). Some authors have brought out stages and practices in explicit teaching to use schematic drawings in solving word problems. For instance, Falomir (2018) differentiated three main instructional activities: (1) teaching students how to create and interpret drawings, (2) supporting students in using the drawings and (3) teaching students metacognitive strategies focused on identifying critical components of word problems to ensure mastery of the diagramming process.

Several, but not all, math-specific interventions that provided drawing practice have shown positive effects. For example, Van Essen and Hamaker (1990) found that fifth-graders, but not first- and second-graders, who practiced constructing drawings for arithmetic word problems improved their problem solving performance in comparison with a control group. Students were not explicitly taught how to compose drawings, but experimenters composed drawings together with students. After completing the drawings, students and an experimenter explained their drawings. Csíkos et al. (2012) carried out an intervention with third-graders and their teachers, using an experimental-control-group design. In the drawing group, students were asked to generate drawings for each problem and to discuss the role of visual representation in group work and teacher-led discussions. Both the experimental and control groups improved their results from pre- to post-test, but the gain in achievement was notably higher for the drawing group. In both of these interventions, attention was paid to raising students' metacognitive knowledge through explanations and discussion.

Studies have shown that findings depend on drawing and problem types. Fagnant and Vlassis (2013) analyzed the effect of two types of schematic drawings on fourth-graders' solving non-routine arithmetic problems. Half of these were schematic drawings which were close to the informal models that students might construct themselves, and the others were half abstract diagrams derived from the typology of Novick and Hurley (2001). Students were first shown either diagram or schematic drawing accompanied with a math problem. In post-test, students were asked to draw by themselves. Experimental groups did better in post-test and the results slightly favored diagrams rather than schematic drawings similar to self-generated drawings. However, 36% of students did not derive any benefit from learning and the results also depended on problem type and individual student.

De Bock et al. (2003) studied the influence of learner-generated graphical representations on eighth- and tenth- grade students' success to solve non-proportional word problems about area and volume. They found that in the drawing-instruction group, drawings were composed in 94% of the cases, and 83% of these drawings were correct. In contrast, without instruction, only 10% of generated drawings, and only 9% of these drawings were correct. However, although the far majority of students who were instructed, composed correct drawings, it did not help them correctly solve the math problems—students in the drawing-instructed group scored lower in the math test than those in the non-instructed group. The authors highlighted in their findings the lack of attention paid to supporting students' metacognitive knowledge and skills. Also, they noted that the drawing process itself might provide incorrect knowledge when being processed in the working memory.

Learner-generated drawing may also be supported as a part of a wider constructive learning strategy teaching. Studies indicate that in ordinary lessons teachers rarely explicitly teach strategies, and still less support metacognitive knowledge and skills (e.g., Dignath and Büttner, 2018; Coffman et al., 2019). Moreover, teachers' knowledge of learning strategies tends to be limited (Dignath and Büttner, 2018; Glogger-Frey et al., 2018). Various constructive learning strategies have also been supported during self-regulated learning interventions (Dignath et al., 2008). These emphasize the need to include learning about different learning strategies and metacognitive knowledge and skills. It is also important to practice strategies in different contexts, including different subject lessons, which promotes automatization, helps reduce the cognitive load related to monitoring new strategies, and helps to overcome utilization deficiency (Clerc et al., 2014).

Differently from the earlier studies that have not provided separate information on learner-generated drawings, our intervention program "Learning with Understanding" included teaching, practicing, and raising metacognitive awareness of three constructive learning strategies, including self-generated drawings (Kikas et al., 2021). Students learned about strategies first quite generally, then practiced these in three main subjects—mother language, science, and math. Finally, students' metacognitive knowledge and skills in applying the strategies was raised *via* discussions.

Aims and hypotheses

The aim of this study was to examine what type of drawings primary school students compose for math word problems and what effect the intervention program "Learning with Understanding" has on the frequency and quality of drawings. Second and fourth grade students were selected as participants due to the following reasons. Second grade is the youngest where to start teaching different learning strategies as during the first grades students study basic academic skills and become acquainted with learning at school. Fourth grade is usually the highest grade in Estonian schools with class teachers teaching all main subjects while starting from fifth grade, subject teachers teach separate subjects. A critical part of the intervention program was practicing learning strategies in different subjects which was easier to accomplish with one teacher. We compared the intervention and control groups, using a pre- and post-test design and carried out analyses separately for second- and fourth-grades. Our research questions and hypotheses were as follows:

First (RQ1), do the intervention and control groups differ in composing drawings in pre- and post-tests? In pre-tests, we expected that only a few students compose drawings and that there are no between-group differences (H1a). In post-tests, we expected more students in the intervention than in the control group to compose drawings for math word problems, at least in the fourth grade (H1b). Earlier, Van Essen and Hamaker (1990) found that only fifth-graders, but not first- and second-graders, composed more drawings after the intervention.

Second (RQ2), how do the intervention and control groups differ in composing schematic drawings in post-test? We expected (H2) that more intervention than control group students would draw schematic drawings. Earlier studies have shown that students start to use more effective learning strategies (creating different models and drawings) only when being taught it (De Bock et al., 2003; Van Meter and Stepanik, 2020).

Third (RQ3), how are pictorial and schematic drawings related to correctness of solving math word problems? We expected (H3) that schematic, but not pictorial drawings are related to correctly solving math tasks (see Hegarty and Kozhevnikov, 1999; Van Garderen and Montague, 2003; Edens and Potter, 2007; Rellensmann et al., 2016). Still, not all studies have found these positive relations (e.g., De Bock et al., 2003).

Materials and methods

Sample

The sample included second- and fourth- grade students from eight Estonian schools. Schools were invited to participate through an advertisement. They could choose between two intervention programs—"Learning with understanding" and "We read"—that were implemented concurrently in different schools. The intervention group included children whose schools participated in program "Learning with Understanding." It was emphasized that participation in the program was voluntary for the teacher and that he/she wanted to integrate the learning strategies into his or her own subjects. The control group was formed from the schools who were in the waiting-list for participating the following year in the program "We Read." The control group students completed both pre- and post-tests, but did not participate in any additional practices in classroom.

The intervention group included 110 students from 6 s-grade classes and 80 students from four fourth-grade classes. The control group consisted of 121 s-grade students, from 7 different classes, and 82 fourth-grade students, from 4 classes. There were 193 boys (95 in the second-grade and 98 in the fourth-grade; 88 in the intervention group and 105 in the control group). There were more girls than boys in the intervention groups in the second-grade, $\chi^2(1) = 9.05$, $p = 0.003$. The intervention and control groups did not differ significantly in gender composition in the fourth-grade, $\chi^2(1) = 3.25$, $p = 0.07$.

Procedure

Pre-test

Students were tested before the intervention program (end of 2018/beginning of 2019). The students were tested with the agreement of the school management and teachers, and with the informed consent from the parents. Permission was granted both to test the children and to use the test results. All relevant ethical standards were followed when testing the children, and the children had the opportunity to terminate their participation in the testing at any time.

The test included reasoning, reading and math tasks. Solving math problems and composing drawings was a part of the test that was used in this study. Students had to solve math word problems but could decide for themselves whether they would use drawings to solve the task. The guide said "make a drawing if necessary." The test was on a tablet, was conducted in Estonian and lasted approximately 45 min. The completion took place in the classroom, and the testing was supervised by at least one university team member.

Intervention

The intervention program was carried out in the first half of 2019 (January-May) and was prepared by the "Learning with Understanding" project team, which included both teachers and researchers (for more details, see Kikas et al., 2021). The program was created for teachers to support the acquisition of more effective learning strategies in lessons and to deepen students' awareness and self-regulated learning.

Practices with teachers

Prior to the intervention program, teachers were given training on learning, memory and understanding, and then the first part of the program was introduced. Teachers were also provided with materials that introduced the idea and principles of the program. In the middle of the program, there was a second meeting to introduce the second part of the program.

It was also an opportunity to discuss issues and difficulties and to exchange experiences.

Throughout the program, teachers received support from researchers. Teachers also completed an online form announcing the tasks they had given to students and providing feedback on the strengths and weaknesses of the intervention. At the end of the program a meeting was held to gather feedback from teachers and to discuss ways to further develop learning strategies.

Practices with students

The program consisted of eight topics, divided into 18-h sections. For students, participation in the program began with addressing the learning process, thinking, memory and memorization, and individual differences. Teachers then introduced three strategies—visualization, making connections (with both personal experience and prior knowledge) and categorization. In the last two lessons, the strengths and weaknesses of the learned strategies were discussed with children and the skills to use one's own strategies were analyzed. Learning strategies were practiced in the mother language (Estonian), math, and science, and subject-specific sample tasks were created for teachers' use.

Teaching and practicing drawing

First, discussions were held on which illustrations are more helpful and supportive for memorizing and understanding important information. Also, discussions on how modeling the tasks helps to solve problems better, and how to create simple, abstract (not necessarily visually attractive) drawings. The practice tasks were selected to be in line with the topics students learnt in ordinary lessons. For example, after reading about the day-night cycle, students were asked to illustrate the movements of the Earth and the Sun in the garden and from a space. The two drawings were compared, and whether the second drawing captured the day-night cycle were discussed.

Post-test

Students were tested again after the intervention program (Spring 2019). The procedure was similar as in pre-test. However, students completed the test on paper. Similarly to pre-test, post-test included reading and math tasks. Solving math problems and composing drawings was a part of the test that was used in this study.

Math test

Math problems

Math problems were developed by Anu Palu and Eve Kikas. The tasks were picked according to the grade level and that the drawing would have an effect in solving an assignment was taken into consideration. The tasks for both grades were similar and thus more difficult for the second grade than for the fourth grade. The instruction in pre- and post-tests was the same: "Solve the problems. If necessary, compose a drawing that helps you solve the task better. Write out the solution and the answer." The pre-test included four problems and post-test three, two of which were the same in both tests (numbers and children's names were changed). For comparing the tests before and after the intervention, we chose two of the same problems—classroom and games tasks. The classroom task was: "There were 12 students in the class, five students left during the break and two students came back to the class. How many students are in the classroom now?" The games task was: "Kadri and Lauri have a total of 24 computer games, Kadri has six more games than Lauri. How many computer games does Lauri have?"

Drawings and coding

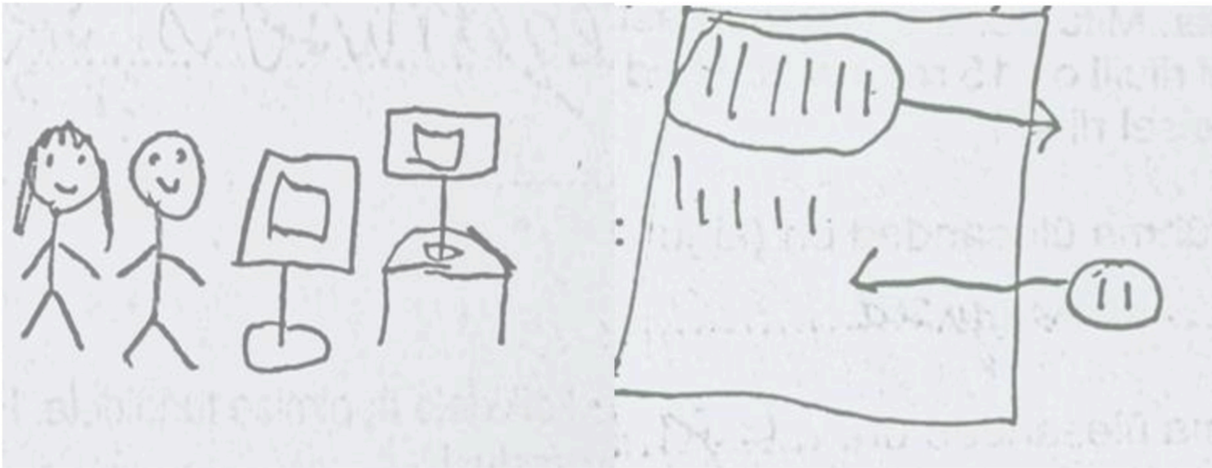
The drawings were coded as no drawing (code 9) if the student did not draw or the drawing could not be interpreted. The rest of the drawings were coded by type, either pictorial (code 1) or schematic (code 2). A pictorial drawing is one that depicts something that may be related to the task, but does not support solving because it does not depict relationships. It might have correct but also superfluous components. A schematic drawing is one that shows relations or numbers (see Hegarty and Kozhevnikov, 1999; Fiorella and Zhang, 2018). Examples are given in **Figure 1**.

The drawings were coded by two evaluators. In order to check the reliability of the evaluator's estimates (for the type of drawing) used in the analysis, the reliability between the evaluators was measured with Cohen Kappa. There was a high reliability between evaluators, k = 0.92, (95% CI 0.87, 0.94), $p < 0.001$.

Data analysis

The dependent variable was coded as an ordinal variable of counts (number of drawings made or number of specific type of drawings, either pictorial or schematic). This allowed us to model these counts as explained by the categorical independent variables using an ordinal log-linear approach. More specifically, we used cumulative logit models following Agresti (2019). The analysis was run in R statistical software *via* the statistical software library multgee introduced by Touloumis (2015).

Since repeated measurements study design tends to lead to positive correlation between responses, a correction was used that is available in the multgee R library as proposed by Agresti (2019) to avoid biased standard error estimators. As suggested by Hosmer and Lemeshow (2000) we also checked that the log-odds do not depend on outcome category or in other words that the "proportionality" condition also known as "parallel logits" condition was met. This was done using the statistical library vgam introduced by Yee (2010) and a chi-squared test of difference of model fit between a proportionality assumed



Pictorial drawing of game task
Schematic drawing of classroom task

FIGURE 1
Examples of drawings.

model and proportionality not assumed model. To test RQ1 and RQ2, we started with a model that included the main effects of all categorical independent features and the interactions of all those features.

For RQ1 and RQ3, Configural Frequency Analysis (CFA) was used (von Eye, 1990; Stemmler and Heine, 2016). CFA identifies patterns of answers that occur more (called types) or less (called antitypes) frequently than by chance. The frequencies were tested with a binomial accuracy test because the expected frequencies of some table squares were very low. Bonferroni correction was used to account for multiple testing.

Results

RQ1: Differences between the intervention and control groups in composing drawings in pre- and post-tests

The percentage and number of students composing drawings in the intervention and control group in pre- and post-test are shown in Table 1. In both groups and grades, the majority of students did not compose any drawings in pre-test. This indicates that the groups were equal at the beginning of the study and confirms random selection. In contrast, in post-test, more drawings were made in the intervention group, both in the second- (40.0%) and fourth grade (31.2%), although an increase in drawings is also visible in the control group.

We created a model that included the main effects and interactions of all categorical independent variables—test (pre and post), group (intervention and control) and grade (second and fourth). Interactions regarding grade did not improve the model, and so they were removed them from the model. We also removed the group's main effect due to following reasons. First, the removal of the group's main effect (Wald = 0.2, $p = 0.64$) did not significantly affect the model at this stage. In the context of the research question, we were interested in the effect of interaction between testing time and group. Second, when checking for the multicollinearity, there was a strong negative correlation between the group and the interaction between the group and the test time ($r = -0.89$). Such correlation creates uncertainty in the model and the standard errors expand enormously. Removing the main effect was reasonable because we were interested in the interaction between the group and the test turn, and it allows a better assessment of the statistical significance to verify the validity of the hypotheses. However, before removing the main effect, we looked at the coefficients and the main effect coefficient showed that in pre-test, the intervention group students were estimated to be 1.21 times more likely to draw than the control group students [Exp (0.20) = 1.22, 95% CI (0.52, 2.85), $p = 0.64$]. This is not statistically significant and thus it can be assumed that the groups were equal in the first test.

We proceeded with a model that included only the main effects of the test turn and grade, and the interaction of the group and the test. The main effect of the test turn was an important variable that improved the model: Wald = 40.49, $p < 0.001$. The estimated odds ratio, which expresses the probability of making more or as many drawings as any number of drawings k, changes five times in the control group during the transition from the

TABLE 1 Percentage and (number) of drawings in intervention and control groups in pre- and post-tests.

	Control group			Intervention group		
	Number of tasks with drawing			Number of tasks with drawing		
Test	0	1	2	0	1	2
Grade 2						
Pre-test	91.7% (111)	5.8% (7)	2.5% (3)	92.7% (102)	5.5% (6)	1.8% (2)
Post-test	73.6% (89)	15.7% (19)	10.7% (13)	60.0% (66)	16.4% (18)	23.6% (26)
Grade 4						
Pre-test	96.3% (79)	2.4% (2)	1.2% (1)	97.5% (78)	1.2% (1)	1.2% (1)
Post-test	78.0% (64)	17.1% (14)	4.9% (4)	68.8% (55)	12.5% (10)	18.8% (15)

TABLE 2 Configural frequency analysis patterns emerging as types.

Pattern	Frequency	Expected frequency	df	*z*-value	*P*-value	Type
1120	26	9.24	1	5.38	<0.001	Type
1121	15	6.48	1	3.17	<0.001	Type

Patterns: 1,120, intervention group; post-test, 2 drawings, Grade 2; 1,121, intervention group; post-test, 2 drawings, Grade 4.

first test turn to the second [Exp (−1.64) = 0.19, 95% CI (0.12, 0.32)]. Also, grade was an important variable that improved the model: Wald = 4.82, $p < 0.05$. The estimated odds ratio, which expresses the probability of making fewer or as many drawings as any number of drawings k, changes 1.6 times when comparing the fourth grade to the second grade [Exp (0.45) = 1.57, 95% CI (1.04, 2.34)].

The interaction between the group and the test turn was statistically significant: Wald = 9.0, $p < 0.01$. The effect of the test turn in the control group, which expresses the probability of making more or as many drawings in the control group in the second test turn compared to the first test as in any number of drawings k, was 1.93 times larger in the intervention group [Exp (−0.66) = 0.52, 95% CI (0.34., 0.79)]. This means that while the control group was estimated to have an average of five times more drawings in the second testing, in the intervention group there were about 9.65 times more. This difference is statistically significant.

Neither the inclusion of grade × test turn interaction nor the triple interaction of grade × test turn × group significantly improved the model. However, the frequency table showed some differences between the grades. CFA was conducted to examine if there were patterns that were observed more (types) or less (antitypes) frequent than chance. Based on Bonferroni adjusted *p*-value (0.002), two types emerged (see **Table 2**). These types suggest that significantly more two drawings than expected were made in both grades in post-test in the intervention group. Thus, the CFA analysis suggests that the impact of the program is across grades (by increasing the number of drawings for both tasks).

RQ2: Differences between the intervention and control groups in composing schematic drawings in post-test

In pre-test, the majority of the control and intervention group students initially made no schematic drawings (see **Table 3**). In post-test, both in the control and the intervention group, at least one fifth of the students created a schematic drawing at least for one task. The number of students who did not compose schematic drawings at all decreased in both groups, but more in the intervention group. In the second grade, in control group, 9.1% students created a schematic drawing in two tasks while in the intervention group, the percentage was 20.0%. In the fourth grade, the percentages were 4.9 and 13.8%. This suggests that the students in the intervention group began to compose schematic drawings more consistently.

As in the first analysis, we first included in the model all potentially important characteristics: the number of tasks where schematic drawings were used (0, 1 or 2) as a dependent variable, the testing turn (pre- and post-test) and group (control group, intervention group) and the interaction of testing turn and group as independent variables. In this model as the previous one, there is also a strong correlation between group and group-testing time interaction (r = −0.94). For the same reasons and following the same logic as explained in research question 1, we removed the main effect for the group. Here the group's main effect coefficient shows the difference between the groups in the first test [Exp (−0.) = 0.81, 95% CI (0.11,

TABLE 3 Percentage and (number) of schematic drawings in intervention and control groups in pre- and post-tests.

	Control group			Intervention group		
	Number of tasks with schematic drawing			Number of tasks with schematic drawing		
Test	**0**	**1**	**2**	**0**	**1**	**2**
Grade 2						
Pre-test	97.5% (118)	0.8% (1)	1.7% (2)	93.6% (103)	4.5% (5)	1.8% (2)
Post-test	76.9% (93)	14.0% (17)	9.1% (11)	63.6% (70)	16.4% (18)	20.0% (22)
Grade 4						
Pre-test	98.8% (81)	1.2% (1)	0.0% (0)	100.0% (80)	0.0% (0)	0.0% (0)
Post-test	78.0% (64)	17.1% (14)	4.9% (4)	71.2% (57)	15.0% (12)	13.8% (11)

TABLE 4 Percentage and (number) of correct and incorrect answers by grade and type of drawing.

	Grade 2		Grade 4	
Type of drawing	**Correct answer**	**Incorrect answer**	**Correct answer**	**Incorrect answer**
No drawing	32.1% (63)	67.9% (133)	58.7% (84)	41.3% (59)
Pictorial drawing	33.3% (2)	66.7% (4)	25.0% (1)	75.0% (3)
Schematic drawing	51.7% (15)	48.3% (14)	73.3% (11)	26.7% (4)

5.88), $p = 0.84$], which means that the random distribution has been successful.

We moved on with a model where the independent variables are the testing turn and the interaction of the testing turn and the group. Characteristic testing turn is also important here and improves the model. Wald = 46.22, $p < 0.001$. The estimated odds ratio, which expresses the probability of making more or as many schematic drawings in the control group as at any level k, varies 10 times between the first testing turn and the second turn [Exp 0.39) = 1.5, 95% CI (0.97, 2.27)].

Here grade was not an important variable and did not improve the model falling slightly above the 0.05 threshold with Wald = 3.25, $p = 0.07$. The estimated odds ratio, which expresses the probability of making fewer or as many drawings as any number of drawings k, changes 1.5 times when comparing the fourth grade to the second grade [Exp (0.4) = 1.5, 95% CI (0.97, 2.27)].

Looking at the interaction, it can be seen that it is statistically significant and improves the model. Wald = 6.97, $p < 0.001$. We see that the effect of the testing turn in the control group, which expresses the probability of making more or as many schematic drawings as any number of schematic drawings k, in the second testing turn compared to the first time, becomes 1.82 times larger in the intervention group [Exp (−0.60) = 0.55, 95% CI (0.35, 0.86)]. This means that while the control group is estimated to make an average of 10 times more schematic drawings on the second test, the intervention group has about 18.2 times more.

RQ3: Relations between composing schematic and pictorial drawings and solving math word problems

Each student had four scores of correct/incorrect answers and types of drawings—in pre- and post-test and for two tasks. We randomly took one score from each student out of all the tasks he/she solved (both in pre- and post-test) to form a random independent selection of tasks, which allowed us to study the relationship between how the drawing was composed and the correctness of the answer. There were 293 assignments from 293 different students. There were proportionally more correct answers than incorrect ones in the tasks solved by the fourth-grade students, and proportionally more incorrect answers than correct ones in the tasks solved by the second-grade students (see Table 4).

In order to investigate the difference between the drawing types and correctness of answers, we used CFA. The results of the Bonferroni-adjusted binomial accuracy test showed that one antitype and one type emerged (see Table 5). The anti-type shows that the second grade students completed the tasks correctly without drawing less frequently than expected under independence. The type suggests that in the fourth-grade, more students than expected solved the problem correctly without making a drawing. While real patterns emerged as far as different drawing types are concerned (schematic vs. pictorial) aside from no drawings, the results seem to suggest that fourth-grade students get more correct answers without drawings than second-grade students without

TABLE 5 Configural frequency analysis of drawing type and grade.

Pattern	Frequency	Expected frequency	df	*z*-value	*P*-value	Type
201	63	89.34	1	−3.16	<0.001	Antitype
401	84	62.58	1	2.95	=0.002	Type

Patterns: 201, grade 2; no drawing, correct answer; 401, grade 4, no drawing, correct answer.

drawings so it is possible the drawings benefit second-grade students more.

Discussion

We examined learner-constructed pictorial and schematic drawings that may be used in solving math word problems. These drawings constitute a learning strategy that should be taught to students (Hegarty and Kozhevnikov, 1999; Van Meter and Garner, 2005; Schmidgall et al., 2019; Ainsworth et al., 2020). The aim of this study was to examine what type—pictorial or schematic—of drawings second- and fourth-grade students compose for math word problems and what effect the intervention program "Learning with Understanding" had on the frequency and quality of drawings. We compared the intervention and control groups' drawings for two-word problems, similar in pre- and post-test and it appeared that during the pre-test, only some students of both groups composed drawings. However, after implementing the program, more the intervention than the control groups' students composed drawings, including schematic drawings. The relationship between composing drawings and solving the task correctly differed in the second and fourth grades.

Composing drawings in pre- and post-test

As expected (RQ1; H1a) and found in previous studies with older students (e.g., Van Essen and Hamaker, 1990; De Bock et al., 2003), initially, neither the second- nor the fourth-grade students composed any kind of drawings. After about 6 months, both the intervention group and the control group composed some kind of drawings (either pictorial or schematic). As expected (H1b), the increase in making any kind of drawings is smaller in the control group, with two tasks performed 10.7% of the time in second grade (vs. 23.6% for the intervention group) and 4.9% for the fourth grade (vs. 18.8% for the intervention group). Different reasons may be offered why the frequency of making drawings in the control group also increased. First, students were tested using tablets during the pre-test—a medium that is not widely used for drawing at this age. Thus, students might compose more drawings in the post-test because it is an easier task on paper. Second, the increase might occur because of normal development supported by teachers. Control group teachers were in classrooms when students were tested by experimenters and thus were able to see that students were asked to compose drawings for math word problems. It could be that students and teachers, who also taught drawing, discussed the test afterward. Still, the increase in drawings was bigger in the intervention group as well as in the second and fourth grades. Specifically, more students in the intervention group in both grades composed drawings consistently—for both problems.

Similar to previous studies showing that young students rarely compose schematic drawings independently and without specific teaching (Hegarty and Kozhevnikov, 1999; Van Garderen and Montague, 2003; Fiorella and Zhang, 2018), only eight students composed schematic drawings for one problem. As expected (RQ2, H2), in the post-test, the intervention group composed schematic drawings more consistently than students in the control group. Namely, 9.1% of the second grade control group students created a schematic drawing for two problems, while in the intervention group, the percentage was 20%. In the fourth grade, the percentages were, respectively, 4.9 and 13.8%. Earlier studies have similarly shown that students start to use more effective learning strategies (creating different models and drawings) only when being taught (De Bock et al., 2003; Van Meter and Stepanik, 2020). Still, control-group students also drew schematic drawings more in the post-test than in the pre-test. The reasons behind the increase may be similar to those we brought up previously regarding both types of drawings. Moreover, modern Estonian school education emphasizes the so-called language of science (cf. Vygotsky, 1997; Kikas, 2003), and students may learn to find different ways of solving math problems, including with the help of schematic drawings. Math textbooks also include schematic drawings, and teachers tend to interpret using these visual aids as a visualization strategy. Today, the importance of constructing drawings besides learning from drawings is acknowledged (Van Meter and Garner, 2005; Schmidgall et al., 2019; Ainsworth et al., 2020). Constructing schematic drawings is a complex task that presumes good knowledge and cognitive skills—students have to select useful information from the text, organize verbal elements, convert it to visual representation that corresponds to the problem and compose drawings (Van Meter and Garner, 2005; Tippett, 2016; Fiorella and Zhang, 2018). Most students need support and practice in learning to construct helpful schemas

(Hegarty and Kozhevnikov, 1999; Terwel et al., 2009; Ainsworth et al., 2020). Also, the specific value of raising metacognitive awareness that is achieved *via* explicit teaching and discussions is emphasized (Dignath et al., 2008; Falomir, 2018; Fiorella and Zhang, 2018). The intervention lessons included teaching, practicing, and discussing schematic drawings and, thus, more intervention group students constructed schematic drawings than control group students.

The current study results for the second grade differ from the previous findings, as the second-grade students also started making more drawings (20% of post-test drawings were schematic and done for both tasks). This finding differs from Van Essen and Hamaker (1990), who found that only fifth-grade students started to draw more after the intervention, but first- and second-grade students did not. The difference may be related to how students were taught composing drawings as a constructive learning strategy—after first general introduction, more specific tasks were used and students could practice the strategy in different subject lessons. One surprising finding was that more second- than fourth-graders in the intervention group made a drawing either for one or both tasks. However, it should be stressed that students were instructed to compose drawings if needed. As the tasks were the same for both age groups, they were somewhat easier for fourth-graders who might not compose the drawing because they did not need it.

Relations between the type of drawing and correctness of solving math word problems

Lastly, (RQ3), we aimed to examine relations between drawing type and correctness of solving math word problems. We analyzed the tasks of pre- and post-test completed by the intervention and control groups.

We were surprised that the fourth-grade students completed the tasks correctly without drawing more frequently than expected. In contrast, second grade-students completed the tasks correctly without drawing less frequently than expected. Thus, it seems that second-grade students benefit from drawings more than fourth graders. However, we must be cautious with this interpretation. Namely, as the tasks were the same, they were more difficult for second than fourth graders. Respectively, significantly more correct answers were obtained in the fourth grade than in the second grade. As students were instructed to compose a drawing if needed, fourth-graders might not have seen the need for it and solved the problem without drawing. In addition, the task was on the left, and the place for the drawing was on the right. Since reading is done from left to right in our culture, it is likely that the task was noticed and read before and the need for the drawing after that. The usefulness of drawing in problem-solving also depends on the task, students' prior knowledge, and cognitive processes (Cromley, 2020).

Altogether, few students composed pictorial drawings. Previously, Van Garderen and Montague (2003) found that sixth-grade gifted students use the schematic type the most, while ordinary sixth-grade students or pupils with learning difficulties use it the least. In addition and contrary to our research both pictorial and schematic drawing types were used to the same extent in all groups. It is possible that since there were fewer tasks in our study and it was not explicitly said that the drawing should be made, a large number of students solved the task without using a drawing. However, if there were more tasks, perhaps more pictorial drawings would have been made.

In both grades, more students obtained correct and fewer students incorrect answers with schematic drawings (**Table 4**). This difference did not reach statistical significance, probably due to the small sample size. This result confirms earlier findings on the advantages of schematic drawings (Hegarty and Kozhevnikov, 1999; Van Garderen and Montague, 2003; Edens and Potter, 2007; Rellensmann et al., 2016). It has also been argued that schematic drawing represents proportional thinking about the relationships between things, while a pictorial drawing represents things that are redundant in solving a task. It is also possible that students solved the problem before and felt that they did not need a drawing, they would not make one or make a pictorial drawing, and if they used the drawing to check the solution, they would make a schematic one. At the same time, Hegarty and Kozhevnikov (1999) indicated that students might be divided into pictorial and schematic drawers, as some vividly imagine the content of a task while others think spatially about the relationships between things.

Conclusion and practical implication

As in earlier studies (Hegarty and Kozhevnikov, 1999; Van Garderen and Montague, 2003; Fiorella and Zhang, 2018), we found that only a few young second- and fourth-grade students construct schematic drawings independently. After implementation of the intervention program "Learning with Understanding," more second- and fourth-grade intervention than control group students composed drawings, including schematic drawings. The finding differs from some earlier intervention studies that showed positive effect mainly in older grades. Different aspects of our intervention might contribute to these effects.

First, as earlier classroom studies have shown that teachers rarely explicitly teach and discuss learning strategies (e.g., Dignath and Büttner, 2018; Coffman et al., 2019), we specifically emphasized the importance of these practices. We educated teachers and provided support throughout the program.

Second, the program for students started with broader topics on the learning process, followed by teaching specific strategies, and ended with an overview of all strategies and reflective discussions (Kikas et al., 2021). Ainsworth et al. (2020) showed that learning is more successful when learners actively develop their understanding of what they are learning. Therefore, it is essential to emphasize the metacognitive level of learning in interventions of teaching learning strategies. Others have also emphasized that raising metacognitive awareness may be a key component of success (e.g., Csíkos et al., 2012). Constructing drawings was one learning strategy besides two others.

Third, in line with suggestions by Fiorella and Zhang (2018), in the introductory lesson on visualization strategy, students were taught different types of schemas for various problems (using schemas to learn the text, understanding to build a car with Lego). After that, students were taught to create and use drawings in math (cf. with stages brought out by Falomir, 2018). Cromley (2020) has pointed out that a student may not have a strategy for solving a task that allows them to relate it to other information given in the task (e.g., life situations or previous knowledge). This means that it is important for a student not just to learn what strategies there are but also when to use them and which ones are currently suitable for him/her. Learner-centered interventions focus on solving such situations, and their effectiveness is assessed by how well students are able to apply the strategies themselves to new tasks. This is also what we aimed at with the intervention.

We found even second grade students can be taught to construct and use schematic drawings. However, to overcome the challenges (working memory constraints, low content and learning-related knowledge, and metacognitive knowledge and skills) young students meet when composing schemas (Leutner et al., 2009; Rellensmann et al., 2016; Fiorella and Zhang, 2018), the teaching should be explicit and students should have a possibility to practice drawing-constructing in solving different tasks in different lessons. An important condition is a consistent learning environment, where different aids are used to explain, practice, and discuss learning and the construction of drawings. These discussions specifically raise students' metacognitive knowledge (see Csíkos et al., 2012). Practicing different strategies in early grades with simple tasks may build confidence that can be used later in their school career when learning becomes more challenging. The education systems in Estonia and other countries, allow class teachers to teach all main subjects facilitating their possibility to discuss and practice new learning strategies in different lessons.

Limitations and future directions

Several limitations should also be mentioned. First, students were tested on a tablet in the pre-test but on paper in the post-test. Some internet connection problems occurred during the first testing that might affect students' outcomes. Also, students have rarely drawn with computers and tablets which might be why so few students created drawings. Although the conditions were similar in the intervention and control groups, in future studies, the medium of the test should be the same throughout the study. Second, students knew that they were participating in the study, so it was not a natural classroom condition. Some children might consider testing unimportant and not take it seriously. As the tasks in both tests were similar, students might be even less motivated in the post-test. However, the motivation of students to participate in the test and complete the tasks greatly influences the results of the research. In future studies, students' motivation and persistence when completing the tests should be assessed and taken into account in the analyses. Third, composing drawings was not obligatory (the instruction was "If necessary, compose a drawing that helps you solve the task better"). It was not possible to distinguish between students who were unable to draw, those who felt they did not have to, or those who didn't have the time or motivation. In future studies, composing drawings could be a separate, obligatory task. Fourth, the effects of the intervention were statistically significant but not high. The reason may be the small sample size and, therefore, further studies should be carried out with larger samples. Fifth, teachers' attitudes, knowledge, and motivation to teach learning strategies play an important role in implementing the program. Each teacher might devote more time to teaching drawing in some lessons than in others (e.g., math compared with science). In the future, teachers' characteristics and preferences should also be examined.

We studied only some aspects of students' self-generated drawing—composing drawings for math word problems. Moreover, a problem-solving task and instruction to draw were given together, and drawing was not obligatory. It might be worth investigating whether the results would be different if the drawing were done first and the solution written afterward. Interviews with children would also give valuable information into the student's perspective and whether they perceive the benefits of drawings and whether they would use it to solve the task or for other reasons. Questions like "Did you draw before solving the problem?," "Did the drawing help you solve the problem?" or "Did the drawing help you check the answer to the task?" could clarify our findings.

Future studies are also needed to examine the different effects of the intervention program. The program chose to look into composing drawings in certain subjects. It would be advisable for future studies to examine students' drawings in other areas (e.g., text comprehension, science problems). Moreover, we compared the differences between the intervention and control groups directly after the program practice, although it is important also to detect the long-term effects of intervention.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

Author contributions

KT: writing introduction, methodology, and discussion. SP: data analyses and writing method part. EK: conceptualization of intervention, funding acquisition, writing introduction, and discussion. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Children's representations of the COVID-19 lockdown and pandemic through drawings

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The COVID-19 pandemic and the measures to face it have placed children and their caregivers in front of many challenges that could represent sources of stress. This work aims to explore the point of view of children through drawing, as a spontaneous means of expression, relating it to parents' perceptions of children's difficulties, strengths, and mentalization skills. The sample consists of 18 children (mean age = 8.22, SD = 1.79). Parents were asked to complete: a socio-demographic questionnaire with information on the impact of COVID-19 on the family, the Strengths and Difficulties Questionnaire, and the Everyday Mindreading Scale. Children were asked to draw three moments: "Before" the pandemic, "During" the lockdown, and "After," when the COVID-19 will be passed. The drawings were coded by constructing a content and expressive analysis grid, adapting coding systems found in the literature. Data were collected at the beginning of the summer of 2020, just after the first lockdown period (from March to May 2020 in Italy). The results of the present work are in line with previous studies that reported experiences of wellbeing and tranquility of children in time spent at home with family during the pandemic. From the drawings emerges that children feel sufficiently able to master the situation, as reflected by including themselves in drawings and providing many details of the house in "During" drawings. The literature also reports a feeling of sadness/loneliness caused by the lack of friends, an element that we also find in the tendency to represent friends significantly more in the drawings concerning the future. Some contents of drawings (inclusion of friends, relatives, and parents) appeared associated with emotional, interpersonal, and mentalizing abilities of children, as perceived by parents. Exploring children's representations of a stressful event like the pandemic through drawings allows to focus both on their difficulties and on their resources, with useful implications for the educational support.

KEYWORDS
children drawings, child development, COVID-19, emotions, relationship, mindreading abilities

Introduction

The COVID-19 disease, declared as a pandemic in March 2020 by the World Health Organization (World Health Organization [WHO], 2020), has spread throughout the world radically changing human habits, relationships, and contexts of life. In addition to the crisis in the socio-sanitary systems and to the impact on physical health, COVID-19 brought about a whole series of psychosocial implications that affected the majority of aspects of people's lives (Adıbelli and Sümen, 2020; Di Giorgio et al., 2020; Marchetti et al., 2020; Petrocchi et al., 2020; Ghanamah and Eghbaria-Ghanamah, 2021; Mantovani et al., 2021). Italy was the first European country that had to face the emergency, so the Government introduced from March to May 2020 stringent measures to contain the epidemic, i.e., a general lockdown. Children and adolescents represented about 16% of the Italian population that during the pandemic could no longer go to school and no longer meet their classmates and teachers (Caffo et al., 2020): in short, they saw their daily life suddenly overturned. Therefore, despite most infected children being asymptomatic or presenting mild clinical manifestations (Jiao et al., 2020), some studies investigated, at different levels and in different ways, the impact of COVID-19 on children's lives. In particular, risk factors included family disruption due to illness or death, financial instability tied to job loss, and educational disruptions as a result of the closures of early child care facilities and schools, as well as transitions to online learning (United Nations Human Rights Office, 2020). Moreover, the fear of infection, frustration and boredom, circulation of misinformation, and limited access to reliable sources of information increased the stress level (Cluver et al., 2020; Presti et al., 2020; Ren et al., 2020).

Given the hard and various challenges that children had to face during this prolonged emergency (Pascal and Bertram, 2021; Samji et al., 2022), it could be relevant to consider both immediate and long-term effects on child development across developmental domains (Benner and Mistry, 2020).

The social domain was the most evidently impacted: with the closure of schools and sport-leisure facilities, children lost not only the opportunity to learn from their peers, teachers, and educators (Haleemunnissa et al., 2021) but also the sharing of experiences, learnings, and feelings that were difficult to achieve through a screen. Moreover, the economic and pandemic-specific factors increased parents' stress and undermined the quality of relationships among family members, including marital, parent-child, and sibling relationships (Prime et al., 2020). Another relevant loss for children was the support of important caregivers like grandparents, who often, especially in Italy, play a crucial role in family welfare—taking care of grandchildren while parents are at work—thus becoming fundamental caregivers for children (Caffo et al., 2020).

Children's behavioral development (Dray et al., 2017; Clark et al., 2020; Wang et al., 2020) was challenged by home confinement: indeed, sudden changes in living habits precluded children from the possibility to relate outside the family, such as practicing physical activities and especially experiencing independence and autonomy in educational contexts different from the family one, such as schools, sports teams, recreational centers, and so on (Brazendale et al., 2017). All these elements became risk factors for the emergence of hyperactivity, conduct problems, sleeping and eating disorders, and psychological distress in children (Petrocchi et al., 2020; Wang et al., 2020; Bianco et al., 2021; Liu et al., 2021). In addition, health emergency widened risk factors already existing in families and fragile social contexts before the advent of COVID-19 (Carneiro et al., 2016; Liu et al., 2021).

Regarding the emotional domain, some authors (Brooks et al., 2020; Jiao et al., 2020; Jiloha, 2020) pointed out the negative emotional effects created by the confinement situation. The adverse impact on the emotional sphere became more severe as the duration of the confinement increased (Brooks et al., 2020). Emotions, such as fear and sadness, were not only linked to the lockdown, but also to the virus itself, as children were concerned about the uncertainty and unfamiliarity of the situation (Idoiaga Mondragon et al., 2021). The study conducted by Orgilés et al. (2020) pointed out a worsening in children's emotional state and behavior, especially difficulties in concentration, boredom, irritability, and loneliness (Orgilés et al., 2020). In addition to the specific psychological effects of the lockdown, great concern was created by the uncertainty about the personal and global effects of COVID-19 (Brooks et al., 2020).

In such a complex emergency scenario, potentially contributing to traumatic situations, children should have the possibility to attribute meaning to the changes that they observe around them or that they personally undergo (Stein et al., 2009). Psychological literature has long stated that "*Children are and must be seen as active in the construction and determination of their own social lives, the lives of those around them and of the societies in which they live*" and not merely as "*passive subjects of social structures and processes*" (Prout and James, 1990, p. 8). It is, therefore, crucial to directly consider children's point of view on the radical changes caused by the pandemic through instruments that are as close as possible to their natural and spontaneous expressive and communicative mode. Drawings seem the most appropriate method to fulfill this goal. First of all, the use of drawings in psychological research has a long tradition both in developmental and clinical psychology (e.g., Machover, 1949; Royer, 1989; Malchiodi, 1998, 2001, 2008; Eaton, 2007; Romano, 2010), and it is supported by the age-appropriateness of the method "*drawing is a natural mode of expression for children age 5–11*" (Koppitz, 1968, as cited in Fury et al., 1997, p. 1154). Secondly, the request to draw a life experience enables researchers to collect information that is unlikely to emerge through verbal and observational methods (Pinto, 2016). In fact, drawing may represent, especially for younger children, a form of communication that is easier to access and has fewer constraints than verbal communication. Moreover, this communication medium can bring out implicit knowledge and content regarding experienced situations, as well as emotional aspects that might be too difficult to express through the verbal channel (Pinto, 2016). In addition, the realization of a drawing is a task that the child can carry out independently and, compared to other methods, that allows limiting the influence of the adult and the researcher (Thomas and Jolley, 1998). Finally, besides exercising and expressing imagination and creativity, the benefits that children could derive from the activity of drawing are known to be various and at different levels (Barnes, 2002; Burkitt et al., 2010; Hetland et al., 2013): cognitive (visual thinking, observation, analysis, problem-solving), behavioral (perseverance, experimentation, and reflection) and also emotional, because creative activities as drawing are known to allow children to express and share their emotions, including anger and fear that situations like a pandemic could elicit (Adıbelli and Sümen, 2020). In particular, in considering a drawing we could distinguish two levels: the representational one and the expressive one (Brechet and Jolley, 2014). Children's experiences could influence the use of specific and different sources of inspiration (Rose and Jolley, 2020) and children's perspectives could be communicated in a drawing through different channels: literal, content, and abstract expression (Brechet and Jolley, 2014).

For all the above reasons, the adoption of drawings has been a common methodological procedure in previous studies investigating the traumatic impact on children of events such as earthquakes or wars, with the double valence of a diagnostic and a therapeutic tool (Malchiodi, 2001, 2008; Romano, 2009, 2010). Regarding the graphical tool, it has already been repeatedly used in taking care of children victims of natural disasters (Malchiodi, 2001, 2008; Crocq et al., 2005; Eaton, 2007; Orr, 2007), as it allows to express emotions and events that were too painful to be told, in a structured way. The expression of feelings and thoughts through the graphic object is less explicit and therefore less threatening than the real word (Steele et al., 1995; Malchiodi, 1997). Through drawings, children are able to reprocess traumatic emotions and thoughts, contextualize the event lived in the history of their lives, and give it a new meaning, thus facilitating the processes of elaboration (Crocq et al., 2007; Hariki, 2007). The act of drawing enables children to discover and organize their impressions by following the inspirations of their own emotionality (Quaglia, 2003). Furthermore, what children draw with care could represent their positive affective tendency, and also omissions in the drawings should be considered informative because they could be an indication of an intolerable reality for the child (Quaglia and Saglione, 1990). Through drawing it is therefore possible to achieve internal cohesion, combining perceptive, affective, driving, and narrative aspects of lived life experiences, in order to create a "unified mental entity" (Royer, 1995, p. 15). Studies regarding prisoners of war camps (Volavkova, 1978) showed that in emergencies the drawing was first of all a spontaneous instrument of survival. Therefore, it is important that children in an emergency or traumatic situation are left free to draw what they want, in order to give meaning to the lived experience (Kalmanowitz and Lloyd, 1999; Al-Krenawi and Slater, 2007). In other studies, instead, children were given a more specific task, for example, the request to draw what happened or to represent themselves during the traumatic event, and/or the body of the victim (Malchiodi, 1998). In traumatic contexts, a widely used instrument is the "Test de trois dessins: avant, pendant et avenir" (Crocq et al., 2005). The technique of splitting time into three moments was introduced by Brauner and Brauner (1976) and it was subsequently resumed in other studies regarding the traumatic impact of wars and earthquakes on children, even if with some differences in the task (Bonnet, 1994; Nebout and Nebout, 2000; Crocq et al., 2002, 2005; Coq and Cremniter, 2004). The structure of the instrument with three points of time allows going deep inside into one's own memory, in order to seek continuity of life between the past and the future, encouraging one to set contact with the world and with others, thus promoting the reintegration of the subject in context. For these reasons, in this work, children's experiences were collected by referring to three moments: "Before" the pandemic advent, "During" the lockdown experience, and in the "Future," when the COVID-19 emergency will be over.

The first general objective of this study was to explore the representations of children related to COVID-19 through drawings and verbal comments on their own drawings. We aimed to observe which themes and emotional connotations emerged spontaneously in drawings, in order to understand which meanings, both in terms of difficulties and of resources, children constructed about the COVID-19 experience. Therefore, in this work drawings were considered first of all as a communicative act (Pinto, 2016), an instrument that children could use to express tacit or explicit contents and to share meanings with another person. We hypothesized that, given the emergency period, negative feelings would emerge, both at expressive and content levels, for example through themes related to the precautionary measures contrasting the infection and through the inclusion of negative connotated expressions. However, we did not *a priori* exclude the presence of positively connoted experiences as, for example, spending more time with the family. Moreover, at the expressive level, we expected that older children would have realized drawings with more expressive elements (Jolley et al., 2004).

Secondly, thanks to the request to produce drawings concerning three different moments (before, during, and in the future, after the pandemic experience), the present study had the purpose to compare representations emerging from three different time points, both at a content level and at an expressive level. To this second aim, we adapted the "Test de trois dessins: avant, pendant et avenir" (Crocq et al., 2005) to make it suitable for the specific features of the pandemic emergency and the specificity of the procedure and the context of data collection. We expected that the memories of the past and the image of the future would have included the representation of multiple people, external spaces, experienced with positive connotations, while the lockdown period would be the one most characterized by the home context and elements that refer to negative experiences. However, negative connotations could also emerge in drawings concerning the past, reflecting melancholic memory of people or experiences that are no longer here, or in the future in the form of fear and dread outweighing hope.

Besides children, another level of analysis included the parents' point of view on their children (third aim of the study). Parents compiled an online set of questionnaires that investigated the impact of COVID-19 in family life, and a report on some social, behavioral, and emotional aspects of their own children's experience and development. The aim was to investigate possible connections between the content and expressivity of drawings on the one hand, and, on the other hand, the difficulties encountered by children during the pandemic, their resources, and their mentalizing abilities to cope with it, as reported by parents in questionnaires. It was expected that there may have been connections between the expressive connotations of the drawings, the level of mentalistic ability and emotional difficulties detected by parents in their children, as previous literature suggests that the emotional comprehension and the expressivity of drawings are connected (Brechet and Jolley, 2014). In addition, difficulties at the relational level could be related to the number and the typology of people included in the drawings in agreement with the idea that children tend to include in their drawings what and who is perceived as reassuring and trusted (Quaglia and Saglione, 1990).

Materials and methods

Procedure

The Ethical Committee for Research of the University of Bergamo gave its approval for the research (Report No. 7 of 22nd May 2020) and all requirements of the ethical guidelines were respected (World Medical Association, 2008; AIP, 2015; American Psychological Association [APA], 2017). The recruitment was done through main social media platforms (i.e., WhatsApp and Facebook) where a brief presentation of the research was inserted, inviting interested parents to reply to the communication in order to be contacted by one of the researchers and to receive all the instructions for participation. In the ads, we reported the required age of the participant, the general aim of exploring children's experience of COVID-19, and the commitment required (online questionnaire, children's drawings, and audio comments). Parents interested in the study were 22 and were all contacted telephonically by one of the researchers to describe the study, explain the fundamental steps necessary to participate, and propose participation for themselves and their child/children. On this occasion, parents could make questions to the researcher, and they received the researcher's contacts for further pieces of information if needed. All parents interested to participate were provided with a link to the online platform of the study. The expression of informed consent was a prerequisite to participate in the study: the document was available for parents' completion in the online link. All participants could withdraw at any time. After telephone contact, we had confirmation of acceptance to take part in the study for 18 children. The online form for parents included three tasks: a socio-demographic questionnaire, the Strength and Difficulties Questionnaire (Goodman, 1997, 2001), and the Everyday Mindreading Scale (Peterson et al., 2009). Then, parents were asked to propose their children to realize three drawings related to the COVID-19 emergence and subsequently to record a verbal parent-child interaction about the three drawings. The request for recording comments was due to ensure that the researcher could understand all the elements of the drawing. Indeed, at a methodological level, the audio contents allow collecting more information about the representations, intending to comprehend also the meanings attributed to the drawings directly by authors, thus avoiding the risk of incurring over-interpretations. Furthermore, since the parents and not the researcher interacted with the children, the audio request could also represent a precious opportunity for the parent-child dyadic system to dialog, discuss, share emotions and meanings elicited from this period of emergency in which, as already mentioned, the whole family system was faced with new challenges and redefined itself according to the new situation. Due to the ongoing health emergency in the summer of 2020 when data were collected, the administration was necessarily done remotely and the direct interlocutors of the children were the parents. We provided parents with some brief instructions to help them in the presentation of the activity to their children and we recommended them not to force in any way the realization of drawings and comments of their children. A time of about 1 week was given to children in order to choose the most suitable time for their drawings and to proceed as spontaneously as possible without fatigue. We required to complete all three drawings in the same session. Inclusion criteria included having children in middle childhood, who speak Italian fluently and live in Italy. As exclusion criteria, we considered having developmental disorders.

Participants

The research involved 18 children (8 males and 10 females), with an age range from 5 to 12 years (M = 8.22, SD = 1.79). Parents involved (4 males and 14 females) had an age range from 35 to 49 years (M = 41, SD = 3.91), with different educational qualification: 50% secondary school qualification, 11.1% Bachelor's degree, 22.2% Master's degree, 16.7% postgraduate specialization.

Measures

The present study combined qualitative and cross-sectional quantitative measures, indeed in drawings we considered both qualitative and quantitative indicators, and questionnaires gave us quantitative data. Children were asked to produce three drawings on three moments of the COVID-19 pandemic and to orally explain the content of their drawings. The request for both the drawings and the audio report was made by parents to their own children.

Parents completed three questionnaires: a Socio-Demographic form, the Strength and Difficulties Questionnaire (Goodman, 1997, 2001), and the Everyday Mindreading Scale (Peterson et al., 2009).

Children's drawings and oral explanations on drawings

The graphical representations were investigated through an adaption of the "Test de trois dessins: avant, pendant et avenir" (Crocq et al., 2005), an instrument used previously in literature to explore the impact of traumatic events such as wars and earthquakes on children's representations (Crocq et al., 2005; Giordano et al., 2015). In the classical version, the task was composed of three parts requiring children to draw themselves, their family, and their house before, during and after the potentially traumatic event, i.e., war or earthquake. In the present study, some adaptations were applied due to the different types of emergences involved (i.e., COVID-19 pandemic), and to the different settings of administration (at home with parents). Parents were asked to make available to the child white sheets, pencils, colored pencils, and to propose them to realize three drawings related to different moments in the timeline of the COVID-19 spread and lockdown period: *a day that they remember before the coronavirus arrived ("BEFORE drawing"), a day among those they have lived during the lockdown ("DURING drawing"), a day of the future, when the coronavirus will be defeated ("FUTURE drawing")*. Subsequently, parents asked their children to explain their drawings, and motived the necessity to audio-record their narratives to ensure that the researcher could understand all the elements of the drawing. Parents were also advised not to force the child to draw or record the comments on the drawings in any way, to avoid intervening in the realization of the drawings and to remember to their children that there was no evaluation, but only an interest to know what children were thinking about the COVID-19 emergence.

TABLE 1 Indices used in coding drawings.

	Indices	Coding
Content		
Typology	Inclusion of COVID-19 references	1 = Absent 2 = Present
	Inclusion of school references	1 = Absent 2 = Present
	Themselves	1 = Absent 2 = Present
	Parents	1 = Absent 2 = Present
	Relatives	1 = Absent 2 = Present
	Friends	1 = Absent 2 = Present
	Other people	1 = Absent 2 = Present
	House	1 = Absent 2 = Present
	Space of the house	1 = Internal 2 = External
Richness	Colors	Number
	Elements	Number
	People	Number
	Details of the house	1 = Absent 2 = Present
Expressive connotation		
	Positive natural elements (sun, rainbow, flowers...)	1 = Absent 2 = Present
	Negative natural elements (clouds or rain, spiders, snakes, sickly leaves or flowers ...)	1 = Absent 2 = Present
	Positive objects (gifts, details on clothes, hearts...)	1 = Absent 2 = Present
	Negative objects (broken objects, empty cavities...)	1 = Absent 2 = Present
	Facial expression of happiness	1 = Absent 2 = Present
	Facial expression of sadness	1 = Absent 2 = Present
	Representation of movement	1 = Absent 2 = Present

For the coding procedure, we followed previous literature (Picard et al., 2007; Giordano et al., 2015), but at the same time, we constructed a specific grid (see **Table 1**) to identify two levels of information: the content of the representations and the expressive connotations of drawings. On one side, we used some indices from previous work that investigated the traumatic impact of natural disasters (Giordano et al., 2015), such as the presence of the house, the representation of themselves, parents, or others. In addition, we evaluated if children included details of internal vs. external spaces, the representation of pandemic characteristic elements (e.g., masks, graphical representation of the virus, the slogan "*Everything will be ok*"...),[1] of their school or of online lessons. At the content level, we distinguished indices related to the richness of pictures and others that detected the type of content. A general index of richness was represented by the number of elements in the drawing (object, people, nature...). For

1 During the first phase of COVID-19 health emergency in Italy "Everything will be ok" was the slogan that was reported with a drawing of a rainbow as a message of hope on billboards and banners hanging on windows and balconies.

the representations of people, indices of richness were the number of human figures included, and the category of people represented (parents, relatives, friends, strangers, . . .). In evaluating the expressive strategies used by children to convey the positive or negative connotation of drawings, we moved on from the theorical framework of Jolley (2010) and we adapted some indices used in the previous work of Picard et al. (2007), aka objects and natural elements that suggest happiness or sadness. We also maintained some indices that were used both in Picard et al. (2007) and in Giordano et al. (2015), i.e., the number of colors, and the presence of happy or sad facial expressions. Moreover, we included at the expressive level the presence of indicators of movement. Specifically, our index of movement representation constituted an integration of the index concerning body position (Picard et al., 2007) and narrative elements (Giordano et al., 2015) related to dynamism. In detail, we considered as presence of movement in the drawings those elements of dynamisms were either deducted from the body position and gestures of characters or from the explanation children gave to their drawings. Drawings were coded independently by two of the authors, that subsequently discussed mismatches in coding, in order to provide a joint decision on the codification to be assigned.

Socio-demographic form

Parents were asked to complete a questionnaire based on the socio-demographic form used for the previous works by Petrocchi et al. (2020) and Bianco et al. (2021), with some differences due to the specificity of the aims of each work. It was composed of 14 questions about: socio-demographical data (age and gender of parent and child, parent's education level, family residence, presence/absence of development disorders and fluency in the Italian language of the child, changes in socio-economic status due to pandemic), the exposure to COVID-19 (if they relatives and/or their friends were positive for the virus infection or manifested correlated symptoms and whether someone died because of COVID-19), the presence of garden or terraces in their home and the people with whom the child had spent the quarantine.

Strength and difficulties questionnaire

The parents' perception of their children's difficulties and/or resources was investigated through the Strength and Difficulties Questionnaire (SDQ; Goodman, 1997, 2001). The original instrument was composed of 25 items grouped in five subscales: *Hyperactivity, Emotional Symptoms, Conduct Problems, Peer Problems*, and *Prosocial Scale*. In this work two items of the *Peer Problems Scale* were removed ("Picked on or bullied by other children" and "Generally liked by other children"), because in the specific period of the lockdown these aspects were not evaluable. Each item could be marked "not true," "somewhat true" or "certainly true." The items that express difficulties were scored 1 for "not true," 2 for " somewhat true," and 3 for "certainly true." The items that express a strength point were scored 3 for " not true," 2 for "somewhat true," and 1 for "certainly true." The scores for *Hyperactivity, Emotional Symptoms, Conduct Problems*, and *Peer Problems* were summed to generate a total difficulties score ranging from 18 to 54. A higher total score indicated a major level of difficulty and this was true also for subscales, except for the *Prosocial Scale* which was not incorporated in the reverse direction into the total difficulties score, as indicated in the guidelines of the questionnaire. In this subscale, the range was from 5 to 15, with a higher score indicating a major presence of prosocial behavior.

Everyday mindreading scale

The parents' attribution of mentalizing abilities to their children was measured through the Everyday Mindreading Scale (Peterson et al., 2009). This instrument was composed of 8 items: six items concern children's attitudes that reflect their difficulty in considering others' perspectives, whereas two items relate to the children's ability to adapt their behavior to the context and to take into account others' emotional expressions. For each statement parents had to rate their own child's difficulty using a 5-point scale where 1 was "not true" and 5 "completely true." We reverse-scored positive items so that a higher score on each item of the scale reflected more difficulty (total scores ranging from 8 to 40).

Data analysis

The collected data have been analyzed using the SPSS statistical software Version 25. The sample size and the distribution of variables led us to use non-parametric analysis techniques. Single sample tests (binomial and chi-square) were executed to examine the distribution of frequencies of indices in the three groups of drawings: "Before drawing," "During drawing," and "Future drawing." The distribution of each variable in the coding grid within the three tests was compared by testing non-parametric hypotheses on repeated measurements. The Friedman test was used for quantitative analyses, Cochran *Q*-test was used in the case of qualitative binary variables. In presence of significant differences between the distribution of the variables, three "pair" comparisons were carried out to investigate the nature of the significant differences that

TABLE 2 Sample description of COVID-19 related information.

Collected information	Percentage
Features of the house	16.7% garden 16.7% terrace 66.7% both of them 0% none of them
Pandemic experience in family	66.7% no cases of COVID-19 positivity 5.6% someone had compatible symptoms but without doing a swab 27.8% cases of positivity in families 16.7% deaths caused by COVID-19
Pandemic experience in friends	60% no cases of COVID-19 positivity 40% cases of positivity in friends
Cohabiting during the lockdown	66.7% parents plus brothers/sisters 22.2% one or both parents 11.2% also grandparents
Changes in socio-economic status due to pandemic	94.4% absence 5.6% presence

exist. Three "pair" comparisons were performed together in a single phase, thus a Bonferroni correction for multiple tests was considered and *p*-values were compared with a significance level $\alpha = 0.05$. Mann-Whitney test was used to compare qualitative drawing indicators and the scores of the parents' questionnaires.

Results

Table 2 reports some specific characteristics of the sample that describe the experience of the lockdown of children and also the impact of the pandemic on their family life. In particular, it seems important to emphasize the fact that all participants had an outdoor space during the lockdown, most families did not experience deaths due to COVID-19 and more than half of the sample did not even encounter any positive cases either in the family or in the circle of friends. All children spent the lockdown in the family with at least one parent and most of children also with brothers or sisters. Finally, the involved families tended not to have experienced significant changes in socio-economic status due to the pandemic.

With reference to the first and most exploratory objective of this paper, Tables 3, 4 show a descriptive overview of the main features of the drawings. Overall, there was a presence of contents and indicators with a positive connotation and a paucity of negative connotations in drawings. The one-sample binomial test showed that in the representations of all the three moments considered, children included themselves in drawings to a greater degree than expected ($p = 0.001$ "Before"; $p = 0.008$ "During" and "Future"). Comparisons based on age showed a significant effect on positive connotated objects, such as pictures of hearts, presents, clothes details, U (N Absence = 13, N Presence = 5) = 55.00, $z = 2.22$, $p = 0.026$. Older children (*Mdn* = 10.15) tended to represent these types of objects to a greater extent than younger children (*Mdn* = 7.44), that generally did not include them in their drawings of the future.

Concerning the second aim of this work, multiple use of colors and the inclusion of facial expressions of happiness were more frequently present in "Before" and "Future" drawings, but also in "During" drawings, where sadness was included by few children and solely in the period of strict home confinement (see Table 4). Similarly, there were positive connotated natural elements (i.e., sun, flowers, rainbow...) in "Before" and "Future" drawings, and even in the lockdown representation. The presence of movement, which once again was prevalent in "Before" and "Future" drawings, was also present in "During" drawings when the possibility of movement activities was limited, as illustrated in Table 4. Representations of the period before and after the lockdown were joined by some absences in pictures: these drawings generally did not include the representation of home ($p = 0.008$ "Before" and $p < 0.001$ "Future"), parents ($p = 0.008$ "Before" and "Future") and other relatives ($p = 0.008$ "Before" and "Future"), compared with the expected distribution. If instead, we consider the drawings relating to the lockdown period, friends and references to school (also as online learning) were generally absent, but also there were not many elements that refer directly to COVID-19. Table 5 shows the comparisons between the distributions of the drawings variables at the three moments considered. As seen above, the house was generally not included in drawings representing the past and future. In line with this first evidence, a significant difference emerged also between representations of these two moments and the pictures concerning the period during the lockdown, where houses were more present, $\chi^2(2) = 19.08$, $p = 0.000$. Moreover, houses represented in drawings regarding the months of closures and home confinement were more detailed as compared with houses included in pictures of a day that children remember before the advent of the pandemic and their imagination of a day in the future when the emergency related to COVID-19 will be over, $\chi^2(2) = 17.17$, $p = 0.000$. Another significant difference, that once again concerns the period of lockdown in contrast with the other moments, was the representation of friends, $\chi^2(2) = 10.31$, $p = 0.006$, that were generally excluded from drawings representing the more critical phase of the emergency and instead were more depicted in the "Future" drawings.

As expected, in agreement with the third objective, there were some significant associations between indicators in drawings and scores in questionnaires. As far as regards the parents' perception of mentalizing abilities of their children, it emerged that children that did not include their parents in the "Before" drawing had, according to their parents' point of view, less difficulty in taking into account the mental states of others (*Mdn* = 12), in comparison with children that included

TABLE 3 Descriptive statistics on quantitative drawing indices.

Index	Before drawings				During drawings				Future drawings			
	Min	*Max*	*M*	*SD*	*Min*	*Max*	*M*	*SD*	*Min*	*Max*	*M*	*SD*
Number of colors	1	13	6.94	3.52	1	12	6.22	3.40	1	11	5.89	3.41
Number of people	0	9	2.78	2.49	0	6	1.89	1.68	0	15	3.44	3.94
Number of elements	1	10	4.44	2.48	1	12	5.50	2.77	1	8	3.83	2.01

TABLE 4 Frequencies of qualitative drawing indices.

Index	Before drawings Percentage	During drawings Percentage	Future drawings Percentage
Representation of the house	16.7	72.2	5.6
Details of the house	16.7	66.7	5.6
House as internal space	16.7	50	5.6
Representation of themselves	88.9	83.3	83.3
Representation of parents	16.7	27.8	16.7
Representation of relatives	16.7	38.9	16.7
Representation of friends	44.4	5.6	55.6
Happy expression	61.1	38.9	72.2
Sad expression	–	11.1	–
Positive natural elements	55.6	44.4	50
Negative natural elements	–	5.6	–
Objects with positive connotation	38.9	22.2	27.8
Objects with negative connotation	–	–	5.6
Imaginary contents	5.6	11.1	–
Elements that suggest movement	61.1	44.4	55.6
School referred elements	33.3	16.7	33.3
COVID referred elements	–	22.2	16.7

their parents in drawing (*Mdn* = 17), *U* (*N* Absence = 15, *N* Presence = 3) = 41.00, $z = 2.22$, $p = 0.027$. In relation to the particular aspects identified by the subscales of SDQ, our results highlighted significant association with "Problems with peers": children that tended to include relatives in drawings regarding the period before the pandemic had lesser relational difficulties with peers according to their parent's evaluation (*Mdn* = 3), whereas children that obtained higher scores in this scale (*Mdn* = 4) tended to exclude relatives from their pictures *U* (*N* Absence = 15, *N* Presence = 3) = 4.50, $z = -2.25$, $p = 0.027$. It is necessary to point out that the index "Presence of relatives" also includes siblings. Finally, the scores in the subscale that measure difficulties in emotion regulation showed multiple significative associations with different drawings' indicators. Concerning the representations of the period before the lockdown, children that represented friends in their drawings had lower levels of difficulty, referred by parents, in the emotional area (*Mdn* = 5), while children with higher emotional difficulties (*Mdn* = 8) tended to not include friends in their pictures, *U* (*N* Absence = 10, *N* Presence = 8) = 15.00, $z = -2.29$, $p = 0.027$. Moreover, children that included references to school in drawings had lower reported difficulties in this subscale (*Mdn* = 5), compared with children that did not draw any elements linked with school context (*Mdn* = 8) in representation of their past experience *U* (*N* Absence = 12, *N* Presence = 6) = 9.00, $z = -2.60$, $p = 0.01$. An interesting result emerged from the comparisons between the emotional subscale and the happy facial expression in drawings related to the period of quarantine (H (2) = 7.89, $p = 0.023$): children whose parents reported lower levels of emotional difficulties (*Mdn* = 5) tended to represent an expression of happiness, instead children that did not include happy faces received higher scores in the emotional difficulties scale from parents (*Mdn* = 8.50).

Discussion

Exploring children's representations of an emergency experience that upset their everyday life has highlighted a generally encouraging picture in considering the impact of COVID-19 on the children involved in this study. However, it is important to underline some characteristics of the sample that may have influenced children's representations and, in general, the ability of families to deploy resources to limit the negative impact of the pandemic on their lives. The availability of outdoor spaces where children could spend time, a limited direct

TABLE 5 Significant differences in the distribution of variables within the three tests.

Index	Drawing			Comparisons		
	1	2	3	1–2	2–3	1–3
Presence of the house	3 (16.7%)	13 (72.2%)	1 (5.6%)	0.002*	0.000**	1.000
Inclusion of details of the house	3 (16.7%)	12 (66.7%)	1 (5.6%)	0.004*	0.000**	1.000
Presence of friends	8 (44.4%)	1 (5.6%)	10 (55.6%)	0.052	0.007*	1.000

1 = BEFORE drawing. 2 = DURING drawing. 3 = FUTURE drawing.
*$p < 0.05$. **$p < 0.01$.

experience of COVID-19 and a limited impact on the socio-economic status of the families, could have affected the ways children involved in our study perceived and lived the pandemic.

Addressing the first aim of our study, in this section we will provide a discussion on the representations of children of COVID-19 pandemic, *via* the themes and expression connotations emerging from drawings. Conversely to what expected, we did not retrieve a high frequency of negative connotations in drawings. This result is in line with the one retrieved by Adıbelli and Sümen (2020) regarding children's positive self-reported quality of life, despite home confinement. However, we should also remember, in our interpretation of this result, that our sample was mostly made by "privileged" families compared to the average of Italian families, even if they lived in a region severely affected by COVID-19 like Lombardy (Mantovani et al., 2021). In a similar direction, we found that children tended to insert themselves in drawings, suggesting that they feel able to cope with the situation also integrating the lockdown experience in the narration/representation of their life story. As pointed out by Masten (2021), a child's reaction to an emergency largely depends on the capabilities that the family can allocate to cope with it, which in turn are influenced by other interconnected systems, first and foremost community support. The results of a work by Mantovani et al. (2021) supported this aspect, showing the importance of the so-called "systemic resilience" (Bronfenbrenner, 1979) characterized by the acceptance of limitations by children and by the effectiveness of parents in addressing the challenges posed by the pandemic. In line with literature, at the expressive level, we retrieved an effect of age on the inclusion of positive connotated objects in drawings (e.g., gifts, details on clothes, hearts...). The literature on children's drawings suggests, indeed, that generally expressive ratings increase with age, but they are often significantly lower for sad drawings (Jolley et al., 2004). Furthermore, expressive contents are linked with emotional comprehension abilities and with knowledge about the situational determinants of emotions (Brechet and Jolley, 2014). Therefore, this age difference could be brought back to the development of expressive strategies used in drawings which has emerged despite the limited number of participants.

In response to the second aim of the study there are some results to highlight on the comparison of the representations of the three moments. All children have completed the drawings of all three moments, and the presence of a limited number of significant differences between "Before, During and Future drawings" could suggest linearity and harmony in the perception of their experience, despite the sudden changes imposed by COVID-19 and the consequent social restrictions. However, the observed frequencies of drawings indicators showed in particular an interesting result, that is the absence of parents especially in "Before" and "Future" drawings. This result goes in line with previous studies on the traumatic impact of natural disasters (Giordano et al., 2015), which report that parents are often not represented because the uncontrollability of the emergency somehow limits their function of protection for children. We may speculate that with the advent of the pandemic children may have perceived the uncertainty and the non-controllability of the situation even for the adults, and therefore they chose to represent the house that appeared to be the only secure place that could guarantee a certain degree of protection, stability and safety, also considering the age range of our participants. Future research in this direction is however auspicated to confirm our proposed explanation. For what concern the significative differences in comparing the three moments, as expected, the theme of the house, place of confinement, was largely illustrated in the "During" drawings that also include more details of the house compared to the "Before" and "Future" ones, reflecting the extremely high relevance of this context in the life of children during the pandemic due to social restrictions. It may be worth noting that adding details to the representation of the house is usually considered an index of care and therefore of a positive emotional investment in what is represented (Quaglia and Saglione, 1990). A significant difference in comparing the three moments, is also the major representation of friends in "Future" drawings, in line with our expected results and findings from other contemporary studies (Idoiaga Mondragon et al., 2021; Pascal and Bertram, 2021): this result may indicate a desire and a hope to return to spend time with friends, thus showing a certain trust in the future which is an important resource.

As far as concerns our third area of investigation, some relevant results emerge from the integration of quantitative and qualitative measures. The children that have more difficulties in taking into account the mental states of the others, as reported by parents, include their parents in "Before" drawings. This difficulty may cause them not to perceive the concern and the uncertainty of their caregiver, that therefore do not lose, in children's perception, their function of protection and shelter.

As already said before, in emergencies children often do not include their parents in drawings: in the face of events such as natural disasters or wars, parents are unable to maintain in the eyes of their children the safety function that they can usually perform, because they cannot control these events and also are tested by them (Giordano, 2012). Thus, children that are able in considering others' mental states could perceive the worries, the uncertainty and probably also the difficulties of their parents in dealing with the COVID-19 pandemic, thus weakening to their eyes the function of protection and refuge of parents. However, we are aware that more future research is needed to confirm this claim. Moreover, children that include friends in "Before" drawing have fewer difficulties in the emotional area, as revealed by the SDQ. Including friends in a drawing of a past event, in the impossibility of spending time with them, at the time the drawings were collected, could be an emotional content too difficult to control for children that have difficulties in their emotional regulation. Indeed, other studies (Idoiaga Mondragon et al., 2021) highlight that children were sad, angry, upset and felt lonely because of the lack of friends. An unexpected result was the significant association between the exclusion of relatives in "Before" drawings and a higher level of difficulty in relationships with peers reported by parents. It could be hypothesized an influence caused by the presence of siblings in the coding label "Relatives." Given the closure circumstances from which families came in the months prior to data collection, it was siblings the peers with whom parents were able to see their children relate with. As seen for other contents there was a tendency to exclude from drawings the elements of difficulty and discomfort. This appears a tendency especially for memories and hopes, whereas in representing lockdown experience some children also took the liberty of reporting a few unpleasant items (sad expressions, negative natural elements). In addition, the scores on the emotional subscale of SDQ were lower in children that included a happy facial expression in their "During drawing." In considering happy facial expression it is important to keep in mind that there is a "mood bias" (Buckalew and Bell, 1985; Jolley et al., 2004), so that children, in general, tend to represent more happy expressions than sad ones.

Despite the interesting results reported so far, we are aware that this work is not without some limits. One of these is the reduced sample size, due to the difficulties in recruiting participants in such stressful period, and also the "privileged" population involved, which forces us to remain very cautious in generalizing the representations and contents that emerged. Another possible limitation is that we did not collect information about the level of familiarity, enjoyment and habit with the practice of drawing by the children involved. It would be desirable in subsequent studies to collect these data in order to insert considerations regarding the drawing of a potentially traumatic situation into the larger and more complete framework of how the child ordinarily knows, appreciates and uses the communicative tool of drawing. In addition, the results of this study may have been influenced by the particularity of the setting of administration. The fact that parents were asked to propose the activity to children was unavoidable, because of the restrictions imposed by the pandemic that prevented the researcher to collect data directly. Of course, this would have allowed us to gain more control over the possible variables in the setting, to collect more information and with a higher level of details that would have then allowed more specific reflection. However, involving parents actively in collecting children's drawings and comments may have given children the opportunity to share emotions with their parents, and to build new meanings together with their reference figures, thus allowing a shared reflection of what they lived during the lockdown and of their hopes and desires for the future (Petrocchi et al., 2020; Prime et al., 2020; Bianco et al., 2021; Masten, 2021). Moreover, this work offered an occasion to discuss also the children's representations of their parents that are generally absent in drawings.

As previously mentioned, using a qualitative research method requires a lot of caution in the interpretation and generalization of the collected data. Even if we consider the expressive indicators taken from the previous studies (Buckalew and Bell, 1985; Jolley et al., 2004; Picard et al., 2007; Brechet and Jolley, 2014; Misalidi and Bonoti, 2014; Rose and Jolley, 2020), they could be influenced by the age of the child or by the typical tendency to include more elements of positive connotation. Therefore, while maintaining the central focus on the perspective of children, it was also very relevant for us to collect, quantitatively, some information from parents. Also, the tasks proposed to parents could have had a first direct relapse in turning their attention and arouse in them a reflection on the behavior and experiences of their children. At the methodological level these additional data have made it possible to insert the graphic expression of children within a wider framework. Indeed, according to Brannen (2005), the combination of quantitative and qualitative research methods may result in confirmation, elaboration, complementarity, or contradiction, but in all cases, the combination leads to an integration and a more complete overview of the selected phenomena. Furthermore, the integration of qualitative and quantitative methods to collect, respectively, children's and adults' points of view could represent a precious source of information with the aim to highlight resources and needs of families, in prevision of potential interventions that could increase family wellbeing and coping skills. From this perspective, it could also be relevant to add information about parents' experiences in order to relate these data, to what is communicated through the drawing by their children. A previous study showed that the level of distress of mothers may influence the attribution of negative emotions to children and their behaviors (Petrocchi et al., 2020). Therefore, it would be interesting observing and comparing the contents and emotions emerging from children's drawings and, on the other hand, from mothers' or parents' representations. This addition would not be intended to reduce the centrality of the point of view of the child, but rather to maintain a vision as much as possible systemic and careful not to isolate the subject from its context, because children and parents are systems in continuous interaction with other external systems (Pianta, 2001).

Conclusion

This study has provided an exploratory look at the experiences of children during the pandemic, thus allowing to have as much as possible authentic knowledge of the representations and the meanings aroused in children by the emergency linked to the pandemic.

The expression through the drawing and particularly the structure of the "Test de trois dessins: avant, pendant et avenir" (Crocq et al., 2005) could be an effective means for enabling children to express and share their experience of an event with exceptional nature, such as the pandemic. This also permitted us to explore the views of children which cannot be ignored given the challenge to their development that the pandemic has brought with it (Haleemunnissa et al., 2021). What seems to emerge is that the children of our sample have generally had sufficient resources to limit the potential negative impact on their development caused by the COVID-19 emergency. This does not mean that children have not perceived the concerns, changes and limitations that the pandemic has brought with it, for instance, the lacking of friendship relationships. The employment of a qualitative method like drawings allows understanding the point of view of the subject in all its complexity, specificity and richness. Indeed, with this type of instrument children are free to express their representation without the fear of being judged or evaluated. For this purpose, the choice, although forced, to delegate the administration to parents could have favored a more spontaneous and natural expression of their emotions, feelings and experiences, thus enriching the relationship between the child and the caregiver in such a complex period like the pandemic.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving human participants were reviewed and approved by the Ethical Committee for Research of the University of Bergamo. Written informed consent to participate in this study was provided by the participants' or their legal guardian/next of kin.

Author contributions

FB, GG, AM, DM, and IC conceptualized the study and supervised it. FB and AC were responsible for the data collection. GG and AC coded drawings. AC and DM analyzed the data. AC, FB, and IC wrote the draft manuscript. GG, AM, and DM provided feedback on the final manuscript. All authors read and approved the final version of the manuscript.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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The representation of bullying in Italian primary school children: A mixed-method study comparing drawing and interview data and their association with self-report involvement in bullying events

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Bullying continues to be a social issue affecting millions of students of all ages worldwide. Research on bullying seems to be dominated by quantitative research approaches employed standardized categories and measures, ultimately limiting our knowledge about children's own view on bullying. Our research follows another direction, aiming to explore the representation of bullying in a sample of Italian primary school children by using and comparing the functioning of two qualitative research instruments: interviews, and children's drawings. In addition, aided by quantitative analyses, we aimed to investigate whether students' involvement in different bullying roles (as bullies, victims, or defenders), as measured by self-assessment, correlated with different characteristics of the representation of bullying emerging from children's drawings and interviews. We recruited a convenient sample of 640 primary school students (mean age = 9.44; SD = 0.67), 53.3% of whom were male. The results showed that all forms of bullying, i.e., physical, verbal, and social bullying, could be identified in interview and drawing data, although references to all types of bullying were more frequent in interview data. In terms of bullying criteria, the presence of a power imbalance between the bully and the victim was most frequently detected in both the interview data and the drawing data, while repetition was more easily detected in the interview data. The interview data showed that sadness was the most frequently reported victim emotions, followed by fear, anger, and lack of emotion. The drawing data showed a similar pattern, although victims were more frequently described as lacking emotions compared to the interview data. In both interview and drawing data, age and female gender were positively associated with references to verbal bullying, and negatively associated with references to physical bullying. Additionally, bully/victim children were more likely than uninvolved children to depict physical bullying in the drawings, while this association was not detected in interview data. In summary, our study shows that, compared with drawings, interviews tend to provide a more comprehensive view of children's own representation of bullying, while drawing data tend to show stronger connections with children's current personal experiences of bullying.

KEYWORDS

bullying, victims, children's drawing, interview, primary school

Introduction

School is a context in which various forms of victimization can occur (Longobardi et al., 2017, 2019; Badenes-Ribera et al., 2022). Bullying continues to be a social issue affecting millions of students of all ages worldwide (Craig et al., 2009; Ossa et al., 2021) which tends to be associated with poorer developmental and academic outcomes for affected children (Moore et al., 2017; Prino et al., 2019; Fabris et al., 2021). Bullying is usually defined as a frequent, repeated, and intentional form of aggression involving an imbalance of power or strength between the bully and the victim (Olweus and Limber, 2010) which may be exerted in different forms, including physical aggression (e.g., being hit, kicked, pushed, shoved), verbal aggression (e.g. being insulted or called nasty and hurtful names or threatened) or social exclusion (e.g., being ignored or excluded from peer groups). Bullying is also considered a group phenomenon in which one or more individuals (bullies) repeatedly and intentionally attack, humiliate, or exclude others (victims) who have difficulty fighting back (Salmivalli, 2010). The social scene of bullying is complex, and peers may participate not only as victims, bullies, or bullies-victims, but also play other roles. There are assistants to the bully who join the ringleaders to attack a victim; reinforcers who are not actively involved in the bullying but are instrumental to the actions of the bully; defenders who actively intervene and try to stop the bullying (e.g., demand teacher intervention or try to comfort the victim); and bystanders who know what is happening but do not take sides with either the bully or the victim (Salmivalli, 2010).

Although peer aggression usually peaks in early adolescence (Perry et al., 1988), forms of bullying can also occur in primary school, and some studies have found certain gender differences in the prevalence of involvement. In particular, males appear to be at heightened risk of being involved in bullying, both as bullies and as victims, while females tend to report more often forms of indirect victimization (Iossi Silva et al., 2013; Ang et al., 2018; Twardowska-Staszek et al., 2018; Jiménez, 2019) and are more likely to engage in forms of indirect bullying such as active social exclusion (Ang et al., 2018).

The majority of research currently conducted on the topic of children's involvement in bullying appears to favor quantitative studies (Patton et al., 2017; Marengo et al., 2021; Samara et al., 2021). Quantitative studies based on self-report questionnaires allow us to increase our knowledge in large samples in a comparable way. However, they have the limitation of not revealing the subjective experiences of the children involved. Unlike quantitative surveys, qualitative research is typically inductive and therefore lends itself to an in-depth exploration of the perspectives, perceptions, and experiences of children involved in bullying (Bosacki et al., 2006; Patton et al., 2017). This is a central aspect of bullying research because it allows researchers to examine more closely how children perceive and define bullying, which has concrete implications for intervention and prevention strategies. Along these lines, qualitative research allows us to examine children's representations of bullying, integrate and extend data from quantitative research, and thus inform researchers and practitioners about intervention and prevention strategies (Torrance, 2000; Espelage and Asidao, 2001; Patton et al., 2017). In practice, as several authors point out (Bosacki et al., 2006), quantitative research forces the child to answer questions designed and suggested by researchers, whereas qualitative research allows children to express their own perspectives and highlight the aspects of the phenomenon that are most important to them. In doing this, we may be more able recognize that there is no single, common definition of bullying and that the definition of bullying, and thus the perception of the phenomenon, may vary between students and adults, such as researchers, school staff, and teachers (Eriksen, 2018). Still, use of qualitative research is not without limitations, as it is typically more time consuming and requires more resources than quantitative research (e.g., personnel performing interviews, or the coding of collected data; Carter and Henderson, 2005). Lack of anonymity may also be another issue possibly introducing bias in the assessment procedure in terms of both lowering proneness to respond, as well as the need to do it in socially desirable way (Bergen and Labonté, 2020).

A common data collection approach in qualitative research is the use of in-person interviews (Silverman, 2016). Using interviews with primary school children, Guerin and Hennessy (2002) found that verbal and physical bullying were the most common forms of bullying in children's narratives, followed by forms of bullying characterized by threats, spreading rumors, and social exclusion. However, in contrast to the definitions proposed by researchers, it appears that repetition, intent, and lack of provocation are not central to definitions of bullying by students (Madsen, 1996; Guerin and Hennessy, 2002; Monks and Smith, 2006; Naylor et al., 2006), while harm inflicted on victims is a salient feature in their definition of bullying (Madsen, 1996; Naylor et al., 2006).

Studies using interviews or open-ended questions also report age and gender differences in children's representation of bullying. As for age, young children tend to differentiate only between non-aggressive and aggressive acts, viewing the latter as bullying even when they do not involve bullying behavior (e.g., children of equal power fighting over a misunderstanding); in turn adolescents and adults have a more complex understanding of bullying, successfully distinguishing between direct and indirect forms of physical, relational/social, and verbal bullying behaviors (Smith et al., 2002; Monks and Smith, 2006; Naylor et al., 2006). For example, in the school context, children are more likely to refer to direct victimization (physical and verbal) compared to their teachers, who in turn tend to refer also to indirect forms of bullying (e.g., social exclusion; Naylor et al., 2006).

When compared with males, females' representations of bullying appear to focus more on the impact of bullying and the emotional well-being of the victims; in turn, males are more likely to describe observable behaviors that may occur in bullying incidents (Naylor et al., 2006; Byrne et al., 2016). Some data show that females tend to report more verbal abuse than males (Naylor et al., 2006). In addition, Naylor et al. (2006) report that females tend to report social exclusion as a form of bullying more often than males; however, some studies do not support this finding (Guerin and Hennessy, 2002; Smith et al., 2002).

Interviews are not the only qualitative techniques used in studying children's representation of bullying among primary school students. Some surveys have used children's drawings to identify children's representations of bullying (Bosacki et al., 2006; Patton et al., 2017). Children's drawing appears to be a useful tool for research because it allows us to examine the representations and perceptions that children exhibit toward a particular topic of inquiry (Bozzato et al., 2021). Drawing is considered an attractive and entertaining activity for children (Kukkonen and Chang-Kredl, 2018). From a methodological perspective, children's drawing could be an investigative tool that benefits children who have difficulty with verbal expression, and through drawing, the child can incorporate elements that are important to him or her in terms of representing the phenomena he or she depicts (DiCarlo et al., 2000; MacPhail and Kinchin, 2004). In addition, several studies point to the importance of children's drawings as a tool for assessing psychological well-being and the quality of interpersonal relationships (Bombi et al., 2007; Laghi et al., 2013; Potchebutzky et al., 2020; Kallitsoglou et al., 2022).

Research on bullying conducted using the drawing technique shows some interesting findings, which we will summarize here. The vast majority of primary school children tend to draw the victim-perpetrator dyad, while children only begin to draw more than two people in the scene as they get older (Bosacki et al., 2006). It appears that children tend to draw the bullying scene protagonists with their own gender, while only a smaller percentage (10%) draw mixed-gender scenarios (in which a male typically bullies a female) (Bosacki et al., 2006). Children usually draw bullies either larger or the same size as the victim, while it is rare for the victim to be drawn larger than the bully (Bosacki et al., 2006; Slee and Skrzypiec, 2015). Most children draw facial expressions for both the bully and the victim (Bosacki et al., 2006). For the bullies, the majority draw positive facial expressions, while only between 6 and 38% of them draw negative facial expressions (Bosacki et al., 2006; Slee and Skrzypiec, 2015). Regarding victims, the majority of them are presented with a negative facial expression and to a lesser extent with a neutral or positive facial expression (Bosacki et al., 2006; Slee and Skrzypiec, 2015). Many children also draw "speech bubbles" or verbal comments, and this appears to characterize younger children in particular (Bosacki et al., 2006). However, as Bosacki et al. (2006) note, not only do the depictions of verbal comments decrease as children get older, but older children are more likely to portray the victim as silent during bullying events. According to Andreou and Bonoti's (2010) survey, nearly half of the children draw themselves in the bullying scene, as victim, bully, or defender, but not as helper or reinforcer of the bully. Girls tend to draw themselves into more verbal victimization scenes than boys, while boys tend to draw themselves as engaging physical acts of bullying. Furthermore, Andreou and Bonoti's (2010) analysis shows that physical, verbal, or mixed (both physical and verbal) forms of victimization appear in the drawings, while other forms of violence, such as attacks on property or social exclusion, are not depicted.

One aspect that we believe is insufficiently explored in the literature is whether experiences with bullying (as victim, aggressor, or bystander) may be associated with children's representation of bullying in some way. In this direction, evidence suggests that the experience of peer victimization does not appear to be associated with children's definition of bullying in interviews (Monks and Smith, 2006; Naylor et al., 2006). However, when confronted with vignettes depicting bullying, bullies tend not to recognize these aggressive behaviors as bullying (Monks and Smith, 2006). This could be because bullies' moral restraint leads them to minimize negative emotions (such as shame and guilt) and emphasize positive reactions to bullying (Ortega et al., 2002). This would result in aggressive acts being less recognized and defined by bullies as bullying behavior (Monks and Smith, 2006). In a large sample of adolescents, Byrne et al. (2016) found that students who had experienced peer victimization were more likely to discuss the emotional impact of bullying on the victim in their definition of bullying compared to those who had not been victimized.

Regarding the relationship between self-reported bullying involvement and drawing in childhood, we are aware of only two studies that have attempted to examine possible correlates in primary school children (Andreou and Bonoti, 2010; Slee and Skrzypiec, 2015). Andreou and Bonoti (2010) examined the correlation between self-report and bullying design and found a weak correlation. Slee and Skrzypiec (2015) found that children who were bullied tended to make more detailed drawings and depict less spatial distance between the figures of the victim and the bully. No significant relationship was found between the frequency of victimization and the size of the bully or victim and some graphic indices traditionally associated with emotional well-being, such as the size of the drawing and the weight of the lines. Overall, then, there is a need to explore the relationship between self-report and qualitative research instruments (particularly interviews and children's drawings) to understand primary school children's representation bullying. Furthermore, there is limited evidence of comparisons between different qualitative approaches such as drawing and interviewing to understand whether both instruments can be considered informative and whether they converge or diverge in terms of the information they provide about the child's experience.

The present study

Research on bullying seems to be dominated by quantitative research approaches, thus disregarding important information about children's representation of bullying and their involvement in the phenomenon. The present study seeks to fill this gap using a mixed method approach. Using two qualitative research approaches, namely the interview and children's drawings, we collected data about the representation of bullying (and the characteristics that define it) in a sample of Italian primary school children. Based on collected data, and aided by quantitative methods, we sought to answer multiple research questions. First, we sought to determine if children's representations of bullying emerging from interview and drawing data differed in significant way. We based this comparison on a set of bullying characteristics naturally emerging from the data, including the type of bullying behaviors enacted by the bully (e.g., physical, verbal, and relational bullying), their compatibility with commonly used criteria for bullying (i.e., repetition, power imbalance, and intentionality), the emotional and behavioral response of the victims, and the presence of other individuals (e.g., teachers and other children). Secondly, we wanted to understand if the children's representations of bullying observed in their drawing and interview would be related to the demographic characteristics of the children, as well as their direct involvement in bullying episodes as measured using a self-report questionnaire. Thus, asking the children to describe their personal representation of bullying through their drawing and interview data, and self-report about their involvement bullying episodes, allowed us to examine how these experiences were associated with their view on bullying. It is noteworthy that, because of the lack of previous studies exploring the first research question (i.e., are there differences in bullying representations between drawing and interview data?), we considered this aim of the study as eminently explorative. In regard to our second research question (i.e., are gender, and age, and bullying experiences

TABLE 1 Difference in the distribution of coded characteristics in interview and drawing data.

Coded characteristics	Interview	Drawing	McNemar's test	
	%	%	χ^2	*p*
Type of active bullying				
Physical bullying	86.41	52.19	180.70	<0.001
Verbal bullying	86.72	55.31	164.61	<0.001
Social bullying	61.41	42.03	53.65	<0.001
Bullying criteria				
Power imbalance	25.00	26.25	0.23	0.634
Intentionality	8.13	5.78	2.48	0.115
Repetition	12.81	2.34	50.07	<0.001
Victim behaviors				
Defense	49.53	27.34	68.09	<0.001
Passive	63.28	64.53	0.20	0.658
Victim emotions				
Sadness	48.13	24.06	80.72	<0.001
Fear	15.63	10.63	7.75	0.005
Anger	8.59	1.41	31.64	<0.001
Lack of emotion	0.94	19.22	109.40	<0.001
Other children				
Are they present?	86.41	37.81	259.03	<0.001
Supporting the victim	61.25	6.88	327.20	<0.001
Pro-bully behaviors	15.78	28.75	33.79	<0.001
Passive	33.59	5.16	153.09	<0.001
Teachers				
Are they present?	65.62	4.69	369.08	<0.001
Do they intervene?	63.44	3.44	370.43	<0.001

*Continuity correction applied.

related to children's representations of bullying?), tentative hypotheses may be derived from previous literature based on interview and drawing data. More specifically, we hypothesized that gender differences might emerge as regards the type of bullying described by children (Naylor et al., 2006: Slee and Skrzypiec, 2015), with a prevalence of references to physical bullying being more frequent among males, and references to verbal bullying appearing more often among females (e.g., Naylor et al., 2006; Andreou and Bonoti, 2010); we also expected victims of bullying to be more likely to refer to direct forms of bullying (i.e., physical and verbal aggression) when compared to students who had not been involved in bullying (Naylor et al., 2006). Following studies based on self-report data we expected that age might also show some associations with the type of bullying mentioned, with a decline in the mentioning of physical bullying and an increase in references to verbal bullying with increasing age (e.g., Marengo et al., 2019).

Materials and methods

Sample

We recruited a convenience sample of 640 primary school students attending grade 4 to 5 in 7 different public primary schools located in North-West Italy. The mean age was 9.44 years (SD = 0.61; range = 8–12) and 53.3% of recruited students were male. All recruited students were fluent in Italian language, and none of the children presented diagnoses related to intellectual deficits or forms of psychopathology that would compromise their ability to participate in the research.

Procedure

The aims of the research were presented in the classroom to the students by the one of the researchers. Participation in the research was on a voluntary basis and no reward was provided to the children, their families or the school. Participating children were administered a protocol that included, in order, the production of a drawing relating to their experience of bullying, a semi-structured interview and a questionnaire relating to their experience of involvement in bullying as a victim, aggressor or bully-victim. Typically, all assessments (i.e., drawing, interview, and self-report questionnaire) were performed on the same day for all students of a specific classroom. Before test administration, the children had the opportunity to familiarize themselves with the researchers. The researchers who administered the protocol were psychologists with experience in the field of developmental and school psychology, who had received training in child drawing administration and interpretation, and had extensive research experience.

Ethical considerations

The study was approved by the IRB of the University of Turin (protocol no. 291061), and was undertaken in accordance with the indications of the Italian Association of Psychology (AIP) and the Helsinki Convention. After obtaining approval from the school headmaster, informed consent for participation in the research was obtained from both parents and children. The absence of informed consent from parents and children precluded the latter from participating in the research.

Instruments

Children's drawings

We involved students in a bullying drawing task in which children were asked to draw a picture portraying what bullying meant to them using the following standardized stem: "Please draw what bullying is like for you." The children were given a white A4 sheet of paper and 12 colored crayons. No time limit was given to the children; however, children typically completed the task in less than an hour. Children completed the task in the classroom along with their peers; however, school desks were separated to avoid mutual interference. In contrast to other research (Bosacki et al., 2006), we did not ask the child to refer to his or her own experiences with bullying, but to describe what bullying was like for him or her by drawing it. In our opinion, this approach was instrumental in allowing the children to draw a more spontaneous representation of what he or she understood bullying to be.

Interview

Following the protocols used by Guerin and Hennessy (2002) and Bosacki et al. (2006), the authors developed a semi-structured interview designed to capture the children's definition of bullying. During the interview, the authors asked the children what bullying means to them, what actions define bullying (i.e., types of bullying), what behaviors the victims engage in and what they feel emotionally when they are attacked, and whether other people (including children and teachers) are usually present when bullying takes place. Interviews were manually transcribed for later analyses.

Adolescent peer relations instrument

Children's involvement in bullying and victimization was measured by administering an Italian adaptation of the adolescent peer relations instrument (APRI; Marsh et al. 2011) for the Italian context. The APRI is a psychometrically validated instrument that can be used to assess involvement in bullying behaviors as bullies and victims among school-aged children; although initially designed for use in adolescent samples, the APRI has also shown adequate functioning among children attending primary school (Finger et al., 2008). The Italian

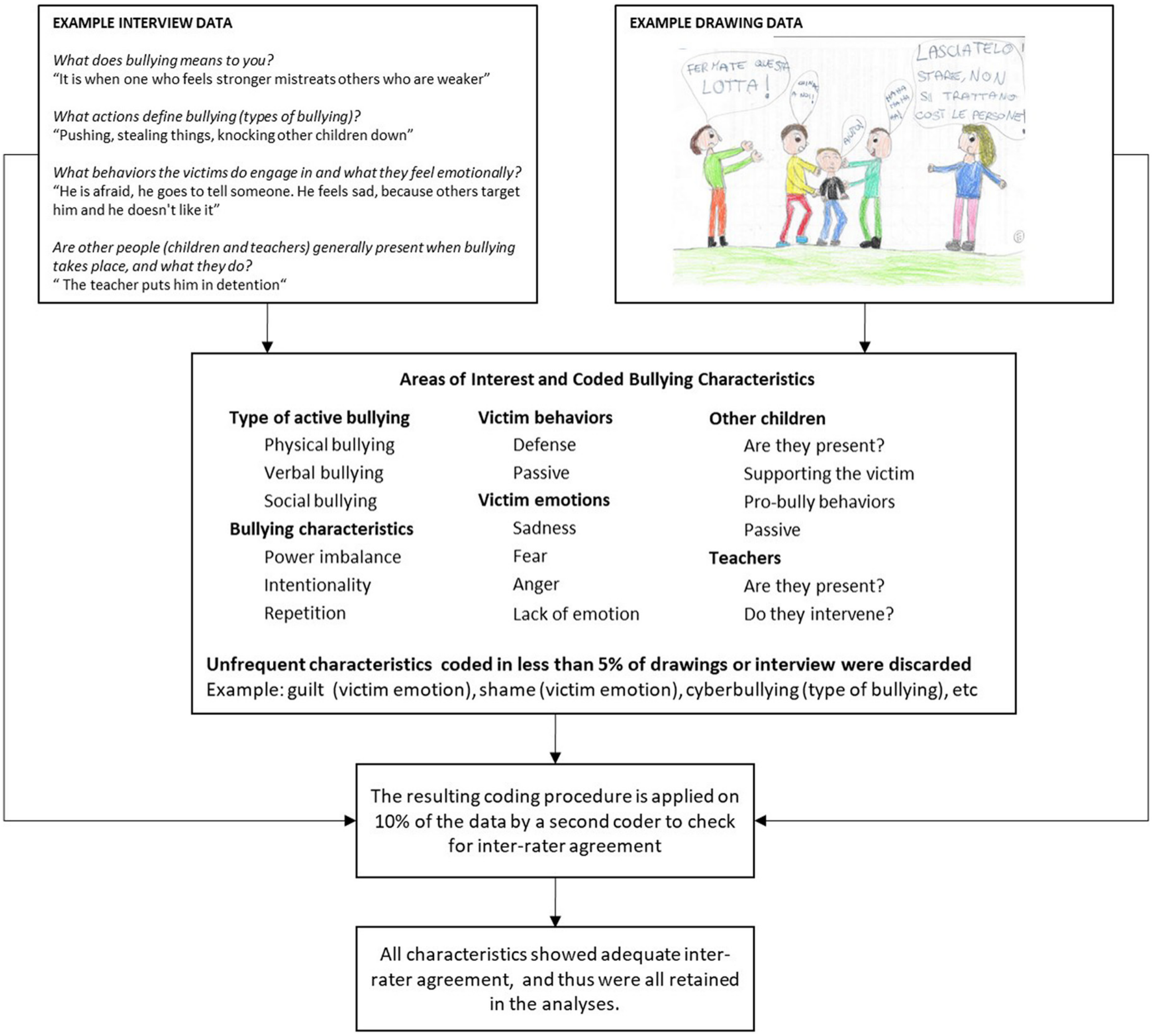

FIGURE 1
Diagram representing the coding of bullying characteristics in drawing and interview data.

version of the APRI has shown good psychometric properties, as well as theoretically coherent associations with external criteria, including age, gender, internalizing and externalizing symptoms, and student-relationship quality, and students' social status in the classroom (Marengo et al., 2019, 2021). The APRI consists of two sections, namely the bully and victimization sections, that can be combined to assess students' involvement in bullying behaviors as a bully, victim, or bully-victim. The bully section consists of 18 items allowing for the scoring of three subscales representing three types of bullying, namely verbal (example item: "I made rude comments to a student"), social (example item: "I got my friends to turn against a student"), and physical (example item: "I hit or kicked a student hard") bullying. Similarly, the APRI victim section consists of 18 items allowing for the scoring of three subscales respectively representing verbal (example item; "I was called names I didn't like"), social (example item: "A student ignored me when they were with their friends"), and physical (example item: "I was hit or kicked hard") victimization. Items are rated using a six-point Likert scale (1 = Never, 2 = Sometimes, 3 = Once or twice a month, 4 = Once a week, 5 = Several times a week, 6 = Daily). Based on responses to each subscale we generated three categorical variables grouping participants based on their involvement in each form of bulling/victimization, that is a distinction was made between uninvolved students and those involved as bully, victim, or bully/victims in each form of bullying (i.e., verbal, physical, and social bullying). For each type of bullying, in order to be identified as either bullies or victims, students needed to have indicated "Sometimes" or a higher frequency of involvement to at least one of the bullying or victimization items. Students were categorized as bully/victims if they responded "Sometimes" or a higher frequency of involvement to at least one item assessing bullying behaviors, and one item assessing victimization. Finally, uninvolved students were identified among those responding "Never" to all administered items.

Data analysis

Content analysis of interview and drawing data

In order to detect relevant characteristics of bullying in collected data, a content analysis was conducted to develop a coding framework for subsequent analysis of the interview and drawing data. Please note that in looking into the data for such characteristics we followed a hybrid approach: first, based on a review of the literature, we determined a set of areas of interest, which we identified as being the following: (1) the specific type of bullying represented in the data; (2) the depiction/mentioning of specific criteria for bullying (i.e., repetition, power imbalance, and intentionality); (3) the behaviors and emotions shown by the victims; and finally, (4) the presence and behavior of other individuals on the scene. As a second step, for each of these areas of interest, we followed an inductive approach to let the characteristics emerge from the data. More specifically, the interview and drawing data were reviewed by one researcher in order to identify those characteristics reflecting differences in the type of bullying event described, the reference to theoretical criteria for bullying, the reactions and emotions of the victims involved, and the presence of other individuals in the scene.

In line with past qualitative studies examining children's drawings of bullying (e.g., Bosacki et al., 2006), the bullying drawings were inspected for evidence of the presence of characters (graphical representations of one or more bullies or victims, as well as other people, including other children, and the teacher); size differences between the bully and the victim, single vs. multiple bullying scenes, the graphical depiction of verbal aggression (e.g., voice or speech bubbles and thought bubbles), physical bullying (e.g., kicking and punching); and of social/relational bullying (e.g., the exclusion/isolation of the victim, and the spreading of rumors against the victim, as depicted through voice or speech bubbles). Compliance with theoretical criteria for bullying (i.e., repetition, power imbalance, and intentionality) was determined based on combinations of the aforementioned characteristics (for example, a difference in size between the bully and the victim was considered indicative of a power imbalance; the presence of multiple bullying scenes representing the same characters was considered indicative of repetition over time; word bubbles).

A similar approach was employed in examining interview data. However, instead of looking for graphical representations of the aforementioned characteristics, we searched the interview transcripts for verbal references indicating the presence of characters, theoretical bullying criteria (i.e., repetition, power imbalance, and intentionality), the victim's emotions and behavior in responding to the aggression by the bully, the type of aggression, and the involvement of other people beyond the bully and the victim during the bullying event.

The detected characteristics were then adapted for use as a coding framework. The reliability of the classifications was tested by checking the correspondence between the coded characteristics and an additional independent coding performed by a second researcher using the same coding framework. Independent coding was performed on a random sample representing 10% of the original interview and drawing data set. The percent agreement between two independent coders was calculated, with 70% agreement considered the minimum acceptable level of agreement. Results showed moderate-to-high agreement between coders, with the coding of sadness in the drawings showing the lowest agreement (78.6% agreement, Cohen's $K = 0.45$) and coding of physical bullying in the interview data showing the strongest agreement (82.5% agreement, Cohen's $K = 0.71$). Of the identified characteristics, only those that occurred in at least 5% of the sample were

TABLE 2 Interview data: correlation between bullying characteristics, age, and gender.

Interview	**Age**	**Gender (female)**
Coded characteristics	***r***	***r***
Type of active bullying		
Physical bullying	−0.04	−0.11**
Verbal bullying	0.13**	0.15**
Social bullying	0.03	0.04
Bullying criteria		
Power imbalance	0.09*	0.00
Intentionality	0.03	.00
Repetition	0.04	0.05
Victim behaviors		
Defense	−0.05	−0.05
Passive	0.03	0.05
Victim emotions		
Sadness	−0.06	0.05
Fear	−0.06	−0.01
Anger	−0.08*	−0.01
Lack of emotion	0.03	0.08
Other children		
Are they present?	0.02	0.02
Supporting the victim	−0.01	−0.04
Pro-bully behaviors	0.12**	0.10**
Passive	0.06	0.06
Teachers		
Are they present?	−0.10**	−0.04
Do they intervene?	−0.11**	−0.05

*$p < 0.05$, **$p < 0.01$.

selected for further analysis (see Table 1). Figure 1 provides a diagram including example interview and drawing data, as well as a schematization of the procedure used to code the bullying characteristics.

Quantitative analysis

First, we examined possible differences between interview data and the drawing in the prevalence of the emerging bullying characteristics. More specifically, we used McNemar's test for paired nominal data to detect differences in the frequency of coded characteristics depending on the type of data collection, i.e., face-to-face interview and drawing.

Next, we examined associations between bullying characteristics and gender, age, and self-reported involvement in physical, verbal, and social bullying. Associations between bullying characteristics and gender and age were examined using the Pearson correlation coefficient. The association between self-reported involvement in bullying and the bullying characteristics was examined using logistic regression. More specifically, for each form of bullying (i.e., physical, verbal, and social), a categorical variable representing different roles students may take in bullying, namely, uninvolved, victim, bully, and bully/victim, was included in the model as a categorical factor, with the uninvolved group serving as the reference. In the tested models, the bullying characteristics were examined as dichotomous dependent variables, coded as follows: Characteristic is present in the data = 1, Characteristic is not present = 0.

Results

Differences in the distribution of bullying characteristics in the interview and drawing data

Table 1 shows the frequency distribution of coded characteristics in the interview and drawing data, as well as the results of McNemar's test for differences in the distribution of characteristics between the two data collection methods.

Overall, all forms of bullying, i.e., physical, verbal, and social bullying, were more likely to be detected in the interview data than in the drawing data. Interestingly, social bullying was the least likely to be detected in both survey methods.

In terms of theoretical criteria for bullying (i.e., repetition, power imbalance, and intentionality), the presence of a power imbalance between the bully and victim was most frequently detected in both the interview data and the drawing data. In addition, we did not find differences in the prevalence of power imbalance and intentionality of bullying behavior between interview and drawing data, while the repetition criterion was found with higher prevalence in the interview data compared to the drawing data. It is worth noting that mentions of these bullying criteria had low prevalence in the data, as they were only found in the data of a minority of students, regardless of the method used.

In terms of behavior, victims were more often described as passively responding to bullying than exhibiting defensive behavior in both the interviews and the drawings. We note, however, that victims were more often described as defensive in the interview data than in the drawing data. There were no differences between interview and drawing data in the representation of the victim as passive.

Regarding the emotions shown by victims, the interview data shows that sadness was the most frequently reported emotion, followed by fear, anger, and a lack of emotions. In the drawing data, sadness also showed the highest prevalence, followed by a lack of emotion, fear, and anger. There were significant differences in the frequency of emotions across data collection methods: victims were more likely to be associated with sadness, fear, and anger in the interview data than in the drawing data; in turn, victims were more likely to be associated with a lack of emotions in the drawing data than in the interview data.

Students mentioned the presence of other children more frequently in the interview data than in the drawing data. Other children were more likely to be supportive or passive of the victim in the interview data than in the drawing data. In turn, children were more likely to exhibit pro-bullying behavior in the drawing data compared to the interview data. Regarding the role of teachers, they were more likely to be reported as present and intervening to support the victim in the interview data when compared to the drawing data.

Associations between age, gender, and bullying characteristics in interview data

Table 2 shows the correlation between the bullying characteristics as detected in the interview data and both age and gender of the students. The significant correlations that emerged were all either small or negligible ($r < 0.10$). First, we found that the representation of physical bullying had a low negative correlation with female gender, corresponding to a low positive correlation with male gender. Verbal bullying and the presence of other children supporting the bully with bullying-promoting behaviors were positively correlated with both female gender and age. Age also showed a positive correlation with the representation of bullying as involving power imbalance between the bully and the victim, and a negative correlation with the victim's expression of anger, although both of these correlations were negligible. Finally, age showed a small negative correlation with the mere presence of teachers when bullying took place, as well with the presence of teachers showing supportive behaviors toward the victim during bullying events.

Associations between age, gender, and bullying characteristics in drawing data

Table 3 shows the correlation between the bullying characteristics detected in the drawing data and the age and gender of the students. Significant correlations emerged, but these were either small or negligible in size ($r < 0.10$). First, we found that physical bullying had a small negative correlation with female gender, which corresponded to a small positive correlation with male gender. Verbal bullying, on the other hand, was positively correlated with female gender and age. Female gender also showed a positive correlation with students' drawing of social bullying and victims expressing sadness. Female gender, in turn, was negatively correlated with the depiction of victims being attacked by a bully, which corresponded to a low positive correlation with male gender.

TABLE 3 Drawing data: correlation between bullying characteristics, age, and gender.

Drawing	Age	Gender (female)
Coded characteristics	***r***	***r***
Type of active bullying		
Physical bullying	−0.09*	−0.20**
Verbal bullying	0.12**	0.25**
Social bullying	0.06	0.11**
Bullying criteria		
Power imbalance	0.04	−0.05
Intentionality	−0.02	0.02
Repetition	0.06	0.04
Victim behaviors		
Defense	−0.05	−0.04
Passive	0.02	−0.005
Victim emotions		
Sadness	0.07	0.24**
Fear	−0.04	−0.06
Anger	0.02	−0.01
Lack of emotion	0.05	0.02
Other children		
Are they present?	−0.01	0.07
Supporting the victim	−0.01	0.07
Pro-bully behaviors	−0.01	0.05
Passive	0.02	0.00
Teachers		
Are they present?	−0.00	−0.06
Do they intervene?	−0.01	−0.08

*$p < 0.05$, **$p < 0.01$.

Associations between physical, verbal, and social bullying roles and bullying characteristics coded in interview and drawing data

Tables 4–6 show the results of the logistic regression analyzes examining the associations between self-reported physical, verbal, and social bullying roles and the characteristics coded in the interview and drawing data. Only the results of models showing significant effects, grouped by the specific form of bullying, are reported in the tables. In all models, uninvolved students served as the reference group for estimating the effects of student involvement in bullying as victim, bully, and bully/victim.

Regarding the association between characteristics coded in the interview and drawing data and self-reported physical bullying roles, Table 4 shows some significant effects. Students who reported being involved in physical bullying were more likely than uninvolved students to describe victims as passive in interview data. Students who reported being victims of physical bullying when responding to the questionnaire were more likely than uninvolved students to report the presence of other children supporting the victim in interview data.

Regarding the effects emerging from the analysis of characteristics detected in the drawing data, we saw that students who self-reported being victims of physical bullying were more likely to depict scenes of physical bullying and less likely to depict verbal bullying in their drawings compared to uninvolved students. Students who were involved in physical bullying as bully/victim were more likely than uninvolved students to draw bullying scenes depicting a power imbalance between bullies and victims. Students who described themselves as bullies (but not victims) were again more likely than uninvolved students to draw scenes depicting bullying events that were repeated in time, and in which other children exhibited pro-bully behaviors. Finally, students who were either victims or bullies were more likely than uninvolved students to draw teachers as present during bullying events.

Regarding the relationship between the characteristics emerging from interview and drawing data and self-reported verbal bullying roles, Table 5 shows some significant effects. Students who were classified as verbal bullies or bullies/victims were more likely to describe social bullying events in interview data than uninvolved students. Students who self-rated as verbal bullies were also more likely to describe victims as passive in interview data than uninvolved students. In terms of drawing data, students who self-reported being a verbal bully/victim were more likely than uninvolved students to draw scenes depicting physical bullying events and intentional bullying aggression, and less likely to show fear of victims.

Table 6 shows the relationship between characteristics coded in the interview and drawing data and self-reported involvement in social bullying roles. Students who self-reported being a social bully were more likely to describe a power imbalance between the bully and his or her victims during the interview than uninvolved students. In turn, students who self-reported being a bully/victim were more likely to draw scenes depicting physical bullying events and more likely to depict victims showing fear compared to uninvolved students. Finally, compared to uninvolved students, students who self-reported being social bullies (but not bully/victims) were more likely to draw children

TABLE 4 Logistic regression: regression coefficients and odds ratio for physical bullying roles predicting coded characteristics in interview and drawing data.

	Interview data				Drawing data			
	Physical bullying roles[a]				Physical bullying roles[a]			
Bullying characteristics	**Victim**	**Bully**	**Bully/victim**	R^{2b}	**Victim**	**Bully**	**Bully/victim**	R^{2b}
Type of active bullying								
Physical bullying	–	–	–	–	0.16 (1.17)	0.30 (1.350)	0.45* (1.57)	0.01
Verbal bullying	–	–	–	–	−0.30 (0.74)	−0.16 (0.852)	−0.52* (0.5)	0.01
Bullying criteria								
Power imbalance	–	–	–	–	0.46 (1.58)	0.56 (1.751)	0.58* (1.79)	0.02
Repetition	–	–	–	–	2.00 (7.39)	2.65* (14.154)	1.91 (6.75)	0.06
Victim behaviors								
Passive	−0.31 (0.73)	1.31* (3.72)	−0.25 (0.77)	0.03	–	–	–	–
Victim emotions								
Sadness	–	–	–	–	−0.36 (0.70)	−0.29 (0.748)	−0.60* (0.55)	0.02
Other children								
Supporting the victim	0.44* (1.55)	−0.08 (0.92)	0.23 (1.26)	0.01	–	–	–	–
Pro-bully behaviors	–	–	–	–	0.38 (1.46)	1.10* (3.004)	0.23 (1.26)	0.020
Teachers								
Are they present?	–	–	–	–	1.62* (5.05)	0.82 (2.27)	1.69* (5.42)	0.054

Values reported in parentheses are odds ratio.
*$p < 0.05$.
[a]Reference group is uninvolved students.
[b]Nagelkerke pseudo R^2 is reported.

TABLE 5 Logistic regression: regression coefficients and odds ratio for verbal bullying roles predicting coded characteristics in interview and drawing data.

	Interview data				Drawing data			
	Verbal bullying roles[a]				Verbal bullying roles[a]			
Coded characteristics	**Victim**	**Bully**	**Bully/victim**	R^{2b}	**Victim**	**Bully**	**Bully/victim**	R^{2b}
Type of active bullying								
Physical bullying	–	–	–	–	0.13 (1.14)	0.12 (1.13)	0.45* (1.56)	0.01
Social bullying	0.29 (1.34)	0.66* (1.94)	0.53* (1.71)	0.02	–	–	–	–
Bullying criteria								
Intentionality	–	–	–	–	0.43 (1.54)	0.07 (1.08)	0.50* (1.64)	0.01
Victim behaviors								
Passive	−0.38 (0.69)	0.77* (2.15)	−0.03 (0.97)	0.03	–	–	–	–
Victim emotions								
Fear	–	–	–	–	−0.30 (0.74)	−0.09 (0.91)	−0.63* (0.53)	0.02

Values reported in parentheses are odds ratio.
*$p < 0.05$.
[a]Reference group is uninvolved students.
[b]Nagelkerke pseudo R^2 is reported.

TABLE 6 Logistic regression: regression coefficients and odds ratio for verbal bullying roles predicting coded characteristics in interview and drawing data.

	Interview data				Drawing data			
	Social bullying roles[a]				Social bullying roles[a]			
Coded characteristics	Victim	Bully	Bully/victim	R^{2b}	Victim	Bully	Bully/victim	R^{2b}
Type of active bullying								
Physical bullying	–	–	–	–	0.19 (1.21)	0.47 (1.61)	0.54* (1.71)	0.01
Bullying criteria								
Power imbalance	0.79 (2.20)	1.12* (3.05)	0.35 (1.42)	0.02	–	–	–	
Victim emotions								
Fear	–	–	–	–	−0.01 (0.99)	0.21 (1.23)	0.81* (2.25)	0.03
Other children								
Supporting the victim	–	–	–	–	−0.70 (0.49)	−1.64* (0.19)	−0.49 (0.61)	0.03
Pro-bully behaviors	–	–	–	–	0.32 (1.39)	0.91* (2.484)	0.51 (1.66)	0.02

Values reported in parentheses are odds ratio.
*$p < 0.05$.
[a]Reference group is uninvolved students.
[b]Nagelkerke pseudo R^2 is reported.

advocating for the bullying and less likely to draw children supporting the victim.

Discussion

The first objective of this mixed-method study was to compare two approaches that can be used in qualitative research on bullying, i.e., interviews and the drawings, to determine if they are comparable as instruments to inform researchers and practitioners about children's representation of bullying, or if they reflect different aspects related to this representation.

Based on our data, it appears that physical and verbal bullying is reported by children much more frequently than social bullying, both in the interviews and in the drawings. These data seem to be consistent with previous literature (Naylor et al., 2006; Andreou and Bonoti, 2010), which seems to indicate that physical and verbal bullying are the forms of peer victimization most frequently mentioned by children, while social exclusion is much less frequently told or reflected in drawings. However, comparing the two methods of data collection, it seems that the interview is more able to identify the different forms of bullying. This could be due to the fact that the child is able to provide more details and comments about bullying through the narrative.

In terms of the characteristics of bullying, our data show that the interview seems to be better at identifying the characteristics of repetition than the drawing. This could be due to the fact that repetition of bullying may be easier to express verbally than through a drawing. In general, however, we must point out that the criteria of power imbalance, repetition, and intentionality are poorly captured in both the drawing and the interview in our sample. This finding seems to be consistent with previous literature (Madsen, 1996; Guerin and Hennessy, 2002; Monks and Smith, 2006; Naylor et al., 2006) that informs us that these characteristics are not salient in children's definitions of bullying, but rather shape adults' definitions, starting with the researchers. In addition, the children tended to report more defensive victim behavior in the interviews than in the drawings. This could be due to the fact that they find it easier to describe these defensive behaviors in the interview than to depict them in a drawing.

The data also show that the victim's emotions are central to the child's representation of bullying. In particular, children tend to describe the victim as showing negative emotions, albeit significant differences in terms of the method of data collection emerged. While there is clear sadness in the interviews, the drawings tend to show a certain lack of emotion with increased frequency. This finding is curious and certainly deserves further investigation. However, the question of negative emotions related to the victim is consistent with the current literature, which has shown that the negative impact on the victim's emotional well-being is a key element in defining bullying by children (Madsen, 1996; Naylor et al., 2006) and that they are more likely to report negative affect related to the victim in drawings and interviews (Bosacki et al., 2006; Naylor et al., 2006; Slee and Skrzypiec, 2015).

In the interviews, children tended to mention more often the presence of others besides the victim-bullies dyad, mentioning the presence of other children and teachers. In the drawings, on the other hand, the presence of other children is depicted much less frequently. Compared to the drawing, when responding to the interview children are more likely to describe teachers as people who intervene in the scene and other children as characters who intervene in favor of the victim or take a passive position towards the bully. In contrast, when drawing children tend to portray others as people who are likely to adopt a pro-bullying behavior. Still, it should be noted that the depiction of others in the drawing (teachers and children) is not common in our sample. This result seems to be consistent with the literature suggesting that children tend to focus more on the victim-bully dyad in drawings about bullying, and older children tend report more characters in the bullying scene (Bosacki et al., 2006). Overall, then, interview data appear to be a more informative qualitative survey tool than drawings when there is an interest in studying the representation of bullying among children. However, it seems that drawings can complement some information that is less clearly elaborated in interviews (e.g., negative emotions of the victim and behaviors conducive to bullying). Thus, this aspect seems to indicate that although interviews are to be preferred in the study of children's representation of bullying, drawings can complement some relevant aspects and, therefore, it might be useful to combine both these qualitative techniques to get a more complete view of children's representation of bullying.

In general, drawings have some advantages over interviews, as claimed by several authors (Butler et al., 1995; DiCarlo et al., 2000; MacPhail and Kinchin, 2004). Drawing is an attractive and enjoyable experience for children which allows them to express the elements of the drawing that are most important to them, and finally, it allows those children who are unwilling, unable, or too excited to express themselves verbally to express their views (Kukkonen and Chang-Kredl, 2018). Of course, the use of drawings also has limitations, particularly the fact that the quality of the representation is related to children's artistic-graphic abilities and that they can only represent values that can be expressed visually (MacPhail and Kinchin, 2004). In this way, interviews can facilitate the description of bullying, as our data show, by overcoming the limitations of drawing. However, the interview could benefit from the addition of drawing to provide a more complete picture of the phenomenon.

The second objective of our study aimed at understanding if the children's representations of bullying observed in the drawing and interview may be related to demographic characteristics of the children, as well as their direct involvement in bullying episodes as measured using a self-report questionnaire. Regarding gender, female gender seems to be positively associated with verbal victimization and negatively associated with physical victimization in both interviews and drawings. These data appear to be consistent with the literature that attributes greater involvement in physical bullying to males, while females are more likely to be involved in verbal bullying (Scheithauer et al., 2006; Kennedy, 2020). In addition, females are more involved in indirect forms of bullying than males (Mazzone et al., 2018). This finding is reflected in our analyses and is particularly highlighted by the interviews, which are therefore more informative regarding this form of victimization.

Females also tend to report more negative feelings of the victim, especially sadness, in drawings but not in interviews. This could be explained by a greater tendency of females to capture the victim's emotional experience in the definition of bullying (Naylor et al., 2006; Byrne et al., 2016), but also by a tendency of females to portray more positive feelings in the drawings (Picard and Boulhais, 2011; Bozzato et al., 2021). However, future studies could clarify why this aspect was not captured in the interviews. Instead, the interviews in our survey show that females are more likely to report pro-bullying behavior in their definition of bullying. This finding is interesting and could be partly due to the fact that the female gender tends to maintain more harmony and closeness in social relationships (Rabaglietti et al., 2012; Sedgewick et al., 2019; Antonopoulou et al., 2021) and tends to exhibit more prosocial behavior (Van der Graaff et al., 2018). In this sense, bullying could be understood as an act that undermines attachment to others and can be seen as the opposite of prosocial behavior, which attracts greater attention in the female gender, who tend to recognize pro-social behavior more easily than males.

Some interesting correlations with age were found in the two methodological approaches. In both the drawings and the interviews, the depiction of verbal bullying increased with age, while only in the drawings a negative correlation emerged between physical bullying and age. Overall, these associations appear to be consistent with the developmental trajectory of peer victimization, whereby physically aggressive behaviors decrease with age in favor of verbal or indirect aggressive behaviors, likely as a result of the development of more sophisticated language and relationship tools (Longobard et al., 2019).

Finally, regarding age, the data collected in the interviews show us that older children tend to report less often the presence of the teacher in the bullying scene and to show more pro-bullying behaviors. In this sense, we must imagine that the peer group becomes the main social reference point for children as they get older and the place where they try to manage conflict situations among themselves in an increasingly autonomous way (Badenes-Ribera et al., 2019). This may explain the tendency to turn less to the teacher as they get older. As previous research (Bosacki et al., 2006) suggests, representations of bullying become more complex as children get older, which could likely explain a greater frequency of reference to bullying behaviors among older children.

Finally, we looked at possible associations between children's participation in bullying as a victim, bully, or bully-victim and their representations of bullying in the form of drawings or interviews. There is virtually no data on this aspect in the literature, so there is a lack of references with which to compare our data. However, some significant associations between involvement in bullying and the characteristics of drawings and interviews emerged from the analyses. Regarding bullies-victims, the most significant data were found in the area of physical bullying. Children who self-reported being physically bullied were more likely to report the presence of other children supporting the victim in the interviews, while they reported the presence of the teacher in the drawings more than those who were not involved in bullying. Clearly, further study is needed to fully understand the significance of these data and why the same result is not evident in other forms of bullying victimization. However, we can hypothesize that physical violence is most prevalent among primary school children and may cause the most apprehension and anxiety due to the effects of aggression. In this sense, the presence of children supporting the victim or the presence of the teacher could be significant for children with previous experiences of physical victimization, as they could reduce the harm and stop the bully's attack.

Some significant correlations also emerged for bullies. Those who reported physical or verbal bullying tended to describe the victim as passive during the attack more often than those who had not been bullies, while those who had committed social bullying tended to describe a greater power imbalance in interviews. Physical and verbal bullying are expressions of direct aggression. Overall, the data seem to reflect the tendency of the bully to select his victims by choosing them from among those who are weaker, less popular, and whose ability to defend themselves is seen as limited. In this sense, the interviews partially reflect the bullying experience from the perspective of the bully. Similarly, perpetrators of social bullying emphasize bullying-supportive behaviors to a greater extent, while they are less likely to identify support for the victim.

Bully/victim students differ from the other groups in that they self-report being both perpetrators and victims of bullying. Regardless of the form of bullying they have experienced, bully/victims were the group that more frequently depicted physical violence in their drawing. Bully/victim students tend to be described as dysregulated and are much more likely than others to engage in physically aggressive behavior and exhibit reactive aggression (Unnever, 2005; Yang and Salmivalli, 2013; Chung and Lee, 2020). It is possible, therefore, that the bullied child is more victimized in the school context, especially physically, and that this may influence his or her personal experiences with bullying, and ultimately the representation of bullying depicted in his/her drawing.

Bully/victim students tended to depict more frequently power imbalance (in the case of physical bullying) and intentionality (in the case of verbal bullying) in their drawings compared to individuals who were not involved in bullying. In addition, bully/victim students tended to express less fear in their drawings, especially in the case of physical and verbal bullying. Bully/victims tend to report more behavioral disturbances and aggressive behavior than bullies or victims or individuals not involved in bullying (Unnever, 2005), and the literature seems to indicate that these individuals tend to report less empathy (Zych et al., 2019) and fewer social and emotional skills (Habashy Hussein, 2013; Zych et al., 2019). Thus, it is likely that children who are victims of bullying, with less empathy and poorer social skills, tend to reflect victims' emotional expressions less well. Different results were found for social bullying. Here, bully/victim students tended to represent fearful emotions of the victim more than non-bullies. This result is curious, and further studies will help to understand the differences. However, we could speculate that social bullying is an indirect form of bullying that does not require direct interaction with the victim, unlike physical and verbal bullying. In this sense, it is possible that perpetrators who engage in indirect bullying maintain better empathic skills, at least at the cognitive level, than perpetrators who engage in direct aggression (Yeo et al., 2011; Li et al., 2015). Further research is needed on this topic.

Finally, bully/victim students were more likely to report the presence of the teacher in their drawings compared to those who were not involved in bullying. However, they did not differ with respect to whether or not the teacher supports the victim when bullying takes place. This aspect is interesting because it seems to indicate some attention on the part of the bully/victims in relation to the presence of the teacher. We can imagine that this corresponds to the subjective experience of the bullying victim who attracts the attention of the teacher, living the dual role of victim and aggressor. In this sense, children who are victims of bullying tend to be poorly adjusted in school and receive negative attention from the teacher to an even greater extent than children who are bullies or victims (Haynie et al., 2001; Olweus, 2001; Marengo et al., 2018).

Conclusion and limitations

To our knowledge, this was the first study that attempted to compare two different data collection methods in the qualitative domain (drawing and interview) in detecting bullying characteristics in the representation of bullying among primary school children. In summary, our data show that the interview appears to be more capable of detecting different forms of bullying and tends to be more informative about a variety of bullying-related characteristics. However, although the interview appears to be more informative in general, the two approaches also differ on the characteristics of elementary school children's bullying representations. This is a new finding that suggests that it is useful to incorporate various qualitative techniques in the empirical study of bullying by children, especially since research on this topic seems to be dominated by the quantitative approach (Patton et al., 2017). In this direction, qualitative research can complement quantitative data and inform us about what aspects characterize children's representations of bullying, which has a significant impact on prevention strategies and interventions. In addition, our study is the first attempt to examine an association between involvement in bullying as a victim, bully, or bully/victim and bullying-related characteristics captured by two qualitative instruments in the same survey. Overall, in addition to gender and age, our data found an association between experiences of bullying and several characteristics of the representation of bullying in drawings and in the interview. It is possible, therefore, that involvement in bullying, depending on the role and type of bullying behavior, may influence elementary school children's representation of bullying. However, the literature on this point is very sparse, and further studies are needed to understand these relationships.

Clearly, the results of this exploratory study need to interpreted with caution, as it is important to consider the limitations of the study. Although we recruited a large sample, it cannot be claimed to be representative of the Italian child population. Future studies could therefore recruit representative samples and apply the same protocol to children and adolescents of different ages and cultures to increase the generalizability of the results and assess their cross-cultural consistency. In addition, we relied solely on child self-report to capture bullying involvement. Future studies could use third party informants, such as teachers or parents. Factors such as text comprehension and social desirability might have influenced subjects' responses to the tests. Finally, the cross-sectional approach prevents us from expressing ourselves in terms of linear causality. Therefore, longitudinal studies will be able to clarify whether involvement in bullying affects the child's representations as determined by the interview and drawing.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving human participants were reviewed and approved by the University of Turin. Written informed consent to participate in this study was provided by the participants or their legal guardian/next of kin.

Author contributions

DM and MS: methodology, formal analysis, writing—original draft, and methods section. CL: conceptualization, writing—review and editing, and supervision. MF: conceptualization, collecting data, and writing—original draft. All authors contributed to the article and approved the submitted version.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

The reviewer SB declared a past collaboration with the authors, CL and MF to the handling editor.

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Family drawing for assessing attachment in children: Weaknesses and strengths

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Introduction

The drawing represents a projective technique widely used by clinical and developmental psychologists to access a child's inner world (Falk, 1981; Pianta and Longmaid, 2010; Procaccia et al., 2014). Particularly, the Family Drawing (FD) developed by the psychoanalyst Corman (1967) is one of the most used tests to explore perceptions of relationships in children aged 5——15 years and, thanks to Kaplan and Main (1986) and Fury (1996) contributions, it can also assess children's attachment representations.

The Family Drawing (FD) with an attachment-based coding system includes three levels: a checklist of individual markers (Kaplan and Main, 1986), which comprises 24 features of drawing whose presence or absence is assessed; four global attachment classifications, *i.e.,* ABCD classifications, namely, Secure (B), Avoidant (A), Ambivalent (C), and Disorganized (D), assigned based on a global evaluation of marker combinations (Kaplan and Main, 1986); eight global rating scales scored from 1 (absent) to 7 (very high) points, added by Fury (1996), who also redesigned criteria of assignment of ABCD categories considering both markers and scale scores. **Table 1** details the characteristics of these attachment-based coding systems.

The administration of the FD follows the procedure described by Kaplan and Main (1986) and Fury et al. (1997). It requires an 8.5 × 11 cm white paper placed horizontally in front of the child and a set of colored markers. Different from other methods, such as the gold-standard Strange Situation Procedure (SSP; Ainsworth et al., 1978; van Ijzendoorn et al., 1992), the child is not subjected to stressful situations or stimuli but is asked to draw a picture of his/her family. As a projective open-ended technique, no other information is given. When the drawing has been completed, the child is asked to identify all the people in the drawing and explain their relationship with the child. The assessment is made according to some indicators that suggest certain patterns of attachment (*e.g.*, lack of color or distance between family members suggests an avoidant attachment, and unusually small figures or exaggeration of body parts suggests an ambivalent attachment, as detailed in **Table 1**).

Because drawing is non-verbal communication, FD is thought to be useful when it is not possible or unreliable to rely on verbal communication. For example, with internationally low-language proficiency adopted children (Pace et al., 2015), children with selective mutism, or other clinical conditions that involve language difficulty (*e.g.*, too fast and confused speech in ADHD, Clarke et al., 2002), as well as when the child may be frightened, reluctant or not used to communicate about family relationships, as in the case of abused children, children exposed to family problems (Leon and Rudy, 2005), or children of depressed mothers (Fihrer and McMahon, 2009).

As shown by a recent systematic review and meta-analysis on this topic (Pace et al., 2021), the FD has been increasingly used to assess attachment in the last decade, either with community, clinical, or at-risk children from 5 to 13 years old. Most of the studies employed a double coding system, *i.e.,* both the Main and Kaplan's ABCD classifications, and Fury's scales (detailed in **Table 1**), with the former being suggested as maybe less accurate than the latter, especially in clinical and at-risk samples. Other findings also suggested a culture-fair potentiality of FD in non-Western collectivistic cultures, because of the possibility offered by this method to assess attachment representations toward multiple attachment figures in the drawing, overcoming the exclusive focus on mother and father typical of Western cultures.

In sum, the scarce studies and review findings opened questions concerning FD psychometric properties and culture-fair potential in non-Western collectivistic cultures, which still need more investigation.

Sub-section 1: How are the psychometric properties of the Family Drawing attachment-based coding systems?

Focusing on the psychometric properties of the FD with an attachment-based coding system, studies provided values of *inter-rater reliability* being from acceptable to good for ABCD classifications, *i.e.,* Cohen's *k* between 0.64 and 0.80 (Madigan et al., 2003; Pianta and Longmaid, 2010; Behrens and Kaplan, 2011), and good to optimal for Fury's global scales, *i.e.,* Cohen's *k* between 0.75 and 1.00 (Fury et al., 1997; Madigan et al., 2003; Pianta and Longmaid, 2010), and Pearson's *r* from 0.54 to 0.95 (Fury et al., 1997; Madigan et al., 2003). These results suggest if independent and blinded evaluators of the FD employ the same parameters, they usually assign the same classification or score, which indicates that the coding guidelines of both ABCD and Fury scale systems are clear and well-explained, understandable by different possible raters.

Regarding FD *discriminant validity*, some studies found relations between children's IQ and both ABCD categories (Pianta and Longmaid, 2010) and Fury scales scores in community and at-risk children (Dallaire et al., 2012). However, other studies did not find any relationship between FD and IQ or children's fine motor skills (Fury, 1996; Madigan et al., 2003; Leon et al., 2007; Pace et al., 2015). Surprisingly, no studies explored the discriminant validity of the child's ability to draw.

Concerning the *concurrent validity*, studies in different populations of children (*i.e.*, community, clinical, adopted, *etc.*) showed the attachment-based FD results partially converged with those of the gold-standard SSP and the Manchester Child Attachment Story Task (MCAST; Goldwyn et al., 2000), a completion task used to assess attachment representations in 4–8 years old children and rated both through four ABCD classifications and 1-to 9-point scales (Jin et al., 2018; Pace et al., 2020; Kallitsoglou et al., 2021).

Particularly, the results of the meta-analyses with the SSP (van Ijzendoorn et al., 1992) and with FD (Pace et al., 2021) converge toward the higher prevalence of secure classifications over the insecure ones in community children and security scores as the highest in Fury's scales. Moreover, with both instruments, the community children showed higher security than clinical and at-risk ones. However, the meta-analytic rate of C categories with the Family Drawing ABCD system was markedly higher than the rate in the meta-analysis of SSP, so the authors have suggested a possible overestimation of the C pattern employing the Kaplan and Main (1986) system on FD which should be further investigated. The authors have also observed higher convergence of results between SSP and Fury scales than with the ABCD system (Pace et al., 2021).

Few studies explored the convergence of FD results with those of the MCAST (Goldwyn et al., 2000), reporting contrasting results across samples, which suggest further investigation. Specifically, Jin et al. (2018) suggested convergence in both classifications and scales of community and (especially) clinical children. Pace et al. (2020) reported convergence of more scales in communities than in at-risk children, and Kallitsoglou et al. (2021) suggested no convergence of scales among the communities. Overall, these results are too heterogeneous to assume that FD can be as trustable as other more validated attachment measures in assessing attachment, and further studies are needed.

Regarding *clinical validity*, several studies showed that FD attachment-based coding systems can discriminate against higher attachment insecurity in clinical and at-risk children (*i.e.*, ADHD, adopted, abused, etc.) using Fury's global scales (Clarke et al., 2002; Dallaire et al., 2012; Pace et al., 2015; Howard et al., 2017; Jin et al., 2018). If future psychometric studies will prove the reliability of the results obtained with the FD, these findings suggest practitioners employ the FD as a simple, economic, and useful method to assess attachment in vulnerable groups.

TABLE 1 Three levels of attachment-based coding system on Family Drawing.

24 Individual markers[a] (Kaplan and Main, 1986)	Four classifications (Kaplan and Main, 1986)	Eight global rating scales[b] (Fury, 1996)
Avoidant markers (A) (1) Lack of color (2) Child positioned far apart from mother (3) Omission of mother or child (4) Lack of individuation of family members (5) Arms downward, close to the body (6) Exaggeration of heads (7) Disguised family members	**Secure (B)** Drawings show centered, grounded and completed figures with open arms; high *family pride/happiness* and low *global pathology*.	**Security (B) scales:** (1) *Vitality/Creativity:* the child's emotional investment in drawing is reflected in creativity, detail, and embellishment; (2) *Family Pride/Happiness*: a child' sense of belonging to the family troupe;
Ambivalent markers (C) (8) Figures separated by barriers (9) Figures crowded or overlapping (10) Unusually small figures (11) Unusually large figures (12) Exaggeration of body part (13) Exaggeration of hands/arms (14) Exaggeration of facial features (15) Figures on the corner of the page	**Insecure-avoidant (A)** Drawings are characterized by distance between family members, uncolored or uncompleted figures (e.g., without arms), and an emphasis on invulnerability is expressed by happy face; high *emotional distance/isolation* and *tension/anger*.	**Avoidant (A) scales:** (3) *Emotional Distance/Isolation*: a sense of loneliness perceived by the child reflected in masked expressions of anger, neutral or negative affects, distance between mother and child (4) *Tension/Anger:* figures without color and detail or scribbled or crossed out;
Insecurity markers (A,C) (16) Lack of background detail (17) Figures not grounded ("floating") (18) Incomplete figures (19) Mother not feminized (20) Males and females undifferentiated by gender (21) Neutral/negative facial affect	**Insecure-ambivalent** Drawings show vulnerability in family relations, with crowded or overlapping figures and a large or small figures; high *Vulnerability* and *Role Reversal*	**Ambivalent (C) scales:** (5) *Vulnerability:* placement of figures on the page and exaggeration of body parts; (6) *Role Reversal:* size or roles of drawing figures.
Disorganized markers (D) (22) False starts (23) Scrunched figures (24) Unusual signs, symbols, or scenes	**Disorganized** Drawing is characterized by confusing and fluctuating figures with unusual signs and symbols; high *bizarreness/dissociation* and *global pathology*	**Disorganized (D) scales:** (7) *Bizarreness/Dissociation*: unusual symbols, signs, and fantasy themes; 8) *Global Pathology*: which is reflected in the global organization of drawing, including, for example, the completeness of figures, the use of color, presence of details, affect, and background scene.

[a]Coded in eight dimensions: the degree of movement present in the figures, the identification of the figures, the completeness of the human forms represented, the quality of the smile, the size of the figures, the centrality of the figures in the sheet, and the global impression of vulnerability/invulnerability.
[b]Main categories are assigned based on high scores in pattern scales and global impressions of balance and enhancement of affective ties (Secure); emotional indifference and coldness (Avoidant), isolation from the family group or fear and worry (Ambivalent), chaos, confusion, and anxiety (Disorganized).

Last but not least, Pace et al. (2021) rated the quality of studies included in the systematic review, revealing fair to moderate quality for most of them, which mostly did not check the influence of demographics on results which should be further investigated.

Sub-section 2: Can the Family Drawing be considered a culture-fair method to assess attachment in children around the world?

As detailed in the review by Pace et al. (2021), attachment of pre- and school-aged children has been mainly evaluated through observational procedures, *e.g.*, the SSP, or narrative completion tasks, *e.g.*, the MCAST. Both of them have limitations at this age: the former because it is mostly based on behaviors that children show with their parents up to 2 years of age and the latter because results can be influenced by the child's verbal abilities or cultural stereotypes transmitted through language (Burgers and Beukeboom, 2020).

Drawing instead has been reported as a culture-fair option to assess psychological abilities, *e.g.*, (Weiss, 1980), and the cited meta-analysis seems to recognize this potential also in FD, as cultural differences did not completely overlap with those hypothesized based on general literature (Mesman et al., 2016). Specifically, the distribution of any ABCD category did not significantly differ between community children from Western (*i.e.*, Canada, United States, Italy, and Greece) or non-Western (*i.e.*, Israel, Japan, Korea, and Cameroon) cultural backgrounds. However, differences emerged employing Fury's scales, with Western community children scoring higher than non-Western ones on all scales related to insecure patterns, revealing a counterintuitive trend. A limitation of this investigation is that cultural differences in clinical and at-risk samples have been not explored despite potentially informative, *e.g.*, by exploring the differences between community and at-risk internationally adopted children who have different cultural backgrounds.

Discussion

This opinion deepened two open questions raised by current literature on Family Drawing with attachment-based coding systems leading to ABCD classifications (Kaplan and Main, 1986) or scales (Fury, 1996).

The first question was about psychometric properties. Current findings highlight the main strength of FD in the inter-rater reliability, almost always reported and with good values for both systems across different samples. Instead, the scarcity of studies suggests a great need for research on discriminant validity. Particularly, it appears important to investigate if the results obtained with the FD are independent of the child's ability to draw, enlarging the potential number of children assessable. If the investigation is routed concerning IQ, on which anyway more studies are needed, there is still a lot to do concerning the ability to draw. Few efforts focused on fine motor skills as a measurable parameter of the ability to draw, to understand if the FD runs the risk to classify as secure children more able to drawn, and less able children are more likely to be classified as insecure. However, a child's drawing abilities depend on different skills besides fine motor ability, the topic which is still uninvestigated, *e.g.*, visuospatial skills (Toomela, 2002). One option can be to use a tool for evaluating drawing abilities (*e.g.*, Clark, 1995), including an evaluation of the same child's abilities in drawing different contents, such as the family and another not-attachment-related topic, to also check if the content of the FD may elicit emotional arousal impacting visual-sensory skills (Costanzi et al., 2019).

Besides, drawing abilities varied according to gender and age (Wright and Black, 2013). Their influence should be further investigated, especially given that scarcity of available data hindered a meta-analytic investigation of their role in a study by Pace et al. (2021). This would help to understand whether gender differences suggested by some findings reflect those recognized in the wider literature on attachment, or whether the drawing ability is influential. Concerning age, existing studies included children in large age ranges, while more research on clustering age groups would help to define the optimal age range where the FD led to more reliable and accurate results.

Concerning concurrent validity, contrasting findings, and limitations of the few existing studies seem to suggest the informative utility to design mixed-method studies employing the SSP and/or the MCAST with the FD, analyzed with both coding systems and possibly including either community, clinical, or at-risk samples. In this regard, authors of studies employing a double method are also encouraged to publish data on convergent validity, *e.g.*, SSP and FD (Fihrer and McMahon, 2009).

The second research question inquired about the culture-fair potential of the FD. On the one side, results with both scoring systems support the universality of pattern B, as expressed without marked differences between Western and non-Western children (Mesman et al., 2016). On the other side, unexpected results raised doubts about the universality of indicators of insecure patterns, particularly the insecure-preoccupied pattern. These indicators of insecurity are based on a typically Western conception of parent–child dyads, and they could not capture the contribution of multiple sources of attachment security typical of some non-Western cultures where multiple adults contribute to raising children (e.g., African countries like Cameroon; Eloundou-Enyegue and Shapiro, 2004; Amos, 2013). In this case, the FD has the potential to leave the child free to draw all the significant figures he/she considers part of his/her family. However, it poses the problem of how to compare the results with those obtained with other measures based on the dyad, *e.g.*, SSP and MCAST.

Beyond inter-country differences, the FD would help in those situations where the reliance on a child's verbal abilities is limited, *e.g.*, inter-country adopted or migrant or asylum seeker or refugee children, or clinical ones, *e.g.*, children with selective mutism or social anxiety.

However, all these enthusiastic purposes urge to be substantiated by future investigations providing empirical support or disconfirming the FD culture-fair potential, for instance, through inter-country investigations or with mixed-method studies designed as proposed above, specifically selecting the previously mentioned subgroups of children as at-risk and clinical participants.

In conclusion, the convoluted and heterogeneous state-of-art of research on FD with attachment-related systems is probably due to a lack of continuous development and control of coding systems starting from the same developers, which led to multiple adaptations of the coding system (*e.g.*, Crittenden's model in Carr-Hopkins et al., 2017) and fragmented contributions affecting the recognition of FD potential. Hopefully, this Opinion Article provides a valuable resource and an important starting point to guide future lines of research to advance the knowledge on this topic.

Author contributions

CP conceptualized, structured the opinion, revised, and rewrote some parts. SM and FV wrote the first draft of the manuscript and made all further revisions until the final version. FV had performed **Table 1** based on CP's indications. All authors contributed to the article and approved the submitted version.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Draw me a brain: The use of drawing as a tool to examine children's developing knowledge about the "black box"

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Recent studies in neuroeducation highlight the benefits of teaching children about how the brain works. However, very little is known about children's naive conceptions about the brain. The current study examined these representations, by asking 6–10 year-old children ($N = 257$) and adults ($N = 38$) to draw a brain and the inside of a belly as a control drawing. The drawings were scored using a content analysis and a list of graphic indicators was derived. First, all the graphic indicators used in the brain drawings were different from those used in the belly drawings, suggesting that children are able to distinguish these two organs. Second, with age, children depict (i) an increasing number of indicators, (ii) more complex indicators, (iii) indicators that are more anatomically correct, to depict the brain. There is an important evolution between 6 and 8 years-old but also between 10 years-old and adults. These results are discussed in relation to children's metacognitive knowledge and to their implications for neuroeducation.

KEYWORDS

brain, drawing, children, development, representation, neuroeducation

Introduction

What knowledge do children have about the brain as a "black box"? This question is of major interest, particularly with regard to the significance of metacognitive knowledge in school learning. Metacognitive knowledge corresponds to knowledge that a person has of their own cognitive processes and the factors that influence them (Flavell, 1979). Accordingly, having an accurate conception of the brain involves general knowledge about the mental functioning and could promote learning. Like Jolles and Jolles (2021) we defend the idea that it is essential to have knowledge about the brain (structure, function, development) in the same way that it is essential to have knowledge about other organs of the body. The contribution of knowledge we have today on the brain for the improvement of academic learning is no longer to be demonstrated. The American

Psychological Association has edited 20 principles from psychological science about effective teaching and learning in preK-12 classrooms, which are for a part of them based on neuroscience literature (American Psychological Association, 2015). This was also supported by the Society for Neuroscience formulating eight essential principles of neuroscience that one should know about the brain and nervous system with educational application from kindergarten to 12th grade (Society for Neuroscience, 2008). The first of these principles is to know the structure and the shape of the brain. The purpose of this study is to interrogate this knowledge through the drawing of the brain. The results obtained could lead to promoting the use of this drawing in class to access the knowledge that students have on the "black box" and thus promote teaching on the role of the brain in school learning. This is in the vein of neuroeducation, an interdisciplinary field of research whose objective is to apply knowledge of brain functioning to classroom practices (Thomas et al., 2019). It has been in full swing for over a decade (Gola et al., 2022), nevertheless, it is surprising how few studies have been conducted on children's developing knowledge about the brain. It seems clear that there is a need to consider children's naive conceptions of the brain particularly in the construction of brain-based educational programs.

The notion of "naive conceptions" corresponds to a way of seeing the world naively or instinctively. As opposed to a scientific conception, it results from intuitive knowledge leading to an understanding of natural phenomena (Vosniadou and Brewer, 1992). Johnson and Wellman (1982) conducted the first study that explored naive conceptions on the relation between mind and brain. Children between the age of 6 and 15 were asked whether various cognitive functions could be possible first without mind and then without brain, or vice versa. With age, children increasingly involve the brain in sensory-motor functions in addition to mental functions. In contrast the mind was dedicated to mental functions. Concerning the mind and brain ontology, although the youngest children did not differentiate between the functions of the mind and the brain, they thought that they were separate in the head. With age, children increasingly believed that the mind depended on the brain. Marshall and Comalli (2012) replicated these results with the same design protocol 30 years later.

Rossi et al. (2015) assessed 8-year-old children's naive mind-brain conceptions, using the Mind-Brain Questionnaire. Children were randomly assigned to one condition: MRI (in which children first participated in a Magnetic Resonance Imaging protocol; Houdé et al., 2011) or control (with no MRI protocol). Children were then presented with a character, placed in different cognitive activities and they had to indicate what the character needed to perform each activity using response cards. This study revealed an educational effect of participation in a MRI protocol on children's naive mind-brain conceptions. Children in the MRI condition seemed to have a better understanding of the relation between mind and brain particularly for dreaming and imagining by materializing the mind into the brain, compared to children in the control condition. Nevertheless, this relation was less clear for seeing, talking, reading, and counting, with no differences between the two conditions. This study emphasizes 8-year-old children's lack of knowledge about the brain and stresses the need to further examine this line of research.

This set of studies could also be linked to what we know about children's thinking abilities through the theory of mind (ToM). The core of this theory, first introduced in 1978 by Premack and Woodruff, relies on the ability to infer mental states of self and others, with many empirical studies showing a progressive shift in children's ability to attribute to others a state of knowledge about a given situation different from their own. As pointed out by Beaudoin et al. (2020), this well-known theory is of interest for many disciplines (e.g., developmental, educational, neuro- and social psychology, social neuroscience). If ToM development during early childhood has highly documented consequences on children's social understanding and social functioning (e.g., Hughes, 2011), its development also has strong intrinsic implications to children's cognitive growth and school readiness (Astington and Pelletier, 2005; Blair and Razza, 2007). According to Wang and Liu (2015), children's mental state understanding is critical to the successful transition to formal schooling, making an integral relation between children's ToM development and their teaching and learning concepts. In line with these studies, it seems relevant to introduce the idea that the way children represent the brain is not unrelated to the way they represent what they know, what they do not know, what others know and what others do not know (e.g., Battistelli and Farneti, 2015). Therefore, in line with the works carried out in neuroeducation that sustain the interest for children to be familiar with the functioning of their brain in order to better grasp learning situations, children's brain conception may be sensitive to ToM development.

Previous studies focus on children's developing conceptualization of brain functions and functioning, but do not address how children portray the brain (i.e., its shape, structure, content, etc.). This issue seems rather complicated to address through verbal methods with children. A body of recent work suggests the use of drawing as an indirect and non-verbal investigation method for this kind of purpose. Indeed, drawing can be reliably used to help children disclose their thoughts on topics that are abstract, not immediately salient in their lives or difficult to talk about (e.g., Ainsworth et al., 2011; Brechet, 2015; Mouratidi et al., 2016). For instance, drawing has been reliably used to examine children's representations of topics such as illness and health (Piko and Bak, 2006; Mouratidi et al., 2016; Bonoti et al., 2019), love (Brechet, 2015), robots (Secim et al., 2021), science (Samaras et al., 2012), death (Bonoti et al., 2013), coronavirus (Bonoti et al., 2022), bullying (Andreou and Bonoti, 2010) and loneliness (Misailidi et al., 2012).

Children's ability to depict the aforementioned topics has been associated with their understanding of the depicted themes but also with their representational drawing skills. When children begin to draw, they first produce traces that are difficult for others to interpret, and then they gradually succeed in producing drawings that are described as "representational" (i.e., depicting elements of reality). Studies on the development of children's representational drawings show a clear age-related improvement between about 3 and 11 years of age (Cox, 2005; Jolley, 2010). Among these representational drawings, the first to appear in children's repertoire is the human figure drawing, which evolves and changes from the age of 3 to about 11. As they become more differentiated in their drawings of the human figure, children also develop graphic models for other themes. Around the age of 5, graphic models for themes such as a house or a tree appear in children's spontaneous drawings. From these early representational drawings, children progress to increasingly visually realistic representations of figures and scenes. Although there are several theoretical approaches in this area, authors generally agree that children's drawing activity is driven by the desire to make realistic representations of the world around them (Luquet, 2001; Willats, 2005). However, after the age of 11, children gradually lose interest in drawing. They begin to consider this as a childish activity (Cox, 2005). As a consequence, many children stop drawing between the age of 10 and 12 and most adults produce drawings similar to those of 12-year-olds (Jolley, 2010).

As a matter of fact, many studies have used drawing to examine how children conceive the human body, by asking them to draw what they think is "inside their bodies" or "inside themselves" (Steward et al., 1982; Eiser and Patterson, 1983; Glaun and Rosenthal, 1987; Reiss and Tunnicliffe, 2001; Reiss et al., 2002; Bartoszeck et al., 2008, 2011; Stears and Dempster, 2017; Andersson et al., 2020). In these studies, the authors examine which body parts and organs are represented by children aged between 4 and 13. This body of research provides information on the proportion of children representing the brain in their drawings (compared to other organs and body parts) by age. The number of drawings depicting a brain increases gradually between the ages of 4 and 7, and from the age of 8, the brain is drawn by at least 80% of children. The brain is consistently drawn after the heart, bones and blood and some studies also show that children draw the brain and belly at about the same age. Although these are valuable data, these studies only report on whether or not children draw the brain but do not provide information about how the brain is depicted when children draw it.

To our knowledge, only two studies have addressed this issue, using the exact same procedure and coding process (Bartoszeck and Bartoszeck, 2012; Jeronen et al., 2016). Precisely, in the most recent study conducted by Jeronen et al. (2016), one classification is used to reveal the conceptions of the brain depicted by Finnish and Brazilian children. This classification comes from the categorization established by Bartoszeck and Bartoszeck (2012) on Brazilian children. In both studies, children aged from 4 to 10 were asked to draw "what they think they have inside their head," using a pencil. An outline of the head and a portion of the neck were drawn on the blackboard of the classroom to serve as a model. The collected drawings were scored according to the model they related to and classified into one of the 7 following categories: mental image model (i.e., the brain is depicted through mental images), hydraulic model (i.e., the brain is depicted by lines as the flow of a small brook), dog bone model (i.e., the brain is depicted as dog bones all over the skull), enteroid/enteric model (i.e., the brain is depicted by tubes or thick threads similar to the intestine on the top of the skull), epithelial model (i.e., the brain is depicted as patches similar to the epithelial tissues), callote/skullcap model (i.e., the brain is depicted by a callote on the top of the skull) and neuroanatomical model (i.e., the brain is depicted by right and left hemispheres). The results based on these categories indicate that younger children's drawings mostly correspond to the mental image model. As they get older, children start to develop a more morphological representation of the brain. However, the neuroanatomical model is still rarely depicted by 10 years-old children. If these two studies sustain the idea that using a drawing task is a promising method to explore children's conception of the brain, their contribution is mainly qualitative. Indeed, in both studies, the data analysis is only descriptive, with no statistical analysis. Moreover, some drawings are provided as examples to illustrate and support the categorization established, but there is no scoring of the exact content of the drawings. Namely, the specific graphic indicators used by children to depict the brain can only be partly inferred from the description of the models and from the examples of drawings provided.

In the present study, 6–10 year-old children and adults were asked to "draw a brain." Contrary to the two studies previously mentioned (Bartoszeck and Bartoszeck, 2012; Jeronen et al., 2016), we chose not to give the outline of the head, so as to leave the children free to draw the shape of their choice and to allow us to analyze the shape of the brains drawn too. We chose to start examining children from the age of 6, in order to make sure that they were old enough to both understand the instructions relative to the brain drawing and have the representational graphic skill to depict their ideas (Jolley, 2010). We also chose to limit our research to 10-year olds because previous research suggests that they have more elaborate representations about the brain (Bartoszeck and Bartoszeck, 2012) and because this is the age limit beyond which children tend to stop drawing (Jolley, 2010). Within this age range, we expanded our sample with a group of 8-year-olds, to be able to grasp any change occurring between 6 and 10 years. Also, as previous studies indicated that among older children, only a few of them depicted a brain which was anatomically correct, we decided to complete the sample with a group of adults. Because this was an exploratory study, we could not formulate hypotheses based on the existing literature. However, this study was designed to answer specific research questions. First, how does the depiction of the brain evolve with age? More precisely, whereas previous studies only rated the drawings according to the global model they related to, we chose to use a detailed content analysis to identify what shape and which graphic cues were used to represent the brain and how its graphic representation changed with age. Second, whereas previous studies only asked children to draw a brain, we chose to add a control drawing: children were also asked to produce a drawing representing another part of the body (namely, the inside of a belly), to be compared with the brain drawing. Through this control drawing, we aimed to answer the following question: is the content of brain drawings specific to the brain or can we find similar features in the drawings of another part of the body? Third, as previous research using drawing to examine children's representation of other topics indicated that their drawings reflected their understanding of the depicted themes but also their graphic skills, the whole sample was asked to make two additional drawings, in order to derive an individual measure of graphic level. This was used to answer the following question: does the content of the brain (and control) drawings depend on the participant's graphic level? And fourth, as a complement to the drawings, we also asked children for verbal responses to answer the following question: what do children (and adults) know about the location and functions of the brain, depending on their age, and what are the sources of their knowledge?

Method

Participants

There were 295 participants: 257 children aged 6–10 and a group of adults. Children were recruited from elementary schools in the South of France. They were of average socioeconomic background and in their normal school year. Parental written consent was obtained and children were tested in accordance with national and international norms that govern the use of human research participants. Children were divided in three age groups: 6-year-olds ($N = 76$; $M = 6$ years 2 months; $SD = 8$ months; 36 girls), 8-year-olds ($N = 91$; $M = 8$ years 1 month; $SD = 9$ months; 44 girls) and 10-year-olds ($N = 90$; $M = 10$ years 3 months; $SD = 7$ months; 48 girls). The adult group was composed of 38 participants aged 18–45 ($M = 25$ years 2 months; $SD = 8$ years; 21 females). They were university students in arts, humanities or social sciences. They were recruited on campus and voluntarily took part in the study.

Materials

The materials used for the drawing tasks were white blank A4 paper, an HB pencil, a set of six colored pencils (red, pink, yellow, blue, green, beige), an eraser and a wooden mannequin of a man.

Procedure

The study was conducted individually in a quiet room in the school and lasted an average of 35 min per participant. First, they were asked to draw a brain and a belly, in a counterbalanced order. For the brain drawing participants were first asked "Do you know where the brain is?" The experimenter noted the answer. If the participant did not know or if the answer was incorrect the experimenter explained "it is an organ that we have in the body, like the heart, but the heart is in here (the experimenter pointed to the location of the heart on her chest) whereas the brain is in the head, here (the experimenter pointed to her head and tapped lightly on her skull)." Then, each participant was instructed to draw a brain: "Here is a blank sheet of paper, a gray pencil and some colored pencils. I would like you to draw a brain." After the brain drawing, the experimenter asked the participants two additional questions: "What is the brain for?" and "How did you know how to draw it?" The experimenter noted the participants' responses to these questions. For the belly drawing, each participant was asked "Here is a blank sheet of paper, a gray pencil and some colored pencils. I would like you to draw what is inside a belly." In this study, the belly drawing was designed as a control drawing to be compared with the brain drawing, in order to ensure that children were indeed depicting organ-specific details and not just some random body parts. Our main objective was to assess the representation that the participants have of the brain, thus of one of the organs that exist inside the skull. The choice of the control drawing was conditioned in order to place the participants in a similar condition, i.e., to assess the representation of what exists inside another part of the body. From our point of view, the belly is just as easily identifiable by the participants as the skull, especially for the youngest ones (6 years old). Note that there was no time limit so that the children were free to elaborate the content of their drawings.

Then, participants were asked to produce two additional drawings in order to assess their level of graphic development. They were asked to draw a man running (from a wooden mannequin model) and a house from memory, in counterbalanced order. In the running man drawing task, participants were presented with a model at a distance of about 30 cm and oriented in a profile view with the man running to the right. The participants were encouraged to look carefully at the wooden man and to draw exactly what they saw (but not the base or the pole) including the direction the man was running. In the house drawing task participants were asked to draw a house and to make it look as real and as life-like as they could.

Coding of the drawings

Content analysis was performed to derive the number and types of graphic indicators used to depict the brain and the belly drawings. As our study was the first to examine this question by analyzing the content of the drawings, we did not have access to an existing rating system. We therefore conducted a posteriori analysis, based on the drawings collected, following the basic principles of content analysis (Krippendorf, 1980; Weber, 1990). This scoring process enables to generate a rating system that closely reflects the content of the drawings. It has been extensively used to examine how children depict various kinds of concepts or ideas (e.g., love, coronavirus, health/illness, etc.) through their drawings (e.g., Brechet, 2015; Bonoti et al., 2019, 2022). Based on this method two raters were first asked to independently identify each and every graphic item relative to the brain or the belly in the drawings. The two raters then compared the items they identified and agreed on a final list. Finally, they discussed the items in the list and generated graphic indicators from it (Figure 1).

The following graphic indicators were generated: *furrows*, *brain stem*, *hemispheres*, *lobes* for the brain and *digestive organs, other organs, bones/blood, water/food* for the belly. Figure 1 presents examples of drawings illustrating each indicator.

Subsequently, the raters were asked to independently review and rate each drawing for the presence of any of the four indicators, assigning a single point to each type of graphic indicator included in the drawing. The judges were also given the possibility to categorize drawings as containing no indicator at all. The inter-judge agreements were high (96% for brain drawings and 98% for belly drawings, kappa coefficient = 0.9 for both) and the judges resolved the few cases of disagreement through discussion. Finally, the number of graphic indicators was recorded for each drawing.

The brain drawings were also scored regarding the shape of the depicted brain. To do so, the same two judges were asked to independently identify the different kinds of shapes used to depict the brain. The two raters then agreed on a final list and discussed the exact definition of each shape. The following four kinds of shapes were identified: *round/oval*, *calotte*, *encephalic* and *other*. Figure 2 presents examples of brain drawings illustrating each kind of shape. Subsequently, the raters were asked to independently review and rate each brain drawing regarding the depicted shape. The inter-judge agreement was high (90%, kappa coefficient = 0.8) and the judges resolved the few cases of disagreement through discussion.

Following the example of Brechet and Jolley (2014) and Rose et al. (2012), the house drawings and the running man drawings were rated using a revised version of the corresponding scales (respectively, Barrouillet et al., 1994 and Cox et al., 1998). Accordingly, the house drawings were rated on a 13-point scale including the following items: outline of house, roof, roof shape, door, door handle, base of the house, two or more windows, position of windows, proportion of windows, curtains, extraneous items and perspective. The running man drawings were rated on a 23-point scale (with points awarded for direction, overlap, partial occlusion, proportion, detail, recognizability of a person, presence of head, torso, arms, hands, legs and feet, and whether these were depicted as a line or as a zone). Two independent judges performed this scoring and reached an inter-rater agreement of 91% for the house drawings and 93% for the running man drawings (kappa coefficient = 0.8 for both). The cases of disagreement were then discussed and resolved between the two judges. For each participant, the scores on the two drawings were computed as a percentage of the maximum score on each scale. These percentages were then recalculated as scores out of 20 (a number chosen because it was in between the maximum scores of the two scales). Finally, we averaged these two scores to obtain a composite score of graphic development (0–20) for each participant.

Coding of the verbal responses

As stated above, participants were asked three questions about the brain: one question before they drew, about the location of the brain ("Do you know where the brain is?") and two questions after they drew, about the function(s) of the brain ("What is the brain for?") and about the source(s) of their knowledge about the brain ("How did you know how to draw it?"). Their responses to these three questions were coded by two adult judges, using the same procedure as for the coding of the drawings. From the participants' answers, the judges had to classify them thematically, so as to extract the main themes. For the location question, three categories were extracted from the participants' answers: *head*, *skull* and *I don't know*. For the function question, six categories were identified: *thoughts*, *intelligence*, *control*, *sensory-motricity*, *life*, *I don't know*. For the source question, five categories were extracted from the answers: *school*, *books*, *television*, *family*, and *I don't know/I just know it*. Note that the answers to the location question were mutually exclusive: each participant gave only one answer out of the three listed. In contrast, the answers to the function and source questions were not mutually exclusive, as the participants often gave responses relative to more than one category. For example, the following answer to the function question "the brain helps to think, to become smart, it is also used to move and smell, it controls everything that goes on in the body, without it we cannot live" would correspond to the following categories thoughts, intelligence, sensory-motricity, control and life. The judges were then asked to independently review and rate each

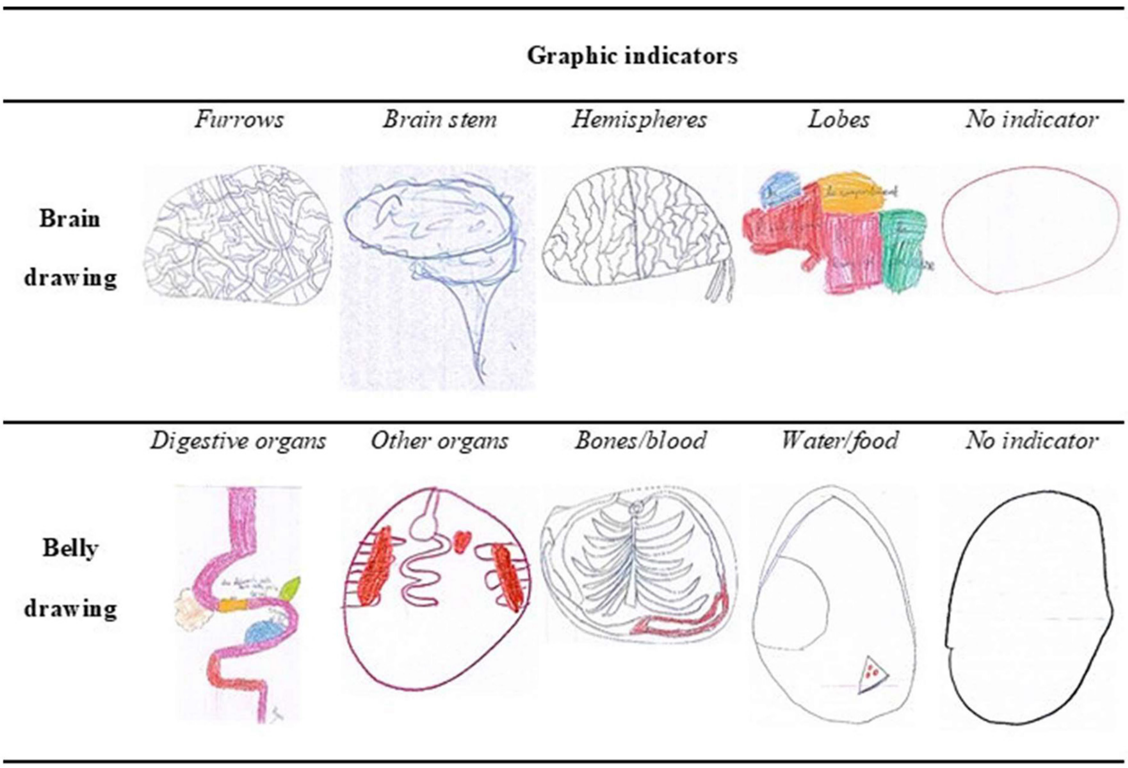

FIGURE 1
Examples of drawings for each type of graphic indicator relative to the brain and to the belly drawings.

answer on the basis of the identified categories. The inter-judge agreement was very high (99%) and the judges resolved the few cases of disagreement through discussion.

Analysis plan

The present study was designed to answer four research questions:

- Q1: How does the depiction of the brain evolve with age?
- Q2: Is the content of brain drawings specific to the brain or can we find similar features in the drawings of another part of the body?
- Q3: Does the content of the brain (and control) drawings depend on the participant's graphic level?
- Q4: What do children (and adults) know about the location and functions of the brain, depending on their age, and what are the sources of their knowledge?

To answer these questions, we examined the number of graphic indicators (in the brain and belly drawings), then the types of graphic indicators (in the brain and belly drawings), the shape of the brain, and finally the responses to verbal questions, as a function of age. First, we carried out a repeated measure analysis of variance (RMANOVA) on the number of indicators (0–4) with Drawing type (Brain, Belly) as a within-participants factor, with Age (6, 8, 10 years-old, adults) as a between-participants factor and with the Level of graphic development as a covariate (Q1, Q2, and Q3). Second, we compared the number of drawings depicting each indicator between each age group using Chi-square analyses for the brain and the belly drawings (Q1 and Q2). For each significant difference we found between age groups, we then decomposed the analysis by examining whether this difference was found for both low and high graphic level subgroups or was specific to one of the subgroups (Q3). And we then repeated the same analysis for the shape of the brain (Q1 and Q3). Finally, we used Chi-square analyses to compare verbal responses relative to the location, the function of the brain and to the source of knowledge, between age groups (Q4).

Results

Number of graphic indicators in the brain and in the belly drawings

Figure 3 presents the mean number of graphic indicators as a function of drawing type and age. We conducted a repeated

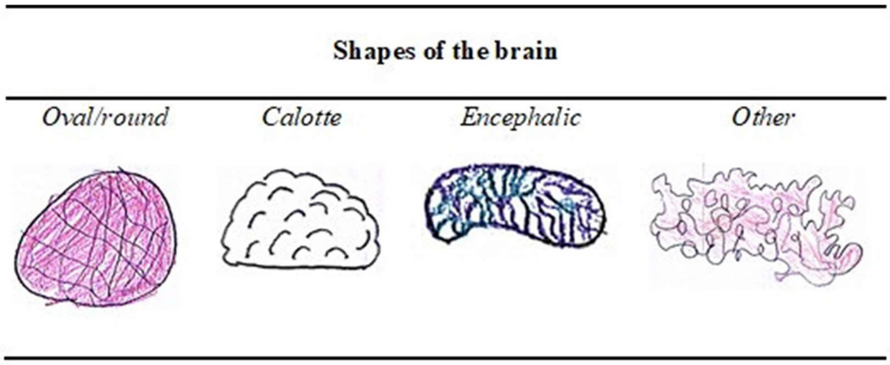

FIGURE 2
Examples of brain drawings depicting each kind of shape.

measure analysis of variance (RMANOVA) on the number of indicators (0-4), with Drawing type (Brain, Belly) as a within-participants factor, with Age (6, 8, 10 years-old, adults) as a between-participants factor, and with the Level of graphic development as a covariate. The results revealed a significant effect of Age [$F(3,290) = 6.30$, $p = 0.001$, $\eta^2p = 0.061$] and Level of graphic development [$F(1,290) = 7.81$, $p = 0.006$, $\eta^2p = 0.03$]. We also found a significant effect of interaction between the Drawing type and the Age [$F(3,290) = 7.42$, $p = 0.001$, $\eta^2p = 0.07$]. Post-hoc comparisons Turkey test revealed a significant increase in the number of graphic indicators for the brain between the age of 6 and 8 (*M*diff = −0.35, $t = -3.44$; *p*bonferroni = 0.01) and between the age of 10 and adulthood (*M*diff = −0.60, $t = -4.71$; *p*bonferroni = 0.001). No significant difference was revealed for the number of graphic indicators for the belly. Moreover, children produced significantly less graphic indicators for the brain than for the belly at 6 years old (*M*diff = −0.61, $t = -5.32$; *p*bonferroni = 0.001) and at 8 years old (*M*diff = −0.47, $t = -4.78$; *p*bonferroni = 0.001).

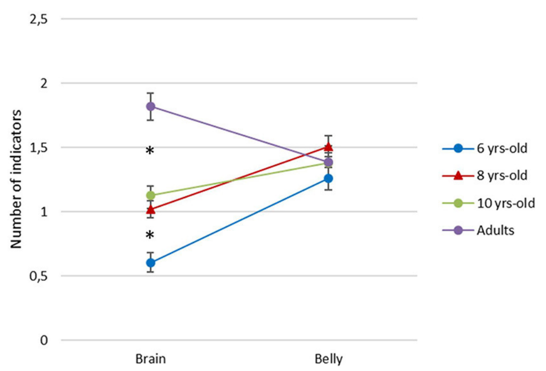

FIGURE 3
Mean number of graphic indicators as a function of age and drawing type.

Types of graphic indicators in the brain and in the belly drawings

To determine whether participants produced different graphic indicators according to their age we compared the number of drawings depicting each indicator between each age group using Chi-square analyses. We used a Bonferroni correction for multiple comparisons: we divided the standard alpha level of 0.05 by 4 and thus used an adjusted alpha of 0.0125. Considering the results of the previous analysis and to account for the potential effect of graphic skills on these comparisons, the sample was split on the median scores for graphic development (*Median* = 13.98), resulting in two subgroups: low graphic level (*score* < 13.98) vs. high graphic level (*score* ≥ 13.98). For each significant difference we found between age groups, we thus decomposed the analysis by examining whether this difference was found for both graphic level subgroups or was specific to one of the subgroups. We have used this categorical approach so that we can present the data in detail by age and graphic level for each indicator. Table 1 presents the number of brain drawings depicting each type of graphic indicator as a function of age and graphic level (low *vs.* high).

For the brain drawings, the analysis revealed a significant increase in the depiction of *furrows* between 8 (61/91, 67%) and 10 (75/90, 83%) [$\chi^2(1) = 6.44$, $p = 0.011$]. When decomposing this comparison for both graphic levels, we found a marginal difference only for children with a high graphic level [$\chi^2(1) = 4.24$, $p = 0.039$]. We also found a significant increase between the age of 6 and 8 in the use of the indicator *brain stem* (respectively, 3/76, 4% and 15/91, 16%) [$\chi^2(1) = 6.77$, $p = 0.009$]. When running this comparison separately for both graphic levels, we found a marginal difference only for children with a low graphic level [$\chi^2(1) = 4.49$, $p = 0.034$]. The depiction of *hemispheres* significantly increased between 10-year-olds (7/90, 8%) and adults (21/38, 55%) [$\chi^2(1) = 35.25$, $p = 0.001$], with a significant difference for low level [$\chi^2(1) = 14.93$, $p = 0.001$] and high level [$\chi^2(1) = 22.11$, $p = 0.001$] subgroups. Finally, the number of drawings with *no indicator* significantly decreased between 6 (33/76, 43%) and 8 (20/91, 22%) [$\chi^2(1) = 8.79$, $p = 0.003$]. When running separate analyses, this difference was significant for children with a low graphic level only [$\chi^2(1) = 9.61$, $p = 0.002$]. We found no significant age difference in the depiction of lobes.

Table 2 presents the number of belly drawings depicting each type of graphic indicator as a function of age and graphic level. For the belly drawings, the analysis revealed a significant increase in the depiction of *digestive organs* between 6 (41/76, 54%) and 8 (73/91, 80%) [$\chi^2(1) = 13.19$, $p = 0.001$]. When running this comparison separately for both graphic levels, we found a significant difference only for children with a low graphic level [$\chi^2(1) = 14.58$, $p = 0.001$]. There was no significant difference with age in the depiction of *other organs*, *bones/blood*, *water/food* and in the number of drawings depicting *no indicator*.

To sum up, for the brain drawings, we found a significant increase with age in the depiction of furrows, brain stem and hemispheres and a significant diminution of the number of drawings with no indicator. For the belly drawings, there was a significant increase in the depiction of digestive organs and almost no drawing with no indicator. When considering the participants' graphic level for these comparisons, it appeared that the differences we found between 6 and 8 were related to children with a low graphic level, whereas the differences we found between 8 and 10 and between 10 and adults mainly applied to participants with a high graphic level. A closer look at the indicators depicted at each age suggests that, for the brain drawing, 6-year-olds are divided between those representing furrows (43%) and those depicting no indicators at all (50%). Then, 8- and 10-year-old children can depict furrows and some of them begin to depict brain stem and/or lobes (but some can still produce drawings with no indicators). Finally, adults no longer depict no indicator and can portray furrows, brain stem, lobes, but also hemispheres. To depict a belly, 6 and 8 years-old children can use each of the four indicators: digestive organs, other organs, bones/blood and water/food. At the age of 10, the indicators are quite similar to those depicted by younger children except for water/blood. Finally, adults tend to focus their graphic representation of the belly on digestive organs and some of them also depict other organs.

Shape of the brain

Table 3 presents the number (and percentage) of drawings using each shape to depict the brain as a function of age and graphic level (low vs. high). We compared the number of drawings depicting each shape between each age group using Chi-square analyses to determine whether participants depicted the brain through different shapes according to their age. We used a Bonferroni correction for multiple comparisons: we divided the standard alpha level of 0.05 by 4 and thus used an adjusted alpha of 0.0125. For each significant difference we found between age groups, we then decomposed the analysis by examining whether this difference was found for both graphic level subgroups or was specific to one of the subgroups.

The analysis revealed a significant decrease of *round/oval* shaped brains between 10-year-olds (58/90, 64%) and adults (14/38, 37%) [$\chi^2(1) = 8.27$, $p = 0.004$]. When decomposing this comparison for both graphic levels, we found a marginal difference only for participants with a high graphic level [$\chi^2(1) = 4.55$, $p = 0.033$]. In contrast, we found a significant increase between the age of 6 and 10 in the depiction of the *encephalic* shape (respectively, 1/76, 1% and 10/90, 11%) [$\chi^2(1) = 6.39$, $p = 0.011$]. However, this difference was no longer significant when the two graphic levels were considered separately. Adults also drew a significantly higher number of *encephalic* shapes (15/38, 39%) compared to 10-year-olds [$\chi^2(1) = 13.68$, $p = 0.001$], with a significant difference for participants with a low graphic level [$\chi^2(1) = 14.93$, $p = 0.001$] and a difference that almost reached significance for participants with a high graphic level [$\chi^2(1) = 5.89$, $p = 0.015$].

Verbal responses

Regarding the location question, almost all participants were able to indicate where the brain was located but there was a difference in the words that were used according to age. We used Chi-square analyses to compare responses between age groups. We used a Bonferroni correction for multiple comparisons we divided the standard alpha level of 0.05 by 2 and thus used an adjusted alpha of 0.025. The analyses revealed a significant decline in the use of the word *head* between 10-year-olds (68/90, 76%) and adults (17/38, 45%) [$\chi^2(1) = 11.38$, $p = 0.001$] and also a marginal decrease in the response *I don't know* between the age of 6 (6/76, 8%) and 8 (1/91, 1%) [$\chi^2(1) = 4.76$, $p = 0.029$]. In contrast, there was a significant increase in the use of the word *skull* between 6 (6/76, 8%) and 10 (21/90, 23%) [$\chi^2(1) = 7.21$, $p = 0.007$] and between 10 and adults (21/38, 55%) [$\chi^2(1) = 12.36$, $p = 0.001$].

For the function question, we first recorded the number of functions cited by each participant. We conducted an analysis of variance (ANOVA) with Age (6, 8, 10 years-old, adults) as a between-participants factor on the number of functions cited. The results revealed a significant effect of Age, $F(3,291) = 11.64$, $p = 0.001$, $\eta^2 p = 0.11$. A *post-hoc* Tukey test showed that 8-year-olds ($M = 1.21$) cited a higher number of functions than 6-year-olds ($M = 1.64$) ($p = 0.018$).

TABLE 1 Number (and percentages) of brain drawings depicting each type of graphic indicator as a function of age and graphic level (L1 = low graphic level and L2 = high graphic level).

			Brain indicators				
Age group	Graphic level	*N*	Furrows	Brain stem	Hemispheres	Lobes	No indicator
6 yrs-old	L1	61	26 (43%)	3 (5%)	2 (3%)	2 (3%)	30 (49%)
	L2	15	12 (80%)	0 (0%)	0 (0%)	1 (7%)	3 (20%)
	Tot	76	38 (50%)	3 (4%)	2 (3%)	3 (4%)	33 (43%)
8 yrs-old	L1	59	38 (64%)	10 (17%)	2 (3%)	9 (15%)	13 (22%)
	L2	32	23 (72%)	5 (16%)	3 (9%)	3 (9%)	7 (22%)
	Tot	91	61 (67%)	15 (16%)	5 (5%)	12 (13%)	20 (22%)
10 yrs-old	L1	28	20 (71%)	2 (7%)	0 (0%)	2 (7%)	5 (18%)
	L2	62	55 (89%)	13 (21%)	7 (11%)	3 (5%)	4 (6%)
	Tot	90	75 (83%)	15 (17%)	7 (8%)	5 (6%)	9 (10%)
Adults	L1	4	4 (100%)	2 (50%)	2 (50%)	0 (0%)	0 (0%)
	L2	34	29 (85%)	7 (21%)	19 (56%)	6 (18%)	0 (0%)
	Tot	38	33 (87%)	9 (24%)	21 (55%)	6 (16%)	0 (0%)
Total	L1	152	88 (58%)	17 (11%)	6 (4%)	13 (9%)	48 (32%)
	L2	143	119 (83%)	25 (17%)	29 (20%)	13 (9%)	14 (10%)
	Tot	295	207 (70%)	42 (14%)	35 (12%)	26 (9%)	62 (21%)

TABLE 2 Number (and percentage) of belly drawings depicting each type of graphic indicator as a function of age and graphic level (L1 = low graphic level and L2 = high graphic level).

			Belly indicators				
Age group	Graphic level	*N*	Digestive organs	Other organs	Bones/blood	Water/food	No indicator
6 yrs-old	L1	61	28 (46%)	19 (31%)	13 (21%)	11 (18%)	9 (15%)
	L2	15	13 (87%)	7 (47%)	4 (27%)	1 (7%)	0 (0%)
	Tot	76	41 (54%)	26 (34%)	17 (22%)	12 (16%)	9 (12%)
8 yrs-old	L1	59	47 (80%)	22 (37%)	14 (24%)	9 (15%)	6 (10%)
	L2	32	26 (81%)	10 (31%)	5 (16%)	4 (13%)	2 (6%)
	Tot	91	73 (80%)	32 (35%)	19 (21%)	13 (14%)	8 (9%)
10 yrs-old	L1	28	23 (82%)	10 (36%)	3 (11%)	3 (11%)	1 (4%)
	L2	62	60 (97%)	14 (23%)	9 (15%)	2 (3%)	0 (0%)
	Tot	90	83 (92%)	24 (27%)	12 (13%)	5 (6%)	1 (1%)
Adults	L1	4	4 (100%)	2 (50%)	1 (25%)	0 (0%)	0 (0%)
	L2	34	34 (100%)	12 (35%)	0 (0%)	0 (0%)	0 (0%)
	Tot	38	38 (100%)	14 (37%)	1 (3%)	0 (0%)	0 (0%)
Total	L1	152	102 (67%)	53 (35%)	31 (20%)	23 (15%)	16 (11%)
	L2	143	133 (93%)	43 (30%)	18 (13%)	7 (5%)	2 (1%)
	Tot	295	235 (80%)	96 (33%)	49 (17%)	30 (10%)	18 (6%)

There was no significant difference between the age of 8 and 10 ($M = 2.00$) and between 10-year-olds and adults ($M = 2.11$). Then, to determine whether participants cited different functions according to their age we compared the number of answers corresponding to each function between each age group using Chi-square analyses. We used a Bonferroni correction for multiple comparisons: we divided the standard alpha level of 0.05 by 5 and thus used an adjusted alpha of 0.01. Table 4 presents the number (and percentage) of answers corresponding to each function according to age. The analyses revealed that the number of participants responding *I don't know* significantly decreased between the age of 6 (17/76, 22%) and 8 (5/91, 5%) [$\chi^2(1) = 10.31$, $p = 0.001$]. The reference to *thoughts* also decreased with age, between 10-year-olds (61/90, 68%)

TABLE 3 Number (and percentage) of drawings using each shape to depict the brain, as a function of age and graphic level (L1 = low graphic level and L2 = high graphic level).

			Brain shapes			
Age group	**Graphic level**	***N***	**Round/ oval**	**Calotte**	**Encephalic**	**Other**
6 yrs-old	L1	61	41 (67%)	6 (10%)	0 (0%)	14 (23%)
	L2	15	9 (60%)	0 (0%)	1 (7%)	5 (33%)
	Tot	76	50 (66%)	6 (8%)	1 (1%)	19 (25%)
8 yrs-old	L1	59	42 (71%)	6 (10%)	2 (3%)	9 (15%)
	L2	32	17 (53%)	7 (22%)	2 (6%)	6 (19%)
	Tot	91	59 (65%)	13 (14%)	4 (4%)	15 (16%)
10 yrs-old	L1	28	22 (79%)	5 (18%)	0 (0%)	1 (4%)
	L2	62	36 (58%)	11 (18%)	10 (16%)	5 (8%)
	Tot	90	58 (64%)	16 (18%)	10 (11%)	6 (7%)
Adults	L1	4	2 (50%)	0 (0%)	2 (50%)	0 (0%)
	L2	34	12 (35%)	3 (9%)	13 (38%)	6 (18%)
	Tot	38	14 (37%)	3 (8%)	15 (39%)	6 (16%)
Total	L1	152	107 (70%)	17 (11%)	4 (3%)	24 (16%)
	L2	143	74 (52%)	21 (15%)	26 (18%)	22 (15%)
	Tot	295	181 (61%)	38 (13%)	30 (10%)	46 (16%)

TABLE 4 Number (and percentage) of answers corresponding to each function according to age.

		Functions of the brain					
Age group	***N***	**Thoughts**	**Intelligence**	**Control**	**Sensory-motricity**	**Life**	**Don't know**
6 yrs-old	76	49 (64%)	28 (37%)	6 (8%)	5 (7%)	8 (11%)	17 (22%)
8 yrs-old	91	68 (75%)	49 (54%)	21 (23%)	19 (21%)	6 (7%)	5 (5%)
10 yrs-old	90	61 (68%)	39 (43%)	41 (46%)	28 (31%)	11 (12%)	2 (2%)
Adults	38	16 (42%)	12 (32%)	24 (63%)	16 (42%)	13 (34%)	3 (8%)
Total	295	194 (66%)	128 (43%)	92 (31%)	68 (23%)	38 (13%)	27 (9%)

and adults (16/38, 42%) [$\chi^2(1) = 7.35$, $p = 0.007$]. All the other functions increased with age in the participants' answers. We found a marginal increase in the reference to *intelligence* between 6 (28/76, 37%) and 8 (49/91, 54%) [$\chi^2(1) = 4.82$, $p = 0.028$]. For *sensory-motricity*, there was also an increase between 6 (5/76, 7%) and 8 (19/91, 21%) [$\chi^2(1) = 6.88$, $p = 0.009$] and between 8-year-olds and adults (16/38, 42%) [$\chi^2(1) = 6.11$, $p = 0.013$]. *Life* was more often cited by adults (13/38, 34%) than by 10-year-olds (11/90, 12%) [$\chi^2(1) = 8.48$, $p = 0.004$]. And there was a difference between each age group in the number of responses relative to *control*: a significant increase between 6 (6/76, 8%) and 8 (21/91, 23%) [$\chi^2(1) = 7.04$, $p = 0.008$] and between 8 and 10 (41/90, 46%) [$\chi^2(1) = 10.15$, $p = 0.001$].

Regarding the question relative to the sources of participants' knowledge, we compared the number of answers corresponding to each source between each age group using Chi-square analyses. We used a Bonferroni correction for multiple comparisons: we divided the standard alpha level of 0.05 by 4 and thus used an adjusted alpha of 0.0125. Table 5 presents the number (and percentage) of answers corresponding to each source as a function of age. The analyses revealed that the number of participants answering *I don't know* or *I just know it* decreased between the age of 6 (23/76, 30%) and 8 (15/91, 16%) [$\chi^2(1) = 4.47$, $p = 0.034$]. The reference to *family* significantly decreased with age, between 10-year-olds (16/90, 18%) and adults (0/38, 0%) [$\chi^2(1) = 7.72$, $p = 0.005$]. In contrast, the reference to *books* significantly increased between 6 (6/76, 8%) and 8 (23/91, 25%) [$\chi^2(1) = 8.72$, $p = 0.003$]. And for *school*, we found a significant increase between 8 (10/91, 11%) and 10 (28/90, 31%) [$\chi^2(1) = 11.05$, $p = 0.001$] and between 10-year-olds and adults (27/38, 71%) [$\chi^2(1) = 17.39$, $p = 0.001$]. Finally, there was no age difference for the source *television*.

TABLE 5 Number (and percentage) of answers corresponding to each source of knowledge as a function of age.

Age group	*N*	Sources of knowledge				
		School	Books	Television	Family	Don't know
6 yrs-old	76	4 (5%)	6 (8%)	25 (33%)	19 (25%)	23 (30%)
8 yrs-old	91	10 (11%)	23 (25%)	31 (34%)	17 (19%)	15 (16%)
10 yrs-old	90	28 (31%)	33 (37%)	27 (30%)	16 (18%)	7 (8%)
Adults	38	27 (71%)	8 (21%)	9 (24%)	0 (0%)	3 (8%)
Total	295	69 (23%)	70 (24%)	92 (31%)	52 (18%)	48 (16%)

Discussion

How does the depiction of the brain evolve with age?

The main goal of this study was to examine children's developing knowledge about the brain, using drawing as an indirect and non-verbal investigation method. Contrary to previous studies, which only rated the drawings according to the model they related to Bartoszeck and Bartoszeck (2012), Jeronen et al. (2016), we chose to conduct a detailed content analysis of the brain drawings to identify what shape and which graphic cues were used to represent the brain and how its graphic representation changed with age. Our results indicate that, with age, children depict (i) an increasing number of indicators, (ii) more complex indicators, (iii) indicators and shapes that are more anatomically correct, with important shifts between 6 and 8-year-olds but also between 10-year-olds and adults. First, we found a diminution of the number of drawings with no indicator between 6 (48%) and 8 (22%) years-old. And it is worth noting that the number of drawings with no indicator kept decreasing until adulthood. This finding echoes previous studies asking children to draw the inside of their body and showing that the number of drawings depicting a brain increases gradually between the ages of 4 and 7 (Steward et al., 1982; Eiser and Patterson, 1983; Glaun and Rosenthal, 1987; Reiss and Tunnicliffe, 2001; Reiss et al., 2002; Bartoszeck et al., 2008, 2011; Stears and Dempster, 2017; Andersson et al., 2020). In our study, almost half of the 6-year-olds only drew the outline of the brain, as an empty shape. Second, we found a significant increase with age in the depiction of furrows, brain stem and hemispheres, leading to a more anatomically correct representation of the brain. These observations are in line with previous studies showing that the neuroanatomical model of the brain was still rarely depicted by older children (Bartoszeck and Bartoszeck, 2012; Jeronen et al., 2016). The addition of a group of adults in our study enabled us to reveal that the representations kept evolving after the age of 10, in particular with the depiction of hemispheres characterizing the adults' drawings. Finally, we examined the shape of the depicted brains, as a function of age. The results indicate a decrease in the depiction of round/oval shaped brains and an increase in the depiction of the encephalic shape. This evolution matches the one related to the content of the brain, in the sense that the encephalic shape is more likely to contain hemispheres and/or brain stem compared to the round/oval shape.

Is the content of brain drawings specific to the brain or can we find similar features in the drawings of another part of the body?

In this study, children were also asked to draw a belly, as a control drawing. First, our results indicate that children depicted specific indicators, with no overlap between brain and belly drawings. This suggests that children, even younger ones, do not draw the inside parts of the body all in the same way since distinct indicators were used depending on the part being drawn. This observation supports the validity of the brain drawing. With regard to the belly drawing, there was no overall variation with age in the number of indicators depicted, contrary to the brain drawing. Our results also indicate that at the age of 6 and 8, children produced more indicators in their belly drawing than in their brain drawing. One may conclude that young children have a better representation of the belly. However, when comparing the type of indicators produced in the two drawings, we can notice that the belly drawing is first characterized by a much more "basic" representation, with indicators such as food and water for example. When depicting the brain, children did not use such "basic" indicators. In contrast, either they draw an empty shape, or a shape containing rather relevant and advanced indicators. It is possible that children did not draw basic indicators for the brain simply because there are no such indicators, contrary to the belly. This would lead to an all-or-nothing representation of the brain with either advanced indicators or no indicators at all.

Does the content of the brain (and control) drawings depend on the participant's graphic level?

Interestingly, when considering the participants' graphic level for the age comparisons we conducted (relative to the types of indicators in the brain and in the belly drawings and also to the shape of the brain), it appeared that the differences we found between 6 and 8 were mostly related to children with a low graphic level. In other words, some indicators or shapes, already represented by young children with a high graphic level, would require a little more developmental progression for children with a low graphic level to represent them in their drawings (e.g., digestive organs in belly drawing). In contrast, the differences we found between 8 and 10 and between 10 and adults mainly applied to participants with a high graphic level. In other words, some indicators or shapes would only shift in number in older participants with a high graphic level (e.g., decrease of the round/oval brain shape, increase of the furrows in the brain drawing). But there were two exceptions to this pattern: the hemispheres indicator and the encephalic shape increased between 10 years old and adults, regardless of the participants' graphic level.

What do children (and adults) know about the location and functions of the brain, depending on their age, and what are the sources of their knowledge?

Finally, children not only drew a brain but were also asked questions about the location and function of the brain and about the sources of their knowledge. The analysis of the verbal responses provides additional information for interpretation. Regarding the location, almost all participants were able to indicate where the brain was located but there was a difference in the words that were used according to age. There was a decrease of the use of the word "head" and an increase of the use of the word "skull." This result is not surprising if we consider the age of acquisition of these words reported by Ferrand et al. (2008): for the word "head" the average age of acquisition is 3.92 years while for the word "skull" it is 7.32 years. The subjective frequency of exposure to these words also found in Ferrand et al. (2008) reinforces the relevance to differentiate them, considering that the word "head" is reported to be encountered at least once every 2 days while this frequency falls to once a week for the word "skull." About the function of the brain, we found an age-related increase in the number of functions that the children cited. While the answers "I don't know" and those referring to thoughts declined, the responses relative to intelligence, sensory-motricity, life and control increased with age. This echoes the developmental pattern we found in children's use of graphic indicators to depict the brain, with the use of indicators which are more complex and anatomically correct with age. This also relates to the gradual disappearance of brain drawings with no indicators. With age, children seem to become aware of the major role that the brain has in driving their behaviors. It remains to be stressed that the vital function of the brain, as an indispensable organ for life, was rare in children but present in adults' responses. On these two aspects, these results show the lesser role granted by young children to this organ which is nevertheless essential to them. Finally, regarding the source of children's knowledge, while the answers "I don't know" or "I just know it" and those referring to the family declined, the responses relative to school and books increased with age. However, it is noteworthy that school does not stand out as a major source of knowledge according to children (5%, 11% and 31% at ages 6, 8, and 10, respectively). From our point of view, there is a need to introduce general knowledge about the brain into school programs, but also to develop students' metacognition in order to help them learning how to learn (Marulis et al., 2020). Lastly, television remained a stable and frequent source cited by all age groups. Obviously, television is still an undeniable source of information for children who can benefit from educational programs, at all ages, with a significant contribution of this medium in the acquisition of knowledge (e.g., Wright et al., 2001). However, this medium can also contribute to the dissemination of neuromyths that are some misconceptions generated by a misunderstanding or a misreading of facts scientifically established by brain research. For instance, the idea that there are critical periods in childhood after which certain things can no longer be learned is such a neuromyth (Dekker et al., 2012). From our point of view, the school should therefore be the major source of information by having teachers trained in brain sciences (Jolles and Jolles, 2021) in order to fight against the dissemination of neuromyths among both students and teachers (Torrijos-Muelas et al., 2021).

Implications on how knowledge about the brain might be implemented at school and help students to learn

The functioning of the brain is rarely integrated into school curricula and taught from kindergarten to secondary school (Marshall and Comalli, 2012). In France the teaching of the nervous system begins late, i.e., at the age of 12. To compensate for this situation, children implicitly acquire information about the brain through different sources (social environment, exposure to scientific knowledge, media) which could lead them to build an incomplete or erroneous mental representation of the brain, and this seems to reflect our findings. These elements converge toward the idea that it is necessary to instruct children about an organ that they "cannot see" (Society for Neuroscience, 2008; Carew and Magsamen, 2010). Because the brain is what gives children the ability to learn, it is important to teach them what the brain is, what purpose it serves and how they can use it to learn (Lanoë et al., 2015). One way could be to use brain drawing in the classroom to assess students' knowledge (Rossi et al., 2017). This very simple and easy-to-use tool for teachers could be used as a starting point for teaching the role of the brain in academic learning.

However, in order to implement knowledge about the brain in schools it is also necessary to train teachers. As early as 1999, Puckett and collaborators emphasized the promises and the perils of brain developmental research (Puckett et al., 1999). In particular, it is now well-documented that teachers follow to neuromyths (Dekker et al., 2012; Howard-Jones, 2014; Torrijos-Muelas et al., 2021). Because training teachers in educational neuroscience is not enough, exposing them to intuitions and faulty beliefs could be a useful context to give them the tools to deconstruct them. Thus, training in the scientific process and its evaluation would allow them to develop critical thinking skills (Pasquinelli, 2012) in order to resist the seductive look of neuroscientific explanations (Weisberg et al., 2008) and the sirens of popular science journals (Van Atteveldt et al., 2014).

Limitations

Although informative, this study has several limitations. Regarding the choice of the control drawing, it responded to a number of criteria. First, it was chosen to ensure that the participants were in conditions as similar as possible to those for the brain drawing (i.e., drawing what exists inside another part of the body). Second, we also needed the children to be able to understand from the age of 6 which part of the body was targeted. Finally, although the heart could have also been an interesting choice, we ruled out this option because of the assumption that, at least for the youngest children, we would have obtained a majority of symbolic and not biological drawings. However, it would be interesting for future studies to compare the brain to other body parts or organs in children's drawings to further examine patterns of similarity and difference. Another issue that would have been interesting to address is the orientation of the brain in the drawings: did the participants represent the brain in a frontal, side or top view? As we did not ask the participants to draw the contours of the head, the orientation of the brain was not always clearly identifiable, which therefore did not allow us to present a rigorous analysis on this subject. Nevertheless, among the drawings for which the orientation was identifiable, note that no participant drew a top view of the brain. Instead, the drawings were distributed between side and frontal views. This is an interesting topic because while some indicators seem more representable through a side view (e.g., brain stem), others are more so with a front view (e.g., hemispheres). But did the participants choose an orientation that allowed them to represent the indicators of their choice or did they adapt the drawn indicators to the chosen orientation? This question remains open and would require further investigation. It should be noted, however, that there was not always a straightforward correspondence between orientation and indicators. Indeed, in some drawings the indicators were favored over the realism of the orientation. For instance, hemispheres have often been depicted in brains seen from a side view. Finally, to allow the children to develop the content of their drawings freely there was no time limit and we did not record the time for each drawing. It is possible that the older children, who produced more indicators in their drawings, spent more time drawing. If this was the case, the causal link would still need to be examined since the amount of indicators could be either the cause or the consequence of the amount of time spent drawing.

Conclusion

In conclusion, this study is part of a long series of research projects that use drawing as a tool for examining children's knowledge, attitudes, and perceptions about events or concepts (e.g., Ainsworth et al., 2011; Brechet, 2015; Mouratidi et al., 2016). Through detailed content analysis of the collected drawings and through the use of additional drawings and questions, we were able to support but also extend the results of previous studies, in order to reach a better understanding of how children conceive the brain. A famous quote from psychologist Ausubel (1968) states that "*the most important single factor influencing learning is what the learner already knows. Ascertain this and teach him accordingly*" (pp. 36). Our results indicate that drawings provide valuable insights into children's current knowledge about the brain that could contribute to the development of effective programs of neuroeducation to improve school-aged children's understanding of how the brain works (Tan and Amiel, 2019; Jolles and Jolles, 2021).

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

Author contributions

CB is responsible for all aspects of the study including the design, experiment, analysis, and write-up. SR participated to the design of the study, the analysis and to the write-up. AM participated to the analysis and to the write-up. NB participated to the write-up. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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The space paradox in graphic representation

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The negative space drawing technique refers to drawing the transparent space around and between objects, rather than drawing the objects themselves. This space-based instruction is thought to attenuate object-specific visual attention and to enhance perception of a spatial expanse. Developmentally, it is equivalent to the Piagetian dichotomic space concept of filled and empty space. A sample of 96 children from 5 to 12 years of age and 24 adults ($N = 120$) drew on a computer tablet a real-life model spacebox placed in front of the participant, with three cubes placed inside the model. Children followed two instructions, a *Visual Realism (VR) Instruction* "Please draw the three cubes and the box as you can see them" and a *Negative Space (NSp) Instruction* "Please draw the space around the objects," with the sequence counterbalanced. NSp outline drawings began to show from 9 years onwards. A positive effect of the NSp technique showed for occlusion drawing because of the depiction of common contour of objects which could create a cohesive scene feature such as a horizon. The VR instruction focused attention toward the space box and enhanced 3D drawing of both the spacebox and the cubes. Thus, it could be concluded—rather paradoxically—that drawing in 3D is better based on object- than on space-based attention, while drawing occlusion is better based on space-based than object-based attention. We suggest, however, that a better definition of VR as attention to object appearances is that VR unifies objects and spatial context into one global plane.

KEYWORDS

visual realism, object-based attention, space-based attention, drawing development, negative space technique, visual attention, spatial concepts, 3D rendering

Introduction

Object-based and space-based visual attention differ from each other insofar as attention is biased either toward object shapes or toward locations that are distributed in space (Beck and Kastner, 2014). Adults are able to devise either kind of attention depending on the task affordances. For instance, in an apparent motion task two stationary objects when presented at a critical interval can be perceived as moving from A to B. This illusory movement perception should employ space-based attention, however, when the instruction was to compare features of the two stationary objects, object-based attention occurred (Zheng and Moore, 2021). Surprisingly, this well-established terminology is not in use in developmental psychology, with PsycInfo showing only one study that is using the concept of object-based vs. space-based attention in its abstract (Valenza and Calignano, 2021).

This is the more astonishing because there is a clear transition in the graphic representations of children from object-based to space-based constructions (Lange-Küttner, 2008a, 2020). What reliably occurs in drawing development is that young children depict just objects in implicit space, while older children make the spatial context explicit by depicting areas and perspective. The theory for this development goes back to Luquet (1927/2001) and Piaget and Inhelder (1956) who analyzed the degree of visual likeness in terms of realism. They assumed that young children draw what they know about objects which they termed "intellectual realism" resulting in fairly schematic drawings of a technical and often minimalistic character (Lange-Küttner et al., 2002), while older children draw their optical impressions and appearances, that is, they would draw what they see, termed "visual realism" (VR). Intellectual realism was shown to be due to a deeply entrenched attitude as children would create the same kind of drawings during immediate repetitions (Lark-Horovitz, 1941) and even after years (Lange-Küttner, 1994). If something happened during practice, it was that children would lose out in details during repetitions, only to be temporarily saved by a new drawing theme, but sometimes they would even regress to earlier stages of realism (Lange-Küttner et al., 2014). Hence developmental psychologists began to explore how children's mental mindsets could be swayed toward more advanced ways of depiction.

How flexible the drawing rules of children would be was first ascertained by giving children half-finished drawings. The early tadpole drawings of children are created by just drawing a circle with a face and adding "arms" and "legs" to this circle. Hence, these human figures had arms coming out of their heads (Freeman, 1975). However, when two circles were presented ready-made as a start, one for the head and one for the trunk, and children just had to add the extensions, they would not add them to the head, but correctly to the trunk. The use of incomplete drawings proved to be a very successful and replicable technique (e.g., Boyatzis et al., 1995). Another way of testing mental flexibility when drawing was to give different instructions. For instance, when children were asked not just to draw a human figure, but to draw a person that does not exist, the younger children would eliminate parts, while the older children would insert parts from different types of objects and modify the actual shape, which is a strategy that is also important in visually realistic drawings (Karmiloff-Smith, 1990). Also this method proved to produce reliable results in follow-up research (e.g., Berti and Freeman, 1997; Picard and Vinter, 1999). Thus, there are techniques that are feasible to both getting children ahead, and to reveal the mechanisms behind different drawing stages and styles.

Also with regards to the drawing of space in three dimensions on a two-dimensional drawing surface, research has produced reliable and replicable results. Young children would draw objects floating in empty space even when in located in a real-life spatial context (Dillon, 2022). Nevertheless, they do conserve not only left-and-right placements, but also depth as objects behind each other are drawn along an implicit vertical axis (Light and MacIntosh, 1980). This can be explained with their knowledge of topological relations between objects (Piaget and Inhelder, 1956). Especially in their work on distance, an experiment showed that children claim that the distance between A and B is reduced when a third object C is inserted (Piaget et al., 1960). This proved the dichotomous quality of topological space, one the one hand space being filled by objects, on the other hand space being an empty and transparent intermedium (Piaget et al., 1960). The topological concept is comparable to solid-state physics in astronomy where objects are floating in the infinite expands of deep space (Plummer et al., 2016; Bower and Liben, 2021). In fact, this notion was picked up in early pedagogy going back to Goethe (Clarke, 1912) and Steiner (Uhrmacher, 1995) who encouraged the teaching of a cosmic perspective where orientation and self-evaluation in space and the universe would lead to spatial exploration and modesty. Modesty appears to be also reflected in children's drawings of spatial systems where the average size of the human figure shrinks, the more explicit the spatial axes system becomes (Lange-Küttner, 1997, 2004, 2009). Piaget (1955) termed this process "de-subjectivation" as children would consider themselves as just another object in space which would lead to an increased ability to modify their own actions in response to failure and create an opportunity to optimize plans and strategies. With regards to drawing, it is the ability for size modification that develops, not just size reduction, as the human figure can be a point in space, or be depicted in an oversized portrait (Lange-Küttner, 2008b).

The relationship between intellectual and visual realism in the drawing of pictorial space was further explored with 3D models that simulate the development of spatial systems in children's drawings (Lange-Küttner, 2014; see Figure 1). Even young children aged 4 would draw walls of small spatial models (Dillon, 2022); the ones in Figure 1 were used in a drawing experiment with children between 7 and 11 years of age (Lange-Küttner, 2014).

Model 1A resembles the implicit empty space of young children's drawings. No walls or delineated fields constrain the empty expanse. Model 1B emulates the "air gap" drawings of children who draw groundline and skyline with horizontal spatial axes (Hargreaves et al., 1981; Cox and Chapman, 1995). Children denote with these stripes that one can walk on the ground due to gravity, there is a blue-colored heaven above, and in between, there is transparent air. The two models in Figure 1C do not show an air gap anymore. Instead, an area with explicit rectangular spatial boundaries is constructed. The only difference in Figure 1D is that the sides of the rectangular field converge so that the spatial field is a trapezoid. Note that while the ground plan reveals this difference, the photographic images of the space boxes show converging lines at every level, representing the optic impression. Thus, only in model 1D

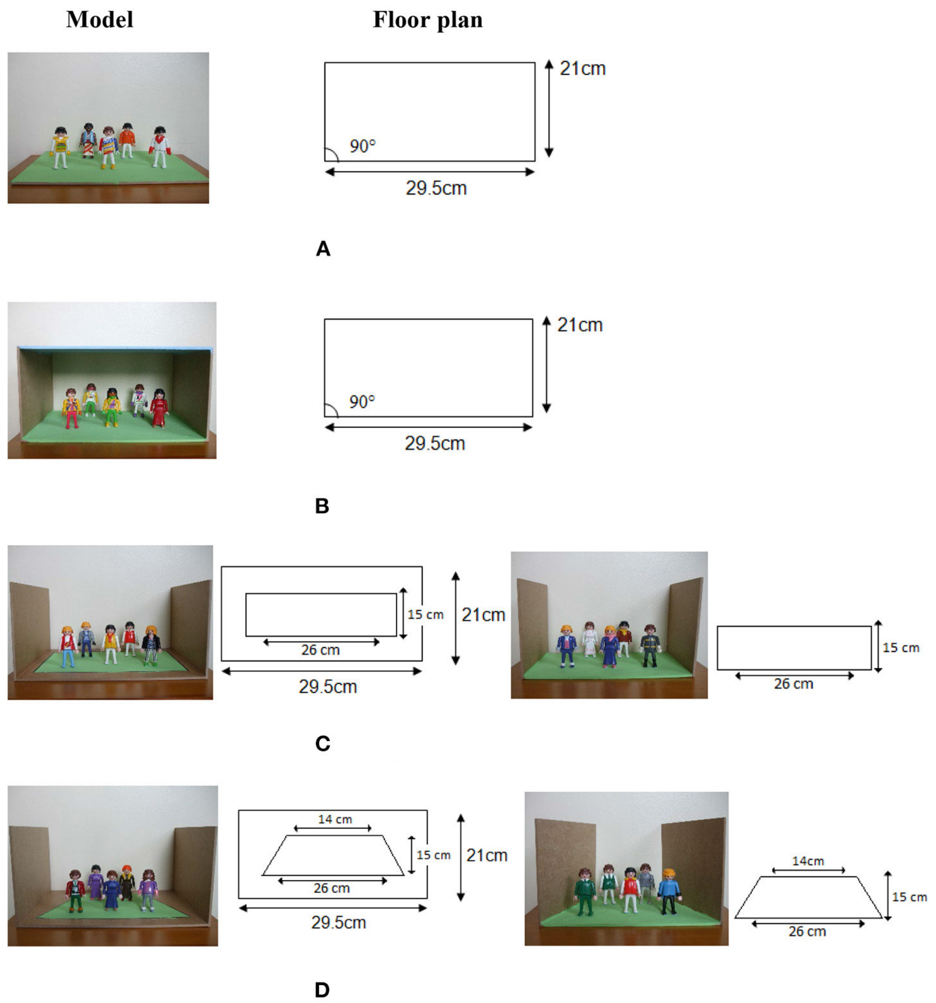


FIGURE 1
Models simulating pictorial space concepts. The floor plan gives information about the objective measurements in cm. In **(B–D)**, the walls on either side were 15 cm high. In **(C)** the ground plan is orthogonal, while in **(D)** the ground plan is trapezoid. **(A)** Empty space. **(B)** Earth space (heaven). **(C)** Playing field boundaries. **(D)** Trapezoid built-in perspective. Figures reproduced with friendly permission of the American Psychological Association (APA) (Lange-Küttner, 2014).

is the ground plan in agreement with the optically correct photographic image. This model lead children as young as 7 years old to sketch the diagonals of perspective, and even more often than 9- to 10-year-olds, while normally, perspective drawings only emerge in the drawings of older children, and also only in a minority of adults (Hagen, 1985).

The current study

However, although the development of the space concept is usually understood space-based, three-dimensional depth can also be constructed by drawing overlapping objects, that is, object-based. In order to do this successfully, children need to learn a new technique which has been called "hidden line elimination" as the object in the front will interrupt the contour of the object behind as only a partial view would be visible. Thus, parts of the occluded object shape need to be omitted. Instead, the figure would have a shape with an open and incomplete outline. However, young children would draw occluded objects either separately, or transparent just drawing one shape over the other (Morra et al., 1996). The developmental problem here is that on the one hand, children find it hard to draw an incomplete rather than a whole object (Lange-Küttner, 2000), on the other hand, a perceptual aspect is that they have to be good in detecting the outline of a shape as for instance in visual noise in the Embedded Figures Test (EFT, Witkin, 1950; Lange-Küttner and Ebersbach, 2013). A cognitive factor is that working memory has to be mature in order to cope with the various aspects of drawing occlusion, for instance, children find it confusing if the occluded object has the same shape as the one in front (Morra, 2002).

Importantly, longitudinal research showed that depth in drawings is first created object-based, using occlusion of objects, followed by the unfolding of the third dimension in the whole of the pictorial space (Lange-Küttner, 1994). In order to test whether children draw object-based occlusion or space-based perspective, we devised in the current study a model that closely matches previous experimental research (Lange-Küttner, 2014). However, the earth model was not populated by visually isolated figures, but by one single and two overlapping cubes (see Figure 2). We selected the earth model (Figure 1B) as it should appeal to the topological notion of space consisting of solid objects in transparent air.

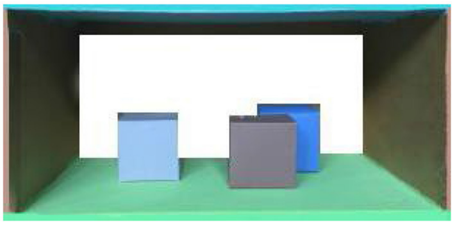


FIGURE 2
The drawing model.

It has been claimed that object knowledge and especially object labels would actually hinder drawing in perspective (Edwards, 1992). There is some evidence that it is true that nonsense objects are less likely to trigger schematic and holistic drawing templates than meaningful figures in children (Tallandini and Morassi, 2008). Both handling and naming objects prevented visually realistic occlusion (Bremner and Moore, 1984). Also knowledge of the true object size can be an obstacle for the depiction of projective size (Reith and Liu, 1995). Thus, object knowledge can indeed inhibit the ability to draw object-based depth which has been evaluated as the suppression of a sensory core (Costall, 1995).

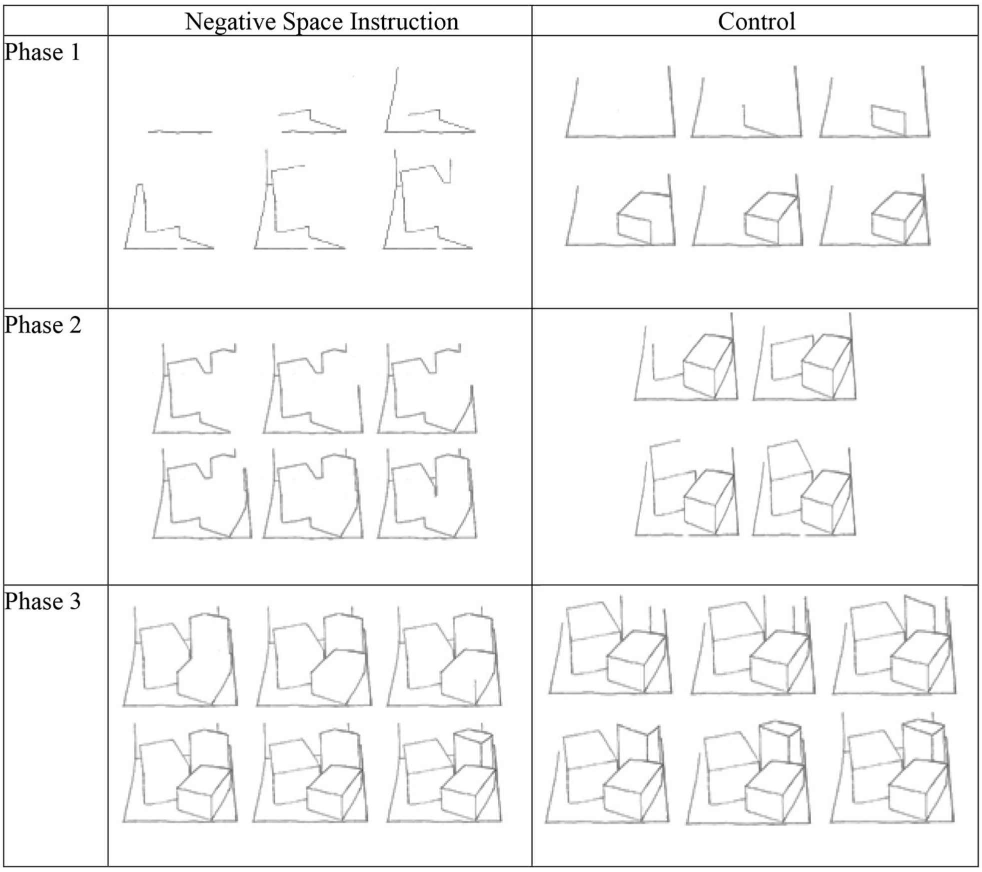


FIGURE 3
Effects of the negative space (NSp) instruction on drawing cubes. See Nunn (2009), p. 199–203, Figures 10.1–10.6.

TABLE 1 Age groups (years; months).

Age in years	*M* (years; months)	*n*	Min	Max	*SD*
5–6	5; 6	24	63	71	3
7–8	7; 7	24	88	96	3
9–10	9; 7	24	111	120	3
11–12	11; 5	24	132	143	4
Adults	32; 5	24	240	540	89
Total		120			

To inhibit the focus on objects in order to foster space-based drawing, the negative space (NSp) technique was suggested (Edwards, 1987). This technique requires to draw the transparent space ("intermedium") between objects rather than the objects themselves. Since the transparent air ends where an object begins, there is a shared boundary which quasi-automatically will reveal the objects. This idea has been empirically tested with adults drawing three overlapping cubes on a carpet (Nunn, 2009). While the negative space technique did not bestow any advantages on the draftsman as the final outputs were very similar, the actual process of drawing was fundamentally changed from object-based to a space-based attention, especially in phases 1 and 2, but not toward the end (see Figure 3).

In the control condition the carpet was drawn first, then the three boxes one by one until the drawing was completed. In the NSp condition, participants first drew the negative space around the objects which coincided with the outer contours of all three boxes as a group and then proceeded to draw the inner edges.

Could this NSp technique also be used with children when drawing overlapping cubes in a space box? Based on previous research, we predicted that when following the negative space instruction, the occluded cubes (object-based depth) would be drawn in a less mature fashion than with the visual realism instruction, while the overall space of the earth model would be depicted in a more advanced 3D fashion (space-based depth).

Methods

Participants

We randomly recruited 120 participants from London (UK) schools. The age in years; months for each age group is listed in Table 1, with 12 females and 12 males in each group. Participants had full or corrected vision. Children with special educational needs (SEN) who were allocated a personal teaching assistant did not participate in the experiment.

Apparatus and materials

The floor and the heaven of the spatial drawing model (see Figure 2) were 29.5 × 21 cm in size. The walls on either side were 15 cm high. The model contained three plastic cubes (brown, blue, and gray) each 5.5 × 5.5 × 5.5 cm in size, one single cube and two overlapping cubes.

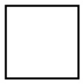
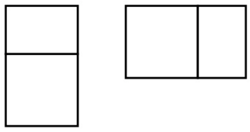
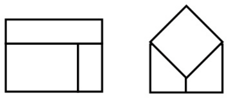
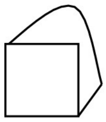
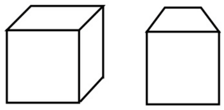
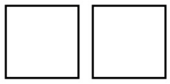
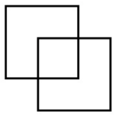
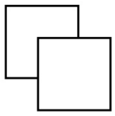
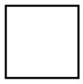
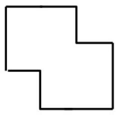
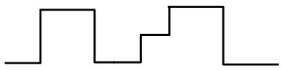
Drawing was carried out with a stylus pen on a convertible Lenovo Yoga tablet/laptop with a Windows 10 system. The size of the screen was 13.3 inches. Windows Paint Software and Icecream Screen Recorder Software, version 370 Pro, made it possible to capture the area of the screen as a video file.

Procedure

The ethics proposal of the study was approved by the London Metropolitan University departmental Ethics Committee. Parents of children were given information sheets and consent forms. Only those children who brought signed consent forms from their parents to school were actually tested. All participants were also asked whether they were happy to take part in the study immediately before the start of the experiment.

In order to test two children at the same time, the equipment was doubled up, that is, there were two drawing models and two convertible laptop/tablets. In a classroom, two tables were allocated, separated, and lined up along a wall so participants were not able to see each other. Each table with one spatial model and cubes was set up in advance. Once the setup was ready, the participants were seated on a chair in front of the model that was placed at a distance of about 40 cm from the participant. The participants were randomly allocated to one of the two sequences of instructions. Sixty of the participants started drawing under the visual realism instruction "Please draw the three cubes and the box as you can see them" and then under the negative space instruction "Please draw the space around the objects." The other half of participants started in the reverse order. The laptop/tablet screen was completely white; all participants drew two pictures on it from the same viewing position. Participants were informed that they had a maximum of 10 min per drawing.

TABLE 2 Categorization of the drawings: cube volume and occlusion.

Cube volume	Description	Score	Examples
Orthographic	One-face cube: all sides implicit	1	
Vertical or horizontal	Two-Face Cube: Front face plus top or side face unfolded	2	
Diagrammatic, fold-out	Front face plus top and side faces unfolded (same ground line)	3	
Partly wrong perspective	3D, but no parallel lines	4	
Oblique/viewpoint perspective	Oblique angles, parallel lines or common vanishing point	5	
Occlusion			
None		0	
Intersection		1	
Occlusion		2	
Outline			
Outline around one cube		1	
Outline around two cubes		2	
Continuous outline		3	

Scoring manual adapted from Lange-Küttner and Ebersbach (2013).

Data generation

The drawings were scored by two 3rd year Architecture student as raters. The raters were blind to the children's drawing instructions. Only the evaluation criteria were explained. Occlusion and 3D volume of the cubes were rated according to an adapted version of the rating manual of Lange-Küttner and Ebersbach (2013); see Table 2. It was also scored whether children and adults were drawing outlines which were to be expected in the NSp Instruction condition.

The space system of the spacebox itself was scored following the rating schedule of Lange-Küttner (2004, 2009, 2014), with a score of 1 for implicit space, a score of 2 for groundline and stripy images, a score of 3 for the depiction of delineated fields and a score of 4 for the depiction of the field in perspective. For the current study, this rating schedule was adapted because a

TABLE 3 Paired samples t-tests of outline drawings after VR and NSp instructions.

Age groups (years)	r	Cohen's d	t	df	p	95% CI	
						Lower bound	Upper bound
5–6	–	−0.204	−1.000	23	0.164	−0.606	0.202
7–8	−0.14	−0.184	−0.901	23	0.188	−0.586	0.222
9–10	0.06	−10.115	−5.463	23	0.001**	−1.620	−0.595
11–12	–	−0.976	−4.783	23	0.001**	−1.458	−0.480
Adults	–	−0.879	−4.307	23	0.001**	−1.345	−0.399

**p < 0.01, r = – (correlations not computed because of floor effect).

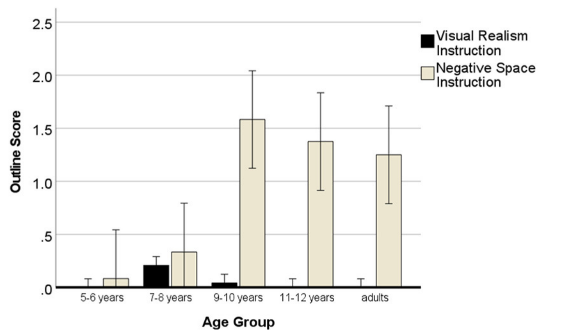


FIGURE 4
Development of outline drawings with negative space instructions. Error bars denote the confidence interval.

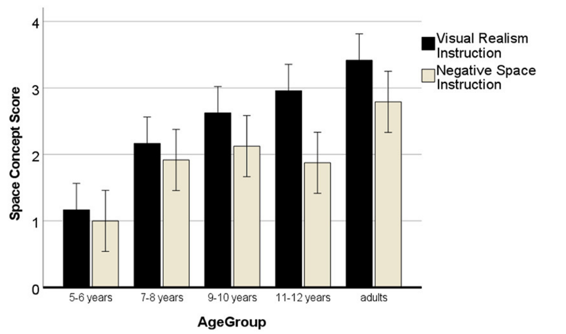


FIGURE 5
Development of the 3D space system in drawings with negative space instructions. Error bars denote the confidence interval.

playing field was not relevant. A drawing of just objects but no drawing of the space box received a score of 0, drawing just a two-dimensional frame for the box was scored with 1, a score of 2 was given for groundline and stripy images, a score of 3 was awarded if the walls at the side were drawn, and a score of 4 for the depiction of the entire spacebox in three-dimensional perspective. Agreement was 70% which is within the normal range. Disagreements between raters were solved in a discussion. From the videos, the second author rated whether the space box, or the cubes were drawn first.

Results

We adjusted the degrees of freedom when the Mauchley's (ANOVAs) or Levene's (T-tests) tests for the equality of variances were significant. This correction is easily identifiable as the samples are of equal size and thus the corrected degrees of freedom clearly differ. Pairwise comparisons within the ANOVA models were corrected by SPSS using Bonferroni. Effect sizes are partial etas. Raw data are available on https://osf.io/7w5sc/.

We first controlled whether the negative space instruction worked by testing the expected outlining of grouped cubes inside the space box. Once this was confirmed, we analyzed the overall space system of the drawings, followed by occlusion and volume of the cubes, and the scores resulting from the video analysis showing whether the box or the cubes were drawn first.

Outline

In this analysis, we expected that outline drawings would only occur in the negative space instruction condition. A 5 (age group) × 2 (instruction) × 2 (sequence) ANOVA with repeated measures for the outline score showed no effect of the sequence of the instruction, $p_s > 0.478$. There was a main effect of age, $F_{(4,120)} = 7.36$, $p < 0.001$, $\eta^2 = 0.21$, a main effect of instruction, $F_{(1,120)} = 69.02$, $p < 0.001$, $\eta^2 = 0.39$ and a significant two-way interaction of instruction with age, $F_{(4,120)} = 9.12$, $p < 0.001$, $\eta^2 = 0.25$. Figure 4 shows that children and adults drew outlines almost only in the NSp instruction condition.

Paired samples t-tests (one-tailed) of outline drawings (Table 3) after the two types of instructions showed the negative space instruction was leading to a significant increase in the expected outlines of cubes in the NSp instruction from 9 years

TABLE 4 Paired samples *t*-tests comparing 3D space systems after VR and NSp instructions.

Age groups (in years)	*r*	Cohen's d	*t*	*df*	*p*	95% CI	
						Lower bound	Upper bound
5–6	0.65**	0.22	1.072	23	0.147	−0.188	0.622
7–8	0.17	0.21	1.030	23	0.157	−0.197	0.613
9–10	0.38*	0.40	1.958	23	0.031*	−0.021	0.812
11–12	0.30	0.77	3.760	23	0.001**	0.304	1.218
Adults	0.17	0.42	2.044	23	0.026*	−0.005	0.813

*p < 0.05; **p < 0.01.

onwards. This confirmed our expectation that the negative space instruction could also be used with children.

Space system

We analyzed whether the two drawings of the space system showed the expected development with age and an effect of instruction with a 5 (age group) × 2 (instruction) × 2 (sequence) ANOVA with repeated measures for the drawing instruction of the space system. The sequence of the instruction was not important, $p_s > 0.165$. Age group showed a significant effect, $F_{(4,120)} = 17.30$, $p < 0.001$, $\eta^2 = 0.39$. Even the 5- to 6-year-olds drew the box with a frame ($M = 1.08$), but they significantly differed from all other age groups, $p_s < 0.002$, who constructed more advanced spatial systems. The 7- to 8-year-olds ($M = 2.04$) and the 9- to 10-year-olds ($M = 2.37$) drew groundlines and stripy pictures, but differed from the adult group who drew the walls of the spacebox ($M = 3.10$), $p_s < 0.043$, but not from each other. The 11- to 12-year-olds ($M = 2.42$) did not differ significantly from the adult group.

Importantly for the hypothesis, the effect of instruction was significant, $F_{(4,120)} = 21.43$, $p < 0.001$, $\eta^2 = 0.16$, but the interaction with age was only a trend and did not reach significance, $p < 0.093$. Figure 5 shows that the VR instruction yielded more advanced space systems in every age group.

However, pairwise comparisons (one-tailed) of the space system of the two drawings showed that the difference was only significant from 9 years onwards (see Table 4). The high correlation between the two drawings in the 5- to 6-year-olds indicates that the youngest children did not make much difference because of the instructions.

Occlusion

The same model of variance was used to test whether occlusion would differ according to instructions. Drawing of occlusion increased with age, $F_{(4,120)} = 30.83$, $p < 0.001$, $\eta^2 = 0.53$, with a higher effect size than for the space concept.

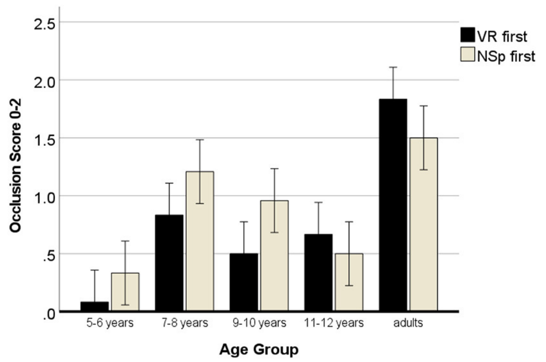


FIGURE 6
Development of drawing occlusion with negative space or visual realism instructions. Error bars denote the confidence interval.

The score of the 5- to 6-year-olds was close to zero drawing spatially isolated cubes ($M = 0.21$), and again they significantly differed from all other age groups, $p_s < 0.003$, except for the 11- to 12-year-olds, $p = 0.081$. The 7- to 8-year-olds showed the best performance of the children's groups ($M = 1.02$) and significantly differed from the youngest ($M = 0.21$), the 11- to 12-year-olds ($M = 0.58$) and the adults ($M = 1.67$) whose score was closest toward the complete overlap score of 2. Different to the 3D space concept, there was not a continuous gradual increase in the occlusion score.

In this model, the sequence was important for the instruction, $F_{(1,120)} = 4.16$, $p = 0.044$, $\eta^2 = 0.04$, and sequence interacted with age, $F_{(4,120)} = 3.13$, $p = 0.018$, $\eta^2 = 0.10$, but the three-way interaction was not significant, $p = 0.404$. Pairwise *t*-tests (two-tailed) per sequence group showed that when the visual realism instruction was given first, occlusion was drawn in the same way as with the NSp instruction (VR $M = 0.75$; NSp $M = 0.82$, $r = 0.47^{***}$) without a significant difference, $p = 0.542$. However, when the NSp instruction was given first, drawing of occlusion was improved (VR $M = 1.03$; NSp $M = 0.77$, $r = 0.37^{**}$), $t_{(59)} = 2.21$, $p = 0.031$, showing that most participants would draw at least intersecting cubes.

TABLE 5 Independent samples *t*-tests comparing occlusion after VR or NSp instruction FIRST.

Age groups (in years)	Cohen's d	*t*	*df*	*p*	95% CI	
					Lower bound	Upper bound
5–6	−0.67	−1.636	14.36	0.062	−0.577	0.077
7–8	−0.69	−1.704	22	0.051	−0.831	0.081
9–10	−0.83	−2.030	22	0.027*	−0.927	0.010
11–12	0.41	1.000	22	0.164	−0.179	0.512
Adults	0.66	1.609	16.34	0.063	−0.105	0.772

*$p < 0.05$.

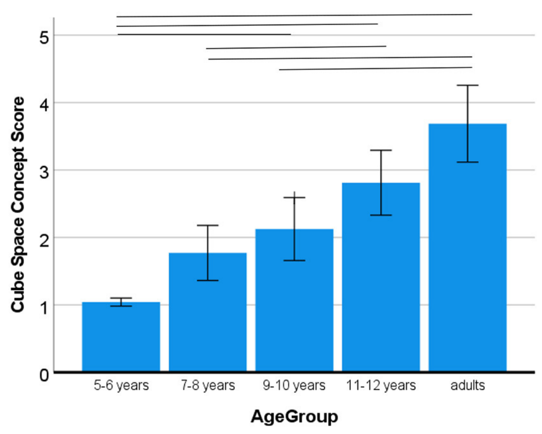


FIGURE 7
Development of drawing cubes in 3D. Error bars denote the confidence interval. Horizontal bars indicate significant pairwise comparisons.

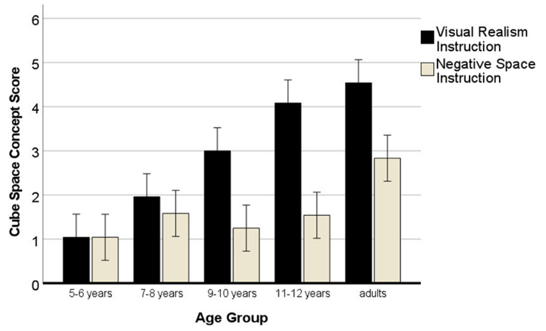


FIGURE 8
Development of drawing cubes in 3D with negative space or visual realism instructions. Error bars denote the confidence interval.

The two-way interaction of sequence with age groups is visualized in Figure 6. It shows that the 5- to 10-year-old children were more likely to attempt to draw the cubes overlapping when they first were asked to draw the space between the objects, rather than to draw what they see, while the 11- to 12-year-olds and the adults were more likely to attempt to draw occlusion when first being asked to draw what they see. The results of the *t*-tests for independent samples (one-tailed) in Table 5 reveal medium effect sizes but relatively low *p*-values, while the change in sign of the *t*-value denotes the interactive effect.

Volume

While we did not have a hypothesis about the effect of the VR and the NSp instruction on the three-dimensional volume of the cubes inside the earth spacebox, we still wanted to control whether there was an effect. Hence, the same model of variance was used to test whether cube volume would differ according to instructions. Like for the volume of the space box, the sequence of instructions did not play a role for the three-dimensional volume of the cubes, $p_s > 0.225$. A main effect of age, $F_{(4,120)} = 23.31$, $p < 0.001$, $\eta^2 = 0.46$, showed a pronounced increase in the depiction of the third dimension of cubes (best score) with age (5–6 years: $M = 1.04$; 7–8 years: $M = 1.77$; 9–10 years: $M = 2.12$; 11–12 years: $M = 2.81$; adults: $M = 3.69$; see Figure 7). As there were many significant pairwise comparisons, all clearly indicating significant progression, these are indicated in the figure and not further explained here.

Moreover, there was a significant main effect of the drawing instruction, $F_{(1,120)} = 78.91$, $p < 0.001$, $\eta^2 = 0.42$, and a two-interaction of instructions with age, $F_{(4,120)} = 10.81$, $p < 0.001$, $\eta^2 = 0.28$ (see Figure 8). The main effect showed that the visual realism instruction yielded more multi-dimensional cube drawings ($M = 2.92$) than the negative space instruction ($M = 1.65$). However, the two-way interaction with age demonstrated that this effect increased with age, the older the participants, the more efficient was the instruction to draw what they were seeing for drawing three-dimensional cubes, and the larger the difference in efficiency to the negative space instruction in this regard.

The results of the pairwise *t*-tests (one-tailed) for the two 3D cube drawings in each age group in Table 6 reveal that the higher efficiency of the visual realism instruction in yielding

TABLE 6 Paired samples *t*-tests comparing 3D cube volume after VR and NSp instructions.

Age groups (in years)	*r*	Cohens' d	*t*	*df*	*p*	95% *CI*	
						Lower Bound	Upper Bound
5–6	−0.04	0.00	0.000	23	0.500	−0.400	0.400
7–8	0.18	0.23	1.141	23	0.133	−0.175	0.636
9–10	0.33	1.04	5.120	23	0.001**	0.537	1.538
11–12	0.25	1.44	7.040	23	0.001**	0.854	2.004
Adults	0.36*	0.88	4.304	23	0.001**	0.399	1.345

**p < 0.01.

TABLE 7 Paired samples *t*-tests comparing occlusion drawing after VR and NSp instructions.

Age groups (in years)	*r*	Cohen's d	*t*	*df*	*p*	95% *CI*	
						Lower bound	Upper bound
5–6	0.15	0.26	1.282	23	0.106	−0.148	0.666
7–8	0.34*	0.12	0.569	23	0.287	−0.287	0.516
9–10	–	0.37	1.813	23	0.041*	−0.048	0.780
11–12	–	0.44	2.145	23	0.021*	0.014	0.853
Adults	−0.11	1.0	4.897	23	0.001**	0.500	1.485

*p < 0.05, **p < 0.01, r = – (correlations not computed because of ceiling effect).

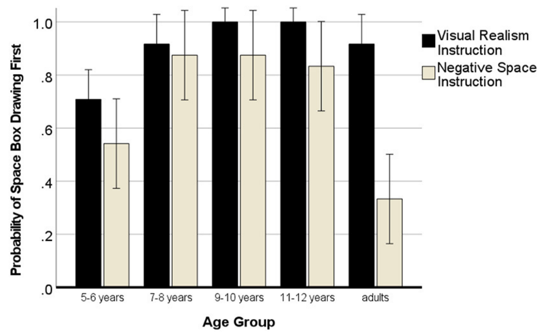


FIGURE 9
Probability of drawing the space box first (space-based approach). Error bars denote the confidence interval.

multi-dimensional cube drawings becomes significant from 9 years onwards.

What was drawn first, the space box or the cubes?

Participants had only the choice to either start drawing the space box, or drawing the cubes. Hence, these two alternatives are linked insofar as if the drawing was started with depicting the space box, the cubes were not drawn first. Hence, it was tested with the same model as before whether the spacebox was drawn first as this would speak to a space-based approach. The sequence of the instructions was not important, $p_s > 0.297$. There was a main effect of age, $F_{(4,120)} = 9.06$, $p < 0.001$, $\eta^2 = 0.25$ (5–6 years: $M = 0.62$; 7–8 years: $M = 0.90$; 9–10 years: $M = 0.94$; 11–12 years: $M = 0.92$; adults: $M = 0.62$), which showed that the 5- to 6-year-old children were less likely to start their drawing with an outline of the space box than any other age group of children, $p_s < 0.005$, but with the same likelihood as adults.

There was a significant effect of instruction, $F_{(1,120)} = 24.88$, $p < 0.001$, $\eta^2 = 0.18$ showing that the visual realism instruction yielded more drawings that were started with the space box depiction (VR $M = 0.91$; NSp $M = 0.68$), however, the extent of the effect of the VR instruction varied with age $F_{(4,120)} = 4.71$, $p = 0.002$, $\eta^2 = 0.15$ (see Figure 9).

The results of the pairwise *t*-tests (one-tailed) for the two drawings start scores in each age group in Table 7 reveal that the higher efficiency of yielding multi-dimensional cube drawings with the visual realism instruction becomes significant from 9 years onwards.

Discussion

The current study investigated whether the negative space (NSp) drawing technique could also be used with children. We used an earth model space box where heaven was symbolized

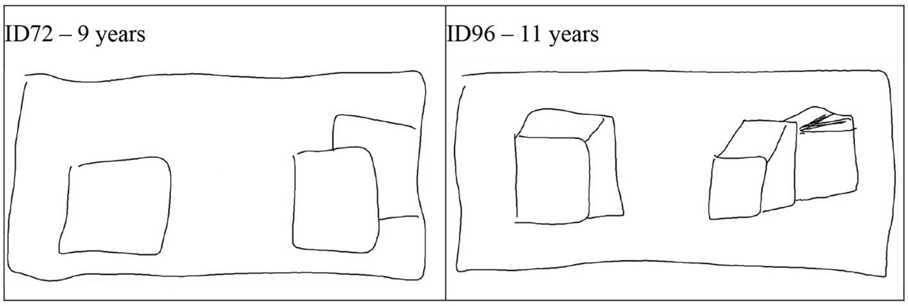


FIGURE 10
Examples of drawing occlusion with 2D and 3D cubes. ID72 - 9 years (See the film clip on https://osf.io/5b4sf/); ID96 - 11 years (See the film clip on https://osf.io/g78xv/).

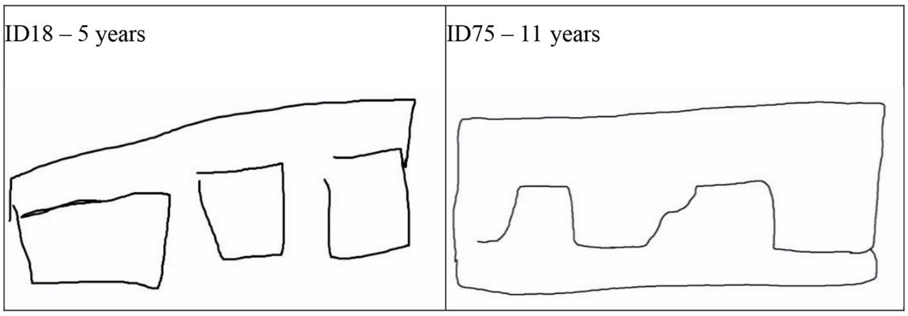


FIGURE 11
Examples of drawing negative space around occluding cubes. ID18 - 5 years (See the film clip on https://osf.io/nxw27); ID75 - 11 years (See the film clip on https://osf.io/vxe7s).

with a blue lid alluding to the stripey air gap pictures that children draw until they are about 11–12 years old when they draw the sky down to the horizon (Lewis, 1990). The gap would contain transparent air and this kind of drawing is in agreement with a dichotomous topological space concept of empty space with solid objects. As such, the earth model space box lent itself to the NSp drawing technique which requires to draw the space between objects rather than the objects themselves (Edwards, 1987, 1992). From research with adults, it had become clear that this instruction changed the drawing process as empty silhouettes were drawn first and internal features were added last (Nunn, 2009). Children are able to draw empty silhouettes, although only a minority would do so spontaneously (Reith, 1988). Thus, we expected that children would be able to draw an outer contour around overlapping cubes. We predicted that with the NSp instruction, the occluded cubes (object-based depth) would be drawn in a less mature fashion because visual attention would be directed away from individual objects. We furthermore expected that the NSp instruction would direct attention toward the overall space of the earth model that would then be depicted in a more advanced 3D fashion (space-based depth). We contrasted the NSp instruction with the visual realism (VR) instruction that explicitly requires children and adults to draw what they see. However, the VR instruction is not drawing visual attention to the intermediate space between objects, and thus away from objects, but it draws attention to the optical impression of object appearances. In this way, both types of instruction direct attention away from object knowledge, for instance, thinking about object built and function, or object labels.

Development of 3D depth depiction

We found that until 8 years there was little evidence that children would draw outlines of the air between objects rather than an object itself. However, from age 9 onwards these outlines did appear with the NSp instruction and, in accordance with our expectations, not when drawing following the visual realism instruction. The three-dimensional space system of both the space box and the cubes developed well with age, while the drawing of occlusion did not. A reason may have been that drawing overlapping cubes becomes much more complicated once the cubes are drawn in three dimensions rather than as squares that holistically and implicitly mean to contain the sides of the cube (Moore, 1986). Figure 10 shows how easy it is to draw overlapping squares in comparison to overlapping 3D cubes. The 11-year-old who knows how to draw 3D cubes still tries to attach the occluded cube in the same way as the 9-year-old, but is unsure on how to create the occluded cube in the third dimension.

When checking the correlations between drawing occluded cubes and 3D cubes here, we found that at a time when cubes are typically represented as holistic squares this highly correlated with occlusion (5–6 years $r = 0.83$, $p < 0.001$), while thereafter, when children learn to unfold and integrate the sides of a cube into a three-dimensional depiction, occlusion and 3D depiction had little variance in common (7–8 years $r = 0.25$, $p = 0.239$, 9–10 years $r = -0.08$, $p = 0.713$, 11–12 years $r = -0.01$, $p = 0.957$). However, in adults, occlusion and 3D depiction of the cubes were not two rather separate processes anymore as indicated by a significant correlation ($r = 0.63$ $p < 0.001$).

The negative space instruction

With regards to the NSp instruction, children drew outlines around empty space mainly from 9 years onwards, but not at all after the visual realism instruction which is what was expected. However, for the three-dimensions of both the space box and the cubes the visual realism instruction was more conducive than the negative space instruction, again especially from 9 years onwards. This effect did not confirm the hypothesis that the negative space instruction should lead to more advanced spatial drawing systems of the space box. Instead, depth depiction was enhanced after the VR instruction for both object-based and space-based 3D dimensionality. Thus, it could be concluded—rather paradoxically—that drawing space in three dimensions is better based on object-based attention toward appearances than on space-based attention. However, one could argue that the visual realism to focus on "what you see" implies attention to the overall optical impressions and thus overcomes the topological dichotomous space concept of empty space and solid objects and merges the two in one continuous image.

Until about 11 years, the negative space instruction tended to advance the depiction of occlusion. Also this result did not confirm the hypothesis predicting that this space-based instruction—as the air is a spatial expanse and in one of the three physical aggregate states (solid, liquid, and *aeriform*)—would lower performance in an object-based method of depth depiction such as occlusion. In occlusion, staggered and overlapping cubes are closer together than two single cubes. The NSp instruction would draw attention to common contour: Figure 11 shows the space around the three cubes drawn by a 5-year-old which looks like a bracket around the three shapes. In contrast, the 11-year-old can merge the outer contour of the cubes into what looks like a horizon line which would be part of a scene. Likewise, the same merging of the common contour of parts also occurs in the drawings of human figures at this age generating a visually realistic silhouette with a smooth outline (Lange-Küttner et al., 2002).

Visual realism is a result of the anatomy and mechanics of visual impressions. The anatomy of the brain was the model for the camera that takes photographic images. However, the brain does more than traditional cameras (modern mobile phones have two and three lenses) because it merges two visual inputs from either eye on one retinal background. This capacity to merge and transform is an essential feature of modern image software that is able to identify local objects in images, but also to merge local regions into one homogeneous pixelated image (Chen et al., 1991). In children, this decomposition and recomposition of a visual image can be mechanically facilitated by a transparent screen in front of the real objects that unifies objects and surroundings on one plane (Lange-Küttner and Reith, 1995; Reith and Dominin, 1997). Such visual operative structures were seen as essential to the epistemology of perception (Piaget, 1969).

Conclusions

The current study makes a valuable contribution to the long-standing debate in developmental psychology on intellectual and visual realism in children's drawings as well as toward the object-based and space-based distinction of attention in cognitive psychology. We referred to earlier research showing that object-based knowledge prevents space-based visual attention that is a prerequisite for drawing visually realistic pictures. It turned out that paradoxically the apparently space-based NSp instruction enhanced object-based depth when drawing occlusion, while the apparently object-based VR instruction enhanced depiction of 3D dimensionality in both figures and context. We thus suggest that the transition from implicit to explicit space creates a new layer of a *holistic scene* that developmentally follows on from the early *holistic objects* that children draw. This notion is in stark contrast to the theory that there is a holistic-to-analytic shift in development (Kemler, 1983). Also holistic visual impressions can improve, for instance, the sure recognition of indoor vs. outdoor whole scenes improves from <20% correct at around age ten to more than 40 and up to 70% in young adults (Tang et al., 2018). Moreover, it seems that object memory vs. scene memory is modular, that is informationally encapsulated, just as intellectual realism and visual realism are deeply entrenched attitudes. In a study by Edgin et al. (2014), the scene-scene test and the object-object test were easier than a scene-object test at all ages which points to different systems. We therefore propose that future drawing research may want to compare whether the type of children's realism and what-and-where spatial memory systems develop in parallel (Lange-Küttner and Küttner, 2015).

Data availability statement

The datasets presented in this study can be found in online repositories. The names of the repository/repositories and accession number(s) can be found at: https://osf.io/7w5sc/.

Ethics statement

The studies involving human participants were reviewed and approved by Departmental Ethics Committee, London Metropolitan University. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

Author contributions

CL-K and XVC developed the idea for this project. XVC collected the data, coordinated the ratings, and created the SPSS spreadsheet. She was awarded a Bachelor of Science degree for her project. CL-K supervised the work, wrote the text, and carried out the statistical analyses for this report. Both authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Primary and middle-school children's drawings of the lockdown in Italy

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This retrospective-descriptive study investigated how primary and middle-school children perceived the first COVID-19 lockdown in Italy (March–May 2020) as manifested in their drawings. Once school restarted after the first COVID-19 wave, and as part of a structured school re-entry program run in their class in September 2020, 900 Italian children aged 7–13 were asked to draw a moment of their life during the lockdown. The drawings were coded and quantitatively and qualitatively analyzed; several pictorial examples are illustrated in this article. Most children used colorful and full-body representations of the self, but in almost half of the pictures drawn by older students, the self was either missing or represented without the face visible. Most children drew the interior of their houses, and the outside world was completely invisible in over half of the pictures. The most represented activities among younger students were playing or sport, followed by screentime or technology-use. Domestic routines and distance learning were also depicted. Most children, but predominantly girls, drew characters showing emotional cohesion clues, and more younger pupils and girls depicted contentment as their main emotion. Conflicting emotions were virtually non-existent. Our data suggest that children coped with the lockdown through play, screen, and technology use. The high incidence of the missing self-representation in preadolescents could indicate how the enforced loneliness and lack of direct physical contact with others impacted their perception of the self. The findings presented here deepen our knowledge of the dynamics connected to the effects of the COVID crisis on children and young people and show how drawings can provide a valuable window into children's emotions and perceptions.

KEYWORDS

children, drawings, COVID-19, lockdown, experience, child development

Introduction

On 4 March 2020, Italy declared its first national lockdown to respond to the COVID-19 pandemic (Presidenza del Consiglio dei Ministri, 2020). Consequently, nine million Italian children were confined in their homes and did not see their teachers or classmates until the following September. Alongside the isolation from their peers and teachers, outdoor activities were also limited or banned. These youngsters had to cope with psychological stressors such as loneliness, insecurity, and instability in their daily routines (Samji et al., 2022; Viner et al., 2022). Fear, loneliness, and boredom permeated the pandemic experiences and daily lives of children across the country (Cellini et al., 2021). International research shows that the lockdown affected the psychological state of approximately 79.4% of children (Panda et al., 2020), who showed signs of increasing anxiety, depression, irritability, and inattention. Additionally, approximately 25% of children developed a substantial fear of the virus, and about 33% experienced trouble sleeping. Such effects were mediated by a composite network of factors, including culture (Furlong and Finnie, 2020), socioeconomic status (Save the Children Italia, 2020), age, and gender (Davico et al., 2021). However, despite the extent and magnitude of the phenomenon, children also responded to the lockdown with resilience and adaptability. Coping factors emerged as products of social-cultural and geographical peculiarities (especially in terms of lifestyle, education, participation in family life, communication, access and use of personal and open spaces, possibility to use technologies actively and creatively; Cortés-Morales et al., 2021). Stoecklin et al. (2021) report that during the lockdown, some children felt free to use their time as they wished and took this opportunity to spend more time with their families, start new hobbies, take care of themselves, and adopt a slower pace of life.

Children's drawings as a representation of reality

One way in which people communicate their experiences, perceptions, or attitudes toward an event is through freehand drawing (Walker, 2007). Drawing an experience has several advantages over other verbal methods in children. It helps them communicate what is not easily put into words, extending their voice and participation, especially for those who are more hesitant to speak or share ideas (Bland, 2018). Through drawings, children graphically and emotionally represent what they feel to be significant according to their understanding and interpretation of the event (Wang and Brown, 2019). Additionally, drawing can be a valuable tool in problem-solving (Soundy and Drucker, 2009).

For children, drawing is one of many developmentally appropriate narrative activities that can take different forms (e.g., playing, story-telling, writing, and performing; Kerry-Moran and Aerila, 2019). Narratives are a way to recount one or more events organized in an order assumed to show the sharer's perspective of the episode (Bruner, 1986). As such, for the child, drawing can be a meaning-making, purposeful activity (Einarsdottir et al., 2009). Drawings provide fundamental intra- and inter-personal universes in which children make sense of their relationship between themselves and the world around them (Capurso et al., 2021b). These characteristics make drawings a rich, creative, and colorful source of information for researchers.

The connection between the different narrative forms and reality is complex, especially in children. First is the issue of the intricate intermingling between sensation, perception, and imagination when recalling events (Johnson and Foley, 1984; Cavallina et al., 2018). Next, from a phenomenological perspective, multiple realities connect the events with their narratives. For example, the anthropologist Bruner (1984) differentiates between the "life as lived" (flow of events that touch a person's life), the "life as experienced," relating to the images, feelings, desires, thoughts, and the specific meanings they assume for an individual, and then "life as told," which is a narrative that is inevitably influenced by the socio-cultural conventions of story-telling.

Idoiaga Mondragon et al. (2022) used drawing as a tool to explore how the COVID-19 lockdown affected children in Spain. They contacted children through their schools' administration, which forwarded a questionnaire to their parents. Children drew their lockdown experience by answering two questions ("What are you doing during the lockdown?" and "What do you miss?"). Physical activities carried out in the home, daily and routine activities, and art projects were the activities most represented during the lockdown. Most children drew their family members and reported positive emotions, and they reported missing playing and team sports.

The present study

The present study utilized a retrospective-descriptive design to analyze how children remembered their own lockdown experiences, related their emotions, and how they depicted these through their drawings. This observational work expands on recent drawing-based children COVID-19 research using qualitative and quantitative content analyses and statistical exploration of the association of different responses with gender and school level group.

We aimed to identify, observe, and measure different variables connected to the COVID-19 lockdown experience by addressing the following research questions: how did children represent themselves, other people, places, and objects when thinking back to the times of lockdown [Research Question (RQ)1]? What are the most commonly represented subjects, places, and actions (RQ2)? What emotional content and type of relationships are reproduced (RQ3)? Additionally, in line with the developmental literature, we hypothesized that there would be differences based on gender or school level in the school children's depictions of their lockdown experiences.

Materials and methods

Participants

Sixty classes (72% primary school, 28% middle school) from three school districts in the Umbria region of central Italy took part in the program. This involved 54 teachers who administered it to 906 students [48.8% female, mean age 9.4 years, standard deviation (SD) 1.7 years, age range 7–13 years] after obtaining parental written consent and approval of each school board (Capurso et al., 2021a).

Measures

The material for this study was drawn from a school re-entry program centered on the possibility for students to share their experiences and emotions connected to the first phase of the Italian lockdown (Capurso et al., 2020, 2021a). The program was built on established crisis management principles for schools, including facilitating classroom discussions and sharing feelings, activities to reconnect socially and with the school's environment, and sharing of coping strategies that the children used during the lockdown. The program included a course for the teachers and an A4 booklet for children to record, draw and work through their lockdown experiences by writing and drawing their thoughts (see additional materials and appendixes in Capurso et al., 2020, 2021a). When classes carried out the activities, each student completed the seven-page school re-entry booklet to produce a set of personal narratives organized as a continuous storyline, starting at the beginning of the lockdown period and ending in class when school restarted. This resulted in a unique sample of children's accounts of their experiences.

Procedure

In September 2020, a group of teachers and their students participated in the re-entry program under the supervision of one of the authors (MC). The teachers took part in a face-to-face four-hour training course. The course explained how to reestablish a sense of school community and outlined the critical role of schools in facilitating the children to process their experiences at cognitive, social, and emotional levels [the training manual is available online in Capurso and Mazzeschi (2020) and is evaluated in Capurso et al. (2021a)]. During the training, the children's booklet was explained in detail, and instructions were provided for its use in class. The teachers were told to start the program as soon as school reopened and finish it within a few days (the average duration was 5.1 days). One of the booklet's activities asked children to "Draw a moment that has remained in your mind from when you had to stay at home." The children could choose any drawing tools they liked to complete the task. The teachers collected the drawings for this paper's data and they were digitized by the research team.

Data analysis

We employed a combination of quantitative and qualitative content analysis to analyze the children's drawings (Huxley, 2020) to respond to RQ1 and RQ2. This technique allows qualitative and inductive determination of constructs of interest and quantitative assessment of their prominence in terms of specific research questions (Krippendorff, 2004). Content analysis can be used on children's drawings to extract meanings and make sense of the authors' understanding, attitude, and experience of a specific topic (Milbrath and Trautner, 2008; Wang and Brown, 2019).

We used several scales of the PAIR coding system (Pictorial Assessment of Interpersonal Relationships; Bombi et al., 2007) to address RQ3. PAIR is a psychological instrument developed to organize and code drawings representing relationships and emotions. Each of the instrument's six scales can be used independently. First, we used the Scale of Value to identify the "self" in the picture, assuming that this was the character with the highest score based on a set of attributes (dimensions, position on the page, body details, and colors). Then, in line with RQ3, we used the following scales:

1. Emotions (centered on the character assumed to represent the self), based on the assessment of graphic clues expressing one of the following nominal and mutually exclusive items; neutrality, contentment, hostility, and discontent.
2. The Emotional Climate (used when two or more subjects were represented), which we reduced to two mutually exclusive nominal categories: sharing the same emotional state or presenting different emotional states.
3. Cohesion, which measures the interdependence between the partners (when more people were present), and provides a score from 0 to 6, based on the presence of six pictorial cues (looking, approaching, acting together, being near each other, sharing a common location, touching each other, or being connected by an object).
4. Distancing, which measures the autonomy of the partners, and provides a score from 0 to 6 based on the presence of six pictorial cues (avoiding looking at the other person, moving away, acting independently from the other person, being far, staying in a specific space (not shared with the other person), and being separated by something).
5. Conflict, which informs on the disruption of the relationship.

Pictorial assessment of interpersonal relationships is based on marking qualitative characteristics in a picture and its represented subjects from a set of described pictorial features. PAIR is a viable tool to study children's representations of their social world, and its development has followed rigorous validation (Bombi et al., 2007).

Development of a coding scheme for the contents analysis

The first and last authors qualitatively classified the analytical constructs by inductively assessing the participants' drawings to develop the coding scheme. The scheme reflected basic drawing characteristics (e.g., color and framing of the subjects) and what the authors believed to be critical content in relation to the lockdown experience (e.g., loneliness, screentime, and social activities), based on the pandemic situation and current literature on the subject. The complete coding scheme is shown in **Table 1**. Next, the authors generated a codebook for the analysis of the drawings (see **Supplementary File 1**). Different codes were created concerning the distinctive themes that were identified in the initial coding scheme (e.g., the theme "what is represented" was divided into the following codes: only the main subject, the main subject with other people, only objects, pets, COVID/death). Subsequently, transcripts from 40 randomly selected drawings were open—coded by the first author and another research team member to generate preliminary codes. Interrater reliability analysis was performed on this subsample by calculating Cohen's kappa (κ) for each code, resulting in consistency values between 0.72 and 0.94 across the codes. The coders discussed coding differences and identified and described any characteristics or details they believed carried the same meaning. The codebook comprised the code with a short descriptive label, a definition of the concept, a list of criteria for inclusion or exclusion, and examples from the children's drawings. In this phase, atypical or uncommon answers (<5%) were either grouped with other similar codes or were added to an "other" category. Once the initial codebooks had been generated, the answers were coded independently, and the authors met regularly to refine the definitions and codes. Summaries of the final codes, definitions, and exemplary drawings are presented in the attached codebook as **Supplementary File 1**. The original dataset (in Italian and Filemaker format) is available upon request from the corresponding author.

Statistical analysis

Most of the codes were treated as nominal variables and were described in terms of the overall frequency of occurrences and percentage; additionally, the number of occurrences and relative percentage were also reported separately based on school level [primary school (PS) vs. secondary school (SS)] and gender (males vs. females). A Chi-square test (χ^2) was performed to assess differences in code occurrences between gender and school-level groups. Given that the two PAIR scales of Cohesion and Distancing produced an ordinal score, a paired *t*-test was run to analyze the differences between Cohesion and Distancing in the total sample, while the differences in the Cohesion and Distancing scores between school level and gender for each one of the scales was calculated using the Univariate Analysis of Variance (ANOVA) with two fixed factors. All analyses were carried out with Statistical Package for Social Science (IBM Corp, 2019).

TABLE 1 Overview of the coding scheme developed for the drawings.

Theme	Code
Color	Color
	Black and white
Framing of the main subject	Full body or face
	No main subject (sbj); sbj with a back view; sbj on screen
Represented place	Inside the house
	Surroundings of the house
	Other; outdoor or cityscape
External world	Not visible
	Partially visible
	Most/all of the scene is external
Activity of the main subject	Play, sport
	Use of ICT
	Daily chores, daily house activity
	ICT/online school
	Escaping the present
	Other
What is represented?	Only the main subject (self)
	Main subject and other people
	Only objects, no people
	Pets
	ICT
	COVID, death
How is ICT represented?	ICT with no people
	ICT with distance school
	Active use of ICT
	Passive use of ICT

Sbj., subject; ICT, information and communication technology. See the codebook (additional material) for a full definition and a detailed description of each code.

Qualitative content analysis of the drawings

The quantitative content analysis allowed us to determine the statistical relevance of specific drawing details; however, the depth, richness, and texture of children's drawn experiences were lost within the broader codes used by the quantitative content analysis. Therefore, we conducted a secondary, in-depth qualitative inductive content analysis (Miles and Huberman, 1994) on selected drawings representing each of the analyzed codes or a relative overarching theme. For the qualitative analysis, the authors selected all the pictures that corresponded to a specific code, displayed them in a gallery, and jointly discussed and commented on them to select what they felt was most meaningful. The units in this analysis were the things appearing in the drawings, their shapes and colors, the people, their expressions, and their activities. The researchers were more interpretive in this stage; they formed questions and wrote conceptual comments on how the chosen picture, the COVID-19 pandemic, and the lockdown context would be connected in the representation of the child's reality.

Results

Of the 906 participants, 900 completed the drawing activity. The drawings were analyzed based on the coding scheme (**Table 1**), and the main results are reported in **Table 2**. As the qualitative content analysis of the drawings inevitably deals with the same principles, relationships, and generalizations as the quantitative data, our comments from the qualitative analysis have been integrated into the following results paragraphs.

Color, subject framing, and representation

Most children used colorful representations (75%) with a full-body view (64%). There was a higher prevalence among primary school (PS) students [color: $\chi 2$ (1) = 98.32, $p < 0.001$; full-body: $\chi 2$ (1) = 48.45, $p < 0.001$; see **Figure 1**]. In 42% of the pictures made by SS students, the self was either missing or represented by a back view, $\chi 2$ (1) = 42.27, $p < 0.001$ (see **Figures 2–5**). Other people were also present in 61% of the drawings.

For example, colorful and well-detailed images are present in **Figures 1**, **6–10**. A large part of the drawing area has been used in these images. These pictures convey a sense of completeness and satisfaction; they show a world filled with friends, pets, and play activities that allowed the child to navigate through the hard times, despite the isolation of the lockdown. The images communicated by these drawings may not necessarily reproduce a lived reality but reflect an internal world capable of remaining active and well organized despite the crisis situation.

Figures 2, **3** show different types of void representation where people (or faces) are invisible. Only technology is present, but even where two people are represented (**Figure 2**), they are static. They disappear on the sofa, and the space is overwhelmed by the invasive presence of the television (TV) (which is showing deaths and COVID-19 case counts). In both pictures, an empty, white space dominates.

The absence of people can also convey a positive expectation, like in **Figures 4**, **5**. For a 10-year-old Italian boy, the affordance of that ball in front of the net in **Figure 4** on a football field is irresistible. That ball is "asking" to be kicked and will be as soon as the lockdown is over, and the field will be filled with boys and girls running and shouting, rejoicing at their regained freedom. The boy is probably projecting all his desire to go out and play with his friends again, and his mind is reassured by the representation of a world that is still there and waiting for his return. In **Figure 5**, someone has just finished baking those hot pies and will be eating them shortly. Both these pictures depict elements of life even in the absence of human figures; they are full of color and warmth and convey positive expectations and a sense of security or community.

Represented activities

Screentime and information and communication technology use

Screentime activities (44%) were the most represented (**Figure 2**), with an overall prevalence among SS children [χ^2 (1) = 35.15, $p < 0.001$]. Given their high usage during the lockdown, we conducted an in-depth analysis of the diverse screentime representations. Technology was used passively by most children (17.22%, **Figure 11**), and information and communication technology (ICT) was depicted without any people present in another 9.56% [this was mostly SS, $\chi^2(1) = 24.16$, $p < 0.001$, **Figure 3**]. Older children also represented distance learning more often [$\chi^2(1) = 14.18$, $p < 0.001$, **Figure 12**]. Finally, 9.22% of the children also used technology more actively (e.g., chatting and working on the computer). **Figure 13** shows an example of the use of technology as a means of positive communication; two girls are using a chat app to stay in touch with each other and make plans. The face of the friend is colored and full of details. The subject's face is not visible, but her hair appears brushed and well-kempt. The white space around gives us a sense of isolation, but the relationship with a friend, placed in the middle of the sheet, appears to alleviate this.

An ambivalent function of technology is visible in several drawings. For example, **Figure 12** shows a distant learning activity, with a desk ready and books and images of school friends on the screen. However, the main subject, the author of the drawing, is absent, and her chair is empty. Another example of emptiness can be seen in **Figure 11**, where a child plays a video game. This time the self is present, but the body is just an outline, bent over, alone, ensconced in front of the screen. **Figure 3** carries an additional paradox because it depicts a screen with a renowned communication app. The problem is that no one is present to use it. In this case, the emptiness of the room is reflected in the emptiness of cyberspace.

TABLE 2 Quantitative content analysis of the drawings for school level and gender.

Code	*N. 900 Total (%)*	*PS (n = 583) (%)*	*SS (n = 317) (%)*	*χ 2*	*P-value*	*Male (n = 437) (%)*	*Female (n = 463) (%)*	*χ 2*	*P-value*
Color	679 (75.44)	501 (85.93)	178 (56.15)	98.32	<**0.001**	327(74.83)	352 (76.03)	0.17	0.676
Black and white	221 (24.56)	82 (14.07)	139 (43.85)			110 (25.17)	111 (23.97)		
Framing of the main subject									
Full body or face visible	643 (71.44)	463 (79.42)	180 (56.78)	47.42	<**0.001**	313(71.62)	330 (71.27)	0.014	0.907
No subject, no face, on-screen, other	257 (28.56)	120 (20.58)	137 (43.22)			124 (28.38)	133 (28.73)		
Represented place									
Inside the house	613 (68.11)	385 (66.03)	228 (71.92)	2.75	0.097	286 (65.45)	327 (70.63)	2.77	0.095
Surroundings of the house	151 (16.77)	114 (19.55)	36 (11.35)	10.30	<0.001	83 (18.99)	69 (14.90)	2.40	0.121
Other, outdoor or city	136 (15.12)	84 (14.41)	53 (16.72)	0.64	0.424	68 (15.56)	67 (14.47)	0.209	0.647
External world visible?									
Not visible	532 (59.11)	325 (55.75)	207 (65.30)	7.75	<**0.05**	245(56.06)	287 (61.99)	3.26	0.071
Partially visible	110 (12.22)	73 (12.52)	37 (11.67)	0.14	0.710	57 (13.04)	53 (11.45)	0.534	0.465
Most/all of the scene is external	258 (28.67)	185 (31.73)	73 (23.03)	7.61	<**0.05**	135(30.90)	123 (26.56)	2.058	0.151
Activity of the main subject									
Play, sport	250 (27.77)	200 (34.31)	50 (15.77)	35.15	<**0.001**	123(28.15)	127 (27.43)	0.05	0.810
Personal use of ICT**	238 (26.44)	147 (25.21)	91 (28.71)	1.38	0.238	115 (26.32)	123 (26.57)	0.00	0.935
Daily chores or routines	134 (14.88)	99 (16.98)	35 (11.04)	5.71	<**0.05**	62 (14.19)	72 (15.55)	0.33	0.565
Distance learning***	72 (8)	32 (5.49)	40 (12.62)	14.18	<**0.001**	28 (6.41)	44 (9.50)	2.92	0.087
Escaping the present	54 (6)	35 (6)	19 (5.99)	0.00	0.995	25 (5.72)	29 (6.26)	0.11	0.731
Other or not applicable	152 (16.89)	70 (12.01)	82 (25.87)	nc	nc	84 (19.22)	68 (14.69)	nc	nc
What is represented?*									
Only the main subject (self)	482 (53.55)	317 (54.37)	165 (52.05)	0.44	0.504	239 (54.69)	243 (52.48)	0.44	0.507
Main subject and other people	266 (29.55)	197 (33.79)	69 (21.77)	14.26	<**0.001**	120(27.46)	146 (31.53)	1.79	0.180
Only objects, no people	145 (16.11)	66 (11.32)	79 (24.92)	28.10	<**0.001**	76 (17.39)	69 (14,90)	1.030	0.310
Pets	103 (11.44)	82 (14.07)	21 (6.62)	11.21	<**0.001**	39 (8.92)	64 (13.82)	5.32	<**0.05**
COVID, death	66 (7.33)	37 (6.35)	29 (9.15)	2.37	0.123	27 (6.18)	39 (8.42)	1.66	0.196
Other	8 (0.88)	2 (0.34)	6 (1.89)	nc	nc	4 (0.92)	4 (0.86)	nc	nc
How is ICT represented?									
Passive use of ICT	155 (17.22)	97 (16.64)	58 (18.30)	0.40	0.529	87 (19.91)	68 (14.69)	4.3	<**0.05**
Only ICT, no people	86 (9.56)	35 (6.00)	51 (16.09)	24.16	<**0.001**	45 (10.30)	41 (8.86)	0.541	0.462
Active use of ICT	83 (9.22)	50 (8.58)	33 (10.41)	0.82	0.364	28 (6.41)	55 (11.88)	8.04	<**0.05**
ICT as part of distance learning	72 (8)	32 (5.49)	40 (12.62)	14.18	<**0.001**	28 (6.41)	44 (9.50)	2.93	0.087
Total of drawings containing ICT	396 (44)	214 (36.71)	182 (57.41)	35.73	<**0.001**	188(43.20)	208 (44.92)	0.33	0.565

*The codes reported under this theme section are not mutually exclusive. **This code encompasses active or passive use of ICT, as reported separately under the ICT representation theme. ***This code is also reported as part of the ICT representation theme and has been repeated here for information completion of the depicted activities. PS, primary school; SS, Italian first degree of secondary school; ICT, Information and Communication Technologies; nc, not calculated. Bold font indicates statistical significance.

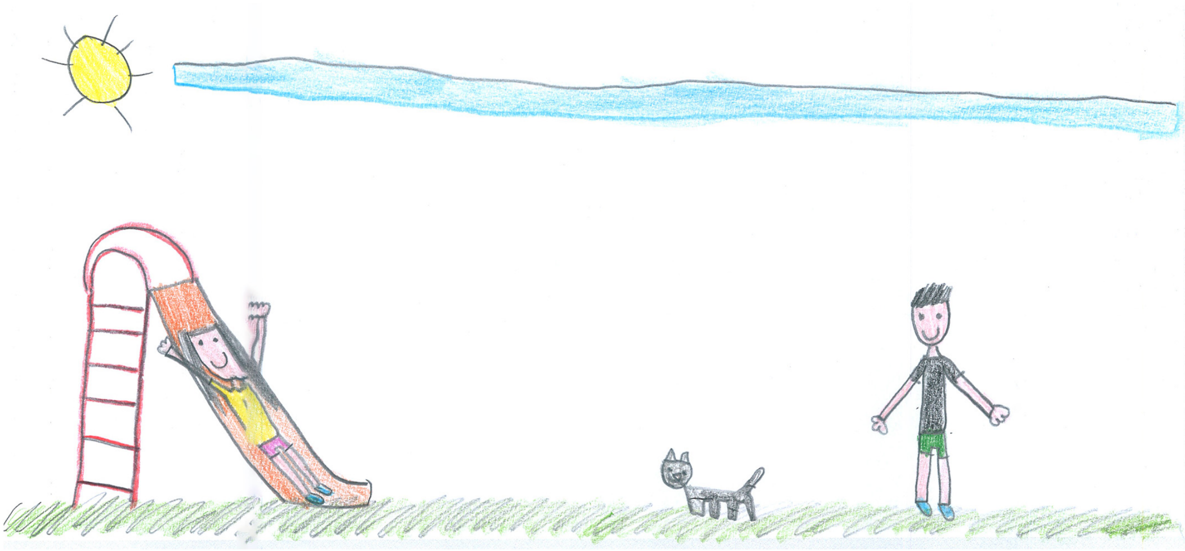

FIGURE 1
A colorful representation with full body view and other people present (PS, Female, 7 years).

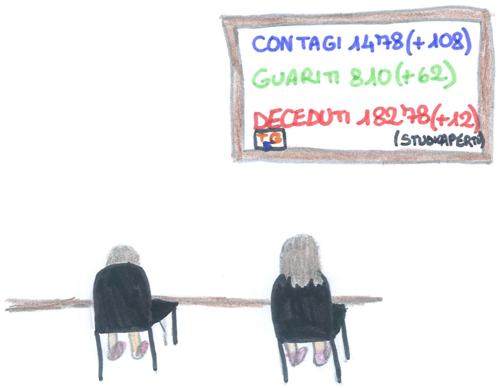

FIGURE 2
An example of back view representation. The screen is reporting on the increase of the contagions, recovered people and death (SS, Female, 11 years).

Other activities

After screentime, PS students depicted play, sport or physical activities (28%, Figures 6, 7, 14, 15) [$\chi^2(1) = 35.15$, $p < 0.001$]. Figure 14 shows a young girl playing alone. The carpet clearly demarks the play area, which draws a clear line between a play world and a more menacing outside world, represented by the TV screen reporting on the COVID-19 pandemic. Even if the girl's face is not visible, all the dolls are smiling. Next to the carpet is a shelf with more play boxes (one of them has been chosen and taken to the middle of the carpet), showing that a large reserve of play activities is available. This young girl shows how play was important to her and how it generated a safe area represented by the carpet, where smiles were still present. They probably represent a projection of a good inner part of the girl's self that she can access and use as a comfort in difficult times. In other pictures where children are playing together, they are always smiling (Figures 6, 7, 10). Domestic routines (15%) were also reported; Figure 8 shows two children preparing a recipe on a kitchen table. They are probably siblings and are working under their mother's vigilant (yet benevolent) eye. These children are taking part in what Bronfenbrenner (1979) would call a dyad based on a joint activity, a relationship that is mediated by the cooperative task of making the recipe. All the family members are smiling, showing shared positive emotions, and wearing trousers of the same color. The outside world is not visible, but life in this family looks harmonious despite the father's absence. Figure 16 is more ambiguous. It shows a boy watering a lawn in front of his house.

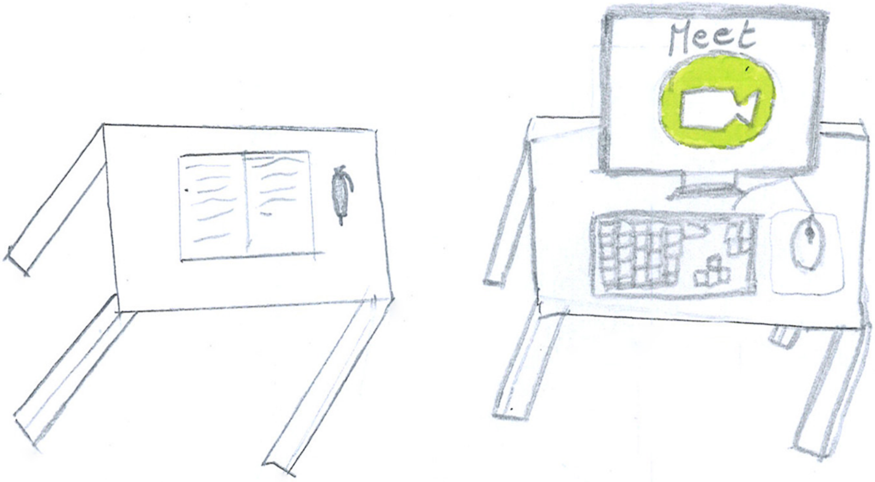

FIGURE 3
Another different example of a drawing with no people. A large white space is filled only with a computer displaying a videocall program and a table with a notebook and a pen, but there is no-one there to use them (PS, Female, 10 years).

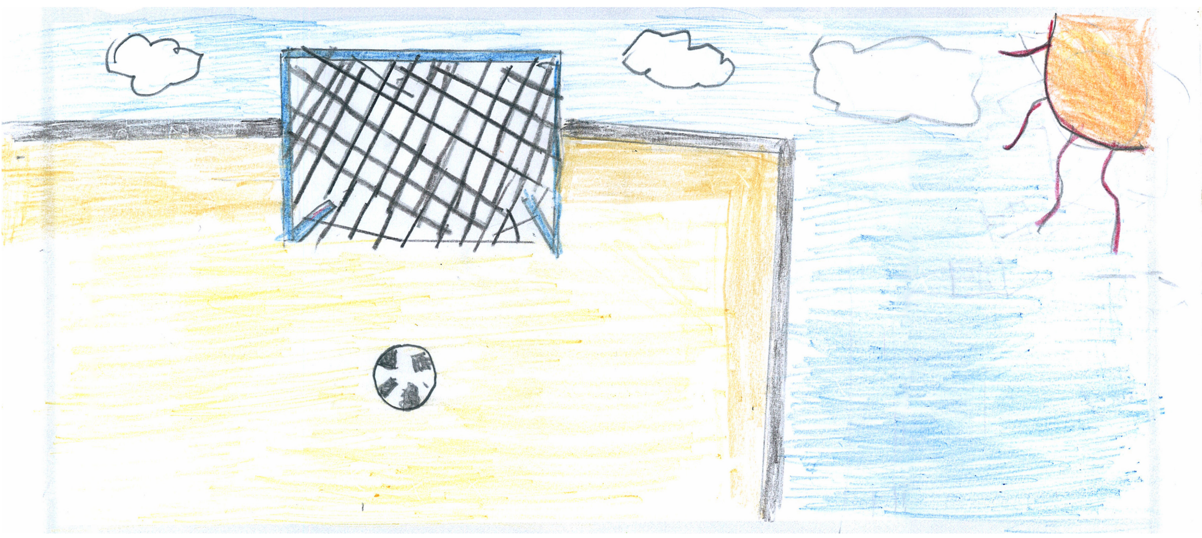

FIGURE 4
A different example of a drawing with no people. The playfield is empty, but the drawing is full of color, sunlight, and that ball in front of the net is "asking" to be kicked soon (PS, Male, 10 years).

The picture is in black and white and conveys all the insecurity connected to the first stage of the COVID-19 pandemic. The sun is partially obscured by the clouds, and at the top right side of the picture, a grinning and intimidating virus is watching. But the picture also contains elements of life. Two flowers are thriving, and the houses in the background emit smoke from their chimneys to reflect the life that is inside. Hovering over the boy's house is a bottle of disinfectant that keeps the virus away.

Finally, 6% of children represented escaping activities such as dreaming; **Figure 17** shows a boy dreaming of a slice of pizza, a typical longed-for snack among Italian children during the lockdown.

Places

Most children (68.11%) drew the interior of their houses (**Figures 2**, **3**, **5**, **11**, **12**, **14**, **17**). The outside world was completely absent in 59.11% of the pictures, with a slight prevalence among SS [χ^2 (1) = 7.75, $p < 0.05$]; For example, in **Figures 5**, **8**, **11**, the absence of the external world amplifies

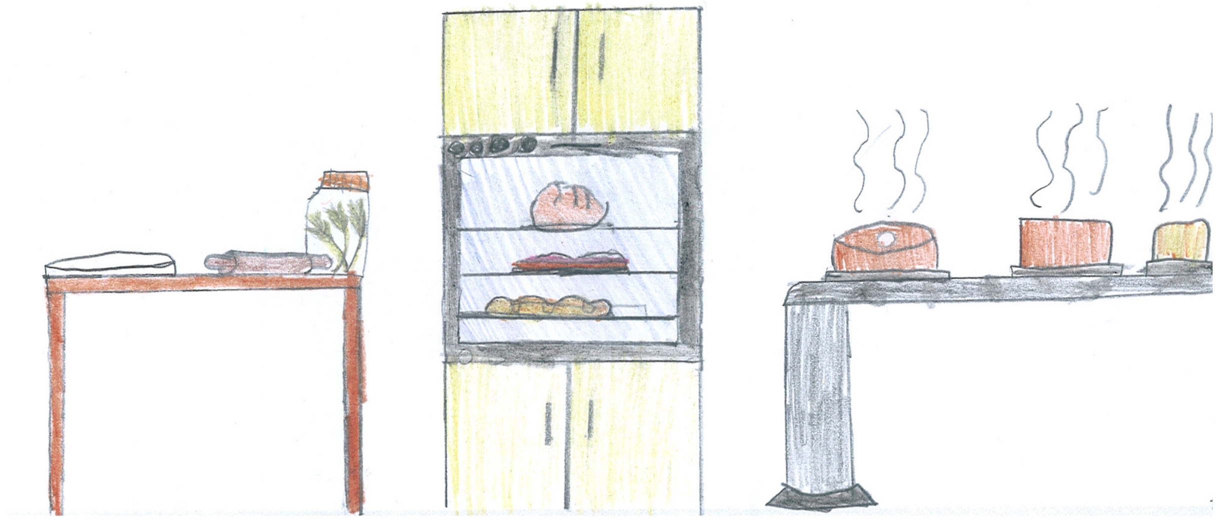

FIGURE 5
An example of missing people; this time the depicted scene is the inside of the house. Someone must have prepared those cakes and surely is going to eat them soon (PS, Female, 10 years).

FIGURE 6
When a play buddy is present, the illustrations are richer in color and details. According to the PAIR system, this picture also has a high cohesion ranking because the children stand on a common area, share the same activity, and are moving toward each other (PS, Male, 8 years).

the sense of intimacy and isolation of the subjects. Sometimes (10.44%), the external world was visible through a window or part of the picture, as in Figure 12. This reminds the child of the life outside that continues despite the lockdown and is waiting to welcome the subject once the isolation is over.

In terms of depicted objects and living creatures, the self was represented alone in 53.55% of the images (Figure 15); when it was associated with other people (29.55%), this was more often done by PS children [χ^2 (1) = 14.26, p < 0.001; see Figures 2, 6). Pets (11.44%, Figure 9) were more often portrayed by PS [χ^2 (1) = 11.21, p < 0.001] and females [$\chi^2(1)$ = 5.32, p < 0.05].

Figure 9 shows a young girl playing with her pet. The girl's body and head dominate compared to the rest of the picture, colors are marked and joyful, and the surfaces are filled with color to confirm the presence of a solid self. The child's arms are elevated to show an overall sense of agency. Even if the rest of the world is not visible, the presence of the pet holding a stick reminds the girl of her

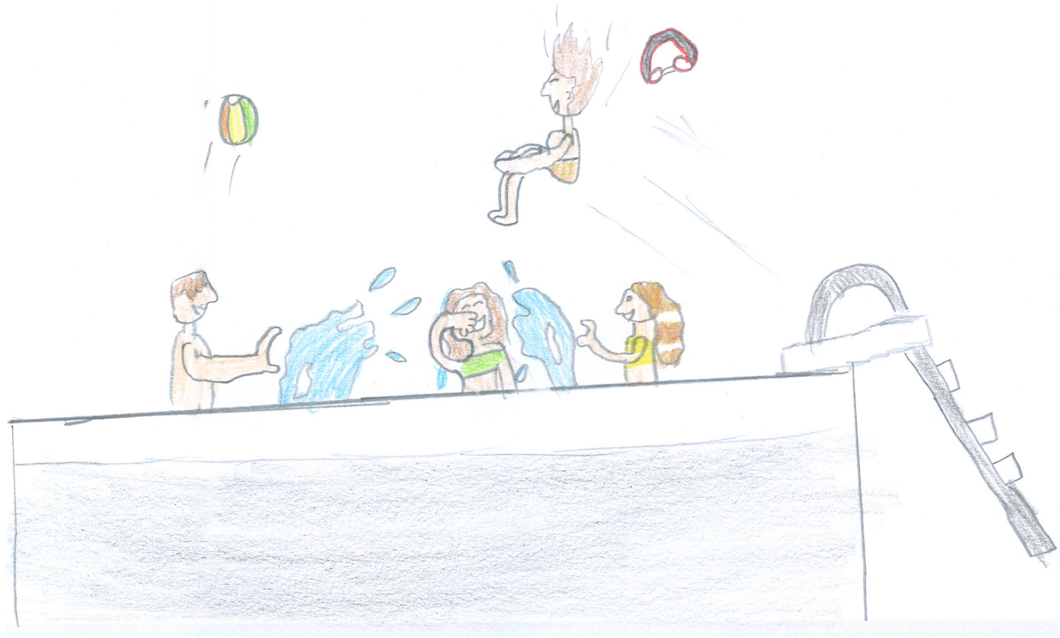

FIGURE 7
A lucky boy who could access a backyard swimming pool (SS, Male, 11 years).

FIGURE 8
Domestic chores, two children helping in the kitchen (SS, Male, 11 years).

time playing fetch with her pet. Not everyone had an open space and a pet to play with. Figure 15 shows a child playing alone with a ball. White emptiness is prevalent in this picture. The subject occupies a small portion in the middle, and he is lonely. Despite this, he is smiling, his arms are open as if to embrace the world, and his body is filled with color and details. This picture is a testimony to the resilience that younger children could show, even when they had no siblings or friends to play with during the lockdown.

FIGURE 9
A young girl is playing with a pet (PS, female, 7 Years).

FIGURE 10
A picture with a high score of distancing according to the PAIR scale. The subjects are separated and far apart, are doing a different activity, and are moving away from each other (PS, Male, 7 Years).

Emotion and relationships analysis with the pictorial assessment of interpersonal relationships scale

The PAIR scale could be applied only to 257 drawings that depicted two or more people; therefore, the following data only apply to this subsample (55% female, mean age 9 years, SD 1.6 years, age range 7–13 years).

Emotions

Contentment (i.e., positive emotions) was expressed in most of the PAIR-analyzed drawings (60.93%, see Figures 1, 6–9, 14, 15), with a prevalence among PS [$\chi^2(1) = 11.88$, $p < 0.001$] and females [$\chi^2(1) = 5.95$, $p < 0.05$]. Neutrality (33.98%, Figure 18) was more common among SS [$\chi^2(1) = 9.43$, $p < 0.05$] and males [$\chi^2(1) = 8.93$, $p < 0.05$]. Discontent (Figure 19) or hostility was seldom detected (5.09%).

Examples of shared positive emotions can be seen in Figures 1, 6–8, 10. These pictures show smiling children playing or engaged in some other collaborative activity. The colors are well distributed and bright. The people have a positive attitude, and the whole image paints an optimistic picture of the represented event.

Conversely, Figure 19 depicts a rare example of shared negative emotions; two young girls sit at a table with a TV between them, reminding them they cannot go out. The color fill is less uniform than in other pictures, and the TV and long table increase the distance between the girls, who appear unable to play together and are left alone with their anger and sadness. The external world is still present since a blue sky and a shining sun are visible through the window, but these act as reminders of what the girls are missing and wishing for.

Emotional climate

The represented subjects often shared the same emotion (59.14%, see Figures 1, 6–8, 14), with a prevalence among PS [$\chi 2(1) = 13.69$, $p < 0.001$] and females [$\chi 2(1) = 10.55$, $p < 0.001$].

Figure 1 is an example of sharing positive emotions. It depicts a couple of children playing outdoors with a pet. Albeit distant, the children are smiling, and their whole body is visible in color with full details; the sky is blue, the sun is shining, the grassed ground fills the bottom of the page, and the drawing

FIGURE 11
A child is passively playing videogames. The body is crushed, folded back on itself and chained to his seat (PS, Male, 10 Years).

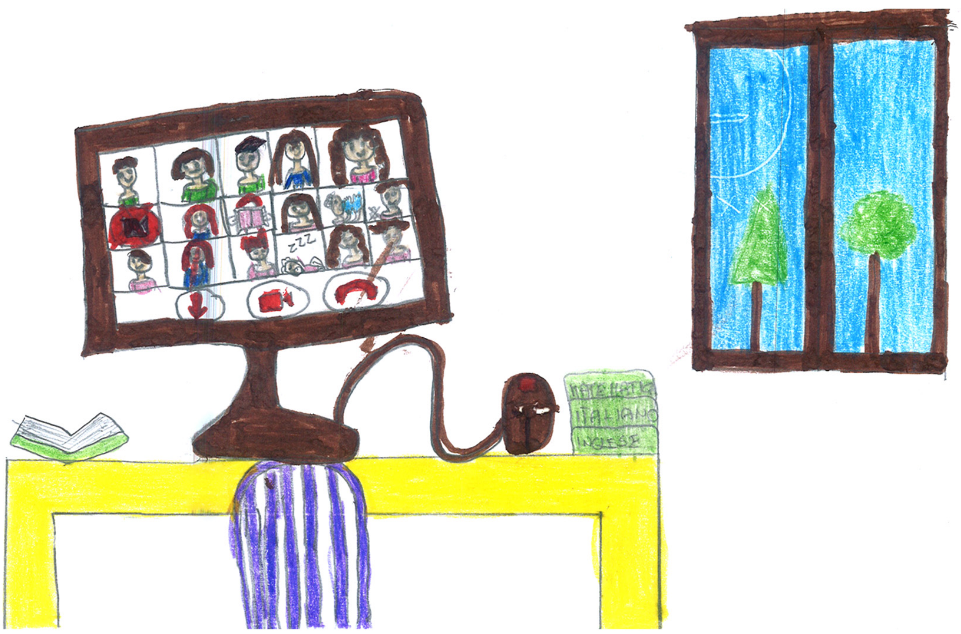

FIGURE 12
Distant learning, but the girls' own chair is empty (SS, Female, 11 years).

space is filled with details and colors. Despite some empty background, this picture was manifestly conceived by a young girl who experienced positive times during the lockdown and could most likely access open space to play with friends or siblings.

Shared neutrality (30.74%, Figure 18) was more frequent among SS [$\chi 2(1) = 6.56$, $p < 0.05$] and males [$\chi 2(1) = 8.67$, $p < 0.05$]. Unilateral or opposite emotions were rare (10.12%; Figure 20 is an example of opposite emotions). The child on the right is somehow excluded from playing with the other two subjects in the middle of the drawing. The child's body is blue, and he shows a sad expression. This picture reminds us that not all children live in a happy family environment without tensions and conflicts, and for some children, the memory of the lockdown is connected to difficult or negative experiences.

Conflict

Virtually no conflict (97.67%) was depicted in the pictures analyzed.

Cohesion and distancing

The descriptive and ANOVA results for these scales are reported in Tables 3, 4. A *t*-test ($t = 2.62$; $p < 0.01$) showed that children reported significant higher cohesion

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FIGURE 13
An example of two girls actively using ICT for a chat. The girl is saying: "when this is over, we'll ride together in our bicycle" (PS, Female, 10 years).

(mean 2.15 ± 1.18) than distancing (1.82 ± 1.48). Moreover, the results revealed no significant differences between males and females ($p > 0.05$) or between PS and SS students ($p > 0.05$). For example, **Figure 6** is an image with a high cohesion score because children are participating in coordinated play activity, moving toward each other, standing in a common area of the playfield, and are looking toward each other. On the other hand, **Figure 20** shows a picture with high distancing, where the child in blue is separated from the other two subjects who are playing together and appear to be walking away and not looking at him.

Discussion

This study analyzed a set of Umbrian-Italian children's lockdown-related drawings, which were retrospectively created in September 2020 when the school was restarted after the first COVID-19 wave. The results of this research offer several insights into how children experienced their first lockdown and how they narrated their lives at home through drawings. The combination of quantitative and qualitative content analysis enabled an

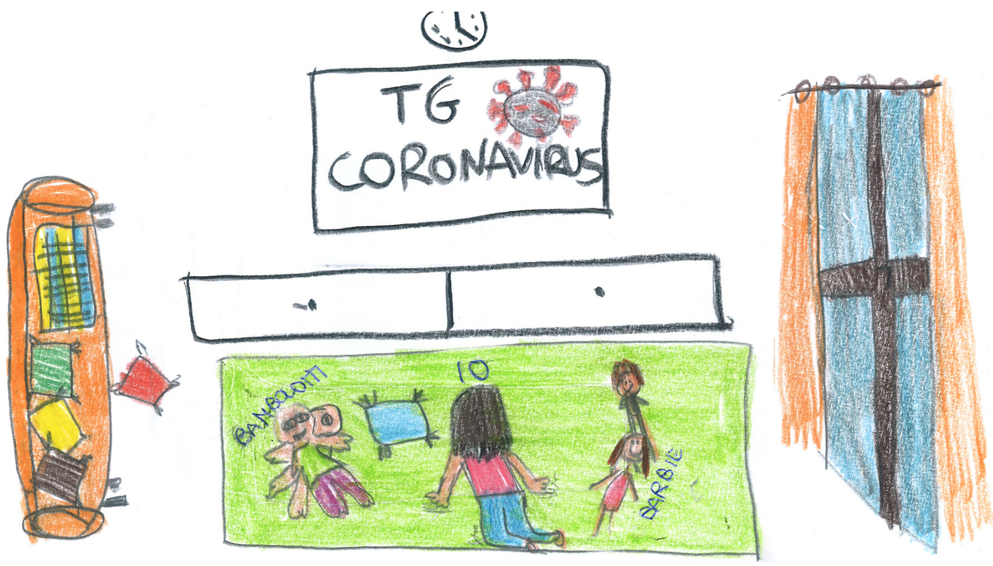

FIGURE 14
Playing at home. The TV screen is showing the pandemic news, but the children are playing inside a separate area, marked by the green carpet, that seems to keep them safe from the menacing world (PS, Female, 10 years).

FIGURE 15
Playing with a ball. A lonely child is playing with a ball, amid a large white empty area. Yet, he is smiling (PS, Male, 7 years).

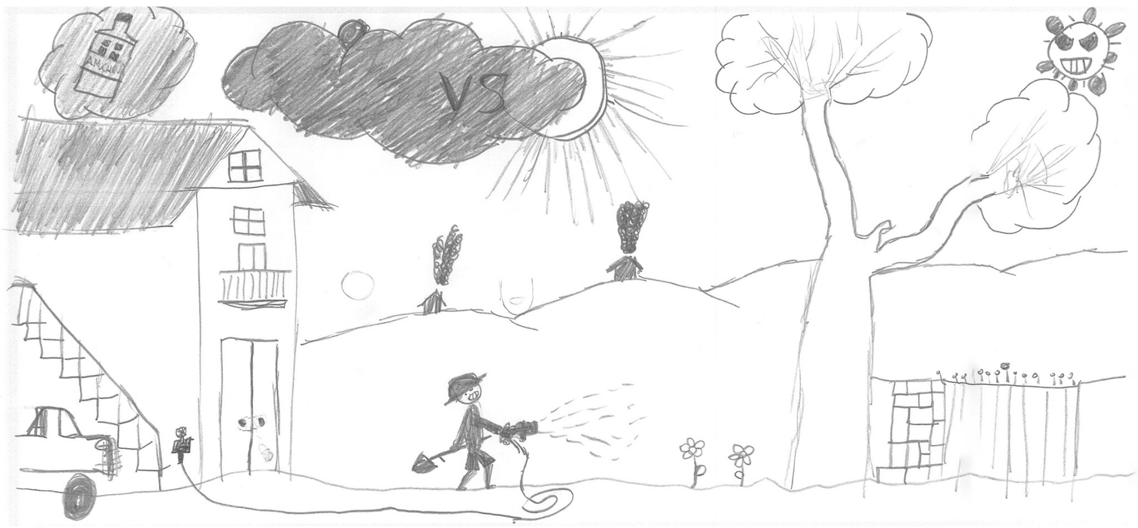

FIGURE 16
Taking care of the garden (SS, Male, 11 years).

in-depth analysis of the children's vision and perceptions of the situation.

The 900 drawings show that most children, despite the difficulties caused by the pandemic, remembered and depicted a happy scene from the lockdown experience. The prevalence of colorful pictures, full-body framing, contentment, play, and family life, convey a positive message. It is important to note that the children in our sample spontaneously drew positive memories of their time at home. The images show that the perceived psychological outcomes of the lockdown are not a causal consequence of the crisis event *per se* but are mediated by systemic factors that affect people and family life (Ford and Lerner, 1992). This finding provides opportunities for support intervention that should and could be organized and sustained by public and community organizations. For example, Singh et al. (2020) recommend activities and interventions involving parents, teachers, pediatricians, community volunteers, the health system, and policymakers. At the children's level, recommendations include engaging youngsters in play activities, communicating with children in an age-appropriate manner about the pandemic situation, limiting their exposure to unfiltered news, providing stable family routines, and outlining possible activities rather than prohibitions. For adolescents, the recommendations

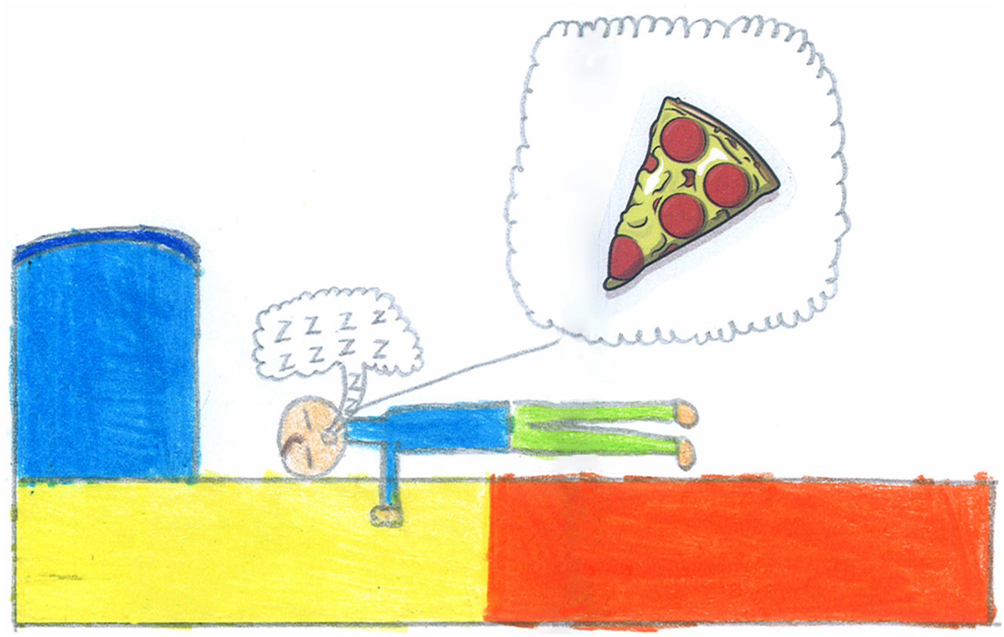

FIGURE 17
Dreaming of a pizza. . . (SS, Male, 11 years).

FIGURE 18
PAIR's shared neutrality (PS, Female, 10 years).

include modeling important life skills like coping and problem-solving, transmitting a sense of control whenever possible, and allowing older children to learn responsibility, accountability, involvement, and collaboration in daily tasks.

The generally positive images of the lockdown found in our study contradict the many pieces of research reporting on fear, anxiety, and depressive problems among children and adolescents due to the COVID-19 pandemic (for a review, see Samji et al., 2022; Viner et al., 2022). One possible reason for this discrepancy can be traced back to the socioeconomic characteristics of our sample. Despite not performing a socioeconomic analysis of the participants due to privacy limitations, the schools in this study were all based in the Umbrian countryside. This area is usually populated by middle- or working-class families, mostly single or double households,

FIGURE 19
An uncommon example of PAIR's negative emotions; TV says: do not go outside (PS, Female, 9 years).

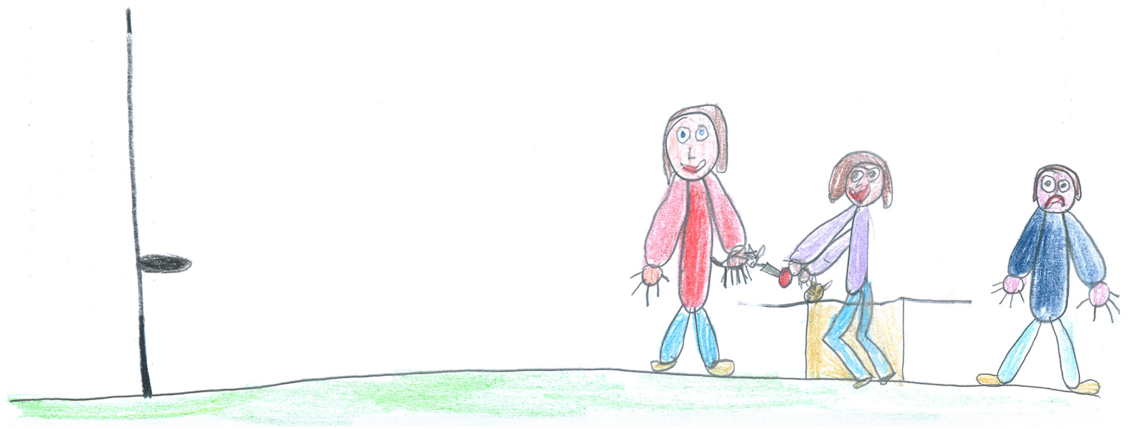

FIGURE 20
An example of PAIR's opposite emotions (PS, Male, 8 years).

with easy access to a backyard or the countryside. Living in a rural area was a protective factor against anxiety, while spending time creatively during the lockdown was significantly protective against experiencing negative emotions and emptiness (Forte et al., 2021).

Another reason why children reported positive memories of the lockdown could be traced back to the metamodel underlying the present research (Ford and Lerner, 1992). Most clinical studies of children's reaction to the lockdown (Panchal et al., 2021) were based on a bio-medical model of "deviations from the norm → diagnosis" (Engel, 1977). They hypothesized adverse mental health outcomes resulting from the pandemic, purposely looked for them and (consequently) found them (Telfener, 2011). In fact, clinical studies are usually based on close-ended questions and prompts, often "suggesting" a specific list of symptoms for the child to choose from. In contrast, our study is based on a more systemic, Whole Child Development view of human experience (Cantor et al., 2021). This approach postulates that contexts, relationships, and environments (experienced in different life settings) are the primary determinants of human development (Cantor et al., 2021). With proper care from supporting, dependable adults and environments, the adverse developmental effects of crises are preventable and reversible; children can overcome the negative effects of adversity and thrive (Cantor et al., 2021). In line with this approach, we hypothesized that despite the adversities, children would have found ways of thriving and exhibited resilience, coping capabilities, and emotional processing skills. Therefore, the prompt asking children to draw their experience

TABLE 3 Quantitative content analysis of the selected PAIR items for emotions, relationships, and conflicts (*N* = 257).

Code	*N. Total (%)*	*N. primary (%.)*	*N. Secondary (%.)*	*χ 2*	*P-value*	*N. Male (%)*	*N. Female (%)*	*χ 2*	*P-value*
Emotions									
Contentment	156 (60.93)	127 (66.84)	29 (43.28)	11.88	**<0.001**	60 (52.17)	96 (67.61)	5.95	**<0.05**
Neutrality	87 (33.98)	54 (28.42)	33 (49.26)	9.43	**0.05**	50 (43.48)	37 (26.06)	8.93	**<0.05**
Discontent or hostility	14 (5.09)	9 (4.74)	5 (7.46)	nc	nc	5 (4.35)	9 (6.33)	nc	nc
Emotional climate									
Shared emotions	152 (59.14)	125 (66.14)	27 (40.30)	13.69	**<0.001**	55 (47.83)	97 (68.31)	10.55	**<0.001**
Shared neutrality	79 (30.74)	50 (26.46)	29 (43.28)	6.56	**<0.05**	46 (40.00)	33 (23.24)	8.67	**<0.05**
Unilateral or opposite emotions	26 (10.12)	15 (7.4)	11 (16.42)	3.96	**<0.05**	14 (12.17)	12 (8.45)	0.33	0.97
Conflict									
No conflict	251 (97.67)	187 (98.42)	64 (95.22)	1.825	0.177	112 (97.39)	139 (97.89)	0.069	0.793
Some form of conflict	6 (2.33)	3 (1.58)	3 (4.78)	nc	nc	3 (2.61)	3 (2.11)	nc	nc

nc, not calculated. Bold font indicates statistical significance.

TABLE 4 Univariate analysis of variance of PAIR cohesion and distancing scales – based on school level and gender (*N* = 257).

	Total	PS	SS			Male	Female		
	Mean ± SD	Mean ± SD	Mean ± SD	$F_{(1,257)}$	*P-value*	Mean ± SD	Mean ± SD	$F_{(1,257)}$	*P-value*
Cohesion	2.15 ± 1.18	2.18 ± 1.23	2.07 ± 1.03	0.215	0.643	2.01 ± 1.16	2.27 ± 1.18	2.49	0.116
Distancing	1.82 ± 1.48	1.89 ± 1.51	1.64 ± 1.40	1.32	0.252	1.80 ± 1.57	1.84 ± 1.41	0.029	0.866

PS, primary school; SS, secondary school.

was neutral in the present study to allow the subjects complete freedom to choose what to draw and what type of experience to report (e.g., positive or negative).

As a result of our method, most children chose to depict a cheerful moment. Our quantitative data appear to suggest several co-factors contributing to a positive recall of the lockdown experience. These include play and physical activities, taking part in an activity with other family members, interacting with a pet, and actively using ICT for peer communication. These factors can all be traced to a common crucial developmental denominator; an active, affective relationship with others. Children who depicted contentment were usually engaged in a task that involved being in a relationship with someone. This often happened within the family, when siblings or caregivers were readily available, around the house with friends, when open spaces were accessible, or even in a solitary play world such as the ones depicted in **Figures 14**, **15**.

Another methodological factor that differs from other clinical studies is the choice to give voice directly to the children. Most previous research reporting on negative mental health outcomes of the pandemic was based on proxy reports (Samji et al., 2022); therefore, these studies reported on the *perception of an informant* on what children felt and how they behaved. The literature shows that informant discrepancies are common when evaluating children's mental health (De Los Reyes et al., 2022), and assessments vary across contexts, and are based on the experience of the person acting as a proxy. An informant would usually respond to questions by reporting on the presence of specific symptoms or problematic behaviors, but this does not reveal what the children actually felt and experienced. Conversely, by giving a voice to children *via* a neutral prompt for them to draw a moment of their own choice from their lockdown experiences, we recognized children's agency, competence, and the fact that their ongoing interactions with their living and social environment transformed the way they experienced the lockdown (Garbarino and Stott, 1992).

In symbolic terms, there are instances of physical and psychological protection in the children's drawings in our sample. The most evident physical protection is the representation of the different rooms in the home as a sheltered space where the virus could not enter and where children felt safe and could engage in different activities. Children draw happy and playful moments in the home with one or more family members. This can be seen as a logical consequence of the increased time spent with parents and siblings, but it also indicates the importance of the quality of family life during the lockdown. Not all children were fortunate enough to live in a comfortable house and with a family that was able to buffer them from the risks and stresses of the lockdown (Prime et al., 2020). Risk factors such as financial concerns and uncertainty about the future would have caused some families to be more acutely affected by the socioeconomic consequences of the lockdown (Bérubé et al., 2021).

Another important protective mental space for children was the one opened up by playful activities. In times of stress, play serves several types of behavioral, cognitive, and emotional functions. Play facilitates younger children to assimilate daily experiences and adapt reality to their own thoughts (Capurso and Ragni, 2016). Exploratory play is the basis for learning, achieving goals, and growth. In emotional terms, play has long been seen as a crucial activity to connect with, express, and recognize their own and other people's emotions (Capurso and Ragni, 2016).

Relationships form the third type of emotional protection. There are three main sources of social support for children and adolescents; family, friends, and school personnel (Chu et al., 2010). The drawings from our sample often depict the presence of family and friends. While the main source of support for younger children is the family, other forms of social support, such as friendships, become more important in older children. Friendships offer several developmental functions, including companionship, stimulation, physical and ego support, social comparison, and intimacy/affection (Ginsberg et al., 1986). Thanks to their interaction with friends, children learn to practice controlling their emotions and responding to the emotions of others (Kouvava et al., 2022), crucial skills during the lockdown.

Generally speaking, younger age and being female are the two independent variables that are most associated with a positive memory of the lockdown times. Remembering a protective experience was more natural for younger children who rely heavily on family life due to their developmental status (Gettler, 2017). Younger children generally drew a relaxed daily life with little constraints in terms of time, space, and content, where enjoyable activities were possible within the safe walls of their homes. For them, the lockdown was often associated with a sense of stability and opportunities to engage in common hobbies, develop greater attachments and enjoy more dialogue with siblings and parents. These findings confirm those of Panchal et al. (2021), who reported that when children were involved in daily routines, had good family relationships, and had access to play, they also felt safe, relaxed, and comfortable within their households. In contrast, peer relationship quality in adolescents tends to become more important than parental relationships (McMahon et al., 2020). They probably lived the lockdown as a time of constraint and limitations to their freedom, and only a few were able to maintain close and intimate contact with their peers. In some cases (**Figure 13**), ICT helped young people to keep in touch and cultivate their friendships despite the distance. Such active use of ICT was reported more often by girls, who also drew more joyful situations and shared positive emotions than boys. The fact that girls rely more on relationships in times of distress has been well documented in the literature (Belle, 1991). In fact, adolescent girls present higher emotional sensitivity to stressful life events, and consequently, they tend to report higher levels of attachment to peers and favor quality intimate relationships (McMahon et al., 2020).

TV, video games, computers, and smartphones are ubiquitous in the drawings. There is a marked prevalence among SS, and males seem slightly more prone to passive ICT use (**Figure 11**), whereas females use it more actively (**Figure 13**). Boredom was a common experience during the lockdown (Melegari et al., 2021), and TV, computer, and video games helped children fill the day. This came with some dangers since the overuse of screentime activities can have harmful consequences, such as sleep disruption, reduced motility, and can lead to an increased risk of psychological difficulties (Lissak, 2018; Nagata et al., 2020). During the lockdown, children with higher levels of screen use had significantly higher levels of mental health symptoms (Li et al., 2021). Our data shows an ambivalent function of the use of technology and the related screentime. On the one hand, technology was sometimes used as a means of positive communication (**Figure 13**). However, conversely, the large number of images associating ICT with a missing self (**Figures 3**, **12**) seem to show that the intensive use of technology and video games was not perceived as fulfilling the need for friendships and real-life social interactions. Cyberspace was often perceived as a place where the self was dissolved, where faces and emotions disappeared, just like the video camera that was often turned off for privacy and technical reasons during distance learning. This suggests that the code relating to ICT required more in-depth investigations (**Table 2**). Screentime can be part of an activity that has a purpose, creates relationships, and requires the active involvement of the subject, such as the one depicted in **Figure 13**. Alternatively, it can be an individual and a closed occupation that creates desolation and, in the end, contributes to the loneliness of the subject (**Figures 3**, **11**). Such ambiguity calls for teachers, educators, and parents to plan the use of screentime and connect it with some activities that promote active relationships. Schools should play a primary role in this kind of planning and should plan, organize, and deliver distance education activities where ICT is used as a tool to reach a final aim or product and not just as a means to deliver traditional subject-based content.

While most drawings convey a positive message, there were instances of negative memories from the lockdown. These were usually connected to drawings showing loneliness/void (**Figures 2**, **3**) or conveying a sense of exclusion and marginalization, as seen in **Figures 19**, **20**.

The pictures with wide empty spaces, indicating a sense of a void, remind us that peer interaction is extremely important to children and that those who lacked it during the lockdown suffered deeply, to the extent that it affected their self-perception. Evidently, not all children had the opportunity for meaningful peer interactions. Children across Europe have reported emptiness as a source of distress (Forte et al., 2021). This data reminds us of the importance of establishing peer support networks in times of crisis and how crucial it is to ensure that such support is available to every child, but especially to those living in families experiencing vulnerability or with a single parent. Such a network could be facilitated by peers, school, or other professional types of interventions.

Support and networking interventions are even more crucial for those children who experienced marginalization, such as those depicted in **Figures 19**, **20**. These images show a household where children did not feel comfortable and expressed their discomfort through pictures showing negative emotions, discontent, low proximity, and high distancing. Supporting families living in vulnerable circumstances is particularly difficult, but evidence-based parenting support programs can be particularly efficacious, especially if they are culturally tailored (Baumann et al., 2015). These programs aim to provide rightful access to high-quality, supportive services that meet the individual needs of each child and family while recognizing the autonomy of each household and respecting each families' priorities. Strengthening pathways to resilience by providing help for parents and professionals working with children is crucial to consolidating the child and family's well-being (Fong and Iarocci, 2020). Support programs can intervene through a public agency or community assistance at financial, emotional, and mentoring levels. During a lockdown, they can employ various online, telephone, or physically distanced delivery options to accommodate family schedules and comply with the pandemic restrictions (Perks and Cluver, 2020). Examples of parenting interventions can be found in the Triple P Parent Program (Sanders et al., 2000), which delivered a set of multilevel family support strategies aimed at creating positive relationships between the child and the parents. The program also supports the abilities and development of the child and improves parental skills to manage problematic behaviors. A second widespread intervention is the Incredible Years Parent Program (Webster-Stratton, 1982). This is a comprehensive, multifaceted, development-based intervention that targets parents, children, and teachers to support social skills and prevent or moderate conduct or oppositional defiant disorders, attention-deficit hyperactivity disorders, and emotional or behavioral problems in neglected or abused children.

Limitations

This study's main limitations are the limited provenance of the subjects and the inevitably subjective characteristics of the interpretation of the drawings. Due to COVID restrictions, the administration of the task in the classroom could not be controlled by the researcher. We used standardized instructions for the children and their teachers to improve control. We ensured that all the children were administered the task in the same place (their classroom), at a comparable time, and under the same circumstances. To establish confirmability, we used the participants' drawings to substantiate the interpretations of the data from the quantitative analysis.

Another limitation is connected to the phenomenological nature and timing of this study. Did the children actually *experience* what they had drawn, or did they project fantasies, wishes, and expectations in their pictures? The study's retrospective nature represents a further limitation since children may have been influenced in their drawing by subsequent experiences between the first wave of COVID-19 and when the data was collected. Indeed, we do not know where the difference between reality and imagination lies in their created images. In some areas of psychology, this difference is of secondary importance. As Thomas and Thomas (1928) stated, if someone perceives a situation as real, its consequences *will be* real. Either way, the drawings and data from this study should not be considered a mirror of reality but rather a personal account of a perceived experience. Moreover, while this study reported on drawings collected from different schools, the sample remains limited to the Umbrian region of Italy. As such, the results are not generalizable to all Italian children. Besides, the COVID-19 experience in Umbria likely differed from other regions, where the first wave of COVID-19 was more dramatic in terms of infections and deaths. Finally, given that culture influences perception and sense-making (Cole, 1998), our findings cannot be generalized to different cultural or geographical settings.

Conclusion

This study used a child-centered drawings-based approach and prioritized their perspectives and experiences, enabling them to share information in ways that worked for them. This method is considered easily accessed by children of different ages, sex, socioeconomic status, ethnicity, and with different language abilities (Milbrath and Trautner, 2008). In this research, the children's drawings enabled us to understand how they perceived play, family life, and emptiness during the first wave of the COVID-19 pandemic.

Our results show the protective role of good relationships, play, and happy and relaxed family environments. Technology is depicted in an ambivalent way; sometimes, it contributes to maintaining good relationships, but often it is associated with a dissolved self-image. The connection between ICT-related social functions and the self-image of children and adolescents needs further investigation in the future.

For most of the children in our sample, the lockdown drawings showed positive moments. However, some of the pictures showed signs of discomfort or even distress, usually connected to a lack of peer or family relationships or the absence of the subject's involvement in meaningful activities. Maintaining developmental trajectories and supporting children's thriving can be achieved even in times of crisis if family, school, and community support systems are networked and if public policies provide family support and pay attention to those who are more vulnerable.

In conclusion, despite many studies reporting children as having suffered due to the COVID-19 lockdown, our results suggest a different narrative. When presented with the opportunity to recall their lockdown time freely, most children, especially the younger ones, depicted joyful moments, and their pictures transmit a sense of resilience, security, and agency. This could indicate that the difficult times during the lockdown were a natural part of their daily lives. Once everything went back to normal, the children were ready to populate all voids they had drawn during the pandemic.

At this very moment, the young boy who imagined that lonely football in **Figure 6** is probably running around and chasing that same ball on a field full of voices, smiles, laughter, shouting, and play.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent to participate in this study was provided by the participants or their legal guardian/next of kin.

Author contributions

MC conceptualized the project, coordinated the data collection, performed the qualitative analysis, and developed the first draft of the manuscript. LB performed the ANOVA and other quantitative analyses, while CM contributed to conceptualizing the work, and supervised the methodology. All authors were involved in writing the manuscript and contributed to the content analysis process.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyg.2022.982654/full#supplementary-material

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The student's drawing of teacher's pictorial Value as a predictor of the student–teacher relationship and school adjustment

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This study employs the scale of Value from Pictorial Assessment of Interpersonal Relationships (PAIR) to investigate the links between the importance attributed by primary students to their teachers and two independent measures of scholastic wellbeing, provided by teachers and parents. During middle childhood, the teacher is one of the most significant adults with whom children interact daily; a student–teacher relationship warm and free from excessive dependency and conflict is very important for children wellbeing; however, children's recognition of teacher importance as an authority figure has been seldom studied. Children aged 7–11 years were individually asked to draw themselves and one of their teachers in two situations (relational Wellbeing and relational Distress); the scale of Value from PAIR was used as a proxy of the importance attributed to teachers in each situation. Teachers completed the Student–Teacher Relationship Scale for Closeness, Conflict, and Dependency of each child; parents answered two items about their children's School Adjustment. All the study variables were firstly analyzed to check gender and age differences. Boys valorized more than girls the teacher's figure; however, teachers perceived more Closeness and less Conflict with girls. Dependency and Conflict decreased with age, as well as (albeit slightly) School Adjustment. To assess the links between pictorial valorization of the teacher in Wellbeing and Distress and teachers' and parents' evaluations, four separate hierarchical regressions were performed, namely, Closeness, Dependency, Conflict, and School Adjustment, controlling children's sex and age. The teacher's pictorial Value in Wellbeing appeared to be related to Closeness and School Adjustment, while a negative relationship emerged between Value and Dependency in Distress. In sum, the recognition of the teacher's role as an authority figure does not hinder a warm student–teacher relationship and impacts positively on school adjustment. In situations of Distress, dependent pupils showed a diminished appreciation of the teacher's importance, possibly as a result of a defensive stance.

KEYWORDS

teacher authority, student–teacher relationship, school adjustment, primary school, children drawing

Introduction

This study examines the importance and authority attributed by children to their teachers and its links with two independent measures of wellbeing in school: the teacher's perception of relationship quality and the parents' perception of school adjustment. As a proxy of children's consideration for teachers, we use the pictorial valorization of the teacher in two drawings, respectively, of positive and negative interpersonal situations. Drawing is liked by the majority of children and allows them to express ideas, even tacit, without the interference of adults' conceptions, as it happens in interviews or questionnaires (Freeman and Mathison, 2009); more precisely, the method for collecting and analyzing children's drawings employed here is Pictorial Assessment of Interpersonal Relationship (PAIR) (Bombi et al., 2007).

PAIR approach to children's drawing

The use of drawing to evaluate children's relationships with significant adults dates back to the application of a projective approach to the representation of family (Hulse, 1951, 1952, cit. in Knoff, 2003), a strategy that was then refined (as reviewed in Handler and Habenicht, 1994; Pace et al., 2021) and also extended to school relationships (Knoff and Prout, 1985). With the projective tradition, PAIR shares the recognition of drawing ecological validity, due to its large practice in children's life (Kihlstrom, 2021) and its potential for overcoming some limitations of children's verbal communication, especially about controversial topics (Chandler, 2003). However, PAIR departs from that tradition in some essential aspects.

First, no unconscious mechanism of projection is assumed, but rather a tacit competence to choose images suitable for a communicative goal; in fact, PAIR explicitly requires the child to show, through the drawing, his/her ideas about a specific topic in order to allow the adult to know something about children. This communicative stance is based (1) on the literature on drawing flourished in the 80s of the twentieth century (Thomas and Silk, 1990; Cox, 1992) from which it emerged that even preschoolers are able to adapt their drawings to the researcher's demands and (2) on a series of empirical studies (summarized in Bombi and Pinto, 1993) demonstrating the children's capacity to reproduce in recognizable ways spatial arrays, gestures, and features of depicted persons that are emblematic of the relationship and/or the situation to be represented. The children's choice of relevant information is enhanced by two requests of PAIR: (a) to include oneself in the drawing, which reduces the risk of stereotypic and unrealistic details, and (b) to make two drawings (e.g., "yourself with a friend" and "yourself with a sibling"). This task is manageable even for young children and functions as a conceptual anchor, similar to the semantic differential techniques (Ploder and Eder, 2015); moreover, it is useful for the researcher to keep under control any pictorial idiosyncrasies, not to be interpreted as indicative of ideas on the theme drawn.

PAIR was developed in a historical phase that Gary Ladd (1999) called "the third generation of studies on social competence," a period characterized by a flourishing of research on the positive side of relationships and on the ability of children to grasp their characteristics. Initially aimed at examining friendship and siblinghood (Bombi and Pinto, 1994; Cannoni, 2002; de Bernart and Pinto, 2005), PAIR has proved equally useful for the representation of a variety of relationships with peers and adults (Bombi and Pinto, 2000) also in intercultural perspective (Pinto et al., 1997; Pinto and Bombi, 2008). In fact, the four main scales constituting PAIR allow the researcher to grasp the fundamental dimensions of human relationships (Fiske, 1992), i.e., the existence of an interpersonal bond tempered by signs of autonomy (scales of Cohesion and Distancing) and partners' psychological affinity that coexists with disparities of importance (scales of Similarity and Value). For each scale, thanks to construct analysis and empirical studies (detailed in Bombi and Pinto, 1993) adequately informative pictorial elements have been identified and are within the reach of children since the age of 5–6 years.

In sum, PAIR is a research tool designed to avoid some recurrent criticisms leveled against the use of children's drawing, primarily the need of interpretations heavily dependent on clinical expertise, which are the more controversial requirements of projective methods (Joiner and Schmidt, 1997; Lilienfeld et al., 2000). Moreover, compared with the classic checklists provided for the scoring of projective tests (see a summary in Chandler, 2003), PAIR stands out because it contains analytical criteria to distinguish between intentional and random productions and to evaluate the communicative incidence of details as a function of the increasing complexity of drawings when children become more proficient in their pictorial activity. PAIR has been internationally published by its authors' research group (Bombi, 2002; Pinto and Bombi, 2008; Lecce et al., 2009; Laghi et al., 2013; Cannoni and Bombi, 2016; Di Norcia et al., 2022a) as well as by other independent researchers (Fraire et al., 2006; Misailidi et al., 2012; Rabaglietti et al., 2012; Sándor et al., 2012; Dimitrova, 2016; Guidotti et al., 2020).

In this study, the scale of Value will be used, which measures the comparative importance of depicted characters according to their reciprocal roles (e.g., adult more valued than child; Bombi and Cannoni, 2001) and relational quality (e.g., enemy less valued than friend; Bombi and Pinto, 1995). The pictorial cues of Value reflect *dominance*, as shown by a figure dimension and upper position, and *personal valorization*, as shown by details provided to its body, clothing, and, if the drawing is not black and white, by the number of colors. Due to these different components, the scale of Value allows the young artists to recognize role disparity as well as personal dignity; for instance, the prominence of parents can be shown by cues of dominance, while the enrichment of the child's figure moderates the unbalance (Bombi and Cannoni, 2001). Even the realistic constraint of different body sizes between the portrayed characters, which could result in dominance when this is not the case, can be circumvented by the disjunction of the figure size and upper position; this is what second-born children (but not first born!) very often did in a study of siblinghood, e.g., representing themselves standing beside a sitting or crouching brother, and hence as able to "look down" at him (Cannoni, 2002; Lecce and Pinto, 2004). Last but not least, the representation of Value is sensitive to the emotional connotation of the relational circumstances, as shown by the increased disparity between siblings in the case of conflict (Bombi and Pinto, 2000). The scale of Value has been employed in some studies on student–teacher relationship (Bombi and Scittarelli, 1998; Bombi and Pinto, 2000; Fraire et al., 2006) showing that children typically recognize the teachers' importance, but the possible change of Value in different situations, and the links with other data about the relationship were not examined.

Teachers' role between warmth and control

The importance of a harmonious relationship between teacher and primary school children has been demonstrated by many studies, especially thanks to the theoretical and methodological contribution of Pianta (1992) and Pianta and Hamre (2009). According to their studies, and subsequent numerous replications (McGrath and Van Bergen, 2015), a positive student–teacher relationship is characterized by high warmth, low dependency, and low conflict and is associated with students wellbeing (García-Moya, 2020; Zheng, 2022), school adjustment (Bosman et al., 2018), and engagement in learning activities (Pianta et al., 2012; Quin, 2017). Many studies have been devoted to the means of promoting such a relationship thanks to the adoption of positive teaching styles (Kincade et al., 2020; Poling et al., 2022).

Even though it is clear from the above-mentioned studies that teachers have to be proactive in the creation and maintenance of a good relationship with students and that it is their responsibility to act as leaders in the classroom, lesser attention has been paid to children's recognition of this role. Sociologists and philosophers (Durkheim, 1956; Arendt, 1958) have repeatedly affirmed the importance of authority figures for the transmission of social and cultural heritage. However, as Arendt noted, authority in the absence of a foundation (either theological or political) can reduce itself to the exercise of power and hence be rejected by liberals for the sake of freedom, or accepted by conservatives at the expense of freedom. A teacher has to select school contents and implement learning activities, but this role of "cultural arbiter" (Bourdieu and Passeron, 1990) requires that students freely accept his/her authority.

Adults' authority over children implies the legitimate use of power in some situations, e.g., in order to prevent a child from doing something that puts him/her in danger. Hence, the use of power cannot be avoided completely in children's upbringing, and psychologists have tried to trace a path for a just exercise of it, distinguishing between authoritative and authoritarian styles. Baumrind (1966) was the first to test the different outcomes of these styles, which were subsequently conceived as the combination of *demandingness*, which requires the exercise of some power, and *responsivity,* which is the demonstration of acceptance and warmth (Maccoby and Martin, 1983). Studies of parenting showed not only the detrimental effects of excessive power, but also those of its absence. Only a balance of power and acceptance proved to be positive for the child's wellbeing, ensuring his/her sense of security and at the same time encouraging his/her responsibility and independence.

Recent work has transposed this conceptual framework to the relationship between teachers and students (Turliuc and Marici, 2012). Since the seminal work of Lewin et al. (1939), we know that students' wellbeing is fostered by a classroom climate in which the teacher is able to use his/her authority without being authoritarian and that if he/she gives up to this role, adopting a *laissez-faire* style, children lose interest in the school activities and behave badly toward each other. Interest in teachers' authority was recently revived by the fact that students' unruly behavior and lack of respect constitute for teachers one of the main factors of stress and abandonment of profession (Friedman, 1995; Evans et al., 2019); sometimes even teacher's victimization has been documented (Kapa et al., 2018). The problem of a correct exercise of authority in class has been examined from a theoretical point of view (Macleod et al., 2012; Lü and Hu, 2021; Chen, 2022) and empirically addressed (Pace and Hemmings, 2007), but research on the correlates of children's perception of teachers' authority is still lacking, as far as we know.

Studies of moral development, however, demonstrated that children do understand what authority is and distinguish the spheres of its exercise (Laupa and Turiel, 1986, 1993; Tisak et al., 2000); moreover, Enright et al. (2020) have recently carried out a series of experimental studies on children's understanding of social status and the associated properties, finding that even 3-year-olds have some idea about the existence of a person "in charge" in some situations and that the role of "boss" implies obedience from subordinates. Overall, these studies suggest that children would apply to teachers their understanding of authority and super-ordinate status.

Is the recognition of authority detrimental to student–teacher relationship? We do not think so. In Italian primary schools, a child-centered style of teaching is prevalent, and the need for resorting to power assertion is not so frequent to disrupt a positive relational style. In such a climate, children's recognition of the teacher's status should enhance the teacher's positive affect.

Gender and age differences in student–teacher relationship

Closeness and conflict have been demonstrated to be central dimensions of the student–teacher relationship, and they are affected by individual characteristics of the child, including age and gender (Saft and Pianta, 2001). Studies based on teachers' reports have clearly established that teachers perceive closer and less conflicting relationships with girls than with boys (Baker, 2006; Hajovsky et al., 2017), a result found also in the Italian context (Molinari, 2009) and throughout elementary school (Spilt et al., 2012); studies based on self-reports confirmed more conflict and less closeness for boys (Koomen and Jellesma, 2015). In addition, data on trajectories showed that conflict remained frequent or increased with age only for those students who exhibited high rates of deviant behavior, especially externalizing, which is more common for boys (Lee and Bierman, 2018; Shi and Ettekal, 2021). However, in non-problematic students conflict tended to decrease with age (Wu and Hughes, 2015; Shi and Ettekal, 2021). As regards other age changes, a trend toward a decrease in closeness was generally found from kindergarten to sixth grade (Baker, 2006; Jerome et al., 2008; Spilt et al., 2012). This normative decline of warmth probably reflects a change in classroom organization, more focused on learning goals than on social relationships, as well as a developmental pattern of children growing more independent from adults (Spilt et al., 2012). Lesser attention has been paid to dependency, i.e., a clingy and possessive behavior which can be acceptable in young students, but becomes more and more inappropriate with age. According to a recent meta-analysis (Roorda et al., 2021), dependency is negatively related to various indices of school adaptation and positively related to behavioral difficulties, especially internalizing. In fact, higher autonomy has been found in well-adapted children (Di Norcia et al., 2022b) and developmental trajectories of diminishing dependency have been demonstrated to be beneficial for children's scholastic wellbeing (Bosman et al., 2018).

The present study

This study addresses two sets of questions:

(1) To what extent do boys and girls, from second to fifth grade of primary school, recognize the teacher's greater importance and authority than themselves in different situations of the school life?

(2) How does the degree of importance attributed to the teacher relate to indices of children's school wellbeing independently provided by teachers and parents?

Based on the literature summarized above, we expect that

- boys and girls alike should acknowledge the importance of the teacher since the early grades of primary school;
- the importance attributed to the teacher should predict a close student–teacher relationship with low conflict and dependency, as well as a positive school adjustment; these outcomes should be also linked to gender and age.

Materials and methods

Participants

Participants were 264 students of primary school in a small Italian town: 140 boys and 124 girls, equally distributed in 15 classes from second to fifth grade (ages ranging from 7 to 11 years). The majority of children came from middle-class or lower middle-class families, with 64% of fathers working as employees, 31% self-employed, 2% manager, and 3% unemployed and 50% of the mothers as housewives, 36% employees, and 14% self-employed. Parents' school degrees were distributed as follows: elementary school (fathers: 4%; mothers: 2%); middle school (fathers: 34%; mothers: 30%); high school (fathers: 44%; mothers: 49%); and college (fathers: 18%; mothers: 18%).

The teachers who took part in this study were women and had a mean age of 46.7 years (range 33–60 years) with an average of about 16 years of service (range 7–30 years). As looping is the typical school policy in Italy, the majority of students had the same classroom teacher throughout the elementary years:

Given a 9-month academic year, the time spent together by students and teachers ranged from 6 months (for children who had joined the class in the year of data collection) to 42 months (for children of the fifth grade who had had the same teacher since the first grade).

Informed written consent was obtained from school authorities and teachers. A questionnaire about demographic information was completed by parents, after signing an informed consent ensuring the voluntariness and anonymity of their participation and participation of their children. Children orally accepted informed consent too and completed two drawings. This research and its procedure were approved by the Ethic Committee of Social and Developmental Psychology, Sapienza University.

Procedure

Our convenience sample was formed on the basis of teachers' willingness to participate; each of them received the Student–Teacher Relationship Scale (STRS) questionnaire in a sealed envelope with the request to return it to us within a few days. Teachers then helped to reach the students' families and to distribute and collect the letters of consent and questionnaires.

Drawings were collected by a research assistant. After a short familiarization in the classroom, he brought the children in small groups to another room with tables wide spaced to avoid copying. Here, he explained that each child could show how he/she was getting along with the classroom teacher by drawing him/herself with that teacher in two different moments: "Wellbeing, which is when things go well, you feel fine together, you get along well," and "Distress, which happens when things are not going well, you do not feel fine together, you do not get along." Then, each child received two sheets (8 1/2 × 11 in.) entitled: "Myself and my teacher [name of the classroom teacher]—Wellbeing" (WDraw) and "Myself and my teacher [name of the classroom teacher]—Distress" (DDraw). No time limit was set, but to avoid exceeding the 30′ allowed by the school, only paper and pencil drawings were required; all children finished this task within 20′. At the moment of data collection, children were asked to indicate which figure represented the teacher.

Measures

Demographic information schedule

Parents reported the gender (0 = girl; 1 = boy) and age of the son/daughter about whom they were completing the questionnaire and information about their own educational level.

Pictorial assessment of interpersonal relationships

Drawings were scored with the above-mentioned scale of Value from PAIR (Bombi et al., 2007) which requires comparing the drawn characters in four subscales: (1) *space occupied*, (2) *dominant position*, (3) *body detail*, and (4) *number of attributes*. In each subscale, the drawn characters receive a zero score if their Value is equal; if their Value is different, a score of 1 or 2 is attributed to the more valued character. Hence, a character can receive 1 or 2 points for each of these qualities: being larger (*subscale 1*), being dominant (*subscale 2*), being more detailed in terms of body parts (*subscale 3*), and being richer in clothing and other accessories (*subscale 4*). As the subscales are independent, each character can receive some points (e.g., character X can receive 1 point for a quite larger size and 2 points for much many body parts and character Y con receive 2 points for a dominant position and 2 points for a very richer clothing); then, the points received by each character can be summed to obtain its individual score of Value (in the example above a score of 3 for character X and a score of 4 for character Y). In alternative, a single score of Value can be obtained focusing on one of the two characters: In this case, the scores attributed to the other (non-focused) character will be first converted in negative points for the focused character and then algebraically summed (in the above example, focusing on character Y, 3 negative scores—corresponding to the value obtained by character X—should be subtracted to its 4 scores, with a final Value score of 1). Following this last strategy, we obtained a single score of Teacher's Value (TVal) with a possible range from −8 to 8.

Each drawing was rated by two independent judges who had not participated in the data collection and were blind to the aims of the study. The percentages of agreement in each subscale ranged from 83 to 91% for the WDraw and from 80 to 92% for the DDraw. For the final score assignment, they discussed each score on which they disagreed, until a full agreement had been reached.

Student–teacher relationship scale

Teachers' perceptions of the quality of their relationships with individual students were measured using the Student–Teacher Relationship Scale (STRS; Pianta, 1999) in the Italian adaptation for children aged 6–11 years (Molinari and Melotti, 2010). In the Italian instrument, the original dimensions of Conflict and Closeness are strictly replicated. The third original dimension, Dependency, is divided into two components: The first (Dependency) includes also items of conflict and measures a relationship marked by jealousy and relational difficulties and the second (Insecurity) regroups those items that suggest an insecure type of attachment. Finally, three items of Conflict focused on the teacher's feelings of stress and lack of efficacy, as well as a reversed item of Closeness, give rise to a fifth dimension (Educational Difficulties). All teacher-rated items are based on

TABLE 1 Descriptive statistics and bivariate Pearson's correlations on study variables.

	1	2	3	4	5	6	7	8	*Range*	*M (SD) boys*	*M (SD) girls*	*M (SD) total*
(1) Gender (1 = boys; 2 = girls)	1								–	–	–	–
(2) Age		1	−0.012	−0.198**	−0.313**	−0.176**	0.022	−0.012	7–11	9.10 (1.21)	9.03 (1.29)	9.07 (1.24)
(3) STRS-closeness			1	−0.276**	0.017	0.012	0.136*	0.055	1–5	3.84 (0.81)	4.14 (0.78)	3.98 (0.81)
(4) STRS-conflict				1	0.494**	−0.063	−0.003	−0.059	1–5	1.38 (0.61)	1.19 (0.47)	1.30 (0.55)
(5) STRS-dependency					1	0.024	−0.086	−0.146*	1–5	1.54 (0.66)	1.60 (0.61)	1.57 (0.64)
(6) School adjustment						1	0.148*	0.000	1–4	3.76 (0.33)	3.80 (0.35)	3.78 (0.34)
(7) Wellness teacher value							1	0.309**	−8 to 8	2.42 (2.43)	1.55 (2.49)	2.01 (2.49)
(8) Distress teacher value								1	−8 to 8	2.36 (3.01)	1.32 (3.68)	1.86 (3.38)

$^*p < 0.05$; $^{**}p < 0.01$.

a five-point Likert-type scale (1 = definitely does not apply to 5 = definitely applies). In this manuscript, we will consider only the scales of Conflict, Closeness, and Dependency, i.e., those more similar to the original instrument. Coefficient alpha reliabilities (α) for Conflict, Closeness, and Dependency scores were 0.79, 0.80, and 0.68, respectively.

Parents' perceived school adjustment

Parents were asked to complete two items (My child's behavior at school is. . . and My child's school performance is. . .) based on the questionnaire "My child and the school" (Bombi et al., 2014) to evaluate their child's school adjustment. Response was rated on a four-point scale from poor to excellent. A total score was calculated as a mean of the single score item.

Data analyses

Data analyses were performed using the statistical program Statistical Package for Social Science (SPSS), version 25.0. Descriptive statistics and bivariate Pearson's correlations were computed on the study variables. A multivariate analysis of variance (MANOVA) was conducted on the TVal scores in WDraw and DDraw with gender and age as independent variables; ANOVAs were performed on all the other study variables with gender and age as independent variables. Finally, four hierarchical regressions analyses were conducted, in order to investigate the predictors of STRS-Closeness, STRS-Conflict, STRS-Dependency, and School Adjustment among the two scores of TVal in WDraw and DDraw. In the first step, sex and age were entered, and in the second step, TVal scores in WDraw and DDraw were added to the regression equation.

Results

Descriptive statistics and bivariate Pearson's correlations are reported in Table 1.

Gender differences emerged for the following variables: STRS-Closeness [$F_{(1,263)} = 9.72$; $p = 0.002$; $\eta^2 = 0.04$; boys = 3.84 > girls = 4.14]; STRS-Conflict [$F_{(1,262)} = 7.31$; $p = 0.007$; $\eta^2 = 0.03$; boys = 1.38 > girls = 1.20]; and TVal [$F_{(1,244)} = 10.09$; $p = 0.002$; $\eta^2 = 0.04$; mean of TVal in W and D: boys = 2.39 > girls = 1.44].

A gradual decrease with age was found in STRS-Conflict [$F_{(3,263)} = 8.16$; $p < 0.001$; $\eta^2 = 0.09$ second grade = 1.51; third grade = 1.37; fourth grade = 1.15; fifth grade = 1.09] with a significant difference only between third and fourth grades and STRS-Dependency [$F_{(3,263)} = 11.93$; $p < 0.001$; $\eta^2 = 0.12$; second grade = 1.78; third grade = 1.69; fourth grade = 1.47; fifth grade = 1.22] with means differing from each grade to the next, except second and third grades. Also, School Adjustment decreased, albeit slowly [$F_{(3,263)} = 2.97$; $p = 0.046$; $\eta^2 = 0.03$; second grade = 3.84; third grade = 3.82; fourth grade = 3.72; fifth grade = 3.71] reaching a significant difference only between second and fifth grades.

No interactions between variables were found.

The hierarchical regression analyses conducted to investigate the predictors of student–teacher relationships and school adjustment among the variables measured through children's drawings showed the following findings. As regards Closeness, step 1 was significant and explained the 0.4% of variance, with female sex predicting a significantly higher closeness and step 2 added a significant increase of R^2 ($p = 0.03$) to the explained variance: Both sex ($\beta = 0.24$; $p < 0.001$) and TVal in WDraw ($\beta = 0.16$; $p = 0.01$) were significant predictors.

TABLE 2 Summary of hierarchical regressions predicting student–teacher relationship from drawing variables.

Step	Predictors	Closeness				Conflict				Dependency			
		B	SE B	β	R^2	*B*	SE B	β	R^2	*B*	SE B	β	R^2
1					0.04**				0.08**				0.11**
	Sex (*M* = 1; *F* = 2)	0.33	0.10	0.20**		−0.21	0.07	−0.19**		0.09	0.07	0.07	
	Age	−0.002	0.04	−0.003		−0.09	0.03	−0.21**		−0.15	0.03	−0.32**	
2					0.07*				0.09				0.13*
	Sex (*M* = 1; *F* = 2)	0.38	0.10	0.24**		−0.22	0.07	−0.21**		0.06	0.07	0.05	
	Age	−0.003	0.04	−0.01		−0.09	0.03	−0.21**		−0.15	0.03	−0.32**	
	Wellness teacher value	0.05	0.02	0.16**		−0.001	0.01	−0.01		−0.01	0.02	−0.03	
	Distress teacher value	0.01	0.02	0.04		−0.02	0.01	−0.09		−0.02	0.01	−0.13*	

**$p = < 0.01$; *$p < 0.05$.

For Conflict, only the first step was significant with 0.08% of explained variance, with female sex (β = 0.21; $p = 0.001$) and older age (β = 0.21; $p = 0.001$) predicting lesser Conflict. For Dependency, both step 1 ($R^2 = 0.11$) and step 2 ($R^2 = 0.13$) were significant ($p < 0.001$), with younger age (β = −0.32; $p < 0.001$) and lower TVal in DDraw (β = 0.13; $p = 0.04$) predicting more Dependency (see **Table 2**).

Finally, as regards the regression on School Adjustment, the first step was significant ($R^2 = 0.04$) with younger age predicting more adjustment (β = −0.20; $p = 0.002$), the second step was significant explaining the 0.7% of the variance with an increase in a significant R^2 ($p = 0.03$), and Teacher Value in Wellness (β = 0.18; $p = 0.008$) was a significant predictor of school adjustment together with young age (see **Table 3**).

Discussion

This study was aimed at exploring (1) whether and how much primary school children recognize the teacher's greater importance and authority than themselves in different situations of the school life and (2) whether and how the degree of importance attributed to the teacher relates to indices of children's school wellbeing independently provided by teachers and parents. The results provided some interesting answers to these research questions, confirming the usefulness of drawing as a way to access children's perspective on school relationships.

TABLE 3 Summary of hierarchical regressions predicting school adjustment from drawing variables.

Step	Predictors	School adjustment			
		B	SE B	β	R^2
1					0.04*
	Sex (*M* = 1; *F* = 2)	0.02	0.04	0.03	
	Age	−0.05	0.02	−0.20**	
2					0.07**
	Sex (*M* = 1; *F* = 2)	0.04	0.04	0.05	
	Age	−0.05	0.02	−0.20**	
	Wellness teacher value	0.02	0.01	0.18**	
	Distress teacher value	−0.01	0.01	−0.05	

*$p < 0.05$; **$p < 0.01$.

The greater valorization of the teacher with respect to the student indicates a correct perception of the respective roles and is stable from second to fifth grade, without differences between situations of Wellbeing or Distress. The authority of the teacher, of which the pictorial valorization is an index, appears internalized even by the younger participants and is not undermined by the slight drop in enthusiasm as age increases, reported by parents in their assessments of school adaptation. Perhaps this parental evaluation reflects the greater cognitive effort that they perceive in their children as they pass from one class to the next. However, the decreased school adaptation does not imply a deterioration of the relationship with the teacher, which remains close, and indeed less and less conflicting and dependent.

A substantial difference in the representation of Value appears between the adult–child relationship studied here and peer relationships, examined in other studies with PAIR. In a relationship between peers, the relative importance of the partners can be freely negotiated, so that the pictorial Value is affected by relational variants (friendship–enmity; Bombi and Pinto, 1993) and circumstances (harmony–conflict between brothers; Cannoni, 2002; de Bernart and Pinto, 2005). On the contrary, the teacher's pictorial Value is not undermined by the emotions associated with the pleasant or unpleasant exchanges portrayed, because the teacher's role is always recognized. One could say that a certain amount of relational Distress is inevitable in the classroom, but this does not disrupt the teacher's importance when the interactions with students are generally marked by low conflict, low dependency, and high closeness, as it was the case for the participants in this study.

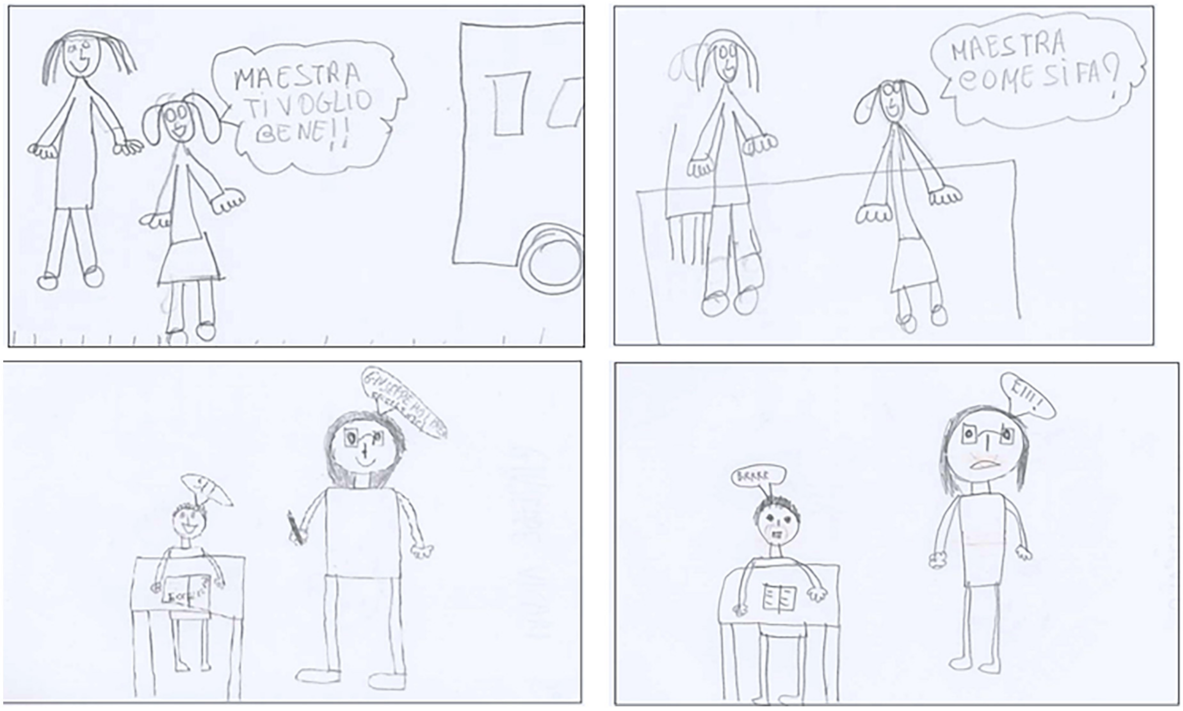

FIGURE 1
Examples of different valorization of the teacher by gender, independently from the situation. Drawings in the upper section are by the same girl; those in the bottom section are by the same boy; both children are in 2nd grade. Wellbeing drawings are at the left. **(Upper drawing):** Child "Teacher, I love you". **(Lower drawing):** Teacher "Giuseppe, your work was excellent"; Child "Yes!" Distress drawings are at the right. **(Upper drawing):** Child "Teacher, how should I do it?" **(Lower drawing):** Teacher "Hey!"; Child "Brrr".

Congruent with this reading of the data is also the fact that the importance attributed to the teacher in Wellbeing and Distress does not have significant links with the Conflict in the regression analysis.

The unexpected gender difference in Value scores is illustrated in **Figure 1**. Independently from the situations, girls have been less likely to stress the disparity between themselves and the teacher, perhaps because their relationship is closer and less conflicting than that of boys, in line with the cited literature (Baker, 2006; Molinari, 2009; Hajovsky et al., 2017). On the contrary, boys could have developed an image of a powerful person, given the greater frequency with which the teacher must resort to authority to manage their behavior. It is also possible that girls perceive teachers (all women in this study) as akin to themselves; in this direction goes also the fact that, when required to indicate a desired profession as grown-ups, one of the more frequent of girls' answers is "teaching" (Cavalli, 2014).

The predictive power of Value scores (not found in the case of Conflict) and the usefulness of the dual representation of oneself with a teacher in different circumstances (not evident in the comparisons by age and gender) are instead confirmed by the regression analyses on Closeness, School Adaptation, and Dependency. In fact, the recognition of the teacher's importance in situations of relational Wellbeing predicts a close relationship and a better school adaptation, while in situation of relational Distress it predicts low dependency. In the first case, the importance of the teacher does not arise from the exercise of power as it happens when she has to correct errors or punish negative behaviors, but is functional mainly to the support given to the student in the school work; the teacher appears as a "significant other" able to use in favor of the student her superiority in terms of knowledge and judgment.

Complementary to this result is the negative relationship observed between teacher's Value and Dependency in Distress; in other words, the ability to recognize the importance and role of the teacher beyond the difficult moment is higher in autonomous children. This result speaks of the importance of uncomfortable moments in the educational context, as a litmus test of progress toward autonomy, which in turn predicts better adjustment to school as shown by the above-quoted literature (Bosman et al., 2018; Roorda et al., 2021; Di Norcia et al., 2022b). The dissonance with the teacher is in fact constitutive of the relationship, as a figure who knows more, who can give rewards or reproaches, and who decides when to work or take a break. The ability to tolerate all of this, even when the teacher does not show herself as a benevolent figure, constitutes a litmus of the student emotional independence. Distress is not well tolerated and translates into

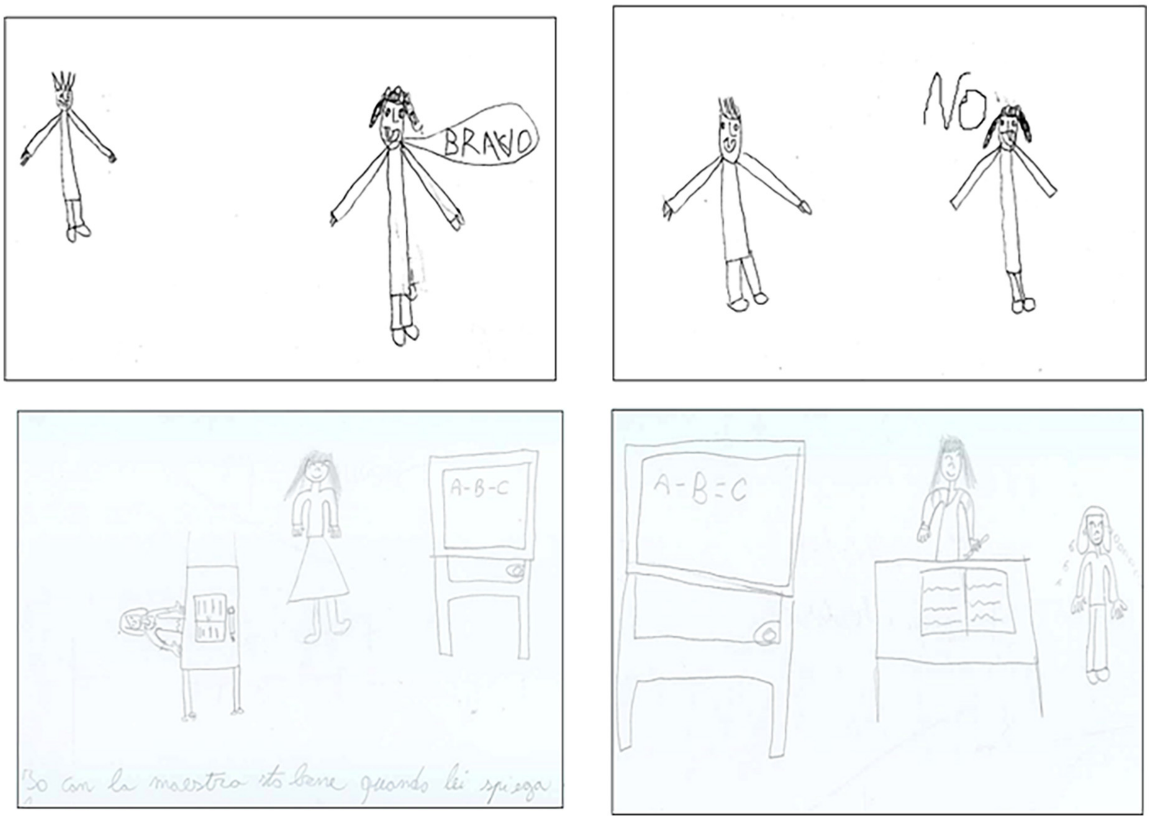

FIGURE 2
Examples of lower valorization of the teacher in Distress. Drawings in the **(Upper section)** are by the same boy (3rd grade), those in the **(Bottom section)** by the same girl (5th grade): to reduce the teacher's comparative value the first employed a simple strategy (enhanced self-dimension), while the second used a more complex pictorial plan: she interchanged the respective positions of the figures, showing the teacher's entire body in the Wellness (caption says: "I feel fine with the teacher when she explains"), and her own entire body in Distress.

an attempt to reduce the teacher's importance (exemplified in **Figure 2**) when the child is still at the beginning of the school experience or remains too long in a sort of symbiotic dependency.

Overall, the links highlighted by this research are in line with the most recent literature on the authority of teachers, understood as a necessary component of their role, which can be implemented without compromising the affective quality of the relationship with pupils, and indeed strengthening it (Pace and Hemmings, 2007; Chen, 2022). The focus on students' perception of authority seems to us a strength of this manuscript, given the scarcity of studies lamented by various authors (Macleod et al., 2012; Lü and Hu, 2021). Another strength is certainly the use of different informants that has made possible to relate the independent evaluations of teachers and parents with the perspectives of children, so as to build a more in-depth picture of the processes taking place in the educational relationship. The use of a solid pictorial tool like PAIR has served to give voice to children since an early age; the drawing proved useful for studying topics, such as teacher's authority, which are not easy to deal with verbally, especially in reference to problematic interpersonal situations.

We are aware of the study limitations, to begin with the cross-sectional design that does not allow drawing conclusions on the temporal dynamics of the processes examined. A replication in different educational environments, whose specific characteristics should be better known, would be necessary to shed light on the ways in which authority is managed and on its consequences for the students perception; in particular, the effect of gender as a factor able to reduce the disparity of Value should be verified in a sample with male teachers. The collection of drawings outside the school context could also be useful to verify to what extent the teacher is recognized as a significant other when he/she is not present and can be compared to other adult figures (Cameron et al., 2020). Measures of teachers' ideas on teaching–learning processes (e.g., Vettori et al., 2019; Bessette and Paris, 2020) as well as other measures of pupils' perspective (e.g., Longobardi et al., 2009; Pezzica et al., 2016) could help to interpret the context in which the teacher's authority is implemented and pave the way for an examination of individual differences in its perception.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving human participants were reviewed and approved by the Ethics committee of Developmental and Social Psychology Department, Sapienza University of Rome. Written informed consent to participate in this study was provided by the participants or their legal guardian/next of kin.

Author contributions

AD performed the statistical analysis and contributed to the conception and design of the study and interpretation. AB wrote the first draft of the manuscript and contributed to the conception and design of the study and interpretation. EC contributed to the data collection, scoring, and interpretation. GP contributed to the conception and design of the study, interpretation, and critical revision of the article. All authors contributed to the manuscript revision, read, and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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The knowledge produced through student drawings

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Drawings have been extensively used as a research method to gather data from research participants including school students regarding their perceptions of mathematics and its teaching and learning. What is valued in drawing-based research in mathematics education, and what kind of knowledge is produced through student drawings, however, is not known. This study examines drawing-based research studies to understand these questions by applying a novel framework – the legitimation code theory (LCT). The study focuses on two cases: one of which looked at middle school students' images of mathematicians (draw a mathematician) and the other examined the same age group students' descriptions of mathematics classrooms (draw a mathematics classroom). Within both studies, greater emphases are on the students' perceptions relating to the discipline-related issues such as teaching and learning of mathematics, mathematics classroom experiences, and practices and tools of mathematicians. Students' perceptions of the mathematics discipline and their attitudes toward mathematics and perceptions of the attributes of mathematicians are also a focus. The study offers the LCT approach to critically analyze the drawing-based research in the mathematics education field to contribute to the production of significant and needed knowledge in the field.

KEYWORDS

draw-a-mathematician-test, draw-a-mathematics-classroom-test, legitimation code theory, student drawings, mathematics education

Introduction

As a research method, drawings have been extensively used to collect data from school students with respect to (for instance) their views about mathematics (Rock and Shaw, 2000), mathematicians (Aguilar et al., 2016) mathematical practices (Johansson and Sumpter, 2010), their views about assessment practices in mathematics classrooms (Remesal, 2009) or high-stakes mathematics tests (Howell, 2017), and classroom practices in mathematics lessons (Pehkonen et al., 2016). A summary of the origin of the drawing-based method with a focus on mathematics education can be found in Hatisaru (2020b). Reviews of previous research using drawing-based method may be found within Hatisaru (2019a) and Hatisaru (2020a). What we know less about is what might be valued and emphasized in drawing-based research in mathematics education, and what kind of knowledge is produced through student drawings. This study aims to investigate these questions and makes an original contribution to the literature. The study follows an untypical (Niss, 2019) form that represents the variety of important elements of mathematics education research (Bakker, 2019) through a thoughtful and unique design and produces a product (Sümmermann and Rott, 2020): a way to look at drawing-based research. That is, by employing a novel framework, legitimation code theory (LCT; Maton, 2014), the study puts the spotlight on the orientations underlying to drawing-based research and offers a conceptualization that can be used to critically analyze the contribution of drawing-based research to the mathematics education field. LCT was selected as the conceptual referent for the study, as it supports analysis of knowledge practices within academic disciplines including STEM education (Winberg et al., 2019; STEM stands for science, technology, engineering, and mathematics) and perceptions of students of subject areas including mathematics, natural science, and psychology (Maton, 2007).

Background for the study and research question

The author investigated a large sample of middle school students' perceptions of mathematicians and their work through analyzing their draw-a-mathematician-test (DAMT; Picker and Berry, 2001) pictures (hereafter referred to as the DAMT research). The students' drawings (Figure 1) grouped into two separate categories: drawings depicting a mathematician at work (Hatisaru, 2020c), or drawings depicting a mathematics teacher in the classroom (Hatisaru, 2019a). The author explored the types of teaching in mathematics classrooms according to the students by concentrating on the latter group (Hatisaru, 2019b). This investigation showed that most students pictured a mathematics classroom where learning was predominantly directed by the teacher, and classroom practices were mainly performing procedures. However, the results were limited, as they were based on students' drawings of mathematicians. To that end, they yielded a need for future explorations. In response to that, the author explored teaching and learning practices in mathematics classrooms by examining a sample of the same age students' drawings of their mathematics classrooms through an adaptation of the DAMT: draw-a-mathematics-classroom-test (DAMC) (Hatisaru, 2020b; the DAMC research). The findings showed that students described mathematics classes as heavily teacher-directed where the teacher was mostly pictured at the whiteboard when lecturing, demonstrating, or explaining (Figure 2; Hatisaru, 2020a), complementing results of the previous study (Hatisaru, 2019b).

As a research method for examining students' perceptions of mathematics classroom practices, one of the main implications of the DAMT and DAMC research studies has been that student drawings contain rich and genuine information, as also revealed in Laine et al. (2020) study. As such, the research methods used in these two research studies provide researchers with a tool to explore the codes underlying drawing-based research. The present study aims to achieve this goal. Drawing on data from the DAMT and DAMC research studies, the study investigates the question: what kind of knowledge is emphasized and produced within drawing-based research in the mathematics education field? The term 'knowledge' is used to indicate the new information added to the shared knowledge of the educational field through research. The term 'codes' is used to indicate the emphasis in a particular study or the knowledge base that is produced from it.

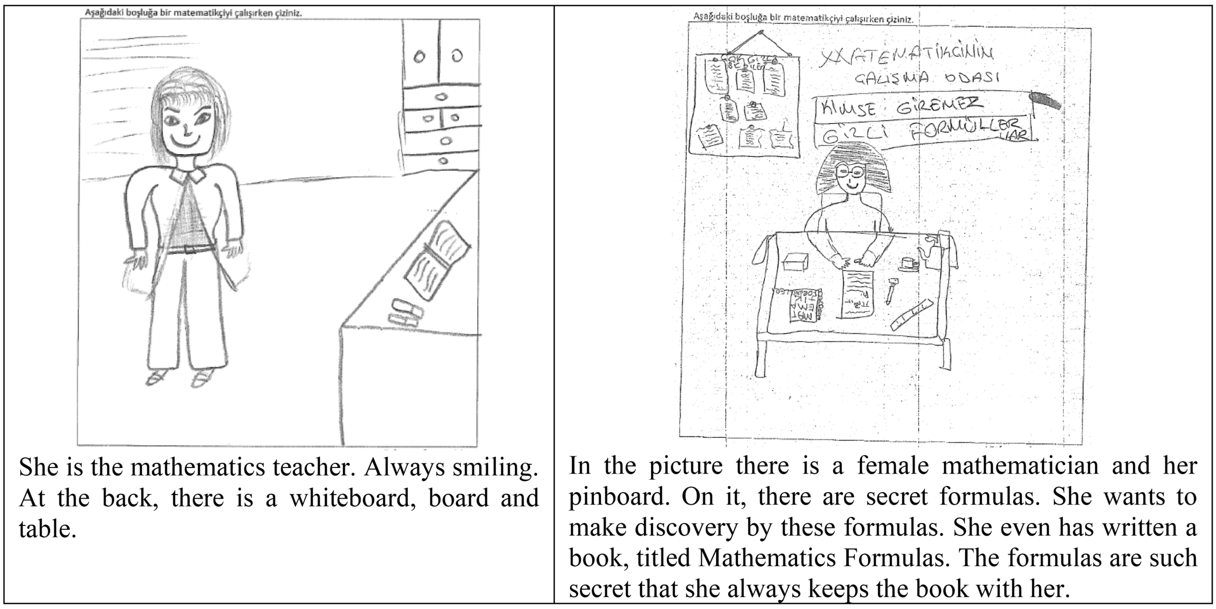

FIGURE 1
Examples of draw-a-mathematician-test (DAMT) research drawings (Hatisaru and Murphy, 2019).

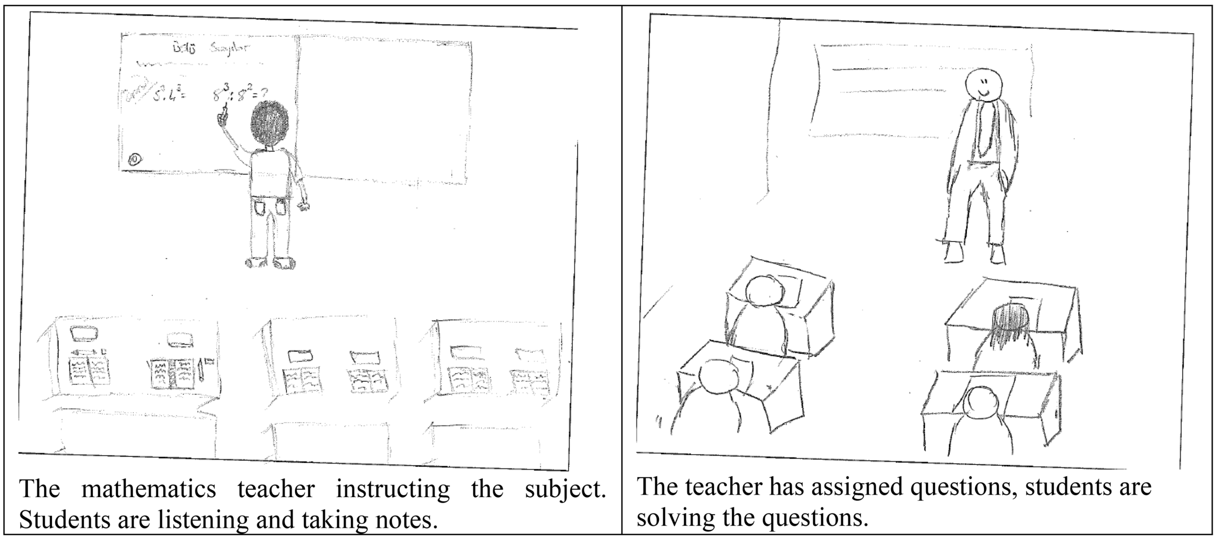

FIGURE 2
Examples of draw-a-mathematics-classroom-test (DAMC) research drawings (Hatisaru, 2020a).

An analytical framework for analyzing drawing-based research: LCT

The practice in research in general is producing knowledge. As the drawing-based methods provide an opportunity to produce knowledge in mathematics education, in this study, LCT (Maton, 2014) is used as the analytical framework. LCT is a conceptual tool used for analyzing knowledge-based practices within academic fields including online education (Maton and Chen, 2020), design disciplines (Carvalho et al., 2009), and STEM education (e.g., Winberg et al., 2019). The most elaborated dimensions of LCT are specialization, semantics, and autonomy. The core assumption of specialization is that any type of knowledge, beliefs, or practice claims are about something, and practiced by someone. Two types of relations are identified regarding specialization in a field or practice: epistemic relations (ERs) that are oriented toward an object (e.g., STEM disciplinary knowledge) and social relations (SRs) that are oriented toward a subject (e.g., STEM dispositions; Maton, 2014). Specialization (i.e., what can be objectively described as knowledge and/or who can be considered as a legitimate knower) is identified based on these relations.

The ER and SR within a specific practice, field, or event may be more strongly (+) or weakly (−) underlined in that practice, field, or event. Four main specialization codes (ER+/−, SR+/−) are originated according to their strengths (Maton and Chen, 2020). The relative strengths can be located into four quadrants in the specialization plane with infinite positions (Maton, 2014), and they form the basis of legitimation, focus or success in the relevant practice (Winberg et al., 2019). The codes that represent relative strength of relations that fit in four quadrants are: knowledge code (ER+, SR−); élite code (ER+, SR+); knower code (ER−, SR+); and relativist code (ER−, SR−).

Whilst the drawing-based studies fit in the knowledge quadrant would focus on perceptions relating to the mathematical content (e.g., the concept of line, ratio, or function), studies in the élite quadrant would focus on perceptions relating to the discipline-related issues (e.g., mathematics learning experiences). Studies in the knower quadrant would focus on dispositions of individuals toward mathematics or their views about mathematicians (e.g., the mood of mathematicians), and, though it is less probable, studies in the relativist quadrant would have no/little focus on mathematical content and no/little focus on discipline-related issues (Figure 3). Therefore, these four codes provide a tool to explore the questions as follows: 'What are the emphases in this particular drawing-based study?' and 'What is the knowledge base that is produced from it?' The codes help to move beyond the surface and uncover the underpinning logic of the relevant study. Some of the drawing-based studies, for example, are likely to place much greater weight on the mathematics discipline itself, and some on the social elements of teaching and learning of mathematics, or other possibilities. By examining these codes, the underlying orientations in drawing-based research can be made more explicit.

Materials and methods

Study context

The current study was situated within two primarily qualitative, drawing-based research studies. The DAMT research explored middle school students' images of mathematics in which the DAMT, (Picker and Berry, 2001), was used to generate data. The image of mathematics construct in the DAMT research comprises

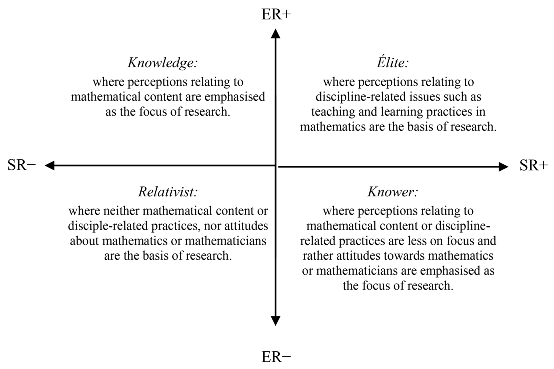

FIGURE 3
Epistemic and social relations in drawing-based research (based on Maton, 2014).

of students' views about mathematicians, perceived needs for mathematics in them, and their attitudes toward mathematics (Sam and Ernest, 2000). The DAMT combined a drawing task with two open-ended written items. The drawing task included picturing a mathematician at work and next describing the picture. One open-ended item asked about possible reasons for the need for mathematics and mathematicians aiming to understand students' perceptions of mathematics and the work of mathematicians. The other asked to complete the sentence: "To me, mathematics is …" aiming to examine students' stated attitudes toward mathematics. Data were gathered from a total of 1,284 grades 6 to 8 students, aged 11–14, enrolled in twenty different middle schools based in Ankara, Turkey.

The DAMC research looked at the same year group students' descriptions of mathematics classrooms. Data were collected from 400 students from three different middle schools in Ankara using the DAMC task (Hatisaru, 2020b). The students were prompted to imagine mathematics teachers and classrooms and draw a picture of their teacher teaching and themselves learning. Then they were prompted to describe the picture including activities of the depicted teacher, the students, and materials and tools that used by them. Comprehensive descriptions of the DAMT and DAMC instruments can be found in the studies presented in Supplementary Material.

The specialization plane would provide a means by which the author could investigate what is valued in the DAMT and DAMC studies, and accordingly, through student drawings, what kind of knowledge has been produced. The possible nature that ERs and SRs could reveal in these studies would vary depending on their strengths (Maton, 2014). The specialization plane would allow the focus of each study to be situated in different locations that might be viewed as reasonable, valued or more heavily weighted.

Data analysis

A translation device is necessary in order to operationalize the analysis of the data using the specialization plane (Maton, 2014). In this study, the translation device presented in Figure 3, generated based on Maton (2014), was used for data analysis. To elaborate, ERs in the knowledge, produced through the DAMT or DAMC research studies, describe stronger or weaker perceptions relating to the mathematics disciplinary content along a continuum, from perceptions highly related to mathematical content to little or no connection. SRs in the study reveal stronger or weaker forms of perceptions relating to the teaching and learning of mathematics along a continuum, from issues highly related to the discipline-related practices in mathematics to those less related. The knowledge quadrant has stronger ERs to perceptions relating to the mathematical content and has weaker SRs to the teaching and learning of and attitudes toward mathematics (ER+, SR–), whereas the knower quadrant has weaker ERs to perceptions relating to the mathematical content or discipline-related practices, and instead has stronger relations to attitudes toward mathematics (ER–, SR+). The élite quadrant has stronger relations to discipline-related issues (ER+, SR+).

The focus of each study, their research aim/questions and data analysis aspects, was analyzed using the lens of the specialization plane. Where the focus of a particular study foregrounded students' perceptions relating to the mathematics discipline (e.g., types of mathematical tasks), this aspect was interpreted as displaying a predominantly knowledge code. In contrast, where the focus of a study demonstrated aspects relating to students' attitudes toward mathematics or their views about mathematicians (e.g., mood of the mathematics teacher), it was clear that some knowledge on the views about mathematicians was produced, demonstrating a knower code. Where the focus was mainly on discipline-related practices of mathematics or mathematicians (e.g., the teacher's classroom activity), this was interpreted as demonstrating an élite code. A particular study might demonstrate more than one focus, and more than one code accordingly.

The analysis was intended to capture the general gist of the practice in the DAMT and DAMC studies, as opposed to a fine-grained micro-analysis, and this approach is defined as soft focus in LCT (Maton, 2014). This soft-focus analysis was applied to each of the studies. The analysis process then shifted to visualizing the focuses of each study on the specialization plane and positioning them on it (Figures 4, 5). These analyzes are presented and elaborated in the following section.

Findings

The DAMT research

The focuses of the DAMT studies are located predominantly in the élite and knower quadrants, and to a lesser extent in the knowledge quadrant (Figure 4). As elaborated earlier, the knowledge code represents a study focus which foregrounds ERs and backgrounds SRs (ER+, SR–). Within these studies, the knowledge produced representing the knowledge code includes students' perceptions of the mathematical content area. It is reported that Algebra, Numbers and Operations, and Geometry were the remarkable mathematical content domains in the students' DAMT portrayals (e.g., Hatisaru, 2019a, 2020c). In addition to these, some mathematical theorems (e.g., Hasse-Arf Theorem) were captured in a few students' drawings which depicted a mathematician (Hatisaru, 2020c).

The élite code foregrounds both epistemic and SRs (ER+, SR+). The knowledge produced representing this code is typically where students' perceptions relating to the work of, and the tools used by, mathematicians (Hatisaru, 2020c) and mathematics teachers (Hatisaru, 2019a) are provided. The findings include that, according to the students, the chief discipline-related activities of mathematicians were studying or creating mathematics, and the chief activities of mathematics teachers were teaching, explaining, or demonstrating. The primary tools used by mathematicians and mathematics teachers included a whiteboard and books, and in a few cases concrete materials and technological tools (Hatisaru, 2019a, 2020c).

Students perceived their mathematics classrooms to be chiefly teacher-directed where the teacher was at the center of learning. There was little group or peer work, and the main classroom resources were a whiteboard and books. In a few drawings where the mode of instruction identified was potentially more student-oriented, students were found to be happier than in drawings where the mode of instruction was chiefly teacher-directed (Hatisaru, 2019b). Mathematics was found useful or necessary for basic everyday life tasks by most of the students such as performing financial calculations or using arithmetic, while some students found it useful for doing university studies. A few of the students thought that mathematics was necessary for problem solving, and a few others viewed mathematics as underpinning science and technology (Hatisaru, 2020d).

The knower code represents a study focus which foregrounds SRs and backgrounds ERs (ER–, SR+). The students' perceptions of the gender and attractiveness of mathematicians and mathematics teachers are among the knowledge produced representing this code (Hatisaru, 2019a, 2020c). It is reported that the students exhibited occupational gender stereotypes. They mostly viewed mathematics teachers as female (Hatisaru, 2019a) and mathematicians as male (Hatisaru, 2020c). While the female teacher stereotype became less strong by age group (i.e., fewer grade 8 students depicted the teacher as female compared to 6th and 7th-graders) (Hatisaru, 2019a), the male stereotype did not change. Many of the students at each grade level pictured male mathematicians (Hatisaru, 2020c). In general, the students reflected a positive mathematics teacher image which was smiley or serious and dedicated, while a small group of students expressed a relatively negative image of mathematics teachers which was angry or silly (Hatisaru, 2019a). Like mathematics teachers, many of the students associated positive feelings with mathematicians depicting smiley or serious, focused and dedicated mathematicians. Only a small number of students pictured a mad, angry, or silly mathematician (Hatisaru, 2020c).

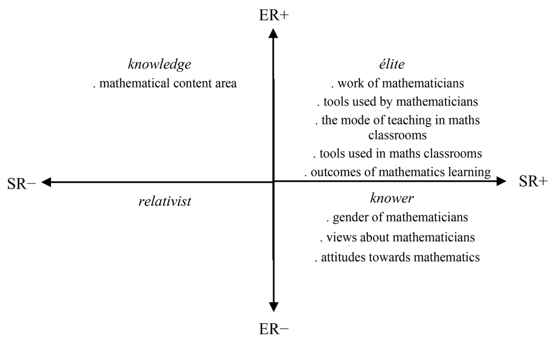

FIGURE 4
Mapping of the DAMT study focuses on the specialization plane.

The students' stated attitudes toward mathematics were found to be generally positive, whereas a small percentage of them stated negative feelings. Most of the responses to "what mathematics means to me" were in the nature mathematics is "an enjoyable subject," "very important" and/or "necessary" (Hatisaru and Murphy, 2019). An interesting observation was that the perceived negative image of the mathematics teacher could result in feeling unhappy in mathematics classrooms or a loathing of mathematics (Hatisaru, 2019a). Within a further investigation taken into how students' stated attitudes toward mathematics are influenced by their perceptions of the teacher, it was suggested that some of the students who perceive their teacher a 'creature' still might associate positive feelings with mathematics, as they find mathematics important and necessary for schooling, but some of them might dislike mathematics or have mixed feelings with respect to the need for learning mathematics due to their negative perceptions of the teacher (Hatisaru and Murphy, 2019).

The DAMC research

The focuses of DAMC studies are located in the knowledge and élite quadrants (Figure 5). As discussed earlier, the knowledge code represents a study focus which emphasizes perceptions relating to the specialized knowledge of mathematics discipline. The study focuses representing the knowledge code include students' perceptions of the mathematical content area, and the types of mathematical tasks used in mathematics classrooms and their representational form (symbolic, visual, verbal) (Hatisaru, 2020b). Findings revealed that mathematics was predominantly represented through symbolic representations in the students' drawings. Contextual or real-life based and open-ended tasks were not common, while the tasks that focused on procedural skills were the most usually included. Symbolic representations dominated student responses where the mathematical tasks were most commonly represented through numbers, equations, and expressions. Only a few of the students used verbal, visual or graphical representations (Hatisaru, 2020b).

The élite code emphasizes perceptions relating to how mathematics is taught or learned. The students' perceptions of the

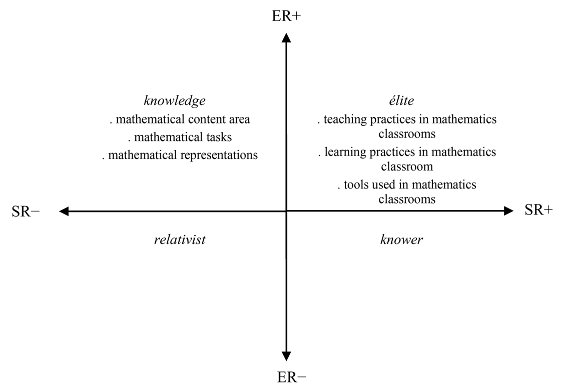

FIGURE 5
Mapping of the DAMC study focuses on the specialization plane.

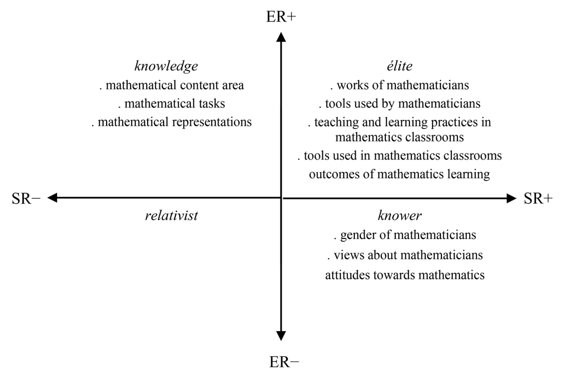

FIGURE 6
Mapping of the DAMT and DAMC study focuses on the specialization plane.

teaching and learning practices in their mathematics classroom, and materials and resources used in the teaching and learning of mathematics, (Hatisaru, 2020a) represent this code. It was found that the students perceived their mathematics classroom as chiefly teacher directed. That is, the teacher is the conductor of learning and instruction. The teacher usually demonstrates and explains the content and asks or solves closed mathematics questions with one answer (e.g., $2x-3=7$, find x). Students are relatively passive; they listen to the teacher who is at the center of class and teaches. The class usually engages in solving routine questions. There are almost no content-related interactions among students in the classroom, and interactions between the teacher and students are limited to the teacher asking routine mathematics questions and students giving responses to them. The main teaching and learning resources are a whiteboard and notebooks or textbooks (Hatisaru, 2020a).

Discussion and conclusion

The focuses or emphasis (dominant codes) within drawing-based research practices are not generally discussed in mathematics education literature. In this study, what might be valued and emphasized on within drawing-based research is explored by applying the LCT (Maton, 2014) to two drawing-based research studies. They are the DAMT which investigated middle school students' images of mathematicians (Hatisaru and Murphy, 2019; Hatisaru, 2019a, 2019b, 2020c, 2020d) and the DAMC which examined the same age group students' descriptions of mathematics classrooms (Hatisaru, 2020a, 2020b) studies (Supplementary Material). The focuses of the two cases are distributed over three quadrants in the LCT specialization plane with a significant involvement in the élite quadrant. This indicates that, within both cases, greater emphases were on the students' perceptions relating to the discipline-related issues such as teaching and learning of mathematics, mathematics classroom experiences, and practices and tools of mathematicians. Students' perceptions of the mathematics discipline and their attitudes toward mathematics and perceptions of the attributes of mathematicians were also a focus, located in the knowledge and knower quadrants, respectively (Figure 6).

The study has neither intended to review all existing drawing-based research studies in the field nor has suggested that knowledge-code studies are significant than knower-code studies, or vice versa. As Maton (2014) indicates, there are many contexts within which knower-code studies are needed and many others within which knowledge-code, or élite-code, studies. Rather, drawing data from two cases, the study aimed to illustrate how LCT offers an approach to investigate the kinds of knowledge produced through student drawings. Employing this novel approach, fruitful insights may arise about what drawing-based research studies within the mathematics education field put greater emphasis on. Using the specialization plane not only reveals what is produced, but also shows the gaps in the literature. That is, whether more research is needed to address students' perceptions of mathematical ideas, concepts, and procedures (knowledge-code studies), or key issues relating to the teaching and learning of mathematics (élite-code studies), or students' dispositions about mathematics or mathematicians (knower-code studies). To that end, this approach potentially contributes to the production of significant and needed knowledge in the field, and this is where further investigations are warranted.

Limitations, future directions

This study investigated the question: What kind of knowledge is emphasized and produced within drawing-based research in the mathematics education field? While the findings provide very useful information about the potential emphasis in drawing-based research studies, and the new knowledge added to the shared knowledge of the educational field through them, there are three limitations of the study that need to be considered. First, to the author's knowledge, the LCT has not been used yet for investigating knowledge practices in drawing-based research in the mathematics education field, whilst it has been widely used for researching knowledge practices based on the other forms of data (e.g., textual; e.g., Maton, 2007; Winberg et al., 2019). As one of the first attempts, the author has generated the translation device presented in Figure 3 based on the existing research. Other mathematics education researchers may generate different translation devices and plausibly may find different or additional findings to those found in this study. The author hopes that mathematics education researchers will pursue this possibility.

Second, examination of all relevant drawing-based research studies was not the intention of the study; rather, the study focused on two cases. Results may vary depending on the context of drawing-based research studies that are examined and the sample size. The study, however, offers a conceptualization that can be used to critically analyze the contribution of drawing-based research in the mathematics education field. Follow-up studies are recommended using the operationalizations developed in this study on the existing drawing-based research studies in mathematics education. More importantly, the study approach may provide researchers with useful insight regarding identifying the gaps in the literature: i.e., whether more research is needed to address students' perceptions of mathematical ideas, concepts, and procedures (knowledge-code studies), or key issues relating to the teaching and learning of mathematics (élite-code studies), or students' dispositions about mathematics or mathematicians (knower-code studies).

Third, the data was analyzed by the author, who had conducted the DAMT and DAMC research studies. Relying on pre-existing self-reported data might have weakened the validity of data analysis, and the author employed several validation processes to overcome that limitation. For example, the translation device employed in this study (Figure 3) was generated based on Maton (2014) and the author's earlier applications of the LCT to STEM education (e.g., Hatisaru, 2021). Those earlier LCT works were helpful to refine definitions of the codes in this study before applying them to the two cases. Moreover, findings from the two cases were presented comprehensively in the Findings section. These rich descriptions not only contribute to the validity check mechanism but are also useful for understanding students' perceptions of mathematics, mathematicians, teaching and learning practices in mathematics classrooms. Finally, mapping of the focuses and data analysis aspects in the DAMT and DAMC studies with the four LCT codes was presented in Supplementary Material to give the reader a sense of how LCT codes were used in data analysis.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary material, further inquiries can be directed to the corresponding author.

Author contributions

The author confirms being the sole contributor of this work and has approved it for publication.

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Conflict of interest

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyg.2022.1042383/full#supplementary-material

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Draw yourself: How culture influences drawings by children between the ages of two and fifteen

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The place children live strongly influence how they develop their behavior, this is also true for pictorial expression. This study is based on 958 self-portraits drawn by children aged 2–15 years old from 35 countries across 5 continents. A total of 13 variables were extracted of each drawing allowing us to investigate the differences of individuals and environment representations in these drawings. We used a principal component analysis to understand how drawing characteristics can be combined in pictorial concepts. We analyzed the effect of age, gender, socioeconomic, and cultural factors in terms of complexity and inclusion of social (human figures) and physical (element from Nature and man-made elements) environments, their frequencies, size, and proportions of these elements on each drawing. Our results confirm the existence of cultural variations and the influence of age on self-portrait patterns. We also observed an influence of physical and socio-cultural contexts through the level of urbanization and the degree of individualism of the countries, which have affected the complexity, content and representation of human figures in the drawings studied.

KEYWORDS
representation, self-portrait, cross-cultural study, drawings, child development

Introduction

Drawing is one of the different ways that human beings express themselves (Lange-Küttner, 2020). This was already the case thousands years ago, as shown by the Sulawesi warty pig painting found on the walls of a cave in Indonesia and dated to at least 45,500 years ago (Brumm et al., 2021). Long seen as the prerogative of modern humans, the findings of older traces cast doubt on the identification of the first species to show drawing behavior. To date, human lineage alone has the capacity to produce figurative drawings (DeLoache, 2004). In young children, drawing is a fundamental early activity as they have not mastered verbal language at this age (Wallon et al., 1998). The analysis of children's drawings became a very active and pluridisciplinary research area from the end of the 19th century onward, and are now a central interest for many researchers who hypothesize that children's drawing productions represent their state of mind, thus providing a doorway into their internal world (Rübeling et al., 2011).

But how should we define drawing? This term simultaneously defines an action (a behavior) and an artifact (the result of this behavior) (Kourkoulis, 2021). Drawing behavior makes it possible to represent objects, thoughts or feelings through visible graphic elements, regardless of whether they are interpretable or not (Martinet et al., 2021). Humans therefore use drawing as a projective tool that can make their internal life, perceptions and experiences visible (Ouedraogo, 2015). This "mirror of the soul" reflects the representativeness of a drawing, and results from the perspectives of both, the one who produces it and the one who observes it. Thus, the child who draws possess an internal representativeness of his or her work, while the adult who analyses the drawing only perceives its external representativeness (Martinet et al., 2021). The more similar the representativeness of both perspectives is, the more convinced we are that children world can be understood from their drawing. A drawing is therefore described as figurative when it can be read without ambiguity by others and permits communication (Kourkoulis, 2021), whatever its degree of realism (Willats, 2005). The analysis of this drawing allows us to understand certain aspects of representations by children, and namely their self-image.

In this respect, it is therefore essential to take into account the development of drawing behavior in humans (Toku, 2001; Lange-Küttner, 2008, 2014). Pictorial expression is made possible by the interaction of three ontogenic stages. The first is the improvement of the child's motor coordination. The second is the development of perceptual skills, which increase with improved levels of attention. And finally, the third corresponds to cognitive skills, notably when the child understands the symbolic meaning of objects and establishes pictorial repertoires (Toomela, 2002). The neurological development occurring during early childhood (0–4 years) allows children to understand themselves and others, at around the age of three, and gives them the ability to communicate with the help of visual symbols (DeLoache, 2004). Children motor and cognitive development is therefore the root of the progressive complexity of their drawings.

Many researchers (Luquet, 1927; Lowenfeld and Brittain, 1987; Baldy, 2005; Royer, 2005; Marcilhacy and Demirdjian, 2011) concur that regardless of the environment in which the drawing child has grown, there is a progression that begins with scribblings, then figurative sketches and finally detailed drawings (Golomb, 1992). Toward the age of two, children begin to draw and include certain graphical elements that they seek to reproduce (Picard and Zarhbouch, 2014). These first artistic productions are referred to as *scribbles* (Kellogg, 1970). At the age of 3–4 years, the first representations of human figures appear in the form of *tadpole figures*. Subsequently, entering infant school provides children with an opportunity to draw, write and understand socially shared meanings (Cox, 1992). This training increases their drawing experience and their use of figurative signifiers (Martinet et al., 2021). Thus, children add external representativeness to their drawing from the age of 4–5 years (Baldy, 2005). Their productions then become more and more differentiated and complex with age (Golomb, 1992), before reaching a critical period at puberty (i.e., period of oppression) (Cohn, 2012) when their drawing activity ceases in favor of verbal language, which is more flexible and economical (Baldy, 2011). An important point is that this critical period as well as other stages of graphic development are not always found at the same ages or in the same way from one culture to another (Toku, 2001; Cohn, 2014).

Drawing behavior is therefore composed of an innate element–a blind individual not exposed to a graphic universe will have resilient capacities to produce a rudimentary figurative drawing (Millar, 1975; Golomb, 1992; Andersson and Andersson, 2009; Cohn, 2012)- but also has another culturally acquired component (Cohn, 2012; Picard and Zarhbouch, 2014). Indeed, the existence of the above general models does not rule out the influence of environmental factors (Rübeling et al., 2011). The recognized importance of cultural variations have changed the way drawing behavior was perceived; it would henceforth be seen in more flexible and diversified terms, some researchers going so far as to speak of graphic language (Goodnow et al., 1995; Baldy, 2011). Verbal language and graphic expression therefore share many similarities and particularly their culturally specific character (Kourkoulis, 2021). The UNESCO defines culture as a set of distinctive spiritual, material, intellectual, and emotional features that characterize a society or a social group. An organized social unit, whether familial, societal or media-based, thus holds its own understanding of the world which is transmitted throughout generations. In this way, children gradually develop a culturally informed understanding of themselves and others (Rübeling et al., 2011; Kourkoulis, 2021). The eco-cultural approach defines two major developmental strategies. In the first, each person sees themselves as part of an economically and socially interdependent whole: this is called the *interdependence strategy*. Conversely, the self is central in the second strategy, and the individuals see themselves as unique and separate from others: This is called the *independence strategy* (Keller, 2007). Children therefore have a different perception of themselves and others according to their culture (Markus and Kitayama, 1991), and this can be observed through their drawings (Rübeling et al., 2011). These two strategies will influence many human behaviors as the way pedestrians cross the road (Pelé et al., 2017), how they share rewards (Kim et al., 1990) or knowledge (Moss et al., 2007). Then, if asked to realize a self-portrait, we may hypothesize that a child from an individualistic culture will represent him/herself in bigger proportions compared to a child who grows in a more collectivist one. In this latter case, we can imagine that the child will implement other people or others elements in his/her self-portrait.

Paying attention to the influence of culture on drawings is relatively recent (Jolley et al., 2010), but some authors have confirmed the existence of cultural variations (Lindström, 2000; Cox et al., 2001; Toku, 2001; Cohn, 2014; Picard and Zarhbouch, 2014). When children draw human figures, they do not seek to represent an anatomically correct body but rather draw people (Rübeling et al., 2011) by varying the height, facial details (Gernhardt et al., 2015, 2016), and facial expressions (La Voy et al., 2001) of these representations. Studies based on qualitative data give examples of the influence of culture on young people who draw. Cox et al. (2001) observed that Japanese children draw motionless figures that are seen from the front or in profile, immobile or running, and that these drawings were of better quality than those drawn by children in the United Kingdom. The authors attribute this superiority to the influence of manga comics on Japanese children. Nomoto (2007) compares the Rey complex figures drawn by French and Japanese children and how these figures evolve over time. He found that while French children attach importance to the overall effect of their drawing and constantly improve the proportions of the figures they draw; Japanese children show meticulous attention to detail and draw increasingly detailed figures. Existing researches suggest that these trends may reflect the differences between the two education systems: The Japanese tradition encourages imitation and insists on the importance of paying attention to details, whereas French education encourages a more global and spontaneous cognition style (Cohn, 2014). The self-portrait is a good means to observe the cultural influence on drawing. Indeed, the predominant cultural model is imprinted on our sense of identity, and reflects partly the degree of attachment we have for the elements surrounding us (Kourkoulis, 2021). The presence or absence of environmental details in the drawings therefore appears to testify their value to the child (Picard and Zarhbouch, 2014).

Studies have observed the understanding of the self and of the social world from the details of drawn human figures, but few have closely examined the elements of environment (elements from Nature and man-made objects) depicted in these drawings. On the same way, only few studies focused on the influence of the level of urbanization on the drawings of children (Rübeling et al., 2011). Moreover, the number of cultures and countries considered in cross-cultural studies is also very limited. Current research mostly focuses on Joseph Henrich's W.E.I.R.D. acronym, which designates Western, Educated, Industrialized, Rich, and Democratic societies (Henrich et al., 2010); it is therefore important to study other societies in order to obtain a clear and global picture of drawing behavior in our species. Our study sought to observe the differences in the representation of the individual and of their environments (social and physical) in self-portraits drawn by children from a large number of countries. We analyzed a total of 958 scanned and available self-portraits produced by children aged 2–15. These children were from 35 countries located on 5 different continents (Porte, 2012). In total, we measured 13 indices-based on classical studies of drawing in children (level of complexity, Baldy, 2005; representation of human figures, Rübeling et al., 2011) but also representation of non-human elements (from Nature and man-made objects)-that we implemented in a principal component analyses (PCA). PCA is used to extract and visualize important information contained in a multivariate data table by combining metrics to form a biologically or psychologically significant dimension, as already shown for personality (Wolf and Weissing, 2012; Bousquet et al., 2015), sociality (Viblanc et al., 2016) or even for drawing (Sueur et al., 2021). This method is expected to combine indices in dimensions linked to important psychological or cultural concepts as the self-representation, the family, or the importance of elements from Nature or man-made objects. We expected that these dimensions will be directly linked to the socioeconomic and cultural environment of children. We also expected drawings to be exclusively self-portraits in individualistic societies (i.e., independence strategy) and to be opened to the family or to elements of Nature in collectivist ones (i.e., interdependence strategy). Children from urban areas may have access to a more graphical environment (architecture, advertising, etc.) which can contribute to the way they represent themselves. Considering that self-representation develops from scribbling to the tadpole figure and finally to more detailed and realistic drawings, we also sought to determine whether any aspects of the drawings could be associated with the age and the gender of the children.

Materials and methods

Collection of drawings

The drawings are 958 self-portraits by children (468 girls; 475 boys; 15 not stated) aged 2–15, from 35 countries spread over 5 continents. In each country, drawings were collected in one to four towns (details given in **Supplementary Table 1**). They are taken from the Early Pictures online archive and were collected between 2005 and 2012 by the French photographer Gilles Porte[1]. Analysis concerns only one drawing per child. The drawings presented by Gilles Porte were produced according to the following procedure: Children were given a sheet of black paper in format A5 and a white pencil (crayon). The crayon

1 https://www.early-pictures.ch/porte1/archive/en/

was prepared (sharpened) in advance. Children were asked to position the paper in "portrait" format when drawing. After such preparation, the children were asked to draw themselves. No further comment was given, and the time of drawing was free. When they finished, they gave back the papers, and names and ages were indicated on the back of drawings by Gilles Porte and the adults in charge on site. The satisfactory balance of this database allowed us to consider both age and gender of children (**Figure 1**).

Ethical note

Children's participation in the creation of this database was on a voluntary basis and was subject to school approval and parental consent. The photographer, Gilles Porte, was given help and permission from Non-Governmental Organizations and the UNESCO to approach certain populations. We have respected the license of this database insofar which was strictly used for research purposes at the Hubert Curien Pluridisciplinary Institute (CNRS), a state-recognized research institute. The database was solely used to discuss the pictorial development of children, with no individual psychological or psychoanalytic interpretation. The ethical rules of this database have therefore been respected.

Drawing analysis

All measures were made by SR and double-checked by MP following ethological sampling (Pelé et al., 2021; Sueur et al., 2021). For each drawing, the following stages of analysis were performed.

Interpretation of the drawing

Each drawing was coded as *figurative* if it had an unambiguously recognizable external representation, *non-figurative* if no graphic element could be interpreted by an outside observer, or *mixed* if it contained both figurative and non-figurative elements.

As previously said, children can represent elements or people that are valuable for them in their drawings (Picard and Zarhbouch, 2014; Kourkoulis, 2021). So, in figurative and mixed drawings, we specifically looked at representation of human figures but also at non-human elements (Nature, man-made objects, and symbols).

Representation of human figures

Concerning the representations of human figures, we first used a recognized classification model that could determine their complexity. This is known as Baldy classification (Baldy, 2005), which defines six stages of transformation of the morphology of the human figure: The round and enumerated human figure (stage 1), the tadpole (stage 2), the intermediary (stage 3), the conventional man that is first filiform (stage 4) then tube-shaped man (stage 5), and finally the outline (stage 6). A mixed intermediate stage (stage 4b) has been added here to define the men composed of single and double lines. A lower (stage 0) has been created for non-figurative level drawings (**Figure 2**).

As the proportion and the level of details can differ from culture to another (Cox et al., 2001; Nomoto, 2007; Cohn, 2014), we then noted the number of human figures present in each drawing (for one individual, see **Figures 3A–C,E,F**; for several individuals see **Figures 3D,G,H**) and the presence (and the number) of sensory organs in the human figures (eyes, nose, mouth, ear, and hand).

Considering proportion of the human figures in the drawings, we measured the size of each head and body drawn by children using the GIMP 2.10.22 software (Peck, 2006). The precision of measurements was improved through the use of a 10 × 10 grid (Casti, 2016) as well as compass and selection tools. GIMP was also used to determine the minimum convex polygons (MCP) which is the smallest polygon that can be drawn around the extreme location points, and which has angles that all measure less than 180 degrees. Commonly used to estimate the home range of animals (Nilsen et al., 2008), MCP was calculated here to measure the coverage of the human figure on the sheet. MCP varies from 0 (no drawing at all) to 100% (the drawing covered the entire sheet). All of these analyses allowed us to add four new indices from our raw data, namely the complexity of the face, i.e., the sum of the observed facial elements ranging from 0 to 5; the proportion of the head to the body size for drawings of human figures (head-to-body ratio in centimeters); the size of drawings and the size of human figures as a percentage of the drawing sheet's coverage. We achieved this by dividing the minimum convex polygon by the total number of pixels of the sheet.

Representation of non-human elements

Four types of non-human figures have been considered: Elements representing Nature (e.g., tree, flowers, and sun; see **Figures 3A,B**), man-made objects (e.g., house, car, boat, and figure; see **Figures 3B–E,G**), symbols (e.g., heart and stars, see **Figure 3F**), and characters (i.e., letters or numbers, see **Figure 3E**). For each of these categories, the number of elements present in each drawing have been noted and since these different elements can be found on the same drawing, they are not exclusive. We also observed whether these drawings included a personification of Nature by noting the presence of facial details on the natural elements represented (see **Figures 3B,G**).

At the end of drawing analyses, a total of 13 variables were analyzed for each drawing, namely: (1) Its level of complexity [based on Baldy's (2005) classification] and (2) its type (*figurative*, non-*figurative*, and *mixed*); the presence of (3)

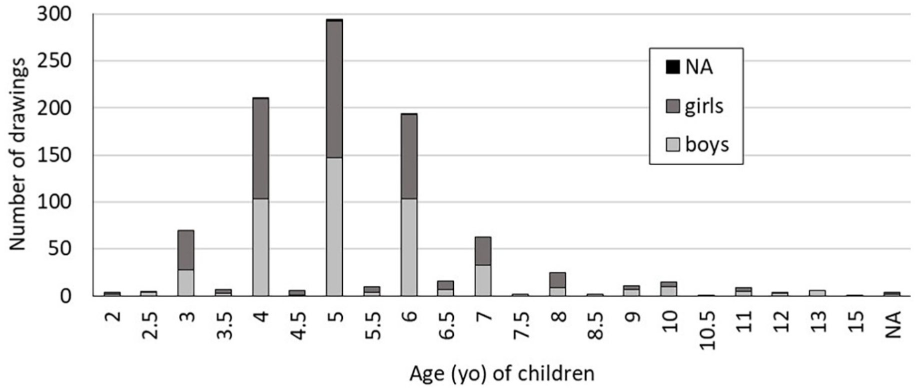

FIGURE 1
Numbers of drawings according the age and gender of children.

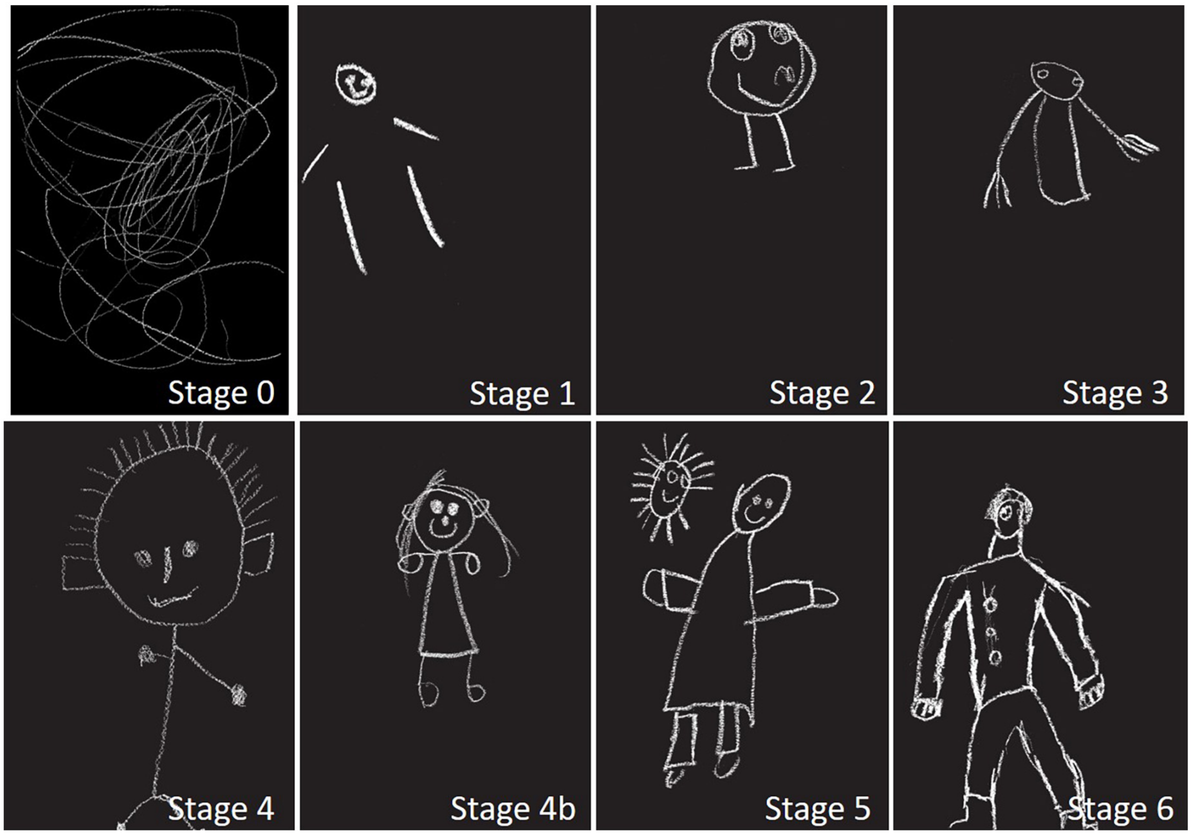

FIGURE 2
Examples of the different types of human figures examined in our study.

human faces and hands, (4) elements from Nature and (5) man-made objects, and (6) the personification of 4 and 5; (7) representations of animals, (8) additional human figures, (9) symbols, (10) letters and numbers, and finally the size of (11) head of human figure (ratio head/body), (12) human figures (MCP), and (13) entire drawings (MCP) (Table 1).

Specific indices of culture

As our study aimed to observe the influence of socioeconomic and cultural conditions on drawing behavior of children, data for three specific indices were collected to categorize each country. The first is the Individualism Index

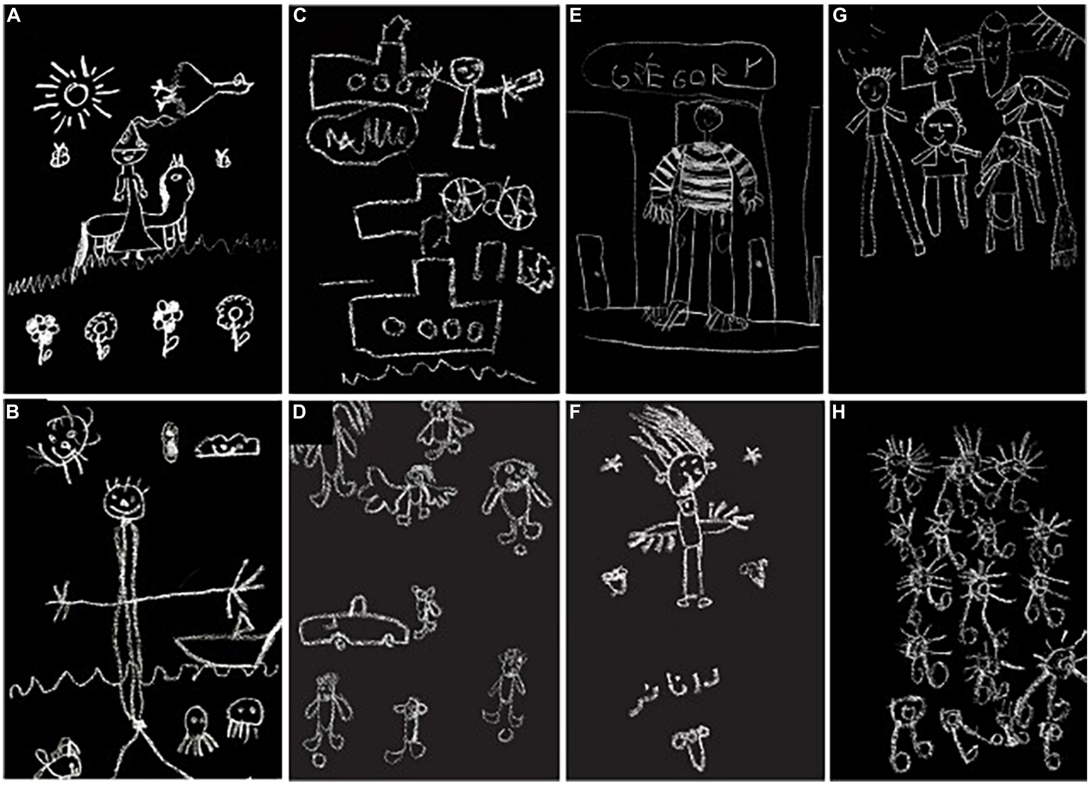

FIGURE 3
Examples of drawings. Four types of non-human figures have been considered: elements representing nature (e.g., tree, flowers, sun; **A,B**), man-made objects (e.g., house, car, and boat, **B–E,G**), symbols **(F)**, and characters (i.e., letters or numbers, **E**).

TABLE 1 Metric loading for the five PCA dimensions of our data.

Variables	Dim. 1	Dim. 2	Dim. 3	Dim. 4	Dim. 5
(1) Level of complexity (from Baldy, 2005)	**0.81**	−0.317	0.053	−0.045	−0.03
(2) Type of drawing (*figurative, non-figurative*, and *mixed*)	**0.826**	−0.267	−0.165	0.048	−0.082
(3) Presence of human faces and hands	**0.752**	−0.299	0.051	−0.009	0.16
(4) Presence of natural elements	0.317	**0.568**	−0.26	0.01	−0.017
(5) Presence of man-made objects	0.168	0.377	−0.082	0.122	**−0.503**
(6) Personification of elements 4 and 5	0.306	**0.525**	−0.278	−0.258	0.239
(7) Presence of animals	0.264	**0.501**	0.342	−0.24	0.176
(8) Additional human figures	−0.07	0.2	**0.625**	−0.283	−0.315
(9) Presence of symbols	0.139	0.196	0.065	**0.632**	0.271
(10) Presence of letters and numbers	0.135	0.133	0.131	**0.737**	−0.145
(11) Head/body ratio (in cm)	−0.154	0.055	0.303	0.043	**0.687**
(12) Size of the human figures (when present) (MCP)	0.412	0.079	**0.759**	−0.16	0.073
(13) Size of the entire drawing (MCP)	0.122	**0.799**	0.315	0.054	−0.016

Colored cells and boldness values indicate the dimension in which each variable was retained. Loading represents the correlation or importance of representativity of a variable in a dimension.
TA positive (respectively, negative) loading indicates a positive (respectively, negative) correlation between a variable and a dimension.
Bold and gray highlighted cases indicate loading for which variable were retained for a dimension, based on the highest value.

Value (IDV), which assesses the links between individuals and the members of their community as a degree measured on a scale of 0–100. A high IDV value indicates that the society can be considered more individualistic (i.e., an independent strategy), while a low value indicates a more community-based society (i.e., an interdependent strategy) (for details about factors included into this metric, see Hofstede, 2010). The second is the Urban Development Index (UDI) which corresponds to the percentage of the population living in urban areas compared to the total population of a country (Molinaro et al., 2020). Indeed, a child living in urban areas has access to a more graphical environment (architecture, advertising, etc.) which can contribute to the way he or she will draw and represent him/herself. However, a child in a largely rural country could have been recruited in a large city, while a child from a largely urban country from a small village whilst children were recruited in schools for which we can assume that they were not only passing through. Since urbanization of a country is not dichotomous but better corresponds to a scale we also and lastly consider the Inequality-Adjusted Human Development Index (IHDI). This index was developed by the United-Nations Development Program and reflects life expectancy, level of education and standard of living (access to culture, goods, services, and transport), and takes the country's inequalities into account.

In order to facilitate our data analysis and observe the influence of the main cultural trends, we split the 35 countries into six groups of culturally similar countries (CSC): Central and South America (CSA), Western countries (W), North and West Africa (NWA), Southern Africa (SA), Middle East (ME), and Asian countries (A) (**Figure 4**).

Statistical analyses

Once collected for each drawing, our 13 variables were grouped into interpretable dimensions *via* principal component analysis (PCA) performed with the R *FactoMineR* package (Lê et al., 2008). PCA is used to extract and visualize important information contained in a multivariate data table by combining metrics to form a biologically or psychologically significant dimension. Here, we aimed and expected metrics to be combined and form dimensions that correspond to cultural (CSC groups) or biological (i.e., age and gender) aspects of the drawing and show performance or aestheticism in the drawing (Dissanayake, 2001; Matthews, 2003). The dimensions obtained were used as response variables, and the coordinates of each drawing in each dimension allowed us to compare the drawings according to the age, gender, IHDI-IDV-UDI, and CSC group of the children. For this, we removed some missing values of our data set (27 drawings from Roma community because the living country of the children were undetermined, four drawings for which gender was not known, and four drawings for which age was not known).

In order to test the potential effect of our multiple independent variables (gender-age-CSCgroup-IHDI-IDV-UDI), we performed a multivariate linear regression model for each dimension of our PCA using the *lm()* function from the R *car* package (Fox and Weisberg, 2019). The potential collinearity between our predictor variables was tested by calculating the variance inflation factor (VIF) of the *car* package (Fox and Weisberg, 2019). This calculation enabled us to remove the IHDI variable that was too strongly correlated with the CSC group variable (VIF > 11) and confirm the absence of problematic (multi) collinearity with other variables (VIF < 4). Our models thus included two factors, namely gender (2 levels) and CSC group (6 levels), and 3 numerical variables, i.e., age, IDV, and UDI. Interaction between age and gender was tested but was not found to be significant and was therefore excluded from the model ($0.3 < p < 0.99$). Given the absence of a normal distribution and homogeneity in our values, we decided to carry out non-parametric tests. The preconditions for these tests were met by our numeric dependent variables, our balanced samples and weakly correlated predictor variables. The *p*-value was then calculated by sampling, performing a Monte-Carlo test with 1,000 permutations for each model with the *PermTest()* of the R *pgirmess* package (Giraudoux et al., 2018). Tests were run three times to check the statistical stability. The significant factors in our models were then observed more closely using *post-hoc* pairwise comparison with the *pairwisePermutationTest()* function of the R *rcompanion* package (Mangiafico, 2019). Consequently, a Benjamini–Hochberg correction was applied. Finally, we observed the force and direction of the correlations between the significant numerical variables and the PCA dimensions.

All the statistical models were carried out using the R software, version 4.0.2 (R Core Team, 2013) with $\alpha = 0.05$.

Results

Out of a total $n = 958$ drawings analyzed, 33% showed environmental elements as well as the self-portrait. Amongst these, 54% contained natural elements (9.5% of which had been personified), 12% showed animals, 13.5% man-made objects, 10% supplementary human figures, 4% symbols, et 3% letters or numbers. On average, the children drew on $35 \pm 20\%$ of the total paper sheet. Human figures took up an average $16 \pm 20\%$ of the drawing space and 87% of these figures included facial elements, with an average of 2.9 ± 1.5 facial details included per drawing.

Five dimensions were retained from the 13 variables for our PCA, with eigenvalues of at least 1. These dimensions explained 63% of the total data variance (dimension 1 = 18.8%, dimension 2 = 15.4%, dimension 3 = 11.4%, dimension 4 = 9.2%, and dimension 5 = 8.1%). Each metric showed a higher loading ($r > 0.5$) in one dimension compared to the others, thus enabling us to classify them (see **Table 1**).

Dimensions 1, 2, 3, and 4 show significant variables to which they are positively correlated, while the fifth dimension is positively correlated with the head-to-body ratio but is negatively correlated with the number of man-made objects. We were therefore able to determine that the first PCA dimension represented the complexity of the drawing but also the meaning, the second was characterized by the inclusion of the living

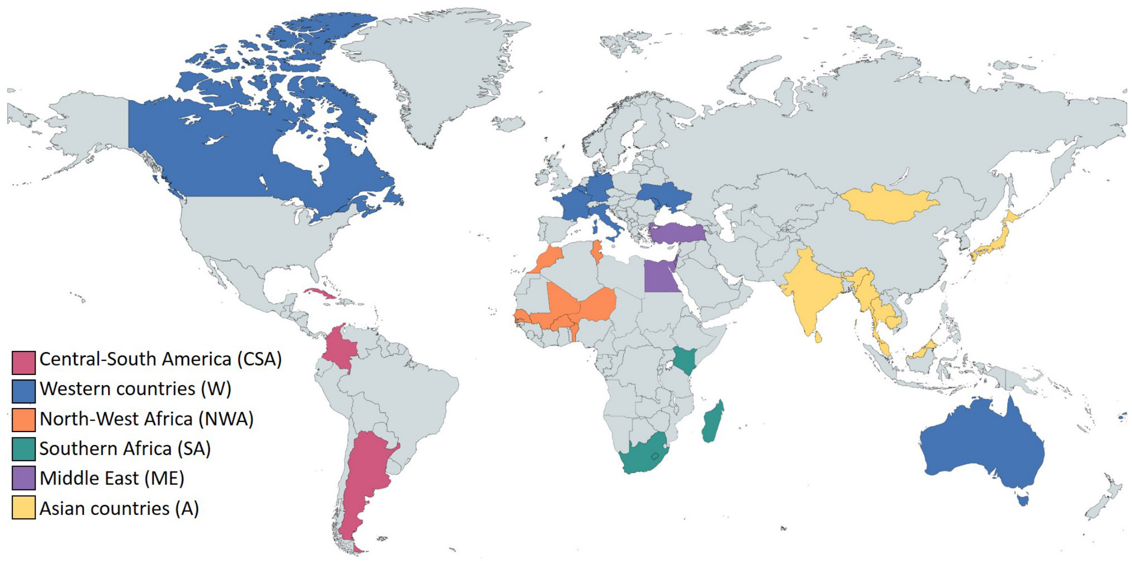

FIGURE 4
World map showing the countries and cultures studied.

environment, the third corresponded to the space attributed to human representation, the fourth represented the characters grouping together the symbols, letters and numbers, and finally the fifth dimension showed the construction of identity, i.e., the importance that children attribute to what they are, built on their own experience and in relation with others, or at least the relative importance of the self and of objects. Of course, this interpretation of the dimensions are quite subjective and we come up to this later in the discussion.

Following the removal of the 35 missing value lines from our dataset, $n = 923$ drawings were considered in our analyses based on the use of 10 variables (i.e., the five PCA dimensions; the gender; the age; the CSC group; the IDV; and the UDI). Three prediction variables were found to significantly influence the values of dimension 1: Age, CSC group, and the UDI (gender $p = 0.129$; age $p < 0.001$; culture $p < 0.001$; IDV $p = 0.885$; and UDI $p = 0.024$). However, pairwise comparisons revealed that there was no significant difference between countries groups ($p > 0.5$). We also observed that the complexity of the drawings increased with the age of the children ($t = 11.81$; $R^2 = 0.130$; $r = 0.361$) and to a lesser extent with the UDI ($t = 2.278$; $R^2 = 0.004$; $r = 0.067$) (**Figure 5**).

Two variables were significant in the second dimension (gender $p = 0.053$; age $p < 0.001$; culture $p < 0.001$; IDV $p = 0.946$; and UDI $p = 0.887$). These two variables are age and CSC group. *Post-hoc* comparisons revealed ten significant differences among pairwise comparisons between CSC groups (**Table 2**). More specifically, children from Central and South America showed more elements of the environment in their drawings than those from other cultures. Drawings by children from Western countries also included elements of their environment more frequently than those drawn by children from African countries and the Middle East. We also note that children living in Southern Africa tend to include fewer elements of the environment in their work than children from countries in North and West Africa, the Middle East and Asia (**Figure 6A**). The tendency to include elements of the environment decreases with the age of the children ($t = -6.423$; $R^2 = 0.041$; $r = 0.204$).

Three variables stand out significantly for the third dimension, namely age, CSC group, and IDV (gender $p = 0.954$; age $p < 0.001$; culture $p < 0.001$; IDV $p < 0.001$; and UDI $p = 0.907$). *Post-hoc* comparisons revealed seven significant differences between CSC groups (**Table 2**). As a result, we note that the space attributed to humans in children's drawings was significantly larger in Asia than in African countries and the Middle East. In addition, children from Southern Africa used less space for human representations than children from Central and South America, North and West Africa or–above all–Western countries (**Figure 6B**). It was also evident that the space attributed to human representations tended to decrease with age ($t = -3.40$; $R^2 = 0.011$; $r = 0.106$). Conversely, the amount of space increased with the IDV of the countries ($t = 3.683$; $R^2 = 0.013$; $r = 0.115$).

In the fourth dimension, two variables were significant, namely CSC group and UDI (gender $p = 0.084$; age $p = 0.415$; culture $p = 0.005$; IDV $p = 0.688$; and UDI $p = 0.042$). *Post-hoc* comparisons revealed significant differences between three CSC groups (**Table 2**). Children from the Middle East included significantly more characters in their drawing (0.3 ± 1.2) than Southern African (-0.1 ± 0.2) and North and West African

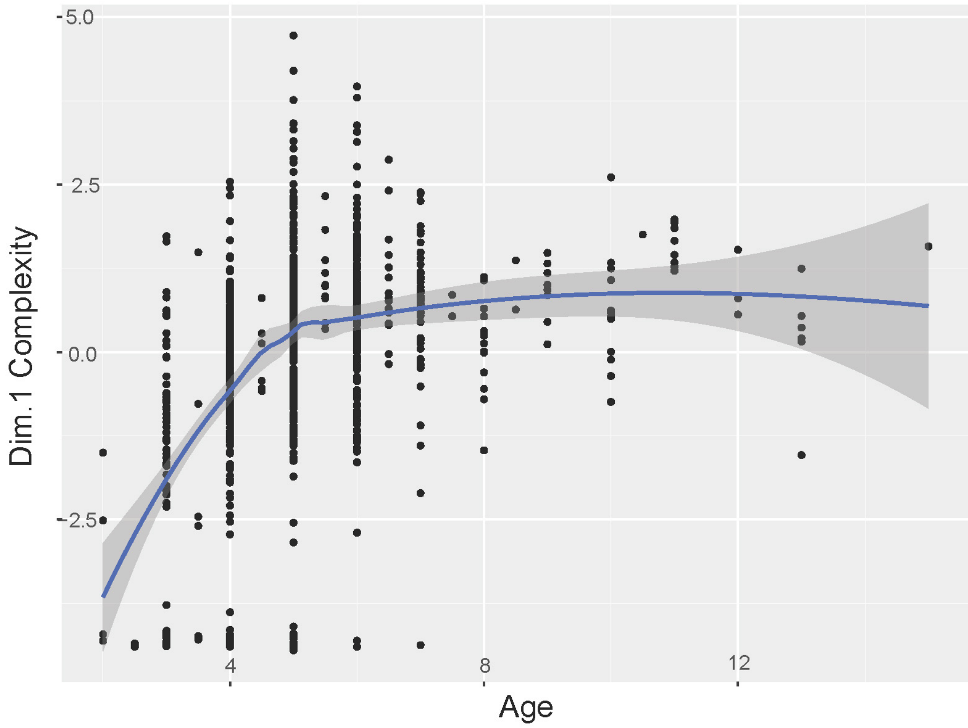

FIGURE 5
Children's drawing behavior for dimension 1 (i.e., complexity) according to age.

TABLE 2 Adjusted *p* of pairwise cultural similar countries (CSC) comparisons for dimensions 2–5 (**p* < 0.05; ***p* < 0.01; and ****p* < 0.001).

Countries	Dim. 2 environment	Dim. 3 individual	Dim. 4 character	Dim. 5 identity
A vs. CSA	< 0.001***	0.247	0.596	< 0.001***
A vs. NWA	0.263	0.042*	0.343	0.019*
A vs. SA	< 0.001***	< 0.001***	0.575	0.587
A vs. W	0.242	0.336	0.363	0.006**
A vs. ME	0.645	< 0.001***	0.076	0.421
CSA vs. NWA	< 0.001***	0.626	0.318	0.017*
CSA vs. SA	< 0.001***	0.008**	0.333	< 0.001***
CSA vs. W	0.007**	0.575	0.783	0.073
CSA vs. ME	0.002**	0.079	0.343	0.002**
NWA vs. SA	< 0.001***	0.042*	0.616	0.081
NWA vs. W	0.04*	0.241	0.124	0.587
NWA vs. ME	0.645	0.241	0.011*	0.28
SA vs. W	< 0.001***	< 0.001***	0.329	0.046*
SA vs. ME	< 0.001***	0.273	0.017*	0.587
W vs. ME	0.294	0.004**	0.385	0.146

Dimension 1 is not present as not influenced by the CSC variable.
CSA, Central and South America; W, Western countries; NWA, North and West Africa; SA, Southern Africa; ME, Middle East; and A, Asian countries.

(0.1 ± 0.9) children did (Figure 6C). The inclusion of characters also increases with the UDI (t = 3.127; R^2 = 0.009; r = 0.097).

Finally, the fifth dimension had three significant variables: CSC group, IDV, and UDI (gender p = 0.689; age p = 0.739; culture $p < 0.001$; IDV p = 0.008; and UDI p = 0.002). *Post-hoc* comparisons then revealed seven significant differences among CSC groups when compared two by two (Table 2). For example, Central and South American children drew human figures with larger heads in relation to their bodies and included fewer man-made objects in their drawings than children in all other cultures

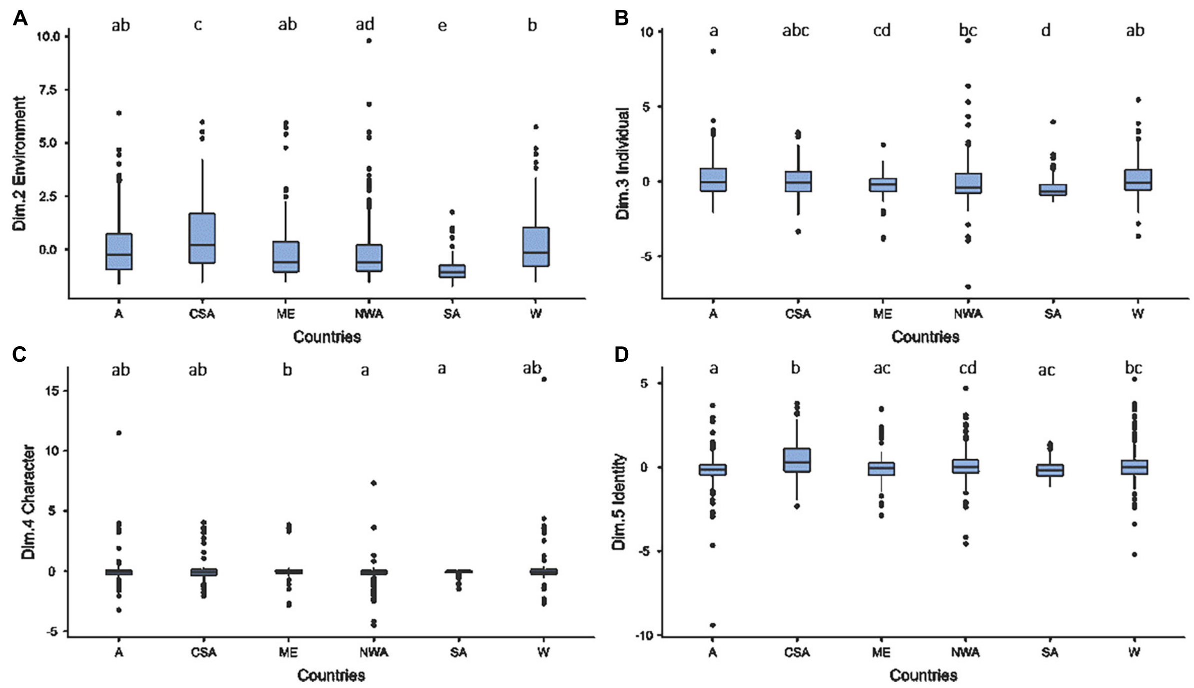

FIGURE 6
Comparison of children's drawing behavior for **(A)** the dimension 2 (i.e., environment), **(B)** the dimension 3 (i.e., individual), **(C)** the dimension 4 (i.e., character) and **(D)** the dimension 5 (i.e., identity). The countries groups that have no letters in common differ significantly.

except those of Western countries. Children in Western societies drew proportionately larger heads and fewer man-made objects than Asian and Southern African children. This tendency was higher in children in African countries than those in Asian countries (**Figure 6D**). Our analyses also showed that the UDI (t = 5.464; R^2 = 0.030; r = 0.097) and the IDV (t = 2.907; R^2 = 0.008; r = 0.895) were positively correlated with identity construction.

Our results do not indicate any significant effect of child gender on the specific drawing variables studied.

Discussion

Our study sought to verify the existence of cultural differences in graphical representations of the self and the social and physical environments, drawn by children aged 2–15 years and originating from different countries. Using a Principal Component Analysis, self-portraits drawn by the children were evaluated in terms of their complexity and meaning, the frequency with which children included elements of their environment, the proportions used to draw human figures and the space attributed to it in terms of the self (i.e., individualism) or the presence of objects (i.e., materialism) and finally the presence or absence of characters (i.e., letters, numbers, and symbols). This is the first time that pictorial elements described in many previous studies were analyzed and combined in this way, revealing patterns and structures that could be universally studied in drawings. The cultural differences that we observed in these self-portraits confirmed that drawing is partly an acquired behavior that is widespread in humans (Kourkoulis, 2021). The physical and sociocultural environments of children appear to shape many aspects of the graphical representations they produce.

Firstly, there was no significant difference in drawing complexity between the different cultures; we could therefore note a worldwide characteristic for the development of human figure composition, with the presence of general models that evolve as the child grows older (Golomb, 1992). The observation of similar scribbles in all the CSC groups evaluated suggests that this expression is a universal step in the development of graphism (Baldy, 2009). Indeed, cognitive and motor capacities must be developed before children can create representations; graphic complexity including the meaning of the production is therefore positively correlated with the growth of the child (Toomela, 2002). However, the influence of culture on this complexity strengthens the hypothesis that the acquisition of graphic shapes and skills differs according to each child's cultural environment. Contrary to certain studies, we have not noted an earlier development of complexity in drawings produced by Asian children who generally produce more detailed graphic compositions through the sustained learning of drawing behavior in their education systems and the common presence of manga drawings in their societies (La Voy et al., 2001). To remind, the Inequality-Adjusted Human Development Index (IHDI) we removed from analyses because of collinearity is linked with the CSC groups as with the urbanization level.

The urbanization level of children's living environments also affects their graphical production in different ways. Our findings show that children from urbanized environments produced more complex drawings with more facial details (Gernhardt et al., 2015) that are even present in their very first representations of human figures (Rübeling et al., 2011). The influence of urbanization is explained by the child's access to drawing materials and opportunities, in particular through the teaching of art at school, and the wide availability of graphical models that children can copy, particularly through the media. A child's graphical capacity is therefore likely to depend on the stimulation provided by their environment, which defines their experience of the pictorial world (Picard and Zarhbouch, 2014). Our findings also suggest that children in urban societies include characters (symbols, numbers, and letters) more frequently in their drawing. As education level is linked to urbanization, our result may be due to the wider presence of educational structures in urbanized societies, thus providing a favorable environment for the learning of verbal language and writing that are then reflected in the child's drawings. Linguistic differences could also explain the presence or absence of symbols or letters in drawings, because the complexity of certain native languages requires a faster evolution of the cognitive capacities that children also use to draw (Toku, 2001). Children who do not attend school and live in social environments with sparse sociocultural means have very limited graphical language and poor levels of inventiveness. Children who attend school and live in areas that are rich in sociocultural and artistic models develops a rich graphical language that facilitates creation. Finally, we observed that the level of urbanization also influences the construction of identity in children: In more urban societies, they are more likely to over-represent themselves in their drawings, with a larger head and the absence of man-made elements. Intercultural studies and the few available historical comparisons globally suggest that diverse cultural environments may provide different evolutive pathways leading to a wide range of drawing types (Baldy, 2009). Children from villages in developing countries are not "behind" Western children in terms of graphical development, but develop distinct graphical styles derived from different cultural patterns. They are on different developmental paths. As highlighted by Merleau-Ponty (2001), what we consider to be the "normal" endpoint of graphical development is actually one of many possible cultural achievements.

These parameters are also influenced by the degree of individualism inherent to each culture. Indeed, societies promoting individualism lead children from childhood toward independence and autonomy, both of which require the early development of confidence and self-esteem (Keller, 2007). This self-esteem is associated with a decrease in materialistic values in childhood (Chaplin and John, 2007), thus influencing graphical representations. Our results show that this individualism also influences the size and number of human representations in the drawings, thus confirming the conclusions of previous studies (Rübeling et al., 2011). The more individualistic a society is, the greater the child's perception of his own value within his culture will be and the more he will maximize his existence as an individual, in particular by representing himself graphically as a large figure that is alone on the paper (La Voy et al., 2001). The space attributed to human representations appears to decrease as the children grow older. This change could be explained by the increased precision and dexterity of graphical representations as the individual gets older, thus making possible to successfully produce smaller representations (Cohn, 2012).

Unlike some authors (Burkitt et al., 2004), we observed that the tendency to include environmental elements in self-portraits decreased with age. We believe that children's school and social experiences could gradually encourage the standardization of representations (Toku, 2001). As they grow older, children may therefore seek to shape their drawing to what their cultural model defines as a "good" representation, thus reducing the number of elements they include in their drawing (Rübeling et al., 2011). Gilles Porte's instruction to "*Draw yourself*" could also encourage children to use less elements to draw themselves (Martinet et al., 2021): The more detailed the instructions are, the more specific the drawings will be (Smith, 1993). Older children may therefore focus more on the instruction due to the evolution of their attention capacity and ability to retain information (Sutton and Rose, 1998), thus leading them to include fewer environmental elements in their drawings (Toomela, 2002). American, European and Asian children seem to give more importance to depicting living elements of their environment in their pictures. This brings us back to the idea that it is more common to see the personification of environmental elements in some cultures than in others (Court, 1992) but, in contrast to other studies, Asian children do not seem to depict more contextual elements than their American and European counterparts in this study (Masuda et al., 2008). Contrary to our expectations, we did not see evidence of a greater consideration of family or Nature in any of the self-portraits produced by children in collectivist societies. As the education level is linked to the CSC groups, our result may be explained by factors such as the exclusion of nature in educational practices (Toku, 2001), the influence of the media presenting more details and backgrounds in some cultures (Kourkoulis, 2021) or the imitation of traditional aesthetic styles of representation of the environment (Masuda et al., 2008). Contrary to other studies (Iijima et al., 2001; Lange-Küttner, 2011; Lange-Küttner and Ebersbach, 2013;

Bozzato and Longobardi, 2021; Bozzato et al., 2021), the gender of children does not appear to influence their drawings of self-portrait. However, it is difficult to demonstrate gender-related differences, and a more thorough analysis of further aspects and types of environmental details in drawings could provide us with a clearer picture.

The preliminary results of our study confirm that to understand drawing behavior, it is both possible and necessary to take its context of emergence into account in order to understand the various cultural influences that affect it. Also, we have shown that it is possible to observe an indication of a child's sense of identity in their drawings through the importance they assign to representations of the elements within their environment. It is, however, important to note that without data specifying what the child intended to draw, our understanding of their drawing remains subjective. Although not completely reliable on its own, the child's verbally expressed intention can be paralleled by what the observer perceives and allows the experimenter to get a more accurate picture of the child's drawing (Martinet et al., 2021). Additionally, our choice to group the 35 countries together to observe the major cultural influences ruled out the possibility of considering the diversity of cultural practices and educational methods between countries of the same group and between regions of the same country, which could affect drawing behavior differently. It would therefore be interesting to make more specific comparisons. The dataset being limited for some age and countries categories, it should be also important to increase the number of drawings, per age, per country but also per cities vs. villages to increase the statistical power of analyses and so the rigor of our explanations. Continuing our research would allow us to discover the wealth of information contained in children's works in greater depth. Our methodology could be applied to examine psychological and emotional traits measured through questionnaire (Kallitsoglou et al., 2021) or direct observation (Shiakou, 2012).

In his masterpiece *The Little Prince*, Antoine de Saint-Exupéry stated that adults never understand anything by themselves, and that children always have to explain to them. What would happen if adults took their turn and tried to understand the messages children convey, by pushing the limits of their own vision through the observation of the child's culturally specific graphical productions? From this perspective, the analysis of drawings is essential and could allow the development of new communication strategies, particularly in our world of constantly evolving cultural diversity.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving human participants were reviewed and approved by Strasbourg University Research Ethics Committee (Unistra/CER/2019-11). Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

Author contributions

MP and CS contributed to conception and design of the study. SR and MP organized the database. SR and CS performed the statistical analysis. SR wrote the first draft of the manuscript. All authors wrote sections of the manuscript and contributed to manuscript revision, read, and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyg.2022.940617/full#supplementary-material

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DRAW.IN.G.: A tool to explore children's representation of the preschool environment

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The use of drawing as a research tool has often been the subject of debate in the field of developmental psychology, especially for the exploration of children's meanings on a specific topic. Methodological limitations do emerge when using drawing in research, especially in preschool age. One of the main critical aspects concerns the lack of systematic and standardized coding methods that include clear and operationalizable categories to analyze the content of the drawings, and that associate a brief interview with the children aimed at avoiding misinterpretations. To bridge this gap, the present contribution introduces a new methodological tool named DRAW.IN.G. (DRAWing and Interview Grid), consisting of a specific procedure and a coding system that allow for a systematic investigation of implicit and explicit levels of children's representation emerging *via* drawings and interviews. The specific topic investigated by DRAW.IN.G. is children's representation of the preschool environment; the scarcity of studies on this issue, despite the importance of including children's point of view in the design processes of educational spaces makes the tool particularly current and relevant to fill some gaps in research in the educational field. The DRAW.IN.G. coding system, developed on the basis of existing literature on the analysis of drawings, includes five main dimensions of children's representation of the educational environment: physical, behavioral, relational, emotional and motivational dimensions, articulated in 18 macro-categories and 90 categories that make up the scoring grid. To assess the validity of the method, a first application was conducted with a sample of 262 children (141 males, 121 females; mean age=55.78 months; SD=11.10; range 37–77 months) from five Italian preschools. Categorical inter-rater reliability of two independent raters showed good to excellent agreement for the categories of the grid, indicating their appropriateness and clarity. The validation study indicated the potential of the method, also revealing some critical aspects to be considered. Both methodological and practical implications are discussed.

KEYWORDS

drawings, interviews, preschool, environment, early childhood education and care centers, qualitative methods

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Introduction

Drawing seems to be a feasible and enjoyable activity for most children, also representing a relatively easy way to obtain information about children's experience (King, 1995). However, the use of drawing as a research tool is controversial and has often been the subject of debate in the field of developmental psychology; although the gains of the method are recognized, many methodological limitations do emerge when conducting research through drawing.

Among the advantages, the literature indicates children's familiarity with the drawing activity, the provision of access to the thoughts and points of view of even the youngest children, the opportunity to investigate contents that are not fully accessible to awareness, and the slow processing of such contents due to the time needed to actually make the drawing (Dockett and Perry, 2005; Einarsdóttir, 2007). Furthermore, it emerged that many children are more inclined to complete drawing tasks than answer questions on a topic (Lewis and Greene, 1983) and provide a more detailed and emotional narrative if they are asked to draw first (Driessnack, 2005; Katz and Hamama, 2013).

Among the disadvantages, the literature indicates the fact that such a form of expression may be idiosyncratic, personal and liable to misinterpretation, and that children might not provide an original work as they could imitate the drawings of others (Thomas and Jolley, 1998; Bland, 2012). Such critical aspects are emphasized in the preschool age; while around the age of 7–9 year-old children develop a graphic language that includes specific symbols and rules of spatial organization, increasing their ability by 9–11 years (Barraza, 1999; Walker and Walker, 2007), in preschool age graphic skills are not yet developed and the drawings provided by children are often partially or totally incomprehensible to adults.

Because of these issues, the need to combine drawing with other tools that can integrate information collection has emerged (Thomas and Jolley, 1998; Bland, 2012); in particular, verbal interaction and discussion with the authors of the drawings on their production seem to be useful aids with which to avoid interpretative errors, especially on the analysis of the content (Yuen, 2004; Darbyshire et al., 2005). The integration of drawings and interviews would thus be effective, also considering that drawings support the expression of implicit meanings, complementing the explicit information obtained from interviews (Crook, 1985; Thomas and Silk, 1990; Farokhi and Hashemi, 2011). The development of standardized methods integrating these two methods thus emerges as a need for research in the field of educational psychology.

As for the aims that can be pursued in research using children's drawings, some authors have stated that drawings are usually analyzed for one (or more) of the following purposes: personality assessment; evaluation of current emotional states; evaluation of personal significance of topic depicted; assessment of intelligence or developmental level; and assessment of possible neurological impairment (Thomas and Jolley, 1998). In relation to this, another critical issue highlighted by the literature is that, while drawings have often been used in the field of clinical psychology to assess personality traits (the first of the aforementioned purposes) or the cognitive development of children (fourth and fifth purposes), little has been investigated about drawings in relation to the second and the third aims, concerning children's emotions and meanings in relation to a specific theme (second and third purposes), particularly in the field of education (Einarsdóttir, 2007; Sharp, 2009; Bland, 2012). Nevertheless, drawings seem to be a proper tool with which to explore children's significance on a specific topic; through drawings, in fact, children provide insights into their feelings and thoughts about that topic by reflecting an image of their own mind (Crook, 1985; Thomas and Silk, 1990).

The knowledge of children's meanings on topics related to their development contexts should be incentivized, as it allows us to include their point of view in educational processes, choices and proposals. The relevance of involving children's voices and perspectives in research has received an increasing attention in recent years (Hill, 2006; Roberts, 2017), as children are considered "beings" rather than "becomings" (Davies, 2014; Gutierrez-Vicario, 2021); the exploration of their perspective is thus fundamental to understand their life words, as they are seen as social constructors and active participants in the processes of their own experiences and learning (Mayall, 2000; Smith, 2007; Harcourt and Einarsdottir, 2011).

The importance of listening to children is supported by several international statements. Article 12 of the Convention on the Rights of the Child (The United Nations, 1989) indicates that children have the right to express their views on matters that affect their lives and that such views should be taken into account by adults. The General Comment No. 7 highlights the importance for young children to participate in decision-making processes concerning their development by expressing their own perspective (The United Nations, 2005). Such an attitude is also encouraged by the Child-Centered Approach promoted by UNICEF (2018), which encourages adults to listen to children's voices about their concerns and thoughts, and to let them participate actively in the educational processes.

The above considerations allow to emerge two main gaps in the literature on the use of drawing as a research tool in educational psychology: on the one hand, the need to develop standardized methods that integrate drawings and interviews, on the other, the need to explore its use for the investigation of children's meanings on specific topics. To bridge these gaps, the present contribution aimed at the initial development and standardization of a new systematic method of analysis of drawing associated with an interview, named DRAW.IN.G. (DRAWing and INterview Grid).

In particular, the DRAW.IN.G. tool aims to identify some elements that can help to approach children's meanings about their experience of the Early Childhood Education and Care (ECEC) environment. The importance of taking into account children's visions about their ECEC spaces has been deepened in a recent review on the topic (Berti et al., 2019) which underlines that there are still too few studies aimed at understanding how children perceive the physical environment of their ECEC services. Nevertheless, children's meanings on such a topic are particularly relevant because they are the first "users" of ECEC spaces and the actors for whom such spaces are designed and realized. Taking into account their point of view would allow us to create environments that respond to their real needs and to make them active participants in the processes involved with their own development (Nah and Lee, 2016; Berti et al., 2019).

From the aforementioned literature review it also emerged that drawings and interviews were the main tools used to obtain children's perceptions on the ECEC environment, but only two of the identified studies combine the use of both tools (Nah and Lee, 2016; Botsoglou et al., 2017). Nonetheless, the integration of drawing with the interview is a particularly suitable method to investigate the point of view of children related to the issues that affect their daily experiences, involving them directly, and that are significant for them also on an affective level. Drawings and interviews thus seem to be particularly useful to explore such issues, as through them children seem to provide indications about their relationship with the world and with other things, also expressing their emotions and thoughts (Farokhi and Hashemi, 2011). Both implicit and explicit aspects of their representation of ECEC spaces would then be explored through the DRAW.IN.G. tool. It should be clarified that for the purposes of this study, the definitions of implicit and explicit refer essentially to the way in which the data are collected: the implicit aspects are in fact deduced from the characteristics of the drawing, intended as a spontaneous action that also includes projective phenomena and knowledges not always aware and accessible to the authors of the drawing, while the explicit aspects are deduced from the interview, and refer to the motivations that are expressed verbally, implying an explicit awareness of the children.

The aim of the present article is to present the DRAW.IN.G. tool as new systematic method of analysis of drawing associated with an interview to explore children's experience of their ECEC environment. Due to the methodological nature of the present study, the Method section consists of the presentation of the tool, its aim and target, the procedure for its administration, the description of the coding phase and of all the categories included in the coding system, and the possible analyses that can be carried out on the data collected through it. The Result section instead consists of the description of the first preliminary administration of the tool, including the characteristics of the participants, the description of analyses, also to assess the reliability of the tool, and the main results emerging from the collected data.

An in-depth description of the above-mentioned preliminary administration can be found in a recent article by Berti et al. (2022). It should be specified that, while the published study aimed at conducting a detailed investigation of children's representation of ECEC spaces, by describing in depth the data collection and the emerging results, the present paper aims to describe the tool used to get such data, by presenting the procedure, the coding system, the included categories and the feasibility of the instrument. The published study aimed at providing data on children's experience, while the present one aimed at providing a new methodological tool to the scientific community. Thus, in the present article the results emerging from the preliminary study are described only briefly, referring to Berti et al., 2022 for further information.

Materials and methods

Aim and target

The DRAW.IN.G. tool is aimed at a systematic investigation of children's perception of the preschool environment by exploring implicit and explicit levels of representation emerging through drawings and interviews. In particular, the experience of space is conceptualized through five different dimensions: physical, behavioral, relational, emotional and motivational. Four dimensions (physical, behavioral, relational, emotional) connoted the implicit level and are investigated by means of drawings; one dimension (motivational) connoted the explicit level and is investigated by means of interviews. The method is addressed to children aged 3 to 6 years old who attend ECEC centers.

The *physical dimension* refers to the physical characteristics of the space, including which place is chosen, if it is indoors or outdoors, if it specific or generic, if architectural elements or furnishings are represented. The *behavioral dimension* refers to behaviors acted out in the space, including playing alone, playing with others, learning, observing nature, privacy moments, transitions from one space to another, eating, sleeping or going to toilet. The *relational dimension* refers to relationships that occur in space, including if people is represented, who is represented, which configuration of people is represented, which position people occupy in the drawing. The *emotional dimension* refers to emotions that connote the space, including by the representation of emotional states and archetypical elements, the use of colors and the position of the drawing in the sheet. The motivational dimension refers to the motivations stated on the choice of the represented space, including playing, learning, observing nature, having relationships, having moments of privacy, having a connection between indoor and outdoor spaces, having continuity between ECEC center and family, aesthetical reasons and functional reasons.

Procedure

Having obtained informed consent for each participant, data collection takes place in a single day for each participating class. Each of the two tools-drawing and interview-is proposed at two different times and concerned two different procedures. The drawing activity, carried out simultaneously by all the children in the class, takes about half an hour; each interview, carried out with each child individually, takes about 5 min. The three phases of the procedure are described below, and their main characteristics are summarized in the Appendix.

Preliminary phase

As a preliminary phase, the researcher should introduce him/herself and the research to the class, specifying his/her role, the purpose of the research, the demand about the task, also trying to obtain informal consent from the children to participate in the study. For example, the researcher should say: "*Hi kids, I'm John and I'm a researcher, in other words, an inquisitive person trying to understand a few things*" (presentation of the researcher) "*Today I would like to understand which are the favorite places of children in their schools, and when I understand it I can write a book so others can find out about my discovery!*" (presentation of the research) "*Your school is made up of many places, some indoor others outdoor, so I will ask you to make a drawing on the place that you like the most here at school. You can draw any place you like, and you can also draw yourself or your teachers or other children or other people, as you like. When you have finished the drawing, I will ask you what you have drawn, so I can understand better*" (presentation of the task) "*Would you make a drawing for my book, so I can figure out what your favorite place is here at school?*" (asking for informal consent).

Drawing phase

After the preliminary stage, the researcher should introduce the drawing activity. Drawings should be made individually, to avoid the risk of imitation and copy among children. Each child should be provided with a blank sheet of A4 paper and each small group or child should be equipped with markers of various colors. It is important that all the main colors are present, both cold and warm: red, yellow, blue, orange, green, violet, pink, brown, gray, black.

When children are ready, the researcher should reiterate the task, by using this formula: *"Please draw the place where you like to stay the most when you are here at school."* This formula has been identified starting from some preliminary studies conducted with preschoolers (Berti, 2021). Starting from these studies, it was decided to focus on the task concerning the preferred place, and not the school in general for different reasons. First, because the aim was to grasp children's personal experience, thoughts, meanings and emotions about their ECEC spaces, and not an objective representation of the environment. Secondly, because preliminary studies have shown that the more general task "*Please draw your school*" seemed too generic, excessively complex and difficult to grasp for children of this age.

The activity should take all the time required; this is usually about half an hour. When a child has finished his/her drawing he/she can go to the researcher, who can start the interview phase. The presence of two researchers would be preferable, so that one researcher (or in his/her absence, the teacher) stays in the classroom with the children who are still finishing the drawing while the other one moves with one child at a time in the area dedicated to the interview.

Interview phase

Immediately after the drawing activity, the researcher should interview each child individually on the basis of an interview grid (see Figure 1). It would be important for the interview to take place in a room separate from the class, to promote the concentration of the children and the intimacy of the moment. The interview consists of three main steps.

Firstly, the researcher should understand what the child has drawn by asking: "*Could you please explain to me what you have drawn?.*" During this first step of the interview, the researcher should identify what are the elements represented (inanimate objects, plants and animals), who are the people represented (if any) and what situation is represented (what is happening and what are people doing). If the child does not explain some of these aspects, the researcher should ask for them indicating the elements on the drawing: *"What is this?"/"Who is this?"/"What is happening?"/"What are people doing?."* The researcher should also ask other questions to better understand the child's graphic representation, being careful not to condition the child by suggesting the answers, for example asking *"Who is this?"* rather than *"Who is this woman"* (he/she may not be a woman) or *"Is this your teacher?"* (it may not be). Given the young age of children, such an involuntary suggestion could generate a desirability bias in children's responses because of their desire for approval.

Secondly, the researcher should ask each child the motivation for his/her preference, by asking *"So this is the place where you like to stay the most when you are here at school. Why do you like to stay here the most?."* Also in this second step, the researcher should also ask other questions to better understand the motivation, being careful not to condition the child by suggesting reasons like for example: *"Do you like to stay here because there are other children?"*

Finally, the researcher should ask the child one last question to allow him/her to express other things about his/her experience at school, beyond what is specifically required by the task, using this formula: *"Is there anything else you want to tell me about your school?."* This last question also has a debriefing function, allowing the child to relax and tell what he/she wants or say, generating a short chat before finishing the interview.

To conclude the interview, the researcher should thank the child for his/her drawing, telling him/her that it was very useful for his/her research and will be included in his/her book.

The activity should take all the time needed; this is usually about 5 min. All the interviews should be video-and audio-recorded to fill the interview grid in a later time. The video should frame the drawing while the child is explaining what he/she has drawn, so that the various elements defined during the first part of the interview can be identified and pinned later as well. The audio should record all the interview, so that a verbatim transcription of the child's answer should be made later. If there is no possibility to record audio video, the identified elements can be pinned in pencil on the drawing itself and the child's answers

DRAW.IN.G.
Grid for the interview

1. "*Could you please explain to me what you have drawn?*".
Please write here the child's answer, also pinning in pencil each element on the drawing.
The main aspects to be identified should be:

- what are the elements represented (inanimate objects, plants and animals);
- who are the people represented (if any);
- what situation is represented (what is happening and what are people doing).

2. "*So this is the place where you like to stay the most when you are here at school. Why do you like to stay here the most?*"
Please write here the child's answer.

3. "*Is there anything else you want to tell me about your school?*"
Please write here the child's answer.

FIGURE 1
Interview grid.

should be indicated in the interview grid by the researcher during the interview.

At the end of the data collection, the materials collected for each child will be the drawing with indication of each represented element, the interview grid and (if any) the audio video recording.

Preliminary screening

Preliminary to the application of the coding system, the children's drawings should be screened in order to select only those relevant to the purposes of the research. Due to their early age, some children may not have understood the task and may have made a drawing that is not relevant to their favorite school space. A drawing is intended as "not relevant" when its content does not correspond to the task of drawing, a condition that can be ascertained during the interview: if the child explains that he has drawn something different from the space he likes most at school, his/her drawing is considered not relevant and must be excluded from the analysis. The evaluation of not relevant. Drawings, given its simplicity, can be carried out by the researcher himself during the interview. Examples of not relevant drawings are reported as Supplementary material.

Coding

Draw.IN.G. coding system

The DRAW.IN.G. coding system was developed specifically for the systematic analysis of implicit and explicit levels of children's representation of ECEC environments emerging through drawings and interviews, as drawings provide information about physical, behavioral, relational and emotional dimensions of space representation (implicit level) and interviews provide information about motivations for preferences (explicit level).

The definition of the macro-categories and categories was based on the researchers' experience concerning the investigation of ECEC spaces (Berti et al., 2019; Berti, 2021) and the existing literature on the analysis of drawings, as described in the following sections. Some categories were identified on the basis of what the children had actually drawn (bottom-up process) while others were defined on the basis of literature (top-down process). The specific processes for the identification of the categories within each macro-category and the references related to the top-down processes are reported in Tables 1–5.

Three independent researchers (two students engaged in master's degree theses in psychology and a Ph.D. student in psychology) analyzed 120 drawings in order to identify the categories to be defined through the bottom-up process. Each researcher analyzed 40 drawings identifying categories that should answer to the questions related to each macro-category, then all the researchers compared and discussed their categories, finding an agreement on the final categories to be included in the scoring grid. The questions related to each macro-category and the identified categories are reported in Tables 1–5.

The final version of coding system includes 18 macro-categories and 90 categories for the physical, behavioral, relational and emotional dimensions (implicit level) and motivations (explicit level). Some included categories are mutually exclusive while others are not, as specified in the following section. The coding system for each dimension is reported in Tables 1–5. Examples of drawings for each category are reported as Supplementary material.

Physical dimension: Macro-categories and categories

The physical dimension refers to the physical characteristics of the space and include five main macro-categories: *PHY_Space,* referring to the school space represented by the child, *PHY_Specificity*, referring to the fact that the space represented was specific or generic; *PHY_Location*, referring to the fact that the space represented was indoors or outdoors; *PHY_Furnishings*, referring to the representation of indoor or outdoor furnishings; *PHY_Architecture*, referring to the representation of the school building.

PHY_Space includes eight mutually exclusive categories: *outdoors* indicates the representation of only outdoor spaces, such as gardens or playgrounds; *class* indicates the representation of the children's only class; *common spaces* indicates the representation of spaces shared by children of different classes, such as the entrance, corridors and halls; *all the school* indicates the representation of the school as a whole, such as the representation of the school building and the surrounding garden; *eating space* indicates the space where children eat; *sleeping space* indicates the space where children sleep; *toilet space* indicates the space where children go to the toilet; *other* signifies other school spaces not mentioned in the previous categories.

PHY_Specificity includes three mutually exclusive categories: *specific* indicates the representation of a specific space, such as the doll's corner for the indoors or the swings for the outdoors; *generic* indicates the representation of a generic space, such as the whole class or the entire garden; *specific in a general context* indicates the representation of a specific favorite space within a larger general context, such as the representation of the doll's corner within the representation of the whole class, or the representation of the swings within the representation of the entire garden.

PHY_Location includes three mutually exclusive categories: *outdoors* indicates the representation of only outdoor spaces; *indoors* indicates the representation of only outdoor spaces; *both* indicates the representation of both indoor and outdoor spaces. *PHY_Furnishings* includes three non-mutually exclusive categories: *indoor furnishings*, *outdoor furnishings* and *both*.

PHY_Architecture includes eight non-mutually exclusive categories: *none* indicates that the representation does not include architectural elements of the school building, while the other seven categories indicate the representation of the elements defined by their name: *walls, floors, ceilings/roof, doors, windows, chimney, fence*. Such categories were extrapolated from the House Drawing test (Markham, 1954).

Behavioral dimension: Macro-categories and categories

The behavioral dimension refers to behaviors acted out in the space and include one variable named *BEH_Behavior* which is defined by 10 mutually exclusive categories: *Playing alone* refers to the representation of the child playing alone in the space, *Playing with others* refers to the representation of the child playing with other people in the space, *Learning moments* refers to the representation of the child reading writing, drawing or being

TABLE 1 Physical dimension: macro-categories and categories included in the DRAW.IN.G. grid.

Dimension	Macro-categories	Researcher's question	Categories	Process[1] (References)[2]
Physical	PHY_Space	Which school space is represented?	Outdoors Class Common spaces All the school Eating space Sleeping space Toilet space Other	Bottom-up
	PHY_Specificity	It is a specific space or a generic space?	Specific Generic Specific in a general context	Top-down (Berti et al., 2019)
	PHY_Location	It is an indoor space or an outdoor space?	Indoor Outdoor Both	Top-down (Berti et al., 2019)
	PHY_Architecture[3]	Which architectural elements are represented?	None Walls Floors Ceilings/roof Doors Windows Chimney Fence	Top-down (Markham, 1954)
	PHY_Furnishings[3]	Which furnishings are represented?	Indoor furnishings Outdoor furnishings	Top-down (Berti et al., 2019)

[1]Process of identification of the categories: Bottom-Up or Top-Down.
[2]References related to Top-Down processes of identification of the categories.
[3]Macro-category including non-mutually exclusive categories.

TABLE 2 Behavioral dimension: macro-categories and categories included in the DRAW.IN.G. grid.

Dimension	Macro-categories	Researcher's question	Categories	Process[1]
Behavioral	BEH_Behavior	What behaviors were represented?	Playing alone Playing with others Learning moment Observation of nature Privacy moment Not specified Transition or wait Eating moment Sleeping moment Toilet moment	Bottom-up

[1]Process of identification of the categories: Bottom-Up or Top-Down.

involved in other activities related to the acquisition of academic skills, *Observation of nature* refers to the representation of the child observing plants, animals or other natural elements, *Privacy moments* refers to the representation of the child during a private moment, such as resting on a bench or taking refuge in a shelter, *Transition or wait* refers to the representation of moments when the child is transiting from one space to another, such as from home to school, or is waiting, as waiting for his mum at the end of the school day, *Eating moment, Sleeping moment, Toilet moment* refer to the representation of the child during eating, sleeping or toilet routines; *Not specified* refers to the representation of a situation that the child does not define (for example, when the child answers "I do not know" or "Nothing" to the question "What are you doing here in the garden?").

Relational dimension: Macro-categories and categories

The relational dimensions refers to relationships that occur in space and include five macro-categories: *REL_Representation*, referring to whether the relationships are represented or not,

TABLE 3 Relational dimension: macro-categories and categories included in the DRAW.IN.G. grid.

Dimension	Macro-categories	Researcher's question	Categories	Process[1] (References)[2]
Relational	REL_Representation	Are people represented?	People represented	Top-down (Bombi et al., 2007)
			People not represented	
	REL_Who[3]	Which people are represented	Child him/herself	Bottom-up
			Friends	
			Teachers	
			Familiars	
	REL_Configuration	Which configuration of people is represented?	No one	Bottom-up
			Only self	
			Only friends	
			Only teachers	
			Only family members	
			Self&Friends	
			Self&Teachers	
			Self&Family members	
			Self&Friends&Teachers	
	REL_Position_horizontal	In which horizontal portion of the paper are people represented?	Left	Top-down (Federici, 2007)
			Center	
			Right	
	REL_Position_vertical	In which vertical portion of the paper are people represented?	Top	Top-down (Federici, 2007)
			Center	
			Bottom	

[1]Process of identification of the categories: Bottom-Up or Top-Down.
[2]References related to Top-Down processes of identification of the categories.
[3]Macro-category including non-mutually exclusive categories.

REL_Who, referring to which people is represented; *REL_Configuration*, referring to the configuration of people, *REL_Position_horizontal, and REL_Position_vertical,* referring to the horizontal and vertical position of the representation of people on the sheet.

REL_Representation includes two mutually exclusive categories: People represented or people not represented. *REL_Who* includes four non-mutually exclusive categories, referring to the representation of the *child him/herself, friends, teachers, familiars*. *REL_Configuration* includes nine mutually exclusive categories, referring to the representation of *No one, Only Self, Only Friends, Only Teachers, Only Family members, Self&Friends, Self&Teachers, Self&Family members, Self&Friends&Teachers.*

REL_Position_horizontal includes three mutually exclusive categories defined by dividing the surface of the sheet into three equal parts and verifying in which of these parts the largest number of people or most of the body of people is placed: *left, center or right*. Similarly, *REL_Position_vertical* include the three mutually exclusive categories: *top, center and bottom*. Such categories were based on Walker and Walker (2007).

Emotional dimension: Macro-categories and categories

The emotional dimension refers to the emotions that connote the space and include six macro-categories: *EMO_Climate*, referring to the representation of emotions through facial expressions; *EMO_Archetypes*, referring to the representation of archetypical elements; *EMO_Colors_tone* and *EMO_Colors_variety*, referring, respectively, to the use of a prevalent colors tone and the use of few or many colors; *EMO_Position_horizontal* and *EMO_Position_vertical*. referring to the horizontal and vertical position of the graphical representation on the sheet surface.

EMO_Climate includes five mutually exclusive categories defined by the facial expression of the child when he/she has depicted himself/herself in the drawing: *positive, negative, mixed, neutral, not represented*. Such categories were based on Bombi et al. (2007). *EMO_Archetypes* includes 10 non-mutually exclusive categories based on the presence in the drawing of the archetypical elements identified by Crotti and Magni (2011) and Serraglio (2011): *Land line, Sky line, Sun, Moon, Trees, Flowers, Rainbow, Animals, Monsters*. *EMO_Colors_tone* includes three mutually exclusive categories defined by the use of a prevalent tone in the drawing: *warm, cold or both*. *EMO_Colors_variety*, includes three mutually exclusive categories defined by the use of few or many colors. Both the categories about colors were based on Crotti and Magni (2011) and Lüscher et al. (1976). *EMO_Position_horizontal* includes three mutually exclusive categories defined by dividing the surface of the sheet into three equal parts and verifying in which of these parts the largest part of the whole representation is placed: *left, center or right*. Similarly, *EMO_Position_vertical* include the three mutually exclusive categories: *top, center and bottom*. Both the categories on the position were based on Walker and Walker (2007).

TABLE 4 Emotional dimension: macro-categories and categories included in the DRAW.IN.G. grid.

Dimension	Macro-categories	Researcher's question	Categories	Process[1] (References)[2]
Emotional	EMO_Climate	What emotional climate is represented?	Positive	Top-down (Bombi et al., 2007)
			Negative	
			Mixed	
			Neutral	
			Not represented	
	EMO_Archetypes[3]	What archetypical elements are represented?	Land line	Top-down (Crotti and Magni, 2011; Serraglio, 2011)
			Skyline	
			Sun	
			Moon	
			Trees	
			Flowers	
			Rainbow	
			Animals	
			Monsters	
	EMO_Colors_tone	What color tone is most represented?	Warm colors	Top-down (Lüscher et al., 1976)
			Cold colors	
			Both	
	EMO_Colors_variety	How many colors were used?	One color	Top-down (Crotti and Magni, 2011; Serraglio, 2011)
			Up to four colors	
			More than four colors	
	EMO_Position_horizontal	What horizontal portion of the paper does the drawing occupy?	Left	Top-down (Federici, 2007)
			Center	
			Right	
	EMO_Position_vertical	What horizontal portion of the paper does the drawing occupy?	Top	Top-down (Federici, 2007)
			Center	
			Bottom	

[1]Process of identification of the categories: Bottom-Up or Top-Down.
[2]References related to Top-Down processes of identification of the categories.
[3]Macro-category including non-mutually exclusive categories.

TABLE 5 Motivational dimension: macro-categories and categories included in the DRAW.IN.G. grid.

Dimension	Macro-categories	Researcher's question	Categories	Process[1]
Motivations[2]	MOT_Reason	What kind of reason does the child express for his preferences regarding space?	Playing	Bottom-up
			Learning	
			Observation of nature	
			Relationships	
			Privacy	
			Indoor/outdoor connection	
			Continuity with family	
			Aesthetical reasons	
			Functional reasons	
			Others	

[1]Process of identification of the categories: Bottom-Up or Top-Down.
[2]Macro-category including non-mutually exclusive categories.

Motivations: Macro-categories and categories

Motivations refer to reason that the child states on the choice of the represented favorite space and include one macro-category named MOT_Reason, which is defined by 10 non-mutually exclusive categories based on what the child reported about the opportunities offered by space that determine his/her preferences: *Playing* refers to opportunity of playing, *Learning* refers to opportunity of reading, writing, drawing or learning other academic skills, *Observation of nature* refers to opportunity of observing nature in the school environment, *Relationships* refers to opportunity of having relationships, *Privacy* refers to opportunity of having private moments, *Indoor/Outdoor connection* refers to opportunity of passing from indoor spaces to outdoor spaces or *vice-versa, Continuity with family* refers to opportunity of having continuity with family experiences also at school, *Aesthetical reasons* refers to esthetic aspects, such as "it's coloured," *Functional reasons* refers to functional aspects of the space, such as "it's comfortable," *Others* refers to other reasons not included in the previous ones.

Analyses

During the coding procedure, each drawing and interview should be coded individually, indicating the frequency of presence of each category. The coding scheme does not necessarily have to be used in its full version: depending on specific interests, only some dimensions, macro-categories or categories may be coded.

In addition to the distribution of frequencies, different analytical approaches can be implemented: individual analyses allow us to investigate the representation of each individual child; group analyses allow us to identify the averages of the aspects emerging from the representation of a group of children, also to investigate differences due to age or gender. Moreover, the analyses can consider each single category, to outline how a group of children represents a specific aspect, or relations among categories, to highlight the patterns of connections that emerge between different categories.

The coding of each drawing and interview should be completed by more than one coder so that inter-rater agreement can be calculated in order to ensure greater validity of the coding procedure.

Results

To assess the validity of the method, a first application was conducted with a sample of 262 children (141 males, 121 females; mean age = 55.78 months; SD = 11.10; range 37–77 months) from five Italian preschools. The procedure followed the three phases described above in the Procedure section; the only difference was that, due to logistical reasons, the drawings were made in small groups (4/6 children) instead of individually. After a preliminary screening to assess the relevance of the drawings produced, we proceeded with the inter-rater reliability assessment on each category of the coding system, then we evaluated the distribution of each category through frequency analyses, also assessing the relationship between each variable and either age and gender of children through the Chi square test. For the investigation of differences in relation to children's age, three Age Groups were defined from the distribution in quartiles: Age Group 1 (age less than 25%; mean: 41.96 months); Age Group 2 (aged 25 to 75%; mean: 54.41 months); Age Group 3 (age over 75%; mean: 55.55 months).

Preliminary screening

From the preliminary screening, 72 drawings were excluded by the researcher as they were not relevant to the task. Thus, scoring and analyses were conducted on a sample of 190 data. A statistically significant relation was found between relevance and age ($p < 0.001$); the relevant drawings were 41.8% in Age Group 1, 79.2% in Age Group 2 and 90.0% in Age Group 3, revealing a developmental trend for relevance.

Inter-rater reliability (k)

Of the 190 relevant data, a sample of 120 drawings and interviews randomly identified (63%) were evaluated by two independent raters. One of the raters was a Ph.D. student in Psychology (female, 37 years old) who participate in the realization of the coding system; the other one was a masters' degree student in psychology (male, 28 years old) who was conducting a thesis on children's drawings and did not participate in the realization of the coding system. Each rater coded each drawing in all the 90 categories. Considering the number of categories of DRAW.IN.G. coding system the 60% of the data was evaluated a reliable sample size for the inter-coders agreement (Sim and Wright, 2005).

Inter-rater reliability was assessed for each macro-category and category by calculating Cohen's kappa coefficient (k) whose values indicate no agreement ($k < 0$) or different degrees of agreement, named slight (k range: 0–0.20), fair (k range: 0.21–0.40), moderate (k range: 0.41–0.60), good (k range: 0.61–0.80), excellent (k range: 0.81–1). K values and range for each macro-category are reported in Table 6.

Frequency analyses and Chi square test

The distribution of the categories of each dimension (physical, behavioral, relational, emotional, and motivations) was assessed through frequency analysis; the relation between each variable and either age or gender of children was assessed through Pearson's Chi square test, considering the frequencies coded from the Ph.D. student, as the rater with more experience in the field. A value of p of <0.05 was considered being statistically significant. *p*-values of the statistically significant relations are reported in the next paragraphs; when they are not reported, it means that there are no statistically significant differences either on gender or age groups in relation to the indicated variable. All percentages and the indication of all *p*-values for each category are reported in Table 7.

TABLE 6 Categorical inter-rater reliability for each macro-category.

Dimensions	Macro-categories	K value	Range
Physical dimensions			
	PHY_Space	0.629	K 0.60–0.80
	PHY_Specification	0.874	K 0.80–1
	PHY_Location	0.633	K 0.60–0.80
	PHY_Furnishings	0.770	K 0.60–0.80
	PHY_Architecture	0.820	K 0.80–1
Behavioral dimensions			
	BEH_Behavior	0.929	K 0.80–1
Relational dimensions			
	REL_Representation	0.962	K 0.80–1
	REL_Who	0.688	K 0.60–0.80
	REL_Configuration		
	REL_Position_Horizontal	0.714	K 0.60–0.80
	REL_Position_Vertical	0.869	K 0.80–1
Emotional dimensions			
	EMO_Climate	0.689	K 0.60–0.80
	EMO_Archetypes	0.694	K 0.60–0.80
	EMO_Colors_tone	0.610	K 0.60–0.80
	EMO_Colors_variety	0.814	K 0.80–1
	EMO_Position_Horizontal	0.617	K 0.60–0.80
	EMO_Position_Vertical	0.607	K 0.60–0.80
Motivations			
	MOT_Reason	0.694	K 0.60–0.80

Physical dimension

As for *PHY_Space*, the distribution of frequencies indicates that half of the children represented the outdoors (50.0%); the class and the common spaces are the second favorite spaces, represented by the same percentage of children (18.9%). Some of children made a general representation of all the school (10.0%) and a few children represented the sleeping room (1.6%) or the eating room (0.5%).

As for *PHY_Specificity*, the distribution of frequencies indicates that most children (51.6%) represented generic space, 38.9% of the children represented specific space and 6.9% of the children represented a specific space also drawing a general context. The Chi square test indicates statistically significant differences between males and females for *PHY_Specificity* ($p = 0.003$): the majority of males (63.5%) represented more generic space while the majority of females (39.4%) represented specific spaces.

As for *PHY_Location*, the distribution of frequencies indicates that most children represented outdoor spaces (55.3%), 37.9% represented indoor spaces and 6.8% represented both outdoor and indoor spaces. As for *PHY_Architecture*, the distribution of frequencies indicates that only 31.1% of children represented such elements, while 68.9% did not represent them. As for *PHY_Furnishings*, indicates that most children represented indoor (56.3%) or outdoor furnishings (63%).

Behavioral dimension

As for *BEH_Behavior*, most of children represented playing with others (32.1%) or playing alone (26.8%). 17.9% of children did not specify the behavior represented. 8.4% of the children represented the observation of nature, 4.7% moments of learning, 4.2% moments of transitions or waits, 2.6% eating moments, 1.6% moments of privacy and 1.6% sleeping moments. The Chi square test indicates statistically significant differences between males and females for *BEH_Behavior* ($p = 0.021$): the majority of males (40.6%) represented playing with others while the majority of females (36.2%) represented playing alone. The second most represented behavior was an unspecified activity for males (21.9%) and playing with others for females (23.4%). The third most represented situation was playing alone for males (17.7%) and an unspecified activity for females (13.8%).

Relational dimension

As for *REL_Representation*, most children (80%) represented at least one person in their drawings, while 20% of children did not represent people. The Chi square test indicates statistically significant differences between age groups for *REL_Representation* ($p = 0.002$): at least one person was represented in 57.1% of children belonging to Age Group 1, in 80.8% belonging to Age Group 2 and in 88.9% of children belonging to Age Group 3, revealing a developmental trend for the representation of people. As for *REL_Who*, the distribution of frequencies indicates that, of the children representing people, the great majority (92.1%) represented themselves, 44% represented friends, 7.2% represented teachers and 2.6% represented family members. As for *REL_Configuration*, the distribution of frequencies indicates that most children represented only themselves (38.4%) or themselves with friends (29.0%). Some children represented only friends (4.7%), only teachers (1.0%) only family members (0.6%), themselves with teachers (3.1%), themselves with familiars (1.6%) or themselves with both friends and teachers (1.6%).

As for *REL_Position_horizontal*, most of children (47.4%) represented people in the middle of the drawing, 28.9% to the left and 23.7 to the right of the drawing. As for *REL_Position_vertical*, most children (51.9%) represented people in the middle of the drawing, 2% to the top and 46.1% to the bottom of the drawing.

Emotional dimension

As for *EMO_Climate*, of the children representing people, the majority (74.6%) represented a positive emotional climate, 11.6% represented a neutral emotional climate, 1.5% represented mixed emotional climate and only one child (0.7%) represented a negative emotional climate. 10.1% of children did not represent the emotional climate. The Chi square test indicates statistically significant differences between males and females for *EMO_Climate* ($p = 0.015$): positive emotional climate was represented more by females (86.8%) than males (62.9%), while neutral emotional climate was more represented by males (17.1%) than females (5.9%). The non-representation of emotional climate also was more

TABLE 7 Distribution of frequencies and Chi-square test for Age and Gender for each category of the first administration of the DRAW.IN.G.

Macro-categories	Categories	Frequencies	Frequencies and Chi-square test for age				Frequencies and Chi-square test for gender		
			Ag1	Ag2	Ag3	*p*	M	F	*p*
PHY_Space	Garden	50.0%	60.7%	49.5%	46.0%	0.883	55.2%	44.7%	0.122
	Class	18.9%	10.7%	10.1%	12.7%		8.3%	13.8%	
	Common spaces	18.9%	17.9%	17.2%	22.2%		19.8%	18.1%	
	All the school	10.0%	7.1%	13.1%	6.3%		12.5%	7.4%	
	Eating space	0.5%	0.0%	2.0%	3.2%		0.0%	4.3%	
	Sleeping space	1.6%	0.0%	2.0%	1.6%		0.0%	3.2%	
	Toilet space	0.0%	0.0%	0.0%	0.0%		0.0%	0.0%	
	Other	0.0%	0.0%	1.0%	0.0%		0.0%	1.0%	
PHY_Specificity	Specific	38.9%	32.1%	33.3%	50.8%	0.137	28.1%	50.0%	0.003**
	Generic	51.6%	53.6%	58.6%	39.7%		63.5%	39.4%	
	Specific in a general context	6.9%	14.3%	8.1%	9.5%		8.3%	10.6%	
PHY_Location	Indoor	37.9%	28.6%	35.4%	46.0%	0.187	30.2%	45.7%	0.085
	Outdoor	55.3%	67.9%	54.5%	50.8%		62.5%	47.9%	
	Both	6.8%	3.6%	10.1%	3.2%		7.3%	6.4%	
PHY_Architecture[1]	None	68.9%	77.8%	71.4%	61.9%	0.255	68.1%	70.2%	0.752
	Walls	18.4%	33.3%	66.7%	57.7%	0.315	55.2%	63.3%	0.524
	Floors	19.0%	16.7%	59.3%	73.1%	0.077	65.5%	56.7%	0.486
	Ceilings/roof	19.0%	50.0%	63.0%	61.5%	0.839	62.1%	60.0%	0.871
	Doors	5.8%	33.3%	22.2%	11.5%	0.378	17.2%	20.0%	0.786
	Windows	7.9%	50.0%	25.9%	19.2%	0.295	20.7%	30.0%	0.412
PHY_Furnishings[1]	Indoor furnishings	56.3%	16.7%	55.3%	45.0%	0.052	46.7%	43.3%	0.17
	Outdoor furnishings	63.0%	64.3%	48.5%	66.7%	0.697	48.4%	65.6%	0.74
BEH_Behavior	Playing alone	26.8%	28.6%	23.2%	31.7%	0.542	40.6%	23.4%	0.021*
	Playing with others	32.1%	35.7%	28.3%	36.5%		17.7%	36.2%	
	Learning moment	4.7%	10.7%	3.0%	4.8%		21.9%	13.8%	
	Observation of nature	8.4%	3.6%	11.1%	6.3%		8.3%	8.5%	
	Privacy moment	1.6%	0.0%	1.0%	3.2%		4.2%	5.3%	
	Not specified	17.9%	17.9%	23.2%	9.5%		5.2%	3.2%	
	Transition or wait	4.2%	0.0%	5.1%	4.8%		1.0%	4.3%	
	Eating moment	2.6%	3.6%	3.0%	1.6%		1.0%	2.1%	
	Sleeping moment	1.6%	0.0%	2.0%	1.6%		0.0%	3.2%	
	Toilet moment	0.0%	0.0%	0.0%	0.0%		0.0%	0.0%	
REL_Representation	People represented	80.0%	57.1%	80.8%	88.9%	0.002**	78.1%	81.9%	0.514
	People not represented	20.0%	42.9%	19.2%	11.1%		21.9%	18.1%	
REL_Who[1]	Child him/herself	92.1%	81.3%	90.0%	98.2%	0.051	92.0%	92.2%	0.962
	Friends	44.1%	43.8%	42.5%	46.4%	0.902	48.0%	40.3%	0.337
	Teachers	7.2%	12.5%	10.0%	1.8%	0.132	6.7%	7.8%	0.789
	Familiars	2.6%	6.3%	2.5%	1.8%	0.613	2.7%	2.6%	0.979
REL_Configuration	No one	20%	42.9%	19.2%	11.1%	0.071	21.9%	18.1%	0.854
	Only self	38.4%	37.5%	48.8%	50.0%		44.0%	51.9%	
	Only friends	4.7%	12.5%	7.5%	1.8%		5.3%	6.5%	
	Only teachers	1.0%	0.0%	2.5%	0.0%		1.3%	1.3%	
	Only family members	0.6%	6.3%	0.0%	0.0%		1.3%	0.0%	
	Self&Friends	29.0%	31.3%	31.3%	44.6%		41.3%	31.2%	
	Self&Teachers	3.1%	12.5%	3.8%	0.0%		4.0%	3.9%	
	Self&Family members	1.6%	0.0%	2.5%	1.8%		1.3%	2.6%	
	Self&Friends&Teachers	1.6%	0.0%	3.8%	0.0%		1.3%	2.6%	

(Continued)

TABLE 7 (Continued)

Macro-categories	Categories	Frequencies	Frequencies and Chi-square test for age				Frequencies and Chi-square test for gender		
			Ag1	Ag2	Ag3	*p*	M	F	*p*
REL_Position_	Left	28.9%	31.3%	25.0%	33.9%	0.756	25.3%	32.5%	0.602
horizontal	Center	47.4%	50.0%	51.2%	41.1%		50.7%	44.2%	
	Right	23.7%	18.8%	23.8%	25.0%		24.0%	23.4%	
REL_Position_	Top	2.0%	0.0%	2.5%	1.8%	0.200	2.7%	1.3%	0.712
vertical	Center	51.9%	56.3%	56.3%	28.6%		48.0%	44.2%	
	Bottom	46.1%	43.8%	41.3%	69.6%		49.3%	54.5%	
EMO_Climate	Positive	74.6%	71.4%	67.6%	84.9%	0.326	62.9%	86.8%	0.015*
	Negative	0.7%	0.0%	1.4%	0.0%		17.1%	5.9%	
	Mixed	1.5%	0.0%	2.8%	3.8%		1.4%	0.0%	
	Neutral	11.6%	7.1%	16.9%	5.7%		5.7%	0.0%	
	Not represented	10.1%	21.4%	11.3%	5.7%		12.9%	7.4%	
EMO_Archetypes[1]	Land line	80.0%	88.9%	73.3%	86.5%	0.171	81.0%	78.8%	0.779
	Skyline	64.3%	55.6%	71.7%	56.8%	0.230	65.1%	63.5%	0.857
	Sun	66.1%	58.8%	63.3%	75.7%	0.534	63.5%	70.6%	0.459
	Moon	0.0%	0.0%	0.0%	0.0%	-	0.0%	0.0%	-
	Trees	39.1%	55.6%	28.3%	48.6%	0.071	39.7%	38.5%	0.894
	Flowers	17.4%	11.1%	21.7%	13.5%	0.439	14.3%	21.2%	0.333
	Rainbow	4.0%	0.0%	8.3%	0.0%	0.091	6.3%	1.9%	0.247
	Animals	10.4%	16.7%	8.3%	10.8%	0.595	7.9%	13.5%	0.335
	Monsters	0.0%	0.0%	0.0%	0.0%	-	0.0%	0.0%	-
EMO_Colors_tone	Warm colors	11.1%	7.1%	16.2%	17.5%	0.241	13.5%	17.0%	0.001***
	Cold colors	19.4%	35.7%	28.3%	20.6%		39.6%	13.8%	
	Both	42.5%	57.1%	55.6%	61.9%		46.9%	69.1%	
EMO_Colors_	One color	6.5%	7.1%	9.1%	9.5%	0.227	11.5%	6.4%	0.026*
variety	Up to four colors	22.9%	39.3%	35.4%	22.2%		38.5%	24.5%	
	More than four colors	43.1%	53.6%	55.6%	68.3%		50.0%	69.1%	
EMO_Position_	Left	8.9%	0.0%	8.1%	14.3%	0.087	7.3%	10.6%	0.870
horizontal	Center	88.4%	100.0%	87.9%	84.1%		89.6%	87.2%	
	Right	2.6%	0.0%	4.0%	1.6%		3.1%	2.1%	
EMO_Position_	Top	2.1%	0.0%	3.0%	1.6%	0.483	2.1%	2.1%	0.771
vertical	Center	84.2%	92.9%	80.8%	79.4%		84.4%	79.8%	
	Bottom	15.8%	7.1%	16.2%	19.0%		13.5%	18.1%	
MOT_Reason[1]	Playing	75.6%	18.1%	50.3%	31.6%	0.197	52.5%	47.5%	0.808
	Learning	5.6%	38.5%	23.1%	38.5%	0.104	53.8%	46.2%	0.949
	Observation of nature	11.5%	33.3%	48.1%	18.5%	0.156	45.7%	54.3%	0.266
	Relationships	19.7%	19.6%	39.1%	41.3%	0.129	51.9%	48.1%	0.900
	Privacy	4.7%	9.1%	54.5%	36.4%	0.617	54.5%	45.5%	0.916
	Indoor/outdoor connection	1.7%	0.0%	75.0%	25.0%	0.504	50.0%	50.0%	0.904
	Continuity with family	2.6%	16.7%	66.7%	16.7%	0.694	83.3%	16.7%	0.131
	esthetic reasons	1.3%	33.3%	33.3%	33.3%	0.808	33.3%	66.7%	0.492
	Functional reasons	2.1%	8.3%	50.0%	41.7%	0.460	66.7%	33.3%	0.330
	Others	10.3%	29.2%	45.8%	25.0%	0.535	41.7%	58.3%	0.241

[1]Macro-category including non-mutually exclusive categories.
Ag1, Age Group 1; Ag2, Age Group 2; Ag3, Age Group 3; M, Male; F, Female; *p*, *p*-value from Chi-Square analyses.
*$p \leq 0.05$; **$p \leq 0.01$; ***$p \leq 0.001$.

frequent in males (12.9%) than females (7.4%). Finally, males were the only ones who represented a mixed (1.4%) and negative (5.7%) emotional climate. As for *EMO_Archetypes*, the most depicted were the land line (80.0%), the skyline (64.3%) and the sun (66.1%), followed by trees (39.1%), flowers (17.4%), animals (10.4%) and a rainbow (4%). No children depicted the moon or monsters.

As for *EMO_Colors_tone*, most children (42.5%) used both warm and cold colors in their drawings, while 19.4% used cold colors and 11.1% used warm colors. The Chi-square test indicates a statistically non-significant relation between such variable and age, while it indicates statistically significant differences between males and females for *EMO_Colors_tone* ($p = 0.001$): both colors were used by 46.9% of males and 69.1% of females. Males used more cold (39.6%) than warm colors (13.5%), while females used more warm (17.0%) than cold (13.8%) colors. As for *EMO_Colors_variety*, most children (43.1%) used many colors in their drawings, while 22.9% used up to four colors and 6.5% used only one color. The Chi square test indicates statistically significant differences between males and females for *EMO_Colors_variety* ($p = 0.026$): more than four colors were used by 50% of males and 69.1% of females. More than four colors were used by 38.5% of males and 24.5% of females. One color was used by 11.5% of males and 6.4% of females. As for *EMO_Position_horizontal*, most children (88.4%) drew in the middle of the sheet, while 8.9% drew to the left and 2.6% to the right of the sheet. As for *EMO_Position_vertical*, most children (84.2%) drew in the center of the sheet, while 15.8% drew at the bottom and 2.1% at the top of the sheet.

Motivation

As for *MOT_Motivation*, most of the cited motivations (75.6%) referred to playing opportunities, 19.7% to relationships, 11.5% to the observation of nature, 5.6% to learning opportunities, 5.1% to functional aspects, 4.7% to opportunities for privacy, 2.5% to the continuity between school and family, 1.7% to the continuity between indoor and outdoor spaces, and 1.3% to esthetic aspects.

Discussion

The study indicated the general appropriateness of the method, in addition to its feasibility, also revealing some critical aspects to consider. First, the method is easy as it takes little time for its administration, i.e., about half an hour for drawing and about 5 min for each interview. Second, it is ecological, as it engages children using tools familiar to them. Third, it is multifaceted, as it analyses different aspects of the representation of space, allowing us to grasp a complex vision of children's experience of their ECEC environment. Fourth, it is flexible, as it allows easy adaptations depending on specific situations and interests, choosing some specific aspects of the space to be investigated.

Regarding the reliability of the instrument, it should be noted that the inter-rater indices revealed a good to excellent agreement for all identified categories, with the exception of only two categories within *PHY_Architecture*: *chimney* and *fence*. This can be due to the fact that such categories were taken from the House Drawing Task but chimneys and fences are not in fact significant elements in the representation of the school building, so probably children did not depict them for this reason. The good to excellent inter-rater agreement of all the other categories indicates that they are clearly defined and allow for consistent assessments, indicating their appropriateness in the analysis of ECEC space representation. The high agreement could also allow for the use of the DRAW.IN.G. method, not only by researchers, but also by professionals who work with children in the educational field, such as teachers and pedagogical coordinators, after a training course in the use of the tool.

The distribution of the categories shows that there are no substantial differences in relation to either the different age groups or gender, except for some aspects already consolidated in the literature. This highlights, in general, how this method is suitable in preschool age regardless gender and is not particularly influenced by the age of children. However, with regard to the age factor, it should be noted that the validation study, as we have seen, shows that only 41.8% of the drawings of children in the lower age group appear to be relevant to the task. These data may indicate the age of 3 years as the age limit of use and that it is therefore preferable to use the DRAW.IN.G. tool with children with children aged 4 and over.

Among the other differences emerging for either age or gender, significant relations were found between age and *REL_Representation* and between gender and the following macro-categories: *PHY_Specificity*, *BEH_Behavior, EMO_Climate, EMO_Colors_tone* and *EMO_Colors_variety.*

As for *REL_Representation*, a significant developmental trend was observed as younger children represented fewer people than older ones, in line with classical studies that argue that social sensitivity increases with age (Piaget, 1926; Mossler et al., 1976). As for *PHY_Specificity* and *BEH_Behavior*, it is interesting to note that males represented more generic spaces and situations where they play with others, while females represented more specific spaces and situations where they play alone. These findings are in line with classic literature indicating that girls are usually engaged in more intimate play and smaller groups, compared to boys (Lever, 1998) and that girls are more oriented in small group interactions, whereas boys tend to choose more physical activities (Maccoby, 1990).

As for the *EMO_Climate* it was found that positive emotional climate was represented more by females, while neutral emotional climate was more represented by males; furthermore, the rare representation of mixed and negative emotional climate was found only in drawings provided by males. Consistently, in relation to the use of colors, cold colors were used more by males while warm colors were used more by females (*EMO_Colors_tone*), and the variety of colors was found to be higher in females than males (*EMO_Colors_variety*). Such findings are in line with existing literature showing gender differences in children's emotional expression, with females showing more positive and internalizing emotions than males, and males showing more externalizing emotions (e.g., anger) than girls (Chaplin and Aldao, 2013).

The specific distribution of frequencies for each variable in relation to the existing literature will not be discussed here, as it is not the core of the present article; it is important here to note that there is a great variability in the frequency distribution of the different categories, indicating that they seem able to discriminate and bring out the different aspects of children's representation of their ECEC environment and the experience they have with it. Furthermore, it is interesting to note that some categories (e.g., *Outdoors* within *PHY_Space*; *Playing with others* or *Playing alone* within *BEH_Behavior*) are particularly recurrent in the representations of children, while others are less frequent but equally interesting and worthy of attention (e.g., *Sleeping room* within *PHY_Space*; *Privacy moments* or *transitions or waits* within *BEH_Behavior*). A discussion on such contents should be found in Berti et al., 2022.

Concerning the possible application of DRAW.IN.G. as a methodological tool, some considerations should be made in relation to the fact that the effort of developing such a tool would be useful and important both in the field of research and practice.

As for the research, the standardization of a tool that allows us to explore children's meanings about their ECEC spaces covers some literature gaps related to the need to develop systematic methods to use drawing in research with children, the need to integrate drawings and interviews and the need to explore the use of drawings for the investigation of children's meanings on specific topics. Furthermore, the construction of the coding system, based on both bottom-up and top-down processes, enriches the tool, including evaluation parameters both built *ad hoc* and already existing in the literature. An added value of the tool is that in fact it consists of both "descriptive" and "projective" aspects for the evaluation of the contents of the drawings. Although the scientific value of projective tools has been questioned in psychology for some time, we think that an integration of both the mentioned aspects could provide a complex and articulated vision about children's experience of the school environment and reflect on different aspects related to it. Furthermore, another strength of this method is that it can be replicated even on the same group of children. For example, if significant spatial changes are made in an educational context, it could be of fundamental importance for professionals working in this context to understand whether and how such changes have an impact on the experiences and representations of children. In this case, the DRAW.IN.G. tool could be used before and after the changes, eventually adapting a specific task to the specific aim. Another important potential of the method is that, in addition to the distribution of the categories, which highlights the relevance of different aspects of children's representation of space, the tool allows us to identify some specific configurations of different dimensions of children's experience of their ECEC environment. This aspect is very interesting for research, as it reveals complex and mostly unconscious relations among the different investigated dimensions that such young children might not be able to explain verbally.

As for the practice, the tool might have a great relevance in the spatial design processes of the ECEC centers; for example, it could be very interesting for a teacher or a coordinator to understand what kind of experience and representation children have of the educational space. In fact, very often the space is thought of by adults, and children are seen as "users" of this space. Nevertheless, recent studies in this area indicate that the involvement of children in design issues represents a way that fosters their development and well-being (Nah and Lee, 2016; Botsoglou et al., 2017). In this sense DRAW.IN.G. is a tool to make children's point of view on the educational environment more accessible to teachers. In addition, both the drawing and the interview, intended as a narration/conversation by the children, are methodologies widely used in educational contexts and are therefore quite familiar to teachers.

For this purpose, simplified variants of the coding grid could be realized. In particular, an adaptation for teachers could include the elimination of some more specific categories, such as the use of archetypes or the position of the drawing in the sheet, while it could focus on some more significant categories from an educational point of view, such as the place represented, the preference for indoor or outdoor spaces, or the inclusion of relationships in the ECEC environment. Adapted versions should focus on specific aspects (e.g., children's perceptions of specific spaces) not including other potentials of the tool more related to research issues (e.g., relations between categories).

Despite the relevance of the standardization of the DRAW.IN.G. tool presented in this article, it is necessary to highlight some methodological limitations. A first important critical aspect emerged from the preliminary analysis of the drawings: as expected, a significant developmental trend on relevance was found. Such a trend indicates that most children aged 3 years had difficulty understanding the task, in fact over 58% of them produced an irrelevant drawing. This datum is in line with classic literature which indicates that as children grow up, the better they are at understanding a drawing task and providing an appropriate response (Luquet, 1913; Piaget, 1929). The finding indicates that the DRAW.IN.G. tool could be more appropriate for children aged 4 years or more; the percentage of not relevant drawings in children aged 4/5 years (about 20%) and 5/6 years (about 10%) is, in fact, acceptable. As it has emerged that not all preschool children understand the task, variants or simplifications could be imagined to investigate even the point of view of the youngest. Further studies involving larger and more heterogeneous samples could clarify this aspect. Future research could also verify the adaptation of this method also for older school age children, such as the ones aged 6 or 7.

Second, although the procedure requires drawings to be made individually, logistical requirements may determine the need to make drawings in small groups of children. Such requirements could, for example, relate to the availability of markers or the arrangement of tables in the classroom, as was the case for the preliminary study. The preliminary study showed that the realization of the drawings in small groups (4–6 children) is feasible; this condition may also be considered favorable for the ecological viability of the administration, when it represents the usual way in which children are used to drawing in the classroom. However, the risk of imitation and copying between children should be considered among limitation, as it could affect the frequency analyses on the elements represented.

Third, in relation to projective indicators included in the coding grid, such as the representation of archetypes or the use of colors, there may be a risk of overestimation of the meanings of the elements that children usually represent in their drawing (e.g., the sun) or possible distortions due to different social habits in males and females related to the use of colors. However, we believe that the inclusion of projective indicators in the DRAW.IN.G. tool could be an added value, especially for the investigation of the emotional dimension, in addition to the facial expression depicted in the drawings: since literature indicates children's preference for the representation of happy expression in the early age (Cannoni et al., 2021), we believe it is important to include other indicators to detect the emotional tonality of children's experience.

Fourth, also in relation to the possibility of subjective interpretations for projective indicators, it would also be necessary to verify the concurrent validity of DRAW.IN.G. At this stage, such verification is not possible, because to test the concurrent validity of an instrument it is necessary that the data obtained with this tool are compared with those obtained by another different and validated tool that measures the same constructs or similar constructs that are supposed to be related (parameters). To our knowledge, there is no validated tool that measures children's experience representation of their school space, and it is also difficult to identify an external criterion/parameter since there are still few empirical studies concerning the investigated construct and therefore a scarce literature on the topic. When this aspect will be more studied, further studies should hypothesize related external parameters to evaluate the concurrent validity. Concerning this issue, we argue that the inclusion in the tool of an interview, in addition to the drawing, can represent a sort of control with respect to the information collected through the drawing, as widely supported by different authors (Yuen, 2004; Darbyshire et al., 2005; Bland, 2012).

Finally, it would also be interesting to validate this tool with children of other nationalities, in addition to the Italian one, to verify whether any differences related to the organization of educational services, and the educational value that is attributed to the spaces themselves, could affect the perceptions of children.

Beyond the aforementioned limits, DRAW.IN.G. represents an attempt to advance our knowledge in the field of the use of drawing as a research tool, trying to bridge an important methodological literature gap. The method presented should be used both in research and in practice revealing interesting potential to bring us closer to children's point of view on their perception of ECEC environment.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

Author contributions

SB and AC designed the study and analyzed the results. SB implemented the first application of the method under the supervision of AC. SB wrote the manuscript. AC revised the manuscript. All authors contributed to the article and approved the submitted version.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyg.2022.1051406/full#supplementary-material

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Drawing techniques as tools for the evaluation of scholastic integration and emotional components in primary and secondary school: A cross-sectional study

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Introduction: In the last decades, many studies have emphasized emotion's role in psycho-educational processes during childhood, such as scholastic integration. Emotional variables in childhood can be assessed through projective graphic techniques, as they allow children to use kinetic components of the draws to communicate emotions.

Method: 1.757 couple of draws were collected, from primary school children (N = 1.270; F = 643 [50.6%]; Age = 8.6; SD = 1.31) and secondary school children (N = 487; F = 220 [45.2%]; Age = 11.72; SD = 0.70) and from eight schools in Sicily and over 60 different classrooms. The Drawn Stories Technique and the Classroom Draw were used to assess children's current emotional state and scholastic integration.

Results: Pearson's correlation showed significant relationships between the Drawn Stories Technique and both sex and age. In contrast, Classroom Drawing total score showed a significant relationship with the female sex but no significant relationship with age. Linear regression analysis, including sex and age as independent variables, showed that sex is a significant predictor of Negative Outcomes of the Drawn Stories Technique, while no effect of age was detected.

Discussion: These findings showed that adequate attention is needed to the learners' emotional-affective world that influences their relationships and their vision within the class group. Although the drawing techniques alone seem to be not as such sufficient to explain children's individual differences in the classroom on the whole, they could be helpful for the teacher to facilitate dialogues with children, modulate didactical materials, and detect and prevent some problems in group class functioning.

KEYWORDS

scholastic integration, projective graphic techniques, drawn stories technique, classroom draw, emotional-affective components, primary school, secondary school

1. Introduction

Since the first development of psychology, drawing has been considered a useful tool to understand an individual's development and personality (Driessnack, 2005). Projective techniques based on drawing acquired ever more popularity among clinicians because of their simple administration and ease of acceptance, especially by children (Gross and Hayne, 1998). The graphic method is considered a useful way to express not only personality dimensions but also the child's emotions, and the affective tone with which children "emotionally invest" the context in which they live (Longobardi et al., 2017).

In the last decades, many studies have shown the fundamental role of emotions on psycho-educational processes during childhood and how good emotion management can be a pathway to better social competence in future (La Grutta et al., 2022). Particularly, current evidence shows that children may be able to express emotions through drawings even if they are unable to communicate or express them verbally (Fury et al., 1997; Malchiodi, 1998; Kim and Suh, 2013; Pace et al., 2013; Goldner et al., 2015). Some others have also suggested that, through their drawings, children can create connections that reveal their own mental internal world (Cox, 2013). For these reasons, drawing could be the best way for children to communicate their feelings, conflicts, and mental states, and it is halfway between acting and dreaming (Cox, 2013). Therefore, graphic techniques are an important assessment tool, capable of providing new knowledge about children's intellectual development, emotional dimensions, and personality traits.

Moreover, based on the dynamic and esthetic qualities perceived in drawings, we can identify various developmental stages in the drawing: 4-year-old children start to draw a more accurate human figure (e.g., gender differences are included), from 6 to 7 years, there are even more details (e.g., the ground line and decorative intent) and also appear text in balloons, and at 8–9 years, children start to use transparency, aerial point of view, perspective, and movement until pre-adolescence in which draws are similar to that in adulthood in accuracy (Quaglia et al., 2013; Scafidi Fonti et al., 2015).

Drawing could also reflect, through some emotional indicators, gender differences in emotional expression, and conflictual themes, which could be different due to biological and cultural factors. For example, males could tend to use more externalization strategies to express their anxiety or conflictual themes in more aggressive manners (broken lines, more deletions, and paper ripped off) than females who could use more internalization strategies (e.g., depressive contents in the draws, blame if they are not able to draw properly; Picard and Boulhais, 2011; Chaplin, 2014; Scafidi Fonti et al., 2015).

According to that, in a clinical context, two of the most frequently used drawing techniques are the Draw-a-Person Test and the Family Drawing Test (Goodenough, 1926; Machover, 1953; Hammer, 1958; Harris, 1963; Corman, 1967), both widely employed in a psychodiagnostic assessment (Skybo et al., 2007). Particularly, the Draw-a-Person Test enables the clinician to capture the child's perception of their own self and to release their private fantasies and anxieties (Machover, 1949), and the perception helps to understand children's representations of their parents (McGuigan and Pratt, 2001; Piperno et al., 2007).

In clinical practice with children, besides these two techniques, spontaneous drawing has always been widely used (Trombini et al., 2004). An example of a graphic technique that is based on both free drawings and narration is the "Drawn Stories Technique" (Trombini, 1994), which was developed originally in a psychoanalytic and psychodiagnostic context to facilitate not only empathic communication and narrations with patients but also the evaluation, detection, and interpretation of psychological suffering in developmental age. This technique permits the expression of free drawing in a sequence of scenes and encourages the construction of many possible narrative developments. The conclusions from these can be evaluated according to well-defined categories, such as the outcome of the story, which expresses the levels of emotional distress of children (Trombini et al., 2001). The psychologist asks a child to draw an invented story, without insisting on any point of view and waiting for the child to draw the story. Through this technique, children can express their affective themes and internal conflicts. These stories can be classified depending on how the story ends: (1) Positive Outcome (PO): the subject ends his narration positively without any accident. (2) Negative Outcome (NO): the subject ends their narration negatively with an accident; (3) Compensated Positive Outcome (CPO): it signed when the story, despite the presence of an accident, ends positively; (4) Absent Outcome (AO): the story is not completed. In particular, in a study conducted by Trombini et al. (2004) on an Italian sample of 211 primary and secondary school children, this technique showed good validity in detecting anxiety and depression through negative outcomes in the stories.

Moreover, clinical practice and a number of studies show that these types of endings indicate the emotional state of the drawer. In particular, PO and CPO indicate an emotional wellbeing and resilience capacity (Figures 1, 2), NO indicates an emotional turbulence that could be related to aggressive, anxious, or depressive themes (Figure 3), while AO can indicate a block of symbolic expression (Scafidi Fonti et al., 2015; Figure 4).

This could be possible because drawing is most beneficial for school-age children because their cognitive thinking is primarily concrete but develops an understanding of abstract concepts. As cognition develops, adolescents become more resistant to drawing and find it easier to express their feelings in words, music, or physical activity (Skybo et al., 2007). Furthermore, drawings are often called upon by professionals as a method of allowing a child to communicate more freely, with no language being necessarily involved, as well as a way of "breaking the ice" between the child and professional (Veltman and Browne, 2002).

Schools are often the primary context where children have acceptance or refusal experiences with their peers (Rubin et al., 2007). In such a context, the emotional development of children could promote their ability to manage the needs of their social and educational environments, keep good relationships with peers, recover from negative emotions, tolerate frustrations, express emotions in adaptive manners, and improve the processes of integration.

In light of this, in such psycho-educational contexts, the use of drawing tools, such as the Drawn Stories Technique integrated with other instruments that are more specific for the scholastic context such as "The Classroom Drawing" (Quaglia and Saglione, 1990), could be an important way teachers have to drive classroom relationships, to facilitate a good affective atmosphere, providing to the pupils a way to learn expressing their emotional states, positive or negative ones, to understand owns and others, to assess the quality of relationships among child, teachers, and classmates, and to evaluate scholastic integration level (Scafidi Fonti et al., 2015).

The classroom drawing is designed to investigate the child's perception of their "feeling good" at school, in terms of classroom integration such as the relationship with the teachers and classmates and the experience of learning and of him/herself as a pupil (Quaglia and Saglione, 1990).

Starting with growing interest in emotional education in Italian schools, the emotional factors that are fundamental in social interaction have been studied with increasing interest, especially regarding their effect on scholastic integration.

In particular, social–emotional competence could be considered a critical factor to target with universal preventive interventions that are conducted in schools because the construct associates with social, behavioral, and academic outcomes that are important for healthy development; predicts important life outcomes in adulthood; can be improved with feasible and

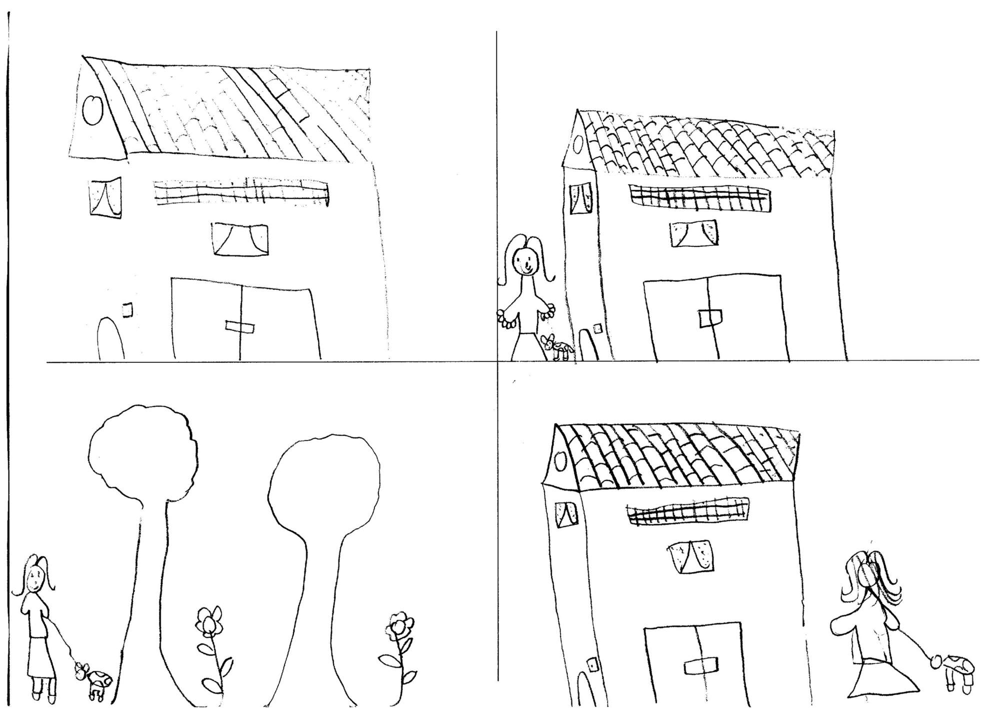

FIGURE 1
Drawn Stories Technique. Positive outcome (PO) example: *"There is a girl in the house. Then, she goes out to walk the dog. Finally, she returns to the house and she is happy about that beautiful walk."* Female, 8 years old.

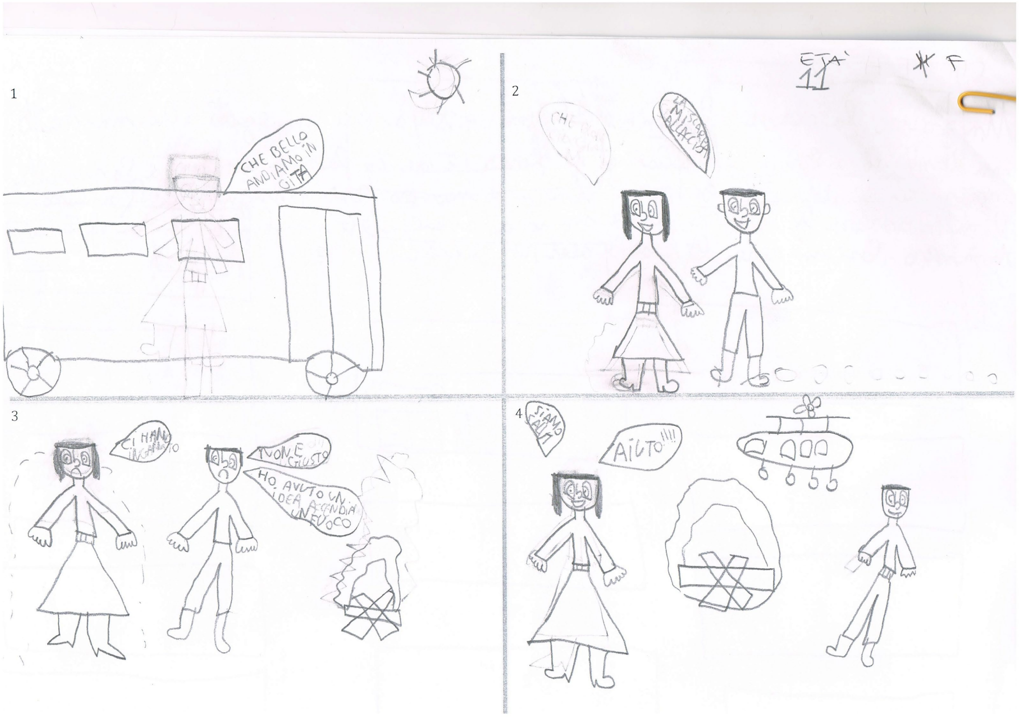

FIGURE 2
Drawn Stories Technique. Positive compensated outcome (PCO) example: "*During a school trip, two scholars stop to look at the landscape but are abandoned by the rest of the class. Finally, they light a fire and have been saved with an helicopter.*" Male, 11 years old.

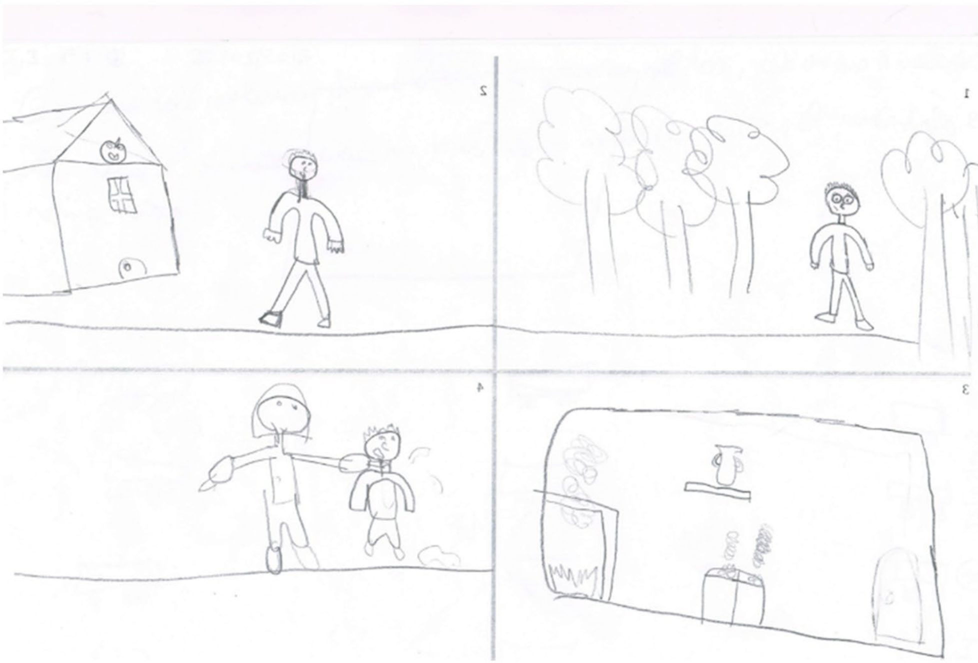

FIGURE 3
Negative outcome (NO) example: "*There is a child that is walking in the woods. He sees an house, due to his curiosity enters in that but he's been killed by a man who's hiding there.*" Male, 10years old.

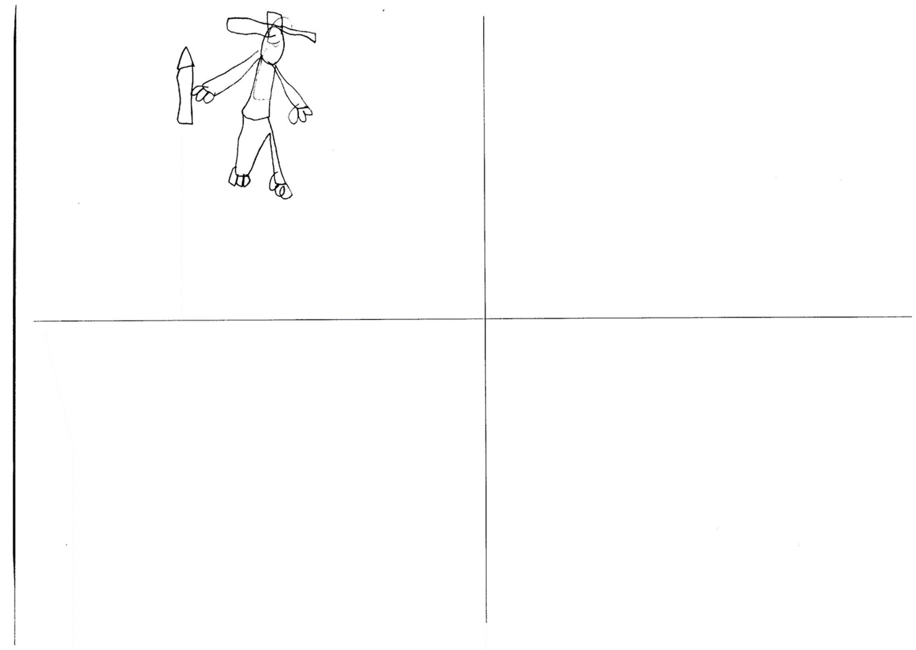

FIGURE 4
Absent outcome (AO) example: *"There is a man.... and then... I do not know."* Female, 9years old.

cost-effective interventions; and plays a critical role in the behavior change process (Domitrovich et al., 2017; La Grutta et al., 2022).

The aim of this study is to show how the "Drawn Stories Technique" and the "Classroom Drawing" can be considered useful tools to assess children's emotional state within the class group and their scholastic integration in an educational context.

Specifically, the main hypotheses of the present study are as follows:

1. There are significant gender differences in the way children express their conflict and emotion through the draws, particularly males would tend to express more aggressiveness than females. Thus, a higher number of Negative Outcomes are expected for males compared with females.
2. There is a positive correlation between the Drawn Stories Technique scores and children's age. Particularly, older children will tend to draw more Compensated Positive Outcomes due to the progressive complexity of emotional experiences and growing resiliency during their development.
3. The quality of scholastic integration assessed by the classroom drawing is positively related to age in primary school and negatively in secondary school, especially as regards the relationship with the teacher (authority).

2. Materials and methods

2.1. Procedures

The selection of schools was based on previous work relationships with schools to collect a convenience sample. Participants were recruited from eight schools in Sicily and over 60 classrooms from 2014 to 2020. Two researchers per class administered the two projective drawing techniques mentioned earlier during the school timetable and in the usual classroom. The completion time lasted approximately 45 min. The drawings were presented one by one to children as activities, without any vote or ratings, and they were motivated by the researchers: "*it's not important how you draw, but we are interested in the stories that you want to share with us.*" Once the children finish their drawings, in turn, the researchers conducted individual brief interviews asking some simple questions such as the following: "*who are the main character of this story*"? "*What is its name*"? "*If you have to choose a character, in this story, that looks more like you, what character you choose*"? "*How the story ends*"? At the beginning of the school year, school principals, teachers, and parents signed the informed consent sheets about the purposes of the research and data collection procedures. Written consent was signed and collected by both parents of every child involved in the study. The study was run in accordance with the national ethics guidelines and in line with the Declaration of Helsinki. This study was approved by the University of Palermo Ethics Committee (no. 83/2022).

2.2. Participants

The research involved a total of 1,757 children with an age range from 6 years to 13 years from primary ($N = 1,270$; $F = 643$ [50.6%]; age = 8.26; SD = 1.31; age range 6–10 years) and secondary school ($N = 487$; n female = 220 [45.2%]; age $M = 11.72$; SD = 0.70; age range 11–13 years) in Sicily. Neither of the participants had special educational needs (SENs) while three participants were deaf and five had autism spectrum disorder. However, all of them were able to finish their drawings.

2.3. Measures

2.3.1. Demographics

Demographic data were taken from class registers according to parents' permission obtained by informed consent. These data were treated and coded to ensure anonymity.

2.3.2. Emotional state

To evaluate the emotional state of children, the previously described "Drawn Stories Technique" was used. The psychologist asks a child to draw an invented story, without insisting on any point of view and waiting for the child to draw the story. After the drawing phase, children are asked to write the story behind the sheet, and then, they are briefly interviewed by the researcher about their stories. In this way, it is possible to determine which character the child identifies with and to score the type of outcome based on what happens to the chosen character.

2.3.3. Scholastic integration

To evaluate scholastic integration, "The Classroom Drawing" was used. Children are asked to draw their class in whatever way they like. The analysis of the drawing takes into account the presence or absence in the drawing of (1) the teacher (relationship with authority, Figures 5, 6); (2) classmates (level of socialization); and (3) the drawer themselves (personal involvement in the class). Each of these elements is scored as dichotomous variables: 0 means their absence (Figure 7), while 1 indicates their presence in the drawing. Their sum provides a global classroom integration index, which therefore ranges from 0 (Figure 7) to 3 (Figure 6), with 3 indicating more adaptive integration levels (Quaglia and Saglione, 1990).

2.4. Data analysis

Statistical analyses were performed using programs available in the Statistical Package for Social Sciences (SPSS for Windows release 25.0). Descriptive statistics were utilized to describe the data (frequencies, percentages, mean, and standard deviation). Moreover, two analyses of variance (ANOVA) were performed in which the outcomes of the Drawn Stories Technique and Classroom Drawing scores were used as the dependent variables. In both cases, gender (male vs. female) and school level (primary vs. secondary) were included as dichotomous factors. Gender and the outcomes of the Drawn Stories Technique were coded as a dummy variable: $F = 0$ and $M = 1$ for gender and $AO = -1$, $NO = 0$, $PO = 1$, and $CPO = 2$ for the Drawn Stories Technique, respectively. Finally, multiple linear regression analyses were performed to test the predictive capacity of gender and age for two specific scores such as Negative Outcomes in the Drawn Stories Technique and the presence of teacher in the Classroom Drawing treated as dichotomous variables 0–1(absence–presence).

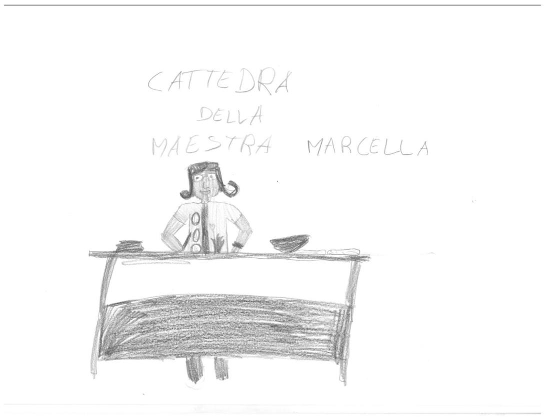

FIGURE 5
Classroom drawing: the presence of the teacher: *"The Teacher Marcella and her desk."* Female, 10 years old.

3. Results

3.1. Drawn Stories Technique outcomes by level of education and gender

Regarding the Drawn Stories Technique, Table 1 shows descriptive statistics of the whole sample with a prevalence of CPO (44.3%), followed by PO (39.2%), NO (14.1%), and AO (2.3%). Using Drawn Stories Technique outcomes as a function of the level of the school, we found that there is a prevalence of PO (45.7%) in primary school children, followed by CPO (39.7%) and NO (11.7%), and AO was reported only in 2.9% of cases. In comparison, in secondary school, the most recurring outcome is CPO (56.5%), followed by PO (22.4%) and NO (20.3%), and AO was reported only in 0.8% of cases.

Moreover, the results, including also gender comparisons, showed that females, both in primary school and secondary school, reported higher CPO (46.7% and 60%, respectively) than males in primary and secondary school (32.5% and 53.6%, respectively); PO is essentially balanced between females and males both in primary (45.7% and 45.6% respectively) and secondary school(24.1% and 21% respectively). In contrast, males

FIGURE 6
Classroom drawing: Group class and teachers. The drawer, the classmates, and the teacher. Integration 3. Female, 12 years old.

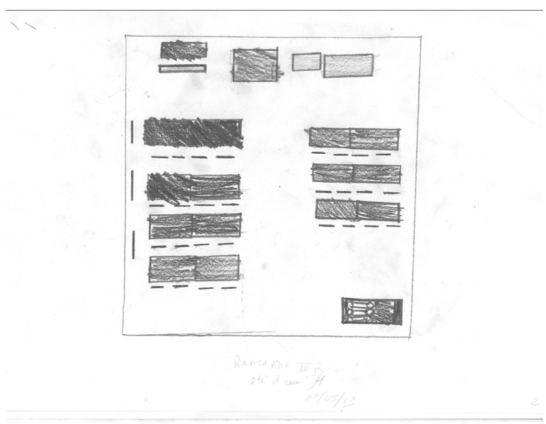

FIGURE 7
Classroom drawing: an empty class example, integration 0. Male, 8 years old.

show higher NO than females both in primary(17.2% and 6.4%) and secondary school(25.5% and 14.1%) (Table 1).

Moreover, to test the hypothesis, ANOVA was performed, and NO was changed into dichotomous and discrete values (0–1). The results showed significant differences between primary and secondary school children in NO ($F = 21.69$ $p < 0.01$) with a small effect size ($d = 0.21$), and also gender differences in NO were significant both in primary ($F = 37.073$; $p < 0.01$;) with a small effect size ($d = 0.34$) and secondary school children ($F = 9.794$; $p < 0.01$) also with small effect size ($d = 0.27$; Table 2).

3.2. The classroom drawing scores by level of education and gender

Regarding the content of the Classroom Drawing, descriptive statistics of the total sample showed a prevalence of low scores of integration, such as 0 (44.4%) and 1 (12.4%), followed by good scores of integration 2 (19.5%) and best scores with 3 (23.7%).

Using Classroom Drawing scores as a function of the level of education, the results show that in primary school children, low scores such as 0 and 1 are reported in 41.8 and 14.4% of cases, respectively. In comparison, higher scores such as 2 and 3 are reported in 19.6 and 24.2% of cases, respectively. Moreover, in secondary school, there is a prevalence of low scores, such as 0 (51.1%) and 1(7%), while higher scores such as 2 and 3 are reported in 19.3% and 22.6%, respectively.

To test, HP3 ANOVA was performed first with total Classroom Drawing mean scores and second taking into account only the relationship with the teacher as a separate dichotomous variable (0–1). The results reported in Table 2 show that primary school children score better than secondary school children. However, this difference is only nearly significant ($F = 3.752$; $p > 0.05$) with a small effect size ($d = 0.10$), whereas, as regards the relationship with teacher score, significant differences were found with primary school children that score better than secondary school children ($F = 7.647$; $p < 0.01$) with small effect size ($d = 0.14$). Regarding gender comparison, total female scores are significantly better than males in primary school ($F = 5.847$; $p < 0.05$) but not significantly better in secondary school children ($F = 0.483$; $p > 0.05$). Finally, also regarding teacher relationship score, females

TABLE 1 Frequencies of Drawn Stories Technique outcomes and classroom drawing scores.

		Primary		Secondary		Total
		Female	Male	Female	Male	Sample
DST	AO	1.2%	4.6%	1.8%	0.0%	2.3%
	NO	6.4%	17.2%	14.1%	25.5%	14.1%
	PO	45.7%	45.6%	24.1%	21.0%	39.2%
	CPO	46.7%	32.5%	60.0%	53.6%	44.3%
CD	0	39.3%	44.3%	48.2%	53.6%	44.4%
	1	12.6%	16.3%	9.1%	5.2%	12.4%
	2	22.4%	16.7%	19.5%	19.1%	19.5%
	3	25.7%	22.6%	23.2%	22.1%	23.7%
TEACH	1	59.6%	65.1%	66.4%	71.8%	62.3%
	0	40.4%	34.9%	33.6%	28.2%	37.7%

DST, Drawn Stories Technique; CD, Classroom drawing; TEACH, Presence of the teacher in classroom drawing; NO, Negative outcome.
*$p<0.05$, **$p<0.01$, and ***$p<0.001$.

TABLE 2 Descriptive statistics of quantitative drawing indices and differences by sex and type of school.

	Primary		Secondary	
	Female	Male	Female	Male
DST	1.38 ± 0.66	1.06 ± 0.825	1.42 ± 0.79	1.28 ± 0.84
ANOVA	$F=8.829$**	0.003	$F=3.570$	0.059
NO	0.06	0.17	0.14 ± 0.34	0.25 ± 0.43
ANOVA	$F=21.698$***	0.000	$F=9.794$**	0.002
CD	1.34 ± 1.23	1.18 ± 1.22	1.18 ± 1.25	1.10 ± 1.26
ANOVA	$F=3.752$	0.053	$F=0.483$	0.488
TEACH	0.40 ± 0.49	0.35 ± 0.47	0.34 ± 0.47	0.28 ± 0.45
ANOVA	$F=7.647$**	0.006	$F=1.676$	0.196

DST, Drawn Stories Technique; CD, Classroom drawing; TEACH, Presence of the teacher in classroom drawing; NO, Negative outcome.

TABLE 3 Correlation analysis.

	2	3	4	5	6
1. SEX	0.16	−0.168**	,060*	-,060*	0.163***
2. AGE		0.69**	−0.014	−0.13	0.081**
3. DST			0.016	−0.017	−0.650**
4. CD				0.777*	0.010
5. TEACH					0.004
6. NO					

*$p<0.05$, **$p<0.01$, and ***$p<0.001$.

score significantly better than males in primary school ($F=4.105$; $p<0.05$) but not in secondary school ($F=1.676$; $p>0.05$).

3.3. Correlation analyses

Regarding bivariate associations in the total sample, Pearson's correlation showed significant relationships between the Drawn Stories Technique and both sex ($r=$ 0.168; $p<0.01$) and age ($r=0.69$ $p>0.01$), while it showed no significant relationship with Classroom Drawing scores ($r=-0.016$; $p>0.05$; Table 3). Regarding Classroom Drawing total score, Pearson's correlations show a significant relationship with the female sex ($r=-0.060$ $p>0.05$) but no significant relationship with age ($r=-0.14$; $p>0.05$; Table 3).

3.4. Regression analyses

In the sample of primary school, linear regression analysis performed selecting specifically "Negative Outcome" (NO) as the dependent variable showed that the model, which includes sex and age as predictors, explained a total of 2.8% ($F=19.037$; $p<0.001$) of variance with sex as only significant predictor of negative outcomes (β =0.167; $p<0.001$) in primary school (Table 4).

Regarding the secondary school, the model explained only 2.2% of variance with sex as the only significant predictor ($\beta=0.116$; $p<0.001$).

Regarding the presence of the teacher in the Classroom Drawing as a dependent variable, regression analyses for the sample of the primary school revealed only 0.5% of the variance ($F=3.083$; $p>0.05$) with sex as the only significant predictor ($\beta=-0.165$ $p<0.000$). In the sample of secondary school, the model revealed only 1.5% of the variance ($F=4.698$; $p<0.01$) with age as the only significant predictor ($p<0.001$; Table 5).

TABLE 4 Linear regression model: sex and age as predictors of negative outcomes in primary and secondary school children.

Primary	*B*	St.Err.	Beta	R^2	Adj.R^2	*t*	Sign.
Model	0.120	0.058		0.029	0.028	2.080	0.038
SEX	0.108	0.018	0.167			6.045***	0.000
AGE	−0.007	0.007	−0.028			−1.000	0.318
Secondary							
Model	−0.372	0.305				−1.221	0.223
SEX	0.116	0.036	0.144	0.026	0.022	3.197***	0.001
AGE	0.044	0.026	0.076			1.689	0.092

TABLE 5 Linear regression model: sex and age as predictors of teacher presence in Classroom Drawing scores in primary and secondary school children.

Primary	*B*	St. Err.	Beta	R^2	Adj. R^2	*t*	Sign.
Model	1.220	0.224		0.005	0.003	5.454	0.000
SEX	−0.165	0.069	−0.067			−2.393*	0.017
AGE	0.015	0.026	0.016			0.569	0.570
Secondary							
Model	−1.672	0.959		0.019	0.015	−1.745	0.082
SEX	−0.067	0.114	−0.026			−0.587	0.558
AGE	0.243	0.081	0.134			2.984**	0.003

4. Discussion

The current study aimed to explore how graphic techniques evaluate children's emotional state and scholastic integration and contribute to a growing literature on the role of emotion-related attributes on psycho-educational processes during childhood, such as scholastic integration. According to our first hypothesis, there is a significant gender difference in the way children express their emotions; specifically, our findings show that males tend to draw a greater number of NO than females in the Drawn Stories Technique, and this tendency is stronger for primary than secondary school children, as confirmed by the only previous research, which used this technique so far conducted by Trombini et al. (2004). According to our findings, a meta-analysis by Chaplin and Aldao (2013) found that gender differences in many of the emotion expressions either diminished (for internalizing emotion expressions) or reversed direction (for externalizing and negative emotion expressions) in adolescence; for authors, it is possible that physiological (e.g., puberty) and social (e.g., at school and in the peer group) changes in adolescence lead to an increase in internalizing emotional expressions for both boys and girls, attenuating gender differences for this emotion category (Chaplin and Aldao, 2013). Overall, this gender difference can be explained in different ways, taking into account biological (Zahn-Waxler et al., 2008; Connolly et al., 2019) and psychosocial factors (Wright et al., 2018; Mancini et al., 2020), but it is important to highlight that negative outcomes indicate a presence of emotional turbulence in the "here and now," and drawing is a fundamental and also the easiest way that children have to contain and regulate emotion (La Grutta et al., 2022). Moreover, the results showed that females reported higher CPO both in primary and secondary school; increases in positive outcomes compensated and negative outcomes could be considered an evolutionary advancement reflecting children's development as a consequence of a more complex reality and a growing resilience capacity.

Gender comparison also showed that females' total scores are better than males in the Classroom Drawing, but this difference is significant only for primary school; this tendency also regards teacher relationship score in which females score significantly better than males in primary school but not in secondary school. These findings support previous research (Baker, 2006; Quaglia et al., 2013; Longobardi et al., 2016) in which the association between teacher relationship quality and the pupil's sex seems to be higher for females and could reflect the teachers' tendency to find less cohesion and affinity in relationships with male pupils that could be connected to the boys' lack of faith in their mental abilities and their difficulty in responding easily to the cognitive demands made by the teacher in terms of effort and scholastic achievement (Longobardi et al., 2016). Another possible explanation is related to the fact that primary school teachers in Italy are primarily females, and this could have an important role in facilitating some identification by girls with them.

The Classroom Drawing seems to reflect children's individual differences only marginally, maybe due to the complexity of the school environment in which some variables such as teachers' educational styles and the physical spaces of schools could influence the current evaluation (Brunetti et al., 2020). Despite this, the classroom drawing is, therefore, an important evaluation tool to assess the teacher–pupil relationship that is regarded as one of the fundamental modes of expression of a bond of crucial importance for the child's emotional and cognitive development (Quaglia et al., 2013; Mancini et al., 2020). The degree of negativity in the relationship with the teacher is associated with poor academic and social behavior and prospectively through secondary school (Baker, 2006). Regarding the age variable, our findings show a negative correlation between secondary school and level of integration, especially for the relationship with the teacher; these results suggest that the development and differentiation of cognitive and self-system processes may decrease the prominence of teacher–child relationship by secondary school when children report less positive relationships with teachers and more investment in peer relationships (Baker, 2006). Moreover, the relationship with the teacher represents the relationship with authority and it is possible that the transition period from childhood to adolescence, which involves an increase in conflicts toward authority and social norms in favor of achieving greater autonomy, could lead to a worse relationship with the teacher as a representation of authority (Smetana et al., 2005).

5. Limitations

Our study suffers from some limitations. First, the cross-sectional research design does not allow us to analyze changes over time. Moreover, we used only projective graphic techniques, and adding different types and more objective tools such as self-report instruments could improve the validity of these findings. Despite all the above, the correspondence with the data found in the literature enabled us to confirm the usefulness of the graphic method as an instrument for the assessment and a means of gaining knowledge of the children's emotional state and scholastic integration to improve pupil emotional health and wellbeing in terms of the social, behavioral, and academic outcomes.

6. Conclusion

In conclusion, our hypotheses are partially confirmed. First, as we hypothesize, gender is significantly related to the different emotional states expressed by children and predicts NO in the Drawn Stories Technique, especially the male sex. However, age showed no relationship with NO while it was related to CPO. This is probably because of the development of children who became more capable of creating more complex stories than younger ones and use resilience strategies to address their emotional problems. Our hypotheses are partially confirmed regarding scholastic integration because age was a significant predictor of better scholastic integration in secondary school but not in primary school, as we hypothesize. However, on the whole, the effect was relatively low so seems that drawing techniques alone are not sufficient to suggest and detect children's individual differences in the classrooms. Despite this, measures of this type are economic, easy to administer, and provide a lot of information even if they are used in a group. It could be helpful to propose some simple "activities" to the children aiming to start teachers thinking about the emotional climate of their classroom to facilitate teacher and children dialogs, talking about what is happening in the class, especially if some critical events happened, such as children's transference or bullying behaviors, but also only modulate didactical materials and detect some dysfunctional signals to prevent problems in group class functioning and promote better integration improving children scholastic wellbeing.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving human participants were reviewed and approved by Bioethic Committee University of Palermo (no.83/2022). Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

Author contributions

SG, ME, ET, and FA conceptualized the study and supervised it. MP and UC were responsible for the data collection. MP, MR, and VS coded drawings. MP and UC analyzed the data. MP, MR, and VS wrote the draft manuscript. SG, ME, ET, FA, and MP revised the final manuscript. All funders should be credited and all grant numbers should be correctly included in this section.

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Deep learning for studying drawing behavior: A review

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In recent years, computer science has made major advances in understanding drawing behavior. Artificial intelligence, and more precisely deep learning, has displayed unprecedented performance in the automatic recognition and classification of large databases of sketches and drawings collected through touchpad devices. Although deep learning can perform these tasks with high accuracy, the way they are performed by the algorithms remains largely unexplored. Improving the interpretability of deep neural networks is a very active research area, with promising recent advances in understanding human cognition. Deep learning thus offers a powerful framework to study drawing behavior and the underlying cognitive processes, particularly in children and non-human animals, on whom knowledge is incomplete. In this literature review, we first explore the history of deep learning as applied to the study of drawing along with the main discoveries in this area, while proposing open challenges. Second, multiple ideas are discussed to understand the inherent structure of deep learning models. A non-exhaustive list of drawing datasets relevant to deep learning approaches is further provided. Finally, the potential benefits of coupling deep learning with comparative cultural analyses are discussed.

KEYWORDS

deep learning – artificial neural network, drawing behavior, sketch, artificial intelligence – AI, art cognition, primates

Introduction

Drawing is a powerful communication medium that can convey concepts beyond words. Two different approaches are traditionally used to study drawing behavior (Pysal et al., 2021): the process approach (Freeman and Cox, 1985; Adi-Japha et al., 1998) and the product approach (Brooks, 2009; Xu et al., 2009). The process approach analyzes drawings through the behavioral characteristics linked to the drawing task and the individual who is drawing. For example, this perspective may require information on behavioral sequences (investigated through coordinates and the time spent drawing each point or behavioral sampling), which is more difficult to collect than the data needed for the product approach. Indeed, the latter analyzes the result of the drawing, based only on spatial and visual information, to infer the underlying behavior. Drawings, as final products, have been widely used to better understand the cognitive capacities of individuals, in particular to investigate the cognitive development of children (Malchiodi, 1998; Barraza, 1999; Cox, 2005; Farokhi and Hashemi, 2011). Studying visual features such as the color palette in drawings, the product approach has been pivotal in describing the diversity of personalities in children (Goldner and Scharf, 2011), identifying mental disorders (Tharinger and Stark, 1990) and post-traumatic symptoms (Backos and Samuelson, 2017), and even revealing concealed emotions (Fury, 1996). Both of these approaches – process and product – are covered in this review.

In toddlers, first drawings are in the form of scribbles, described as a motor activity not directed by the eyes, but by the mechanical functioning of the motor system arm-wrist-hand (Piaget and Inhelder, 1967; Freeman, 1993). At this age, scribblers appear to take little interest in their final products, whereby the process of drawing itself or improving the technique prevails over the will of representation (Thomas and Silk, 1990; Golomb, 1992). Figurative drawings, where what is drawn is representative for both the subject and external eyes, only appear at 3–4 years of age (Golomb, 1992; Freeman, 1993).

However, figuration and internal representativeness are not always similar. Since the end of the 19th century, researchers have developed a methodology to address the difficulties of studying drawings and scribbles (Farokhi and Hashemi, 2011). These analyses are limited by the subjective judgment of the observer (Lark-Horovitz, 1942), which is prone to several biases, especially with respect to semantic analyses. These issues are minor when computing low-level features such as color statistics, but are fundamental when trying to extract higher-level features; for example, one observer may see a house where another observer only sees a scribble, or both observers may fail to detect the drawer's intention to represent a house. The distinction between figuration and internal representativeness is essential, particularly when analyzing young children's drawings. Indeed, while previous theories proposed that the drawing among the youngest reflect motor activity only, recent studies have provided evidence for a symbolic function of drawing as early as 2 years old, suggesting that even young children can learn and become aware of the two visual aspects of drawing: the referent, which is the concept of what is drawn, and the signifier, which is the drawing object itself (Longobardi et al., 2015). However, a young child using drawings for symbolic representation may not intend to represent the formal aspects of reality through his or her first drawings, but rather seeks to express the world around him or her in a physiognomic way, using the line as means of expression (Longobardi et al., 2015). In other words, what is regarded as a scribble for an adult can be a symbolic representation for a young child. To understand the emergence and development of drawings, it is important to interpret such drawings. To do so, asking very young children about their product is impossible, as they cannot communicate verbally. To address this problem, one could ask adults to interpret the drawings. However, by doing so, adults would typically fail to detect the intention of the drawer and the meaning of scribbles. Asking the child about his/her intention only partially solves this problem because for a given child, the answer has been shown to vary from 1 day to the next (Martinet et al., 2021). The answer is also dependent on the subject's verbal communication skills, which are naturally limited in toddlers, as in other great apes. This is not a problem for free-form drawings (i.e., no instruction), but becomes challenging for task-based drawings (i.e., instructions and constraints on the drawings; Martinet et al., 2021). The same problem arises among great apes such as chimpanzees (*Pan troglodytes*), who are well known for their drawing behavior (Martinet and Pelé, 2020). Indeed, captive chimpanzees spontaneously draw and paint if provided with appropriate materials (pen, paint, brushes, and paper) and can continue this behavior without being reinforced with food (Boysen et al., 1987; Tanaka et al., 2003).

To interpret the intention behind drawings, objective and mathematical analyses have been developed. Martinet et al. (2021) elaborated an innovative mathematical tool based on spatial fractal analysis, and Beltzung et al. (2021) used temporal fractal analysis for this purpose. The combination using a principal component analysis of simple metrics (number of lines, circles, colors, cover rate, etc.) can also provide interesting results regarding interindividual differences in human (Sueur et al., 2021) or orangutan drawings (Pelé et al., 2021).

The rise of deep learning

Over the last few decades, researchers have been investigating drawings using AI and computer vision (Eitz et al., 2012; Li et al., 2013). The latter encompasses sophisticated techniques and algorithms which can extract features in an image that are meaningful to human visual perception, such as facial features (e.g., eyes and nose). These techniques are widely used for detection [e.g., corner and edge detection (Li Y. et al., 2015)], segmentation (e.g., K-mean, P-Tile), and recognition (convolutional neural network). Most analyses use computer vision to extract features which are then fed into a classifier.

It is important to note that traditional models and machine learning have been successfully used as approaches to study the drawing behavior. For example, by measuring the proportion of time the pen was in contact with the paper, Cohen et al. (2014) have shown a link between the Digital Clock-Drawing test and depression. Polsley et al. (2021) used machine learning methods, as Random Trees and Random Forest, to demonstrate how curvature and corners in drawings are linked to the age. These mathematical analyses and indices are objective contrary to former measures and are a good starting point for developing more objective studies using artificial intelligence (AI).

Currently, the most efficient and promising way to learn from images, including drawings, is deep learning (Figure 1; Ravindran, 2022), a sub-branch of computer vision and artificial intelligence, and more precisely neural networks, also used for speech recognition (Graves et al., 2013) and text classification (Liu et al., 2017). Deep learning allows us to go further by avoiding some anthropomorphic biases, such as the confirmation bias. For example, when analyzing drawings without deep learning, the features may be unconsciously selected accordingly to the beliefs of the human devising this process. By using almost raw data, deep learning thus reduces such biases.

The first mathematical model defining the concept of artificial neurons dates back to McCulloch and Pitts (1943). Deep learning only

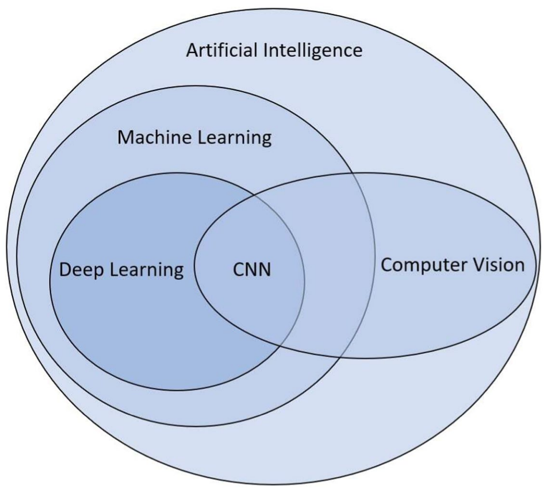

FIGURE 1
Euler diagram of artificial intelligence and neural networks in computer vision.

surged in 2012, when a deep convolutional neural network (CNN) named *AlexNet* (Krizhevsky et al., 2012), outperformed other methods by a large margin in a popular competition of image classification, the ImageNet Large Scale Visual Recognition Challenge (ILSVRC; Deng et al., 2009). CNNs (Figure 2) form a subcategory of artificial neural networks, specifically designed for processing images by learning filters (*via* convolutional layers) that optimize performance in a predefined task (e.g., categorizing images or regressing images with a continuous variable). These filters allow capturing a hidden representation of images (Mukherjee and Rogers, 2020). A glossary of technical terms is presented in Table 1.

Although deep learning is now a flagship approach to image analysis, most of these algorithms have been trained and designed for photos. Compared to photos, drawings and sketches are sparser and can be abstract. DL models thus need to be created to specifically process this type of data (Zhang et al., 2016; Yu et al., 2017; Pysal et al., 2021).

These models can successfully classify drawings from several categories with high accuracy but allow limited interpretability. Indeed, deep learning models are often considered black boxes because of the number of parameters reaching tens of millions (Krizhevsky et al., 2012). Nevertheless, as in all scientific domains, interpretability and comprehension are key points when developing a model. What does a model outperforming human recognition 'discover' and 'comprehend' in the data that humans do not? Is it possible to extract and decipher the discriminant features and are humans able to understand them? To improve the interpretability of these models and to answer these questions, multiple methods have been developed and are discussed later in this review. Nevertheless, interpretability and explainability remain important challenges in deep learning (Gilpin et al., 2018) and are among the most active research topics in AI (Zhang et al., 2016; Wu T. et al., 2018; Rudin, 2019). According to Gilpin et al. (2018), "the goal of *interpretability* is to describe the internals of a system in a way that is understandable to humans" and *explainability* (for deep networks) consists in giving an explanation to "the processing of data inside a network, or explaining the representation of data inside a network" (note that the definitions of these concepts are still debated, see for example Tjoa and Guan, 2021). When studying drawings, the interpretability of AI is also fundamental to improving the knowledge of the ontogeny of drawing and the emergence of representativeness. Likewise, the AI processing of children and chimpanzees drawings can be compared to allow a better understanding of the evolutionary history of drawing. To achieve this goal, the assumptions on the underlying mechanisms of the drawing behavior can be formalized and implemented in a neural network model. With this objective, Philippsen and Nagai (2019) combined Bayesian inference and deep learning. They developed a neural network capable of completing partial drawings based on prior information. The goal of their study was to use this model to replicate children's and chimpanzees' drawing behavior to analyze the relative importance of different priors.

As previously mentioned, in children, the quality and representativeness of drawings improve with age (Martinet et al., 2021). In addition to age, other variables influence representation, such as sex (Picard and Boulhais, 2011) and cultural background (Alland, 1983; Gernhardt et al., 2013). For example, Gernhardt et al. (2013) demonstrated that the number of facial details and facial expressions in drawings vary among children from different cultures. Deep learning is a promising tool for understanding cultural variations in drawing. To the best of our knowledge, no such studies have been carried out yet. However, deep learning applied to drawings has recently been used to characterize mental disorders in individuals, such as Autism Spectrum Disorder (Anne et al., 2018), to predict the Draw-a-Person test (Widiyanto and Abuhasan, 2020), the Clock-Drawing test (Chen et al., 2020), and detect mild cognitive impairment (Ruengchaijatuporn et al., 2022).

Overall, deep learning in complement to other machine learning methods has the potential to greatly improve our knowledge of the ontogeny and evolutionary history of drawing behavior. This review presents and discusses the different applications of deep learning in drawing analysis and aims at giving the keys for readers who are interested by using deep learning to study drawing behavior and want to go further. The first section introduces different approaches to drawing analysis based on deep learning, which have already been applied or appear promising. These approaches are not discussed in relation to their performance (e.g., score of accuracy), but on the insights they can bring on the understanding of the drawing behavior. The second section reviews publicly available datasets that are well suited for studying drawings and sketches using AI and outlines the challenges. The review is concluded by discussing future research frameworks and perspectives in deep learning as applied to drawings.

Approaches in deep learning for drawing(s) analysis

This section is divided into two parts. The first part is focused on model-centric analyses, which refers to studies directly using the outputs of a model to make interpretation of the results. The second part focuses on analyses based on model-internals. The studies considered in this

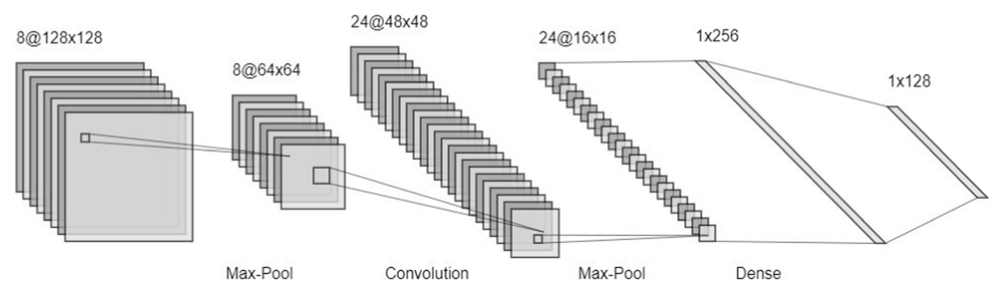

FIGURE 2
Example of a CNN architecture. The model takes an image as input; the image passes through layers to finally be classified between predefined classes.

TABLE 1 Glossary of technical terms.

Terms	Meaning	Definition
AI	Artificial Intelligence	All techniques allowing reproduction of intelligence.
ML	Machine Learning	Subset of AI techniques which learn from the training data.
DL	Deep Learning	Subset of ML techniques based on artificial neural networks. The analyzed features are learned by the model.
ANN	Artificial Neural Network	Model consisting of layers made up of units, also called neurons. An ANN can be shallow, or deep (DNN) when consisting of at least 2 hidden layers (i.e., layers between input and output).
CNN	Convolutional Neural Network	An ANN is specifically designed for images using convolutional layers.
RNN	Recurrent Neural Network	An ANN designed to process sequences, such as time series.
GNN	Graph Neural Network	An ANN where node relationships are studied.
GAN	Generative Adversarial Network	Unsupervised DL method capable of generating fake but realistic data.
VAE	Variational Autoencoder	An ANN belonging to the family of autoencoders, consisting of an encoder that compresses the data, and a decoder that reconstructs the data. Reconstruction in VAE is through a sampling of the hidden representation of the statistical model, rather than the hidden representation itself.
DA	Data augmentation	Techniques allowing an increase in the number of training data, by altering them through different transformations.
TL	Transfer Learning	Method consisting of reusing a model already trained on another task.

part use the weights of a model after being trained (i.e., *post hoc* interpretation methods), such as heatmaps, to discover for example of the information is encoded in the model.

Model-centric analyses

As in classical drawing studies, deep learning approaches can be classified as focusing either on drawings as a product or on the process of generating drawings and sketches. While the first approach investigates only the spatial dimension of drawings, the second considers the temporal dimension.

Product approach

Prediction-based analyses

Machine learning models are often trained with the aim to predict labels for unlabeled data (i.e., that have never been seen by the model). In deep learning, this prediction task can be conducted at several levels, from labeling the image as a whole (classification) or predicting a label for every pixel of an image (segmentation).

Classification

The most popular application of deep learning is classification. Classification plays a major role in computer vision in tasks as varied as classifying Alzheimer's disease from magnetic resonance images (Wen et al., 2020), identifying fish species (Li X. et al., 2015), and recognizing malware images (Yue, 2017). Classification is also a preliminary step in other tasks, such as segmentation. CNNs are mostly used for image classification in a supervised learning paradigm, where a model is trained to classify images into categories predefined by the user, by learning from a dataset of labeled images (i.e., images for which the category is known). Once trained, the model is used to predict the categories of new, unlabeled images.

The first CNN developed for sketch classification was Sketch-a-Net (Yu et al., 2017), which achieved better performance than humans in object classification. It may be surprising that a model trained on data labeled by humans can outperform humans at classification. Indeed, CNNs learn a latent representation, that is, hidden features from the data, which is more complex than human representation. Sketch-a-Net performs better on sketches than neural networks trained on photos, highlighting the need for specific architectures for drawings (Yu et al., 2017). A CNN can thus outperform and replace classical methods used in sketch classification based on predefined classes. For example, in psychology, Vaitkevičius (2019), built a CNN capable of successfully classifying scribbles in 20 different classes as defined by the psychologist Rhoda Kellogg (e.g., "single dot," "imperfect circle through single vertical line," "spiral line"). Compared to other classifiers used in computer vision (e.g., support vector machine (SVM), random forest, k-nearest neighbors), CNN achieves the best results, matching the efficiency of neural networks in analyzing non-figurative drawings, demonstrating how deep learning can automatize complex and laborious tasks. Another example is Rakhmanov et al. (2020), who used a simple CNN architecture (two convolution layers and two fully connected layers) to classify drawings according to the Draw-a-Person test (Goodenough, 1926), a cognitive test in which the subject (a child, most often) draws a human figure, and a score is assigned to the drawing based on several criteria (e.g., the number of eyes, body proportions, presence of the mouth) to assess the child's intellectual maturity. This test is used for several purposes, such as detecting behavioral disorders or measuring nonverbal intelligence. Several parameters are tested during the training of the neural network mode, and data augmentation is applied to compensate for the low number of drawings, to significantly increase the accuracy. Data augmentation is a computer vision technique which is widely used in machine learning, which increases the size of the training data set by slightly modifying the original instances (that are images in this case, by applying rotation, horizontal flip, color contrasts for example) during the training phase. DA also reduces overfitting, a phenomenon that occurs when the model is too specialized for the training data and generalizes poorly on new data. Although the deep learning model was able to learn and produce relevant results, Rakhmanov et al. (2020) found that other methods of computer vision, such as the bag of visual words (BoVW) approach, outperformed CNN (62% accuracy for BoVW versus 52% for CNN). This example shows that a straightforward CNN design does not necessarily outperform state-of-the-art methods.

Thus, more complex CNN structures are required to learn the hidden representation of an object from sketches. To this end, Zhang et al. (2016) built *SketchNet*, a neural network capable of classifying sketches in object categories to discover the shared structures between real images and sketches belonging to the same category. The classification part of this model relies on associating a sketch image with a positive real image (from the same category) and a negative image (from another predicted category). The authors used an architecture consisting of three subnetworks optimized to extract features of the sketch images, positive images, and negative images. The features of the sketch and real images were eventually merged. *SketchNet* is based on prediction rankings. For a given sketch, the model computes the probability of the sketch belonging to each category, before returning the top five prediction categories (i.e., the five more likely predicted classes for this sketch) and the nearest real images.

Segmentation

Classification can be used as a preliminary step for other tasks, such as segmentation. Image segmentation partitions the pixels of an image into multiple regions and assigns a label to each pixel. This technique is widely used in various fields, such as medicine (Brzakovic and Neskovic, 1993) and video surveillance (Patro, 2014). It can rely on classical computer approaches, but more recently, also on deep learning (Figure 3).

While classification helps improve segmentation, the opposite is also true. Sketches can be classified as a whole after segmentation and analysis of individual components, as in semantic sketch segmentation (SSS), which aims at labeling individual strokes. Semantic segmentation is notoriously difficult, however, because of complex perceptual laws, such as those proposed by Gestalt theory (Wertheimer, 1938). For example, the law of closure states that in an image with missing parts, the brain visually fills in the gaps. Interestingly, CNNs have been found to reproduce some perceptual laws. It appears that perceptual laws may or may not be present depending on the training set, and more generally the weights of the model (Kim et al., 2019, 2021; Jacob et al., 2021). For these reasons, it is a complex task to understand if and how neural network perception differs from that of humans, and these questions are still debated. Moreover, as with classification, it is necessary to develop architectures and models of semantic segmentation for sketches, specifically because of the differences between sketches and photos.

One of the first CNN-based models of sketch segmentation was *SketchParse*, proposed by Sarvadevabhatla et al. (2017). *SketchParse* automatically parses regions of sketches and has proven to be effective, for example, in separating the head, body, and tail of a horse. However, *SketchParse* parses regions, not strokes, which limits the utility of segmentation in studying drawings as a process because regions most often are not consistent with strokes.

Graph neural networks (GNNs) can overcome this limitation. Starting from these neural networks, it is possible to cluster strokes into semantic object parts. Yang et al. (2021) proposed *SketchGNN*, a convolutional GNN which outperforms state-of-the-art models, such as SSS and stroke labeling. Their model also extracts features at three different scales: point-level, stroke-level, and sketch-level. *SketchGNN* can for example label each pixel of a sketch representing a face, to associate with the pixel a larger face component, such as the nose or the mouth, without taking into account the order of the strokes. Predicting object parts by strokes labeling could allow for comparing the structure of specific parts of an object depending on the culture of the drawers, for example to compare object proportions. Another interesting SSS model was proposed by Li et al. (2019). Their model is an hourglass-shaped network consisting of an encoder and a decoder. The 2D image passes through a network which predicts the segmentation map. The corresponding segmentation map is then transformed into a stroke-based representation, which is used to refine the segmentation map. Due to the lack of 2D annotated sketches, the network is trained on edge maps extracted from 3D models already segmented and labeled, which can thus be transformed into sketches. Moreover, as the model is trained on 3D models, several viewpoints are available, that may not be the ones frequently represented in drawings. As it would be questionable to analyze freehand sketches by using a network mainly trained on 3D model-transformed sketches, the authors evaluated their model on freehand sketch datasets (Eitz et al., 2012; Huang et al., 2014); their model outperformed previous ones. Comparing children's and 3D model-transformed sketches, for a given category, could improve our knowledge of their spatial representation.

Generation-based analyses

Deep learning used for image classification and segmentation is usually referred to as discriminative AI, where models are trained to convert high-dimensional inputs (e.g., images) into low-dimensional outputs (e.g., the names of depicted objects). In contrast, generative AI generates high-dimensional outputs (e.g., images) from low-dimensional inputs (e.g., semantic representations). Most people know generative AI

FIGURE 3
Examples of segmentation results through CNNs from Chen et al. (2017). Reprinted with permission.

through web-based applications that allow drawing one's portrait in Van Gogh's style or putting fake words in Obama's mouth on a video. However, beyond these applications, generative AI has become one of the most growing research areas in AI because of a very large array of applications (Wu et al., 2016; Kell et al., 2020; Yang and Lerch, 2020; Bian and Xie, 2021), which include a study of drawings.

Generation

Pallavi (2019) devised SuggestiveGAN, a generative adversarial network (GAN; Karras et al., 2019). A GAN is an unsupervised algorithm in which two neural networks compete. Fundamentally, one neural network (the discriminator) is a classifier to distinguish real images from fake images; the other neural network (the generator) tries to generate the most 'realistic' fake images (according to the real dataset). SuggestiveGAN is able to reconstruct incomplete drawings (with missing strokes). The proposed model grasps the structure of the drawings at the expense of the details.

Style transfer

Style transfer involves applying the style of an image to another image, but not the content. Gatys et al. (2016) proposed a CNN-based method of style transfer that quickly achieved high popularity owing to its impressive visual results. The method has been popularized by the famous Van Gogh painting, whose style has been widely transferred onto various kinds of portraits and landscape photos. The authors defined the style from the Gram matrix of activations, a measure of covariation between filters within a given layer (usually, all convolutional layers are used to define the style). The content is defined by the activation of the deepest convolutional layers. The stylized image is then obtained by searching a new image that simultaneously minimizes the distance between its content and that of the 'content' image, and the distance between its style and that of the 'style' image. One of the most famous examples of Gatys et al. (2016) model is the transfer of Van Gogh's painting style to photographic portraits or landscapes.

Since the seminal work of Gatys et al. (2016), other CNN-based style transfer algorithms have been proposed and applied to various contexts [e.g., in user-assisted creation tools (Jing et al., 2020)]. For drawings and sketches, it is necessary to design specific models of style transfer as in the classification of drawings which are sparser and have a higher level of abstraction compared to paintings. Chen Y. et al. (2018) proposed *CartoonGAN*, a GAN-based style transfer algorithm developed for cartoon stylization. The model generates cartoon images based on real-world photos, which can be useful for photo editing or for artists to gain time. More recently, Chen C. et al. (2018) proposed a framework capable of synthesizing face sketches while preserving details, such as skin texture and shading.

Hicsonmez et al. (2017) applied style transfer to drawings to learn the styles of different book illustrators. Their objective was to apply the style of drawing from an illustrator (the "style image"), to an image produced by a different illustrator (the "content image"). Their framework shows that this technique can be successfully applied to drawings. Dissociating the style and content of a drawing, and modeling how these two components vary separately would have numerous implications in drawing studies. For example, by using the style of children's drawings, one may analyze the development of motor skills through the complexity of the strokes, by using only the style component of the drawing, while dissociating the motor constraints from the representational constraints. The style component can also be used to investigate the link between different types of curves used (broken curves and smooth curves) and internal representativeness (Adi-Japha et al., 1998). Moreover, studying the development of the style of the drawing system and the writing system, using style transfer, would help in understanding the differences and similarities between the two systems. Finally, using generative AI like the one developed by Chen C. et al. (2018), but instead generating realistic photos from drawings would shed light onto children's representation of the world.

Process approach

Prediction-based analyses

Classification

In addition to the product approach, sketch recognition could allow a better understanding of the cognitive processes underlying the drawing. It is known that the development of drawing and writing shows kinematic differences according to age (Adi-Japha and Freeman, 2001). Thus, classifying drawings and writing across ages could lead to discriminant low-level features, such as shapes, that could help in understanding the links as well as differences among techniques between these systems. Writing is not the only phenomenon correlated with drawings. Indeed, as shown by Panesi and Morra (2021), executive functions (e.g., shifting, inhibition) and language are linked to drawing behavior. Their work proposes several tasks to which different scores are assigned, such as the absence/presence of structures in human figure drawings, which can be further automated through deep learning. All these cognitive processes are directly linked to cortical activity, which is typically investigated using brain imaging [e.g., electroencephalography (EEG) and electromyography (EMG)]. Applying deep learning to brain imaging can be achieved within a framework such as that proposed by Leandri et al. (2021) through recurrent neural networks (RNNs), which are specifically designed for temporal sequences.

He et al. (2017) developed a model able to use the temporal information of the strokes to perform sketch recognition as well as Sketch-based Image Retrieval (SBIR), which aims at finding real images visually similar to a given sketch. The proposed model is based on a CNN coupled with a R-LSTM (Residual Long Short-Term Memory) network. Multiple representations of the drawings are learnt by considering 60, 80, and 100% of the strokes of the drawings separately. The performance achieved by this model demonstrates how stroke ordering information can be used in deep learning and how it plays a role in classification. To go further, Xu et al. (2022) proposed to consider drawings as graphs thanks to GNNs (Graph Neural Network). A classical application of such architectures is node classification. A graph consists of edges and links, and GNNs analyze the relationships between the nodes. In sketches, these types of models take the relationships between the strokes into account. Their proposed model, called Multi-Graph Transformer, allows for capturing geometric and temporal information about the drawings, as well as understanding the relationship between strokes. These models could thus be useful to improve our knowledge on the links between object parts and object representations. These approaches could also help at understand which strokes are the most relevant for classification or comparing which parts of an object are drawn first depending on the culture or age for example.

Segmentation

The information contained in the stroke order and temporal sequences can provide very rich information, which may be hard to decipher just through image classification. Wu X. et al. (2018) designed a stroke-level sketch segmentation model, *Sketchsegnet*, that is based on a variational autoencoder (VAE) which learns the probability distribution from the data. In *Sketchsegnet*, widely used in image generation (Razavi et al., 2019; Zhu et al., 2020), the VAE consists of a bidirectional RNN (*BiRNN*; Schuster and Paliwal, 1997) for the encoder and an autoregressive RNN (Inselberg and Dimsdale, 1990) for the decoder, thus accounting for the sequence order of strokes. For each sketch category, labels are predefined (e.g., 'cream' and 'cone' for an ice cream). Their model achieves an accuracy of 90% for stroke labeling.

Thus far, research on sketch and drawing segmentation using AI has been primarily methodological, with only rare applications to better understand the ontogeny and evolutionary history of drawing behavior. Nonetheless, segmentation could be of great interest in this kind of analysis. For example, segmentation can be used to analyze body proportions, which are indicative of the emotional state in children [e.g., disproportionally large hands can express aggression (Leo, 2015), and the relative size of the head and trunk varies with age in children (Thomas and Tsalimi, 1988)]. In addition, annotated sketch databases are not common, and annotating sketches will lead to bias, depending on the perception of the person doing the annotation. For this reason, SSS should be studied in depth through unsupervised stroke-level segmentation or by using temporal sequence algorithms (Gharghabi et al., 2019), which also consider the time spent not drawing. Applying SSS to scribbles could lead to semantic segmentation, not necessarily obvious to human perception. Moreover, SSS allows the analysis of specific regions, such as the head, at a certain level of detail despite the complexity. This could help in understanding the relative importance of different visual stimuli in shaping the representation space of children. Models using 3D sketches, similar to Li et al. (2019), can elucidate the emergence of 3D geometry in children, and more generally, the development of spatial ability in children, necessary for representativeness. Using deep learning to analyze low-level features such as the spatial distribution of strokes, their orientation and form, and how these vary with age could also be informative about the ontogeny of the drawing behavior in humans and other animals.

Generation-based analyses

As drawings are directly linked to the temporal sequences of the strokes, it is fundamental to consider the process when generating parts of drawings, to generate meaningful strokes. Among the first to use generative AI were Ha and Eck (2017) who studied the behavior of drawing by developing a neural network capable of reproducing and mimicking human drawing through conditional and unconditional generation. To do so, they considered each drawing as a list of points, and each point as a vector of length 5 to characterize the position and state of the pen at a given time. The generative model used in this study was VAE. In Ha and Eck's (2017) model, both the encoder and decoder are recurrent neural networks, and hence, the name *Sketch-RNN*. When given an incomplete sketch, *Sketch-RNN* generates strokes to complete the sketch. As a result of the random nature of VAE, the model can predict different final results for the same initial sketch. The authors suggested that *Sketch-RNN* could be used, for example, to help students learn how to draw.

A model combining an RNN with Bayesian inference was developed by Philippsen and Nagai (2019) to unravel the sensory and cognitive mechanisms of drawing behavior. They relied on a 'predictive coding' scheme, according to which the brain constantly generates and updates internal, cognitive models of the world to predict the consequences of our actions in response to sensory inputs (Rao and Ballard, 1999). The authors investigated how varying the integration of sensory inputs with cognitive models influenced the ability of the RNN to learn to complete partial drawings. They found that a strong reliance on cognitive models is necessary to complete representational drawings, thereby highlighting the importance of internal models for efficient cognitive abilities such as abstraction and semantic categorization. Interestingly, the authors also stressed that drawings generated with a weak reliance on cognitive models differed from children's drawings but resembled chimpanzee's drawings. This result echoes previous suggestions that the inability of chimpanzees to complete representational drawings could be attributed to their poor predictive cognitive skills, such as those involved in imagination (Saito et al., 2010; Watanabe, 2013). This study also demonstrates the benefits of generative AI in understanding the development and evolution of drawing behavior. This predictive coding scheme can have other applications, such as understanding pathologies like metamorphopsia (e.g., straight lines that appear distorted) from the drawings of patients to unravel the neuronal mechanism that leads to these drawings.

Model internals-based methods

As we have seen, drawing behavior can be studied by designing and training deep neural networks models and directly interpret the output. However, these approaches do not take advantage of the internal knowledge learnt by the model. To address this issue, it is possible to develop techniques that use model internals, such as the weights and the neuronal activations of each layer separately.

Predictive models based on CNNs have been shown to outperform other models such as SVM and k-nearest neighbors, in most applications. However, as with any quantitative model, predictive power comes at the cost of interpretability, and a notorious limitation of CNNs is their low explanatory appeal (Rudin, 2019). Regarding the ability of CNNs to help understand human behaviors, some researchers have suggested that AI is simply replacing a black box (the brain) with another. Other researchers have argued otherwise (Hasson et al., 2020). Ribeiro et al. (2016) developed a model to classify photographs of wolves and huskies. Based on accuracy alone, the model worked well. However, this model was in fact performing badly; all the pictures of wolves in the training set had snow in the background, and pictures of huskies did not. In learning the most discriminative features to separate images of wolves from those of huskies, the model thus focused on the presence or absence of snow in the background and did not encode the features of these canines. This purposely bad-designed experiment highlights how the qualitative analysis of learned features can increase the model interpretability. CNNs have explicit architectural specifications; they are trained with user-defined learning rules; and one has direct access to the weights (strength of connections between neurons) and neuronal activation. Analyzing how varying these hyperparameters improves or deteriorates the fit between models and empirical data offers exciting venues of research, in exploring both the neuronal mechanisms of information processing and their behavioral expressions (e.g., Richards et al., 2019; Lindsay, 2021). A remarkable example is the study by Philippsen and Nagai (2019) discussed previously, in which the authors varied the hyperparameters prior to analyzing the relative importance of sensory inputs and cognition in drawing behavior. More generally, when devising and training a model to discriminate between children and adult drawings, or between drawings of humans and other great apes, independent of model performance, one may be interested in knowing which features are responsible for AI discrimination. To do so, two possible approaches exist: local interpretation, allowing us to understand the features of a specific image (i.e., based on the data), and global interpretation, allowing us to understand class discrimination (i.e., based on the model).

Local interpretation

Local interpretation encompasses techniques aiming at understanding a specific prediction (i.e., for a given instance) for a given model. Applied to deep learning, such methods can help understanding which part of an image played a role for a given prediction task. This section will provide examples of such techniques applied to sketches.

Bag-of-features (BoF) is a computer vision algorithm that aims to extract the occurrence count of features, and is more interpretable than CNNs. Brendel and Bethge (2019) developed *BagNet*, a neural network that combines the flexibility of CNNs and the interpretability of BoF. Although *BagNet* was originally created to analyze natural images, Theodorus et al. (2020) used this model to interpret sketch classification. They compared *BagNet* to non-interpretable CNNs such as *VGG* (Simonyan and Zisserman, 2015), *ResNet* (He et al., 2016), and *DenseNet* (Huang et al., 2017), to determine whether the increased interpretability is due to the model itself or to the difference between natural images and sketches. *BagNet* was trained to classify sketches into 251 object categories. For each model (*VGG*, *ResNet*, *DenseNet*), the authors extracted and compared class activation maps (CAMs; Zhou et al., 2016) for multiple images. For a given category, CAM indicates which region of an image influences the prediction of that category the most (Figure 4). To go beyond the qualitative interpretation allowed by a simple description of CAMs, Theodorus et al. (2020) developed a quantitative metric of interpretability, the heatmap interpretability (HI) score, which evaluates the quality of a CAM. A high HI score indicates a meaningful heatmap. Figure 4 illustrates that the CAMs from *ResNet-50* and *DenseNet-109* have a low HI compared to *VGG-16* and *BagNet-33*, because highly activated pixels are largely scattered. Concurrently, a questionnaire was used to empirically evaluate the interpretability of the model. Each respondent was given one correctly predicted image per category with its corresponding heatmap and was asked to label object parts according to the heatmap. Comparing the CAMs for several categories, the authors concluded that their model did not use the same features as humans do for classifying object sketches. For example, the CAMs for the categories of 'sword' and 'knife' showed that the model only focused on the tip of these objects during classification, while humans also considered the handle and the shape of the blade.

Theodorus et al. (2020) provided an example of how interpretable deep learning models could be used for sketches. Although their model does not understand object representation as humans do (Baker et al., 2018; Jacob et al., 2021), training models on different age classes separately and analyzing the heatmaps of several object categories can help formulate hypotheses about the development of drawing behavior in children. CNNs can be used in conjunction with eye tracking. By using the framework proposed by Theodorus et al. (2020), the dots from CAMs for a given object can be compared to those of humans when classifying an object. Eye-tracking and CNN can also be used for a phylogenetic approach to understand the visualization, understanding, and representation of objects of different apes, for a comparison with young children.

In addition to heatmaps, other techniques offer interpretations, such as perturbation-based models. An example of such a method is ZFNet (Zeiler and Fergus, 2014), where parts of a given image are occluded and replaced by a gray square. Using this method, boxes can be occluded to understand which parts of the image are important for classification. However, it should be noted that the transparency of the prediction must be rigorously studied, as it may not be achievable through local interpretations (Ghassemi et al., 2021).

Global interpretation

To understand how information flows in the model, another possibility is to study the global interpretation, such as feature visualization. The first convolutional layer of a CNN extracts basic features, that is, edges and color blobs (Qin et al., 2018), which are easy to visualize and understand, while the deeper layers extract more complex shapes, which can describe parts of objects, entire objects, or complex patterns abstract to human perception (Singer et al., 2020, 2021) showed that photographs and drawings are similarly represented in the early and intermediate layers for networks trained on photographs.

Feature visualization has been widely studied in computer vision (Zeiler and Fergus, 2014; Yosinski et al., 2015; Olah et al., 2017), but few studies have been conducted on sketches and drawings. Young-Min (2019) studied the visual characteristics involved in comic book page classification. First, they designed a model to classify comic book pages between several comic artists. They then investigated visual features using a previously published method (Szegedy et al., 2015), with nine representative neurons for each layer. The results showed that, contrary to photograph classification, the features used by the CNN in classifying drawings of comics were not parts of objects, such as face features, but common artistic patterns (e.g., textures).

Applying these techniques to sketch classification, neural networks can discover new features for several classification problems, such as between very young children and chimpanzees, or even compare the drawing style between different cultures. The hierarchical order of the layer can also be meaningful in understanding the drawing behavior of children at several levels, ranging from a stroke to an object shape construction. For instance, when looking for interspecific and intraspecific differences in drawings, the first convolutional layer of a CNN can extract basic features, differentiating humans from other great apes. For a given CNN trained for classification, one can test whether the depth of the layer discriminant of the classifier is linked to the degree of behavioral divergence (that could be developmental, cultural, genetic, or phylogenetic). One would expect early layers to be discriminant enough to classify between species, and deeper layers would be needed for more complex classification, such as cultural or developmental divergences. As orangutans are more dexterous with their hands than chimpanzees and gorillas (Mackinnon, 1974), the first layer could separate humans and orangutans as well as the two other species.

Another way to interpret CNNs is by using the model parameters proposed by Chen et al. (2016), who developed InfoGAN, a generative model for interpretation that maximizes mutual information to discover latent features. This method has been evaluated using various datasets, such as the MNIST dataset (LeCun, 1998), a database of handwritten digits. In this case, the generator was able to discover latent features describing, for example, digit type, width, and rotation of the digits. InfoGAN has also been used on the CelebA face dataset (Liu et al., 2015), revealing encoded features like the azimuth, the presence of glasses, hairstyle, and emotion. From these results, we anticipate that InfoGAN would have a high appeal in studying sketches, to explore the development of perception and representation in children by identifying features that are common and those that are discriminant between children and adult drawings.

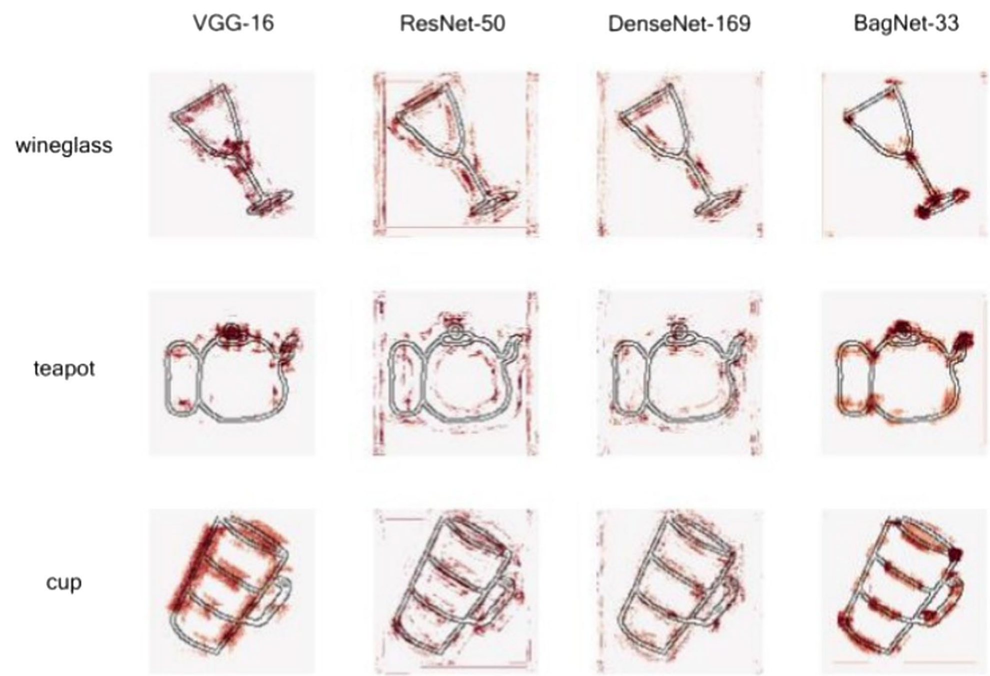

FIGURE 4
CAM of three objects by different models from Theodorus et al. (2020). The more the dots are clustered, the more of the corresponding area is considered in the model. Note that *VGG-16* and *BagNet-33* learned the representation of object parts. Reprinted with permission.

Long et al. (2018) collected drawings from young children, older children, and adults to understand how object representation develops with age. They used a method called transfer learning, where a model trained on one task is reused for another task. Transfer learning saves computing resources and allows for high performance with a relatively small number of datasets because it exploits the fact that some properties learned by a model to solve one task are useful for many other related tasks. In the study by Long et al. (2018), sketches were encoded by a pre-trained CNN; features were extracted from layers across several depths; and representational dissimilarity matrices (RDMs) were calculated for each of the three-age classes and compared. Their study showed that the way older children represent objects is more similar to that of adults than young children. Moreover, this also raises the possibility of studying different levels of representation of drawings through different layers of CNNs. Thus, local and global interpretations are possible with CNNs.

Available datasets for drawing(s) analysis

As a result of the widespread availability of touch-screen devices, drawings and in particular, sketches, can now be more easily collected and analyzed. Moreover, scholars can also collect drawings online through crowdsourcing or online drawing games. However, these datasets have been rarely used in psychological or anthropological studies, possibly because of the lack of associated metadata on the participants, such as their age, location, gender, culture, or drawing skill level. This metadata can be difficult to collect because they may require ethical approval.

Datasets can be organized into two families: amateur and expert datasets. In this review, amateur datasets mostly collate data on sketches and drawings without associated metadata on the person who did the drawing (in particular the drawing skills). Expert datasets gather drawings that have been extracted from books or comics. This kind of data can lead to other difficulties, such as copyrights. Moreover, the style difference between two experts may be significantly larger than that of between two amateurs, meaning that results obtained with one expert dataset may not be easily generalized to another expert dataset. We provide a non-exhaustive list of drawing datasets that are summarized in Table 2.

Amateur datasets

A major –and one of the first – sketch datasets is *QuickDraw* by Google. This dataset includes more than 50 million sketches belonging to over 345 object categories (Jongejan et al., 2016). *QuickDraw* is an online game where participants are asked to draw an object in 20 s, and a network is trained to recognize that object. For each sketch, the category is stored, as well as a Boolean indicating if the category was recognized by the game, the timestamp of the sketch, the country where the drawing was made, and the spatial and temporal data of the strokes. Despite some limitations (e.g., the lack of metadata such as the sex and age of the person who did the drawing), *QuickDraw* is a highly promising tool for investigating cultural differences in drawing-based object representations.

The second important amateur dataset is the TU-Berlin dataset, which provides more than 20,000 sketches of 250 categories of common objects drawn by 1,350 unique participants (Eitz et al., 2012). TU-Berlin sketches were collected *via* Amazon Mechanical Turk (AMT), a crowdsourcing marketplace where requesters hire crowd-workers to perform particular tasks (in our case, drawing an

TABLE 2 Summary of the presented datasets.

Dataset	# of images	# of categories of drawings	Drawing skill	Type of approach (product or process)	Metadata
Quick, Draw!	50 million sketches	345 (objects categories)	Amateur	Both	Country
TU-Berlin dataset	20,000 sketches	250 (object categories)	Amateur	Both	Human prediction available for each drawing
Sketchy dataset	75,471 sketches of 12,500 photographs	125 (object categories)	Amateur	Both	Drawings paired with a photograph
Manga109 dataset	109 Japanese comics with 194 pages each	94 (professional creators)	Expert	Product	Labeled rectangles around frames, faces…
Hicsonmez et al. dataset (2017)	6,500 pages	24 (professional illustrators)	Expert	Product	

All these datasets are at least partially available online.

object from a given category). Furthermore, each drawing is associated with a second category, for which other participants are asked to identify the drawn object. The temporal order of the strokes is available for each drawing; however, the personal data on the participants are not available.

A third dataset is the Sketchy database, which consists of 12,500 photographs of 75,471 sketches belonging to 125 object categories (Sangkloy et al., 2016). Each sketch is paired with a photograph, and each photograph is linked to a number from 1 to 5, characterizing the ease of sketching. Temporal data on strokes are available for each sketch. As most of the datasets are constructed by asking the participants to draw a particular object, there may be a large variability with respect to the drawn object and its features. For example, when asked to draw a dog, two participants may think about completely different breeds, which can be undesirable for the analyses. For this reason, datasets containing sketches representing photographs can lead to a decrease in variability, which can be an asset for this type of data.

Experts' datasets

Among expert datasets, Manga109 (Fujimoto et al., 2016) provides 109 Japanese comic books drawn by 94 professional creators with each book containing 194 pages on average. These books date from 1970 to 2010 and several genres are illustrated. Each page is annotated with rectangular areas characterizing the position of metadata, such as frames, text, and character (face, body), through software developed for this study.

Hicsonmez et al. (2017) collected more than 6,500 pages from a total of 24 children's book illustrators, with the goal of recognizing the authors using deep learning.

The list of datasets in this review is not exhaustive, only the main datasets are described. Other sketches datasets exist, such as COAD (Tirkaz et al., 2012), SPG (Li et al., 2018), SketchyScene (Zou et al., 2018).

Future research framework and perspectives

This review provides an overview on how deep learning has been and could be used to increase our knowledge of drawing behavior. Understanding the ontogeny of drawing behavior has many fundamental applications including, diagnosis of pathologies and understanding perception. However, the classical methods used in psychology or comparative cognition, to analyze drawings, rely on verbalization by the author and the subjective interpretation of the experimenter, which limits the reproducibility of results; one way to overcome this is to use deep learning. Simple classification using deep learning can lead to high accuracy, but the interpretability and reliability of the input are not easy to assess, which is also true for supervised (classification, feature visualization) and unsupervised (InfoGAN) learning. Methods have been developed to interpret these results, such as heatmaps and similarity matrices, that are relevant to sketches. Another approach uses generative modeling (e.g., GANs) to generate drawings, to analyze the generative process, and eventually infer the underlying behavior. However, while drawing ontogeny is known to critically depend on various factors such as culture, age, and sex, the large datasets of drawings and sketches, currently used to train CNN and other AI algorithms, usually lack this kind of information. Thus, it is important to develop new datasets, methods, and criteria to advance our understanding of drawing behavior. A dataset with many ancillary variables could, for example, allow cultural analysis. By unraveling the extraordinary predictive capacity of models and through ongoing research to make these models more transparent, AI will undoubtedly significantly contribute to improving our understanding of the fundamental behavior of drawing, for humans and their relatives.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Children's drawings as a projective tool to explore and prevent experiences of mistreatment and/or sexual abuse

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Reality shows us that situations of mistreatment and sexual abuse in childhood are still seldom visible, despite their high prevalence around the world. It is essential to detect and address them, especially among children in situations of dire risk or neglect. The purpose of this study is to determine if graphic emotional indicators are expressed in the drawings of the projective Draw-a-Person (D.A.P) test, made by children in situations of dire risk or neglect. The sample is made up of 34 children, between the ages of 5 and 11 (17 girls and 17 boys), attended by Specialised Child and Adolescent Care Services of the Barcelona Town Hall (Spain). The drawings were coded quantitatively. The results indicated that most of the drawings show a frequency of graphic emotional indicators, as well as graphic indicators common to experiences of mistreatment and/or abuse, which confirm the existence of emotional problems. However, no significant differences based on gender and age were found, except for one indicator of sexual abuse (body omitted/distorted), which is significantly more common in the boys. Results also revealed that the drawings of human figure enable the children to express their experiences of traumatic situations which are difficult to verbalize. These findings have important implications for professionals, as the use of this projective technique can help to early identification and design treatment strategies in situations of mistreatment and/or abuse in children and their families.

KEYWORDS

children's drawings, childhood mistreatment, childhood sexual abuse (CSA), the projective Draw-a-Person (D.A.P.), psychometric properties

Introduction

The mistreatment in childhood, understood as physical or emotional abuse, sexual abuse and emotional and physical neglect, is a common experience globally that affects all cultures (Pereda and Abad, 2013; Varese et al., 2013; Stoltenborgh et al., 2014). In the case of childhood sexual abuse (CSA), it is regarded as the biggest public health problem and a violation of human rights (Putnam, 2003; Norman et al., 2012), with serious long-term negative repercussions on individuals' physical and mental health (Putnam, 2003; Peltzer and Pengpid, 2016; Read et al., 2017). Data published in numerous international studies confirm that abuse in childhood plays a causal role in many adult mental health problems, including depression, anxiety disorders, substance abuse, personality disorders and psychosis (Kendler et al., 2000; Varese et al., 2012; Teicher and Samson, 2013; Read et al., 2017). Paradoxically, most cases of childhood sexual abuse or neglect are not identified by the mental health services (Read et al., 2017).

There is also evidence that experiencing multiple kinds of abuse over a period of time increases the risk of developing psychological and emotional problems compared to children who have only experienced occasional abuse (Warmingham et al., 2019). Indeed, childhood is an essential, highly sensitive period in human development. Marques-Feixa and Fañanás (2020) recently showed that mistreatment of children plays a crucial role in [arresting] individuals' neurobiological and psychic maturation. The same authors also state that when this abuse arises in childhood, it deregulates several neurobiological and stress-regulatory systems that are essential in the consolidation of complex cognitive and emotional-regulating functions. These systemic changes can make individuals more vulnerable to suffering from different mental disorders and other medical conditions during childhood and adulthood.

The data from global studies on child sexual abuse (CSA) and its prevalence around the world seem to concur that it occurs persistently (Pereda et al., 2009; Stoltenborgh et al., 2011; Nguyen et al., 2017). According to the World Health Organisation (WHO, 2016), around the world 20% of women and 5–10% of men claim to have suffered from sexual abuse as children. Likewise, the differences in geographic regions of the world with different beliefs and cultural values may affect the estimated incidence of CSA (Kenny and McEachern, 2000). For instance, studies conducted in Asian countries show a lower prevalence of CSA than in non-Asian countries, which could be attributed to conservative cultural sexual norms (Elliott and i Urquiza, 2006; Nguyen et al., 2010). Furthermore, different meta-analyses (Pereda et al., 2009; Stoltenborgh et al., 2011) report a higher prevalence of CSA among girls than boys. However, other times the sex of victims of abuse depends on the specific context where the abuse occurs; for example, in the case of victims of clergy abuse, the vast majority of victims are males (Faller, 2020). In recent decades has been increasing public attention to the child abuse (CSA) occurring within civic institutions, such as school setting, youth sports, religious institutions and other youth service child and youth-serving organizations (Harris and Terry, 2019).

Despite the greater awareness and social concern for the mistreatment, neglect and sexual abuse among children today, one of the major difficulties in bringing visibility to it is detection (Tello, 2020). As some research indicates, the majority of children do not disclose their sexual abuse during childhood (London et al., 2005, 2008). Keeping their sexual abuse to themselves, often leading to more several mental health and other detrimental consequences than if they had disclosed (Faller, 2020). This information revels the importance of having instruments for children that could to help them to express their traumatic experiences. The majority of instruments used to evaluate sexual abuse in children are interviews and self-reported questionnaires, like "The Adverse Childhood Experiences International Questionnaire" (ACE-IQ). The ACE-IQ is designed to be administered to adults aged 18 years and older and to assess childhood adversities worldwide. It is comprised three categories of child abuse (psychological, physical and sexual contact), two categories of neglect and four categories indicative of exposure to household dysfunction (Pace et al., 2022b). It primarily uses interviews to assess children, despite the limitations in verbal expression at that age and the traumatic situation itself. Drawing has usually been used in clinical contexts, and the use of drawing with children who have experienced sexual abuse is considered extremely important because it helps them express their emotions more freely (Cohen-Liebman, 1999; Kissos et al., 2019). There is a need to create more sensitive interviews so that children will not relive the trauma or experience new trauma *via* intrusive or inappropriate interviews (Katz et al., 2014; Lev-Wiesel et al., 2021). Therefore, drawings can be included in interviews, but they are assessed more qualitatively and often lack a scoring system. In short, there is a lack of instruments to assess CSA in childhood.

The current study

In order to contextualize the present study, we will explain briefly how the Child Protection System in Catalonia (Spain) is organized. One out of every five people in Catalonia (Spain) has suffered some type of sexual violence during their childhood, according to the "Save the Children" report entitled *Ulls que no volen veure* [Eyes that do not want to see] (2017), Currently, the Barcelona Town Hall manages the child and adolescent care service comprised of specialised interdisciplinary teams, SEAIA (Specialised Child and Adolescent Care Services), made up of professionals from the fields of psychology, pedagogy, social work and social education. Its purpose is to attend to children in situations of dire risk and/or neglect. Situations of serious risk mean circumstances in which the development and wellbeing of children and adolescents are limited or harmed by some personal, social or family situation, provided that the effective protection of such children or adolescents does not require separation from the nuclear family (LDOIA, Law 14/2010, on Rights and Opportunities for Children and Adolescents in Catalonia). On the other hand, the same law defines situations of neglect as those where children or adolescents find themselves in a situation where they lack the basic necessities for the comprehensive development of their personality, provided that their protection does require the application of a measure involving separation from the nuclear family. SEAIA's mission is divided into four areas of intervention: (1) Individualised assistance for children/adolescents and their families (diagnostic study, monitoring the development of the child and their family through support and other interventions), (2) Advice/Collaboration with Basic Social Services, (3) Community work, and (4) Institutional collaboration. Regarding the instruments currently used in these teams are interviews and questionnaires geared at families and caregivers, such as the Adult Attachment Interview (Barudy and Dantagnan, 2010) and the Questionnaire to Evaluate Adopters, Caregivers, Guardians and Mediators (CIUDA, Bermejo et al., 2014). For children, interviews are held and drawings are used, although they are not coded. Therefore, it is essential to have objective, valid, reliable tools that are age-appropriate in order to detect and/or confirm situations of mistreatment and/or sexual abuse, which are so difficult to express verbally.

Drawings and projective methods

There is a consensus in regarding drawings as a non-intrusive technique (Jacobs-Kayam et al., 2013; Kissos et al., 2020), given that drawing is a natural and spontaneous language for children, as it is ontologically and genetically more primitive than writing and does not require special training (Ballús and Viel, 2007). This study has used drawings of human figures by children as a graphic projective tool within the conceptual framework of psychoanalysis to facilitate non-verbal expression of the children's traumatic experiences. According to Piaget and Inhelder (1920), drawing involves the externalisation of a previously internalised mental image, which projects the individual's internal worlds onto external spaces (Siquier de Ocampo et al., 1987). Therefore, it provides access to the unconscious (Frank, 1939). According to this same author, projective techniques provide an approach to an individual's personality and persuade them to reveal how their experience is organised, giving them few guidelines or little structure (the instructions in this study: "Draw a person"), so that their personality and especially their feelings can be projected (Avila, 1997). The subject is considered to project their self-concept, which is constructed from each individual's subjective experiences (Schilder, 1935). It is not developmental but instead is unique to and characteristic of each person. Projective techniques, however, are understood to be partial tools in a comprehensive diagnostic process.

While it is true that graphic projective techniques have often been used in the clinical area, in research (such as Machover, 1953; Koppitz, 1968; Hammer, 1978; Bellak, 1979; Frank de Verthelyi and Rodríguez, 1985; Wohl and Kaufman, 1985; Buck, 1995) and in the field of sexual abuse (Wohl and Kaufman, 1985; Van Hutton, 1994; Royer, 1999; Colombo et al., 2004; Maganto and Garaigordobil, 2009b; Pont, 2012), the psychometric requirements of reliability and validity have been one of these tools' most controversial issues (Avila, 1997; Maganto and Garaigordobil, 2011). Projective techniques, and analyses of drawings in particular, initially put the emphasis solely on qualitative analysis, thereby undermining the data's objectiveness and validity. The lack of methodological rigour in the use of drawings in psycho-diagnoses in the 1960s and 1970s resulted in the techniques being criticised and disparaged (Maganto and Garaigordobil, 2011; Allen and Tussey, 2012). However, according to Ballús et al. (2020), over the last few years there has been a proliferation of research using projective methods while incorporating quantitative measures with psychometric properties (Maganto and Garaigordobil, 2009b; Barbosa and Sales, 2014, 2015; Tuset and Fernández, 2017; Ballús et al., 2019a,b), adding objectivity and reliability to these methods.

On the other hand, although it is true that the literature review concludes that there is no evidence that drawings can be used as a valid indication of personality or for diagnosis, some scoring systems may be adequate for screening purposes (Goldner et al., 2018). Different scoring systems have been developed based on the Draw-A-Person (DAP) test by Machover (1953), such as the DAP-SPED scoring system (Naglieri et al., 1991). It uses an objective approach based on the frequency of items depicted in human figure drawings that are considered indicators of possible emotional problems in non-clinical versus clinical populations. Similarly, Maganto and Garaigordobil (2009b) developed and validated a psychometric DAP test, the Two Human Figures test (T2F), which gives the test validity and reliability with its scoring system to identify developmental and emotional indicators (some of them common to experiences of sexual abuse) in children aged 5 to 12. The test is both quantitative and qualitative, enables the emotional indicators to be coded and makes it possible to determine whether or not emotional problems are present according to the percentile obtained, while it also offers a more qualitative analysis of the meaning of the emotional indicators found. Moreover, in the research on drawings often is questioned the discriminant validity with the results obtained (in this case with the T2F) and the drawing ability of the child (Clarke et al., 2002; Pace et al., 2022c). Regarding the Two Human Figures test (T2F), the items of Developmental Indicators scale (52 items) was developmental (Maganto and Garaigordobil, 2009b). That is, its frequency in drawing increases as the subjects get older. It is based on assigning standardised scores when development indicators are present, and the resulting value is then transformed into percentiles for each age and sex. That's means, the T2F test classifies and situates the child's drawing in reference to his or her normative group, based on age and gender. In addition, these items correlate with intelligence evaluated by Raven (1995).

In terms of the empirical evidence to detect sexual abuse in self-figure drawings, as Kissos et al. (2020) state, in the past 20 years different studies have shown that the drawings in DAP tests by individuals who are the victims of sexual abuse have specific graphic features that differ from those drawn by persons who have not been abused (Faller, 2014). Previous studies have suggested that the omission or distortion of body parts in self-figure drawings implies conflictive relationship with the part and are associated with trauma and abuse (Koppitz, 1968; Dyer et al., 2015). For instance, in trauma and abused victims' self-figure drawings, the whole body or certain body parts are omitted or distorted (Jacobs-Kayam et al., 2013; Dyer et al., 2015; Goldner and Frid, 2021), and there are other indicators as well, such as the head detached or disconnected from the body (Faller, 2003; Handler and Thomas, 2013; Goldner and Frid, 2021). Moreover, other studies also provide validation of four indicators of sexual abuse (Jacobs-Kayam et al., 2013) that have previously been documented (Lev-Wiesel, 1999; Amir and Lev-Wiesel, 2007): (1) the face line, (2) the eyes, (3) the hands and arms, and (4) the genitals. The presence of three or more of these features is considered to indicate sexual abuse. Furthermore, recent studies (Goldner et al., 2021) code the drawing style with some of the following indicators of sexual abuse: pre-schematic drawing; size of figure: small (about 2 cm) or oversized; and presence of aggressive symbols.

The present study, in line with the latest research projects, uses graphic projective techniques incorporating not just the qualitative analysis characteristic of these techniques but also quantitative analysis through the codification of several graphic indicators. The main aim of this research is to determine whether graphic emotional indicators, including those of child sexual abuse (CSA), were expressed in the drawings of the projective DAP test made by children in situations of dire risk or neglect. We have formulated two hypotheses based on previous findings: First (H1), graphic indicators of child sexual abuse (CSA) will be found in the drawings of the children in the sample, in situations of dire risk or neglect (Jacobs-Kayam et al., 2013; Dyer et al., 2015; Goldner et al., 2021). Second (H2), more than a half of the participants will have a highest frequency of emotional indicators, corresponding to the upper percentiles on the emotional scale of the Two Human Figures test (T2F), confirming the existence of emotional problems (Magannto and Garaigordobil, 2009b).

Methods

Participants and procedure

The sample is made up of 34 children in situations of serious risk or neglect who in 2018 were receiving care from Barcelona's Specialised Childcare Services (SEAIA) in Catalonia (an autonomous community in northeast Spain, which has 16% of the total national population).

The 34 children in this study range in age from 5 to 11. The sample consisted of 17 girls and 17 boys with a mean age of 7.91 (SD = 1.6). Two age groups were created to facilitate data analysis in accordance with the authors of one of the instruments used, the Two Human Figures test (T2F) by Maganto and Garaigordobil (2009b). These authors stated that the majority of the emotional indicators are common to all ages, but some are only significant after the age of 7. Therefore, two age groups were made, matching this division. The first group was aged 5–7 ($n = 14$) and consisted of 8 girls and 6 boys, with a mean age of 6.36, and the second group was aged 8–11 ($n = 20$) and made up of 9 girls and 11 boys, with a mean age of 9 years.

The children in the sample were chosen at random from the child population receiving care from by Barcelona's SEAIA in 2018. According to the data provided by the Catalan government's Directorate General of Child and Adolescent Care (2018), the number of children and adolescents in the population was 1,402,825. In December of that year, 18,262 children and adolescents were receiving assistance under the protection system. Of them, 8.672 (47.4%) were involved in an intervention with the family without separate, while the remaining 9,590 (52.6%) had a protection measure in place involving separation from their nuclear family. Specifically, 3,742 children (39%) were subject to a family-foster care measure (65.2% with extended family, 24.2% in foster families and 10.4% in pre-adoption foster care); other 5,681 children (59.2%), were in residential care, and the 167 remaining children (1.7%) were in other situations (hospital, juvenile justice, etc.).

The project was approved by the Ethics and Research Committee at the Universitat Ramon Llull (URL) in Barcelona (Spain). In accordance with the professional conduct regulations, signed parental consent and personal data protection were obtained. Likewise, to ensure the anonymity of the personal information of the children in the research, the subjects were assigned an identification number and only their age and sex were stated. The data were collected at SEAIA's Barcelona office. The test was administered to the children individually by the SEAIA staff, who had previously been trained by the principal investigator. Moreover, their attitudes and reactions to the test were noted. Afterwards, two members of the research team specialising in projective techniques analysed the test.

Measures

Indicators of childhood sexual abuse in human figure drawings

Based on the empirical evidence from recent studies on the specific graphic characteristics presented by the human figure drawings (DAP) of sexually abused children (Lev-Wiesel, 1999; Amir and Lev-Wiesel, 2007; Jacobs-Kayam et al., 2013; Dyer et al., 2015; Kissos et al., 2019; Goldner and Frid, 2021; Goldner et al., 2021), new indicators have been taken into account for this study.

The indicators of child sexual abuse (CSA) used to assess the human figure drawings are as follows: (1) whole body or body parts are omitted or distorted (Jacobs-Kayam et al., 2013; Dyer et al., 2015; Goldner and Frid, 2021), (2) the head is detached or disconnected from the body (Faller, 2003; Handler and Thomas, 2013; Goldner and Frid, 2021), (3) the face line is double or hollow, or the chin or cheek are shaded (Lev-Wiesel, 1999; Amir and Lev-Wiesel, 2007; Jacobs-Kayam et al., 2013), (4) the eyes are in the form of dots, hollowed, shaded or omitted (Lev-Wiesel, 1999; Amir and Lev-Wiesel, 2007; Jacobs-Kayam et al., 2013), (5) the hands and arms are depicted as clinging, detached, cut off or are omitted (Lev-Wiesel, 1999; Amir and Lev-Wiesel, 2007; Jacobs-Kayam et al., 2013), (6) the genitals are shaded or blocked off from the rest of the body (Lev-Wiesel, 1999; Amir and Lev-Wiesel, 2007; Jacobs-Kayam et al., 2013), (7) pre-schematic drawing (blocked human figures, primitive figures corresponding to ages 4–5; Goldner et al., 2021), (8) the size of the figure: small (about 2 cm) or oversized such that the figure occupies most of the page (Goldner et al., 2021), and (9) the presence of aggressive symbols (Goldner et al., 2021).

The projective two human figures test

The instrument used was the Two Human Figures test (T2F) of Maganto and Garaigordobil (2009b). It's a psychometric proposal for the graphic projective test Draw-A-Person (DAP), from the developmental and projective perspectives giving it greater validity and reliability. The scoring system is based on frequency of items in a human drawing. Which is described for the authors, as a screening instrument to be used in clinical, educational and social settings to identify children with developmental (52 Indicators) and emotional problems (35 Indicators). For the purpose of this study, the drawings were coded only using the 35 Emotional Indicators scale. Participants were asked to draw a person, on a sheet of Din A4 paper which they had been handed previously, along with a pencil and rubber and with no time limit. Once they had finished, they were given a second sheet of paper and is requested to draw a person of the opposite sex. For the youngest children, the instruction was to draw a boy or girl, according with Machover (1953).

Using Spanish samples of 1,222 and 1,623 participants aged 5 to 12, results showed that the instrument was both reliable and valid for to identify developmental and emotional problems (Maganto and Garaigordobil, 2009a). Regarding the Developmental Indicators scale (52 items), it is based on assigning standardised scores when development indicators are present, and the resulting value is then transformed into percentiles for each age and sex. Two criteria to accept these items were agreed upon: (1) the item was developmental; that is, its frequency in drawing increases as the subjects get older and (2) it correlates with intelligence evaluated by Raven (1995). To check this, contingency analyses were performed by calculating the Chi-square by ages and age groups for both the male and the female human figure drawings, and Pearson correlations were performed between the scores earned on the T2F and Raven. The results revealed significant correlations ($p < 0.05$) between the variables, confirming the validity of the test. The Cronbach's coefficient (0.86) and the Spearman-Brown (0.86) were also calculated and found satisfactory.

Regarding the Emotional Indicators scale (35 items), these Emotional Indicators meet three criteria (Tuset and Fernández, 2017): (1) they distinguish between clinical and non-clinical groups, (2) they are not developmental, and (3) they are unusual at any age (frequency under 10%). Sixty indicators were initially chosen, but the Chi-squared contingency analysis of Pearson for each of the figures, between the clinical and non-clinical sample, concluded that statistically significant differences were only found in 35 of the emotional indicators. Furthermore, the analyses performed between emotional items and age showed a negative covariation, in that as development advances, the representation of those emotional indicators drops. This enabled us to conclude after what age these items should be considered emotional indicators. Therefore, of the 35 emotional indicators, 23 indicators are common to all ages, 6 indicators are applied from the age of 7 onwards and another 6 indicators from the age of 9 onwards.

TABLE 1 Conversion of directs scores form the T2F-E test to percentiles according to age (Maganto and Garaigordobil, 2009b).

Percentiles	5years old	6years old	7years old	8years old	9years old	10years old	11years old	12years old
99	6 or >	7 or >	8 or >	9 or >	9 or >	10 or >	10 or >	11 or >
95	4–5	4–6	6–7	6–8	6–8	7–9	7–9	8–10
85	3	3	5	5	5	5–6	6	6–7
75	2	2	4	4	4	4	5	5
<75	0–1	0–1	0–3	0–3	0–3	0–3	0–4	0–4

95th and 99th percentile: Existence of emotional problems; 85th percentile: High probability of emotional problems; 75th percentile: Possible existence of emotional problems; < 75th percentile: No emotional problems.

TABLE 2 Frequencies of indicators of sexual abuse in human figure drawings (CSA).

Indicators of CSA		Children aged 5–11 (*n* =34)						
		Female (*n* =17)		Male (*n* =17)		Total Present	Chi-Square	Value of *p*
		Present	Absent	Present	Absent			
1. Body omitted / distorted	*n*	6	11	12	5	18	4.250	0.039*
	%	35.3	64.7	70.6	29.4	52.9		
2. Head	*n*	2	15	2	15	4	0.000	1.000
	%	11.8	88.2	11.8	88.2	11.8		
3. Face line	*n*	1	16	3	14	4	0.283	0.595
	%	5.9	94.1	17.6	82.4	11.8		
4. Eyes	*n*	7	10	7	10	14	0.000	1.000
	%	41.2	58.8	41.2	58.8	41.2		
5. Hands/arms	*n*	8	9	4	13	12	2.061	0.151
	%	47.1	52.9	23.5	76.5	35.3		
6. Genitals	*n*	1	16	0	17	1	0.000	1.000
	%	5.9	94.1	0	100	3		
7. Preschematic drawing	*n*	3	14	4	13	7	0.000	1.000
	%	17.6	82.4	23.5	76.5	20.6		
8. Size of figure	*n*	3	14	2	15	5	0.000	1.000
	%	17.6	82.4	11.8	88.2	14.7		
9. Aggressive symbols	*n*	3	14	3	14	6	0.000	1.000
	%	17.6	82.4	17.6	82.4	17.6		

*$p < 0.05$. The presence of three or more indicators in italic (Indicator 3, 4, 5, 6), is considered to indicate sexual abuse (Jacobs-Kayam et al., 2013).

These Emotional Indicators, according to the T2F's authors, need to be interpreted with two complementary aspects taken into account: (1) Number of indicators and (2) Types of emotional indicators present. As for (1) Number of indicators, the assessment is quantitative based on the application of cut-off points according to the percentile, aforementioned (Table 1), which determine whether or not the subject presents emotional problems (*75th percentile:* points to the possible existence of emotional problems; *85th percentile:* considered a high level of probability of the existence of emotional problems*; 95th percentile:* confirms the existence of emotional problems). The assessment of (2) types of indicators, is qualitative based on the review of literature from experts in the field carried out by Maganto and Garaigordobil (2009b). Moreover, the authors also point out that some emotional indicators have particular clinical-emotional relevance. Within the 23 indicators common to all ages, these indicators are the following: (1) Bizarre, unreal, grotesque or monster figure, (14) Genitals or sexual characteristics, (19) No eyes, (20) No mouth, and (21) No body. And the six indicators applied from the age of 7, include the following: (25) Leaning figure.

Data analysis

The data were analysed using the JASP statistical programme (version 0.16.3). First, to analyse indicators of sexual abuse (CSA), the descriptive statistics (mean and standard deviation) of the sample and the frequencies and percentages of the indicators were calculated. Then, the chi-square ($\chi 2$) was conducted to carry out a comparative study with the results obtained (presence or absence of indicators) based on gender. Finally, the descriptive statistics (mean and standard deviation) of the sample and the frequencies of the emotional indicators in Two Human Figure test (T2F), were used.

Results

The results that presented below are intended to respond to the hypotheses raised. For the first hypothesis (H1), on whether graphic indicators characteristic of child sexual abuse (CSA) will be present in the drawings of the children in the sample. Only the first human figure drawings were used. As for the second hypothesis (H2), more than a half of the participants will have a highest frequency of emotional indicators, corresponding to the upper percentiles on the emotional scale of the Two Human Figures test (T2F), confirming the existence of emotional problems. In this case, both humans figure drawings (first and latter of the opposite sex), were taken into account.

Indicators of sexual abuse in human figure drawings

Chi-Squared analyses were conducted to identify associations with indicators of sexual abuse and the gender of the participants. The results of our study revealed gender differences between the participants. As shown in Table 2, there is a significant difference between boys and girls ($\chi 2 = 4.250$; $p = 0.039^*$) in Indicator 1. Body omitted/distorted (Omission or distortion of the entire body or parts of the body). The boys showing a greater presence of the item, that's mean, 70.6% the boys versus 35.3% the girls. It should be noted that this Indicator, 1 Body omitted/distorted, has been the indicator of sexual abuse CSA with the most frequency (52.9%; *n* =18), This occurred in over half of the subjects based on the distortion (*n* =8) or omission of the entire body (*n* =5) or parts of the body (*n* =5). Otherwise, no significant differences were found between gender or age in the other indicators. Illustration 1 (see Figure 1), was the first drawing (male figure) by a 7-year-old boy. This is an example of Indicator, 1 Body omitted and other CSA indicators as Indicator 4 (dot/shaded eyes), Indicator 7 (pre-schematic drawing) and Indicator 8 (small figure size).

Descriptive statistics (mean and standard deviation) of the number of indicators presented in each of the individuals were calculated according to whether they were boys or girls. The results of frequency of indicators of CSA show that there are no differences between boys (*M*=2.18; SD=1.24) and girls (*M*=2; SD=1.41). Moreover, the results showed than more than half of the drawings (61.7%;) present between two and five indicators. Specifically, 44.1% show between two and three indicators and 17.6% show between four and five indicators. However, in no case were indicators 3, 4, 5 and 6, which indicate sexual abuse, obtained at the same time (Jacobs-Kayam et al., 2013).

In addition, as shown in Table 2, the most frequent Indicators of Sexual Abuse (CSA) are three: Indicator 1. Body omitted/distorted (52.9%; *n*=18), Indicator 4. Eyes (41.2%; *n*=18). They represented eyes with a single dot (*n*=6), with shading (*n*=4) or hollow (*n*=4).

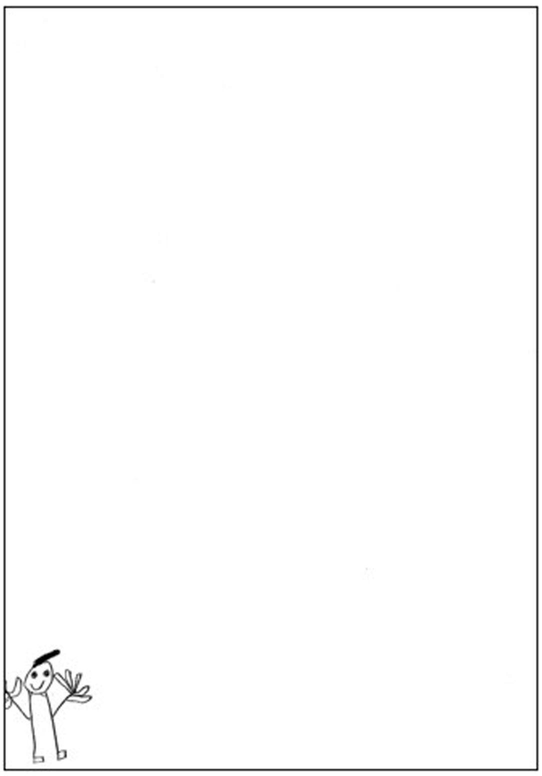

FIGURE 1
Subject 16: First drawing (male figure) of 7-year-old boy. CSA indicators: Indicator 1 (omission of body), Indicator 4 (dot/shaded eyes), Indicator 7 (pre-schematic drawing) and Indicator 8 (small figure size).

Likewise, Indicator 5. Hands/arms (35.3%; *n*=12), were represented as detached (*n*=2) or omitted (*n*=10).

Nevertheless, 20.6% of the sample produced a pre-schematic drawing (Indicator 7); that is, they drew a primitive figure corresponding to one that a child aged 3 or 4 would make. As for the presence of aggressive symbols (Indicator 9), they were observed in 17.6% of the sample, more specifically with the expression of teeth (*n*=4), nails (*n*=1) and weapons and blood (*n*=1). As for the size of the figures (Indicator 8), 14.7% of the participants drew either very small figures, smaller than 2 cm (*n*=1) or very large figures (*n*=4). Indicator 2 (Head detached from rest of body) was observed in 11.8% of the drawings, the same as Indicator 3, (double face outline). Finally, we should note that only 3% of our sample drew genitals (Indicator 6).

Emotional indicators in projective two-human-figure drawings

First of all, we should point out that 94.12% of this study's subjects drew a human figure of their own sex first, whereas 5.88% drew a figure of the opposite sex.

Based on the Two-Human-Figure drawings (T2F), the results were interpreted from two standpoints according to the T2F's authors: (1) a quantitative analysis on the number of indicators based on the application of the cut-off points mentioned above, and (2) a qualitative analysis referring to the type of emotional indicators found in the sample based on the review of the expert literature on the topic conducted by Maganto and Garaigordobil (2009a).

Quantitative analysis (number of emotional indicators)

To perform the quantitative analysis of the results, the frequency of indicators of each individual in each of his or her drawings, both the female and male figure, was calculated along with their corresponding percentages, following the instructions proposed by Maganto and Garaigordobil (2009a) in Table 1. Moreover, the descriptive statistics (mean and standard deviation) each of the percentiles was calculated. Regarding the frequency and type of emotional indicator, no differences were found by sex or age. As regards the number of emotional indicators in the sample, the presence of emotional problems is confirmed in 52.94% of the participants in this study (Table 3), as they received scores equal to

TABLE 3 Total frequency of Emotional Indicators in Two Human Figure test (T2F).

Percentiles	Female (*n*=17)		Male (*n*=17)		Total (*n*=34)			
	n	%	*n*	%	*n*	%	*M*	SD
99	4	23.53	5	29.41	9	26.47	9.33	1.73
95	6	35.29	3	17.65	9	26.47	5.89	1.05
85	2	11.76	5	29.41	7	20.59	4.71	1.25
75	2	11.76	1	5.88	3	8.82	4	0
< 75	3	17.65	3	17.65	6	17.65	1.17	0.98

95th and 99th Percentiles: Existence of emotional problems; 85th Percentile: High probability of emotional problems; 75th Percentile: Possible existence of emotional problems; < 75th Percentile: No emotional problems.

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TABLE 4 Frequencies of emotional indicators common to all ages in Two Human Figure test (T2F).

Emotional indicators	Children aged 5–11					
	Male drawing (*n*=34)		Female drawing (*n*=34)		Total (*n*=68)	
	n	%	*n*	%	*n*	%
1. Bizarre, unreal, grotesque or monster figure (*)	4	11.8	3	8.8	7	10.3
2. Asymmetric limbs	8	23.5	6	17.6	14	20.6
3. Cut figure	2	5.9	2	5.9	4	5.9
4. 2 or more figures	1	2.9	3	8.8	4	5.9
5. Enclosed or framed figure	0	0	2	5.9	2	2.9
6. Big figure	3	8.8	4	11.8	7	10.3
7. Transparencies	2	5.9	2	5.9	4	5.9
8. Crossed or wandering eyes	4	11.8	1	2.9	5	7.4
9. Teeth	3	8.8	4	11.8	7	10.3
10. Long arms	4	11.8	3	8.8	7	10.3
11. Arm extensions	2	5.9	1	2.9	3	4.4
12. Big hands / fingers	6	17.6	7	20.6	13	19.1
13. Nails	1	2.9	2	5.9	3	4.4
14. Genitals or sexual characteristics (*)	1	2.9	4	11.8	5	7.4
15. Big feet	3	8.8	2	5.9	5	7.4
16. Face shading	5	14.7	1	2.9	6	8.8
17. Body shading	2	5.9	2	5.9	4	5.9
18. Limb shading	2	5.9	2	5.9	4	5.9
19. No eyes (*)	0	0	0	0	0	0
20. No mouth (*)	0	0	0	0	0	0
21. No body (*)	5	14.7	5	14.7	10	14.7
22. No arms	3	8.8	3	8.8	6	8.8
23. No legs	1	2.9	4	11.8	5	7.4

Frequencies of emotional indicators common to all ages in Two Human Figure test (T2F).
(*) Special clinical relevance indicators (Maganto and Garaigordobil, 2009b).
Indicators in italic: Suggestive of sexual abuse (Royer, 1999; Pont, 2012).

or above the 95th and 99th percentiles. Each of these subjects presented an average of 5.89 and 9.33 indicators between the male and female figures drawings. Nevertheless, 20.59% showed a high level of probability of presenting emotional problems, given that they obtained scores equal to or above the 85th percentile. In this case, each of these subjects presented an average of 4.71 indicators between the male and female figure drawings. In addition, 8.82% of the subjects may present emotional problems, as they obtained scores equal to or above the 75th percentile. Four emotional indicators were recorded in each of the three subjects in the male and female figure drawings. By contrast, 17.65% of the sample presented no emotional problems, as they obtained scores below the 75th percentile, with an average of 1.17 indicators between the male and female figures.

Qualitative analysis (types of emotional indicators)

To perform the qualitative analysis, the frequency and percentage of the different types of emotional indicators were calculated, which Maganto and Garaigordobil (2009b) divide into three age groups: (1) Emotional indicators common to all ages (5–11), (2) Emotional Indicators from age 7, and (3) Emotional Indicators from age 9.

First, Table 4 shows the results obtained common to first group (1) Emotional indicators common to all ages in the sample ($n = 34$). The most frequent indicators were Indicator 2. asymmetric limbs, at 20.6%; Indicator 12. big hands or fingers, which is suggestive of sexual abuse, at 19.1% (Figure 2); and Indicator 21*, omission of body, which has special clinical relevance, at 14.7%. However, note Indicator 1*, bizarre, unreal, grotesque or monster figure, which has special clinical relevance, is present in 10.3%. Furthermore, other indicators suggestive of sexual abuse were found, such as Indicator 14, genitals or emphasised sexual features, which was found in 7.4% of the sample; Indicator 7, transparencies in 5.9% and Indicator 18, limbs shaded in 5.9% of the sample. Illustration 2 (see Figure 2), was the first drawing (female figure) by a 7-year-old girl, suspected of having been abused. This is an example of the next T2F emotional indicators: Indicator 2 (asymmetric limbs), Indicator 12 (big hands or fingers), Indicator 18 (limbs shaded) and Indicator 25 (leaning figure).

Second, Table 5 shows the results to second group (2) Emotional Indicators from age 7, ($n = 28$). First, the most frequent item among these subjects was Indicator 28, addition of 3 or more details, at 16.1%. Moreover, Indicator 26, hands cut off, which is suggestive of sexual abuse, was observed in 12.5% of the subjects.

FIGURE 2
Subject 31: First drawing (female figure) of 7-year-old girl, suspected of having been abused. T2F emotional indicators: Indicator 2 (asymmetric limbs), Indicator 12 (big hands or fingers), Indicator 18 (limbs shaded) and Indicator 25 (leaning figure).

TABLE 5 Frequencies of emotional indicators from age 7 in Two Human Figure test (T2F).

Emotional indicators	Children aged 7–11					
	Male drawing (*n* =28)		Female drawing (*n* =28)		Total (*n* =56)	
	n	%	*n*	%	*n*	%
24. Poorly integrated figure	3	10.7	4	14.3	7	12.5
25. Leaning figure*	1	3.6	2	7.1	3	5.4
26. Hands cut off	2	7.1	5	17.9	7	12.5
27. No feet	3	10.7	4	14.3	7	12.5
28. 3 or more details	5	17.9	4	14.3	9	16.1
29. Intense erasing or second attempt	4	14.3	4	14.3	8	14.3

(*) Special clinical relevance indicators (Maganto and Garaigordobil, 2009b).
Indicators in italic: Suggestive of sexual abuse (Royer, 1999; Pont, 2012).

Finally, the results shown in Table 6 demonstrate the emotional indicators to third group (3) Emotional Indicators from age 9 ($n = 12$). Indicator 34, omission of nose, was recorded in 29.2% of the drawings by the children aged between 9 and 11. Nevertheless, indicators suggestive of sexual abuse, such as Indicator 30, tiny figure, were found in 12.5% of the participants, and Indicator 32, empty eyes, was found in 16.7% of the subjects.

We would finally this section by illustrating these data with two human figure drawings produced by a 7-year-old girl. First, in response to the instruction to "draw a person", she drew a female figure as a first drawing (see Figure 3) which presented three indicators of sexual abuse (CSA) and four emotional indicators (T2F). These indicators of child sexual abuse (CSA) are as follows: (2) head detached from body, (4) dot/shaded eyes, (5) hands and/or arms cut off/omitted; while the emotional indicators are (17) shading of body, (18) shading of limbs, (24) poorly integrated figure and (26) hands cut off. She was then asked to draw figure of the opposite sex, that is a male. This second drawing of the second human figure (see Figure 4) represented a male figure with genitals and added a very small female figure, with transparencies in the genital area. This male figure has one indicator of sexual abuse (CSA) and four emotional indicators (T2F). The indicator of sexual abuse (CSA) was indicator (6) genitals, while the emotional indicators were are as follows: (4) two or more figures, (7) transparencies, (14) genitals or emphasised sexual features and (17) shading of the body.

To conclude this section, we have summarised the results founds. The findings indicated the high frequency of both indicators of sexual abuse (CSA) and Emotional Indicators in Two Human Figure test (T2F) in the most human figure drawings in the sample, which confirm the existence of emotional problems. These also point out that

TABLE 6 Frequencies of emotional indicators from age 9 in Two Human Figure test (T2F).

Emotional indicators	Children aged 9–11					
	Male drawing (*n* =12)		Female drawing (*n* =12)		Total (*n* =24)	
	n	%	*n*	%	*n*	%
30. Tiny figure	*1*	*8.3*	*2*	*16.7*	*3*	*12.5*
31. Big head	0	0	0	0	0	0
32. Empty eyes	2	16.7	2	16.7	4	16.7
33. Short arms	2	16.7	2	16.7	4	16.7
34. No nose	3	25	4	33.3	7	29.2
35. No neck	3	25	3	25	6	25

Indicators in italic: Suggestive of sexual abuse (Royer, 1999; Pont, 2012).

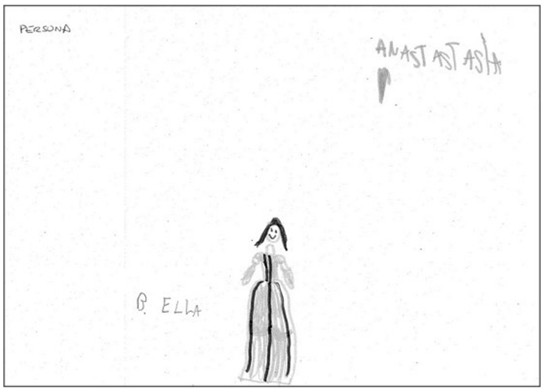

FIGURE 3
Subject 8: First drawing (female figure) of 7-year-old girl. CSA indicators: Indicator 2 (head detached from body), Indicator 4 (dot/shaded eyes), Indicator 5 (hands cut off/omitted). T2F emotional indicators: Indicator 17 (shading of body), Indicator 18 (shading of limbs), Indicator 24 (poorly integrated figure) and Indicator 26 (hands cut off).

FIGURE 4
Subject 8: Second drawing (male-figure) by a 7-year-old girl. CSA indicator: Indicator 6 (genitals). T2F emotional indicators: Indicator 4 (two or more figures), Indicator 7 (transparencies), Indicator 14 (genitals or emphasised sexual features) and Indicator 17 (shading of body).

Indicator, 1 Body omitted/distorted, is the indicator of sexual abuse CSA with the highest frequency, which was found in more than a half of the drawings in the sample. No differences based on gender were found in the study, with the exception of Indicator 1 of sexual abuse (CSA), which was more significant in boys.

Discussion

The purpose of this study is to determine whether graphic emotional indicators are expressed in the drawings of the projective Draw-A-Person (DAP) test made by children in situations of serious risk or neglect. The results show that the two hypotheses presented in the Introduction section are confirmed.

First of all, it is important to stress that virtually the entire sample, when given the instruction to "draw a person", drew a figure of their own sex first. That means that this test is valid and consist with the theoretical underpinnings of graphic projective techniques, which consider that the subjects project their self-concept, physical and emotional aspects, which is constructed from each individual's subjective experiences (Hammer, 1978; Siquier de Ocampo et al., 1987; Goldner and Frid, 2021). Therefore, the human figure drawings made by the children in this study can be considered the mental picture of their self.

The first hypothesis (H1), "graphic indicators of child sexual abuse (CSA) will be found in the drawings of the sample in situations of dire risk or neglect", is confirmed, as demonstrated by the results. Graphic indicators characteristic of child sexual abuse (CSA) was found in more than a half of the drawings by children in situations of serious risk or neglect within the sample. This is consistent with previous findings indicating the presence of specific graphic characteristics in the human figure drawings (DAP) of sexually abused children (Lev-Wiesel, 1999; Amir and Lev-Wiesel, 2007; Jacobs-Kayam et al., 2013; Goldner et al., 2021). Because the drawings in DAP tests of victims of sexual abuse have specific graphic features that differ from those drawn by persons who have not been abused (Faller, 2014; Kissos et al., 2020). As for the presence of graphic indicators characteristic of child sexual abuse (CSA) in human figure drawings, the findings of this study indicated a greater presence of three indicators of special projective significance for expressing sexual abuse: (1) body omitted or distorted, (4) eyes and (5) hands and arms, dovetailing with other studies. The first one, (1) body omitted or distorted, found in over half of the sample and more significantly in boys, that may represent anxiety about the body or certain parts of the body's parts (Koppitz, 1968; Van Hutton, 1994; Goldner and Frid, 2021). These results are consistent with previous findings which reported that this is a frequent indicator in trauma and abused victims' self-figure drawings. The sexual traumatization can lead to profound disturbances in the self-system, including de body image (Jacobs-Kayam et al., 2013; Dyer et al., 2015; Goldner and Frid, 2021). Furthermore, no studies have found that confirm the differences in gender and therefore these results should be dealt with cautiously and checked in subsequent studies with larger samples. The second indicator (4) eyes, could expresses a refusal to see (Colombo et al., 2004; Amir and Lev-Wiesel, 2007; Jacobs-Kayam et al., 2013). And the third indicator, (5) hands and arms, may expresses anxiety and guilt (Koppitz, 1968; Royer, 1999; Jacobs-Kayam et al., 2013; Goldner and Frid, 2021).

Moreover, Indicator (7) pre-schematic drawings, were also present showing a primitive figure that a child aged 4 or 5 would draw (Goldner et al., 2021). These drawings suggest a lack of cognitive maturity and mistreatment of children plays a crucial role in [arresting] the neurobiological and psychic maturation of individuals, and during childhood deregulates several neurobiological systems that are essential in the consolidation of complex cognitive functions and emotional regulation (Marques-Feixa and Fañanás, 2020).

The second hypothesis (H2) presented in the Introduction section, "more than a half of the participants will have a highest frequency of emotional indicators, corresponding to the upper percentiles on the emotional scale of the Two Human Figures test (T2F), confirming the existence of emotional problems", was also confirmed. The findings point out that the vast majority of the sample has emotional problems or a high probability of having them. Bearing in mind that the children in this sample are in situations of severe risk or neglect, this is consistent with previous findings indicating the chronic experience of numerous types of mistreatments raises the risk of developing psychological and emotional problems (Warmingham et al., 2019). Moreover, the emotional indicators suggesting the presence of sexual abuse included several that strengthened the graphic indicators characteristic of child abuse (CSA) mentioned above. Specifically, indicator (7) transparencies, which graphically may represent anxiety over the body part that is transparent, which is possibly linked to some experience of mistreatment and/or abuse. Likewise, indicator (14) genitals or emphasised sexual features (Lev-Wiesel, 1999; Jacobs-Kayam et al., 2013), is also considered to be of special clinical relevance, by the T2F's authors, which could express body-related distress associated with sexuality. The last one, indicator (21) no body, also considered to be of special clinical relevance and coincident with the indicator of sexual abuse CSA, (1) body omitted/distorted) of the first hypothesis (H1). This is one of the less frequent emotional indicators from the T2F test, as only 1.5% of the clinical subjects, with similar frequencies in both sexes, omit the body (Maganto and Garaigordobil, 2009b). These findings suggest that much of the sample studied may have experienced situations of mistreatment and/or sexual abuse.

Nevertheless, a variety of indicators is also present, such as (12) large hands or fingers, (17) shading of body, (18) shading of limbs, (22) omission of arms and (26) hands cut off. These indicators are related with the presence of anxiety over doing activities with their hands and/or arms, creating feelings of worry or guilt among the children for not behaving properly (Koppitz, 1968; Colombo et al., 2004; Pont, 2012). In addition, we found indicator (32) empty eyes, which is frequent among sexually abused children (Lev-Wiesel, 1999; Amir and Lev-Wiesel, 2007; Jacobs-Kayam et al., 2013), referring to a denial of reality, not seeing or not wanting to see. However, it should be noted that no significant differences based on gender and age were found in this study, except for the indicator of sexual abuse (body omitted/distorted), mentioned above.

Finally, we should mention the example of the two drawings (Figures 3, 4) by the 7-year-old girl (Subject 8). We can see how drawing the second human figure, in this case a male, enabled her to express the hard-to-detect abuse she had experienced. These drawings communicated the physical abuse and there are consistent with previous findings indicating that drawing encourage disclosure of disturbing content (Amir and Lev-Wiesel, 2007; Goldner et al., 2021). The fact in Catalonia (Spain), one out of every five people has suffered from some form of sexual violence in their childhood (Save the Children, 2017), and its prevalence around the world seems to concur that is occurs persistently (Pereda et al., 2009; Stoltenborgh et al., 2011; Nguyen et al., 2017). Unfortunately, it is particularly difficult to detect it in children and most of them, do not disclose their sexual abuse during childhood (Read et al., 2017; Faller, 2020). Difficulties in detection are keeping child mistreatment and abuse hidden from the public eye (Tello, 2020). To have tools like the DAP are needed to improve in childhood mistreatment and abuse detection.

Conclusions and limitations

The results of this study suggest that the human figure drawings (DAP), and especially the two human figures (T2F) projective test, facilitate the externalisation of traumatic situations of mistreatment and/or abuse experienced by children. Moreover, these findings have important implications for professionals, as the use of this projective technique can help to alert and to identify aspects of risky situations, and in turn, it can help in the design of global intervention strategies in children and their families in situations of mistreatment and/or abuse.

Nevertheless, several limitations of this study should be taken into consideration. First, the participants are only from one urban area, Barcelona, and one country, Spain. Future studies replicating the findings with an expanded sample, including subjects from different countries, are needed. This would enable the results from this study to be checked and validated. Second, our results are based solely on drawings. Future studies, should include additional measures such as narratives, which would be values complement to drawings, allowing other relevant variables such as attachment in child abuse to be evaluated (Fresno et al., 2018; Muzi et al., 2021). Finally, our findings concentrated on drawings of the projective Draw-A-Person test (DAP). Future research could use other drawings tools at the same time, such as Family Drawings (FD), to assess attachment representations as a cross-cultural method (Pace et al., 2022a). These could provide to further explore the children's experiences of mistreatment and/or sexual abuse in other cultures.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

The project was approved by the Ethics and Research Committee at the Universitat Ramon Llull (URL) in Barcelona (Spain). Written informed consent was obtained from the participants legal guardian/next of kin.

Author contributions

EB is the principal researcher, conceptualized, structured data and writing most part of the manuscript. MªC and MªP contributed to documenting and writing data of the Child Protection section in Catalonia and the SEAIA teams of Barcelona City Council. PB organized the sample data, analyzed the statistical data and performed the Tables. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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Human perception and machine vision reveal rich latent structure in human figure drawings

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For over a hundred years, children's drawings have been used to assess children's intellectual, emotional, and physical development, characterizing children on the basis of intuitively derived checklists to identify the presence or absence of features within children's drawings. The current study investigates whether contemporary data science tools, including deep neural network models of vision and crowd-based similarity ratings, can reveal latent structure in human figure drawings beyond that captured by checklists, and whether such structure can aid in understanding aspects of the child's cognitive, perceptual, and motor competencies. We introduce three new metrics derived from innovations in machine vision and crowd-sourcing of human judgments and show that they capture a wealth of information about the participant beyond that expressed by standard measures, including age, gender, motor abilities, personal/social behaviors, and communicative skills. Machine-and human-derived metrics captured somewhat different aspects of structure across drawings, and each were independently useful for predicting some participant characteristics. For example, machine embeddings seemed sensitive to the magnitude of the drawing on the page and stroke density, while human-derived embeddings appeared sensitive to the overall shape and parts of a drawing. Both metrics, however, independently explained variation on some outcome measures. Machine embeddings explained more variation than human embeddings on all subscales of the Ages and Stages Questionnaire (a parent report of developmental milestones) and on measures of grip and pinch strength, while each metric accounted for unique variance in models predicting the participant's gender. This research thus suggests that children's drawings may provide a richer basis for characterizing aspects of cognitive, behavioral, and motor development than previously thought.

KEYWORDS
human figure drawing, convolutional neural networks, children's drawings, child development, machine vision, VGG 19, Draw-A-Person, ontogeny

Introduction

In 1883, the Italian art historian Corrado Ricci was driven to shelter from the rain during his return from a monastery in Bologna. As he waited for the storm to pass, he noticed an interesting pattern in the crude drawings appearing along the side of his shelter's archway: the drawings closer to the ground appeared less "technical and logical," and also less vulgar, than those higher up. To Ricci, the observation suggested that the human drive to create images may follow a regular developmental trajectory, and the first effort to understand what children's drawings suggest about their mental functioning was born.

Since Ricci's (1887) treatise, many other scientists have seen the potential of drawings to evaluate children's development due to the relatively consistent pattern of drawing progression found in typically developing children, as well as the unique characteristics of drawings produced by particular groups of children who were not neurotypically developing (Piaget, 1956; Goodnow, 1977; Gardner, 1980; Karmiloff-Smith, 1990; Cox, 1993; Case and Okamoto, 1996). For example, drawings have been used to assess children's general developmental level (e.g., Denver Developmental Screening Test, [DDST]; Frankenburg and Dodds, 1967; McCarthy Scales of Children's Abilities [MSCA]; McCarthy, 1972), children's emotional functioning (e.g., kinetic family drawing; Koppitz, 1968; Burn and Kaufman, 1970; Naglieri et al., 1991), gender stereotypes in science (Miller et al., 2018), perceptual motor development (Bruininks-Oseretsky Test of Motor Performance II [BOT-II]; Bruininks and Bruininks, 2005), cognitive development (Piaget, 1956; Case and Okamoto, 1996), spatial reasoning (Freeman, 1980; Cox, 1986; Lange-Küttner and Ebersbach, 2013), and intellectual functioning (Goodenough, 1926; Harris, 1963; Koppitz, 1968; Naglieri, 1988; Arden et al., 2014). Drawings are also commonly used as part of neuropsychological assessments with adults, with the assumption that they provide a valuable source of evidence of cognitive and perceptual-motor abilities or impairments (Lezak, 1995; Smith, 2009). While researchers have used a variety of different drawing tasks, many of these assessments rely on human figure drawing, which is the task that we focus on in the current study.

Human figure drawings were initially used to provide a quick, initial evaluation of intelligence (e.g., Draw-A-Man; Goodenough, 1926; Goodenough-Harris Drawing Test; Harris, 1963; Draw-A-Child; McCarthy, 1972; Draw-A-Person; Naglieri, 1988). Such assessments evaluate the presence of important characteristics in drawings of human figures (e.g., body parts, facial features, body proportions) *via* a checklist. While simple to use, these coding scales fail to capture the rich structure apparent in children's drawings, which potentially reflect perceptual, cognitive, and motor characteristics of the participant. In this study we describe two novel computational approaches to capturing the underlying structure in human figure drawings, then empirically assess whether the resulting descriptors can be used to predict individual cognitive, motor, and demographic characteristics of the participant.

Before describing our approach, it is useful to consider why human figure drawings have so long been viewed as providing insight into children's mental abilities. Perhaps the clearest reason is that noted in Ricci's original work: drawings produced by young children, though clearly simpler and less polished than those of older children and adults, are not arbitrary or random but exhibit common features across different ages and developmental stages (Kellogg, 1969; Cox, 1993). When drawing a person, scribbles transition to circles, then "tadpole" figures in which limbs are directly attached to a circular head. Older children differentiate the head from the body, gradually depict articulated limbs, and so on (Figure 1). It's easy to see a parallel between the developing mind and these systematic changes in how children depict others, an observation that spurred the use of drawings to measure intelligence in childhood (Goodenough, 1926).

In addition to these patterns, drawings are useful for assessment because they possess an ecological validity, a generalizability to a child's real life, uncharacteristic of most contemporary tools. Almost all children draw for fun. Unlike made-in-the-lab tools for measuring working memory, inhibition, or speed of processing (Weintraub et al., 2013; Zelazo et al., 2013), children performing a human figure drawing assessment will have had prior experience with the task, will not struggle to understand what is required, or to remember instructions, and will not typically find the task boring or unmotivating. Moreover, while most developmental assessments generate transient responses that the evaluator must score or transcribe, a drawing represents a permanent unfiltered record of the child's behavior in the image produced. Another strength is that drawing relies minimally on language and so has the potential to measure aspects of cognition and behavior independent of linguistic capabilities. Perhaps most importantly, where many assessments seek to isolate and measure distinct, individual aspects of functioning, drawing requires the joint use and coordination of many faculties together: perception, imagery, spatial cognition, planning, conceptual knowledge, and motor control. Drawings thus have the potential to uncover many different and intersecting facets of the developing mind using an engaging task that does not rely heavily on language and that children regularly undertake in everyday life.

The central challenge for meeting this potential has been to develop a means of measuring the important underlying structure in the drawings children produce, and figuring out how to relate this to characteristics of the child (Beltzung et al., 2021; Sueur et al., 2021). Drawing is open-ended: a sketcher can depict even highly familiar and well-structured items like human figures in a bewilderingly large variety of ways. It is not immediately obvious which properties of children's drawings "matter" for evaluating various mental or behavioral characteristics, or when the idiosyncrasies of their artwork reflect a mere flight of fancy versus a telling detail.

The earliest effort to formalize measurement of structure in drawings took the form of a detailed checklist and set of instructions for scoring. In the early 20th century, Florence Goodenough used her experience with thousands of children's human figure drawings to identify characteristics that, in her view, varied in a reliable manner across development. The original Draw-A-Man test (Goodenough, 1926) contained 46 standard features, with 5 additional items for images in profile, that should appear in the best drawings. An overall score was derived by raters inspecting a given drawing and checking off all the properties they could discern.

Subsequent decades saw both revisions and expansions to this general approach. Harris (Harris, 1963) expanded the checklist to include 71 features for drawings of a woman and 73 features for drawings of a man, and required children to draw a man, a woman, and 'the self' (p. 72). These categories were later adopted by Naglieri (1988), who again revised the checklist to include 65 features. Both tests developed quite stringent instructions for determining which depictions should receive full credit.

Other variants have sought to capture important structure more efficiently. Within the McCarthy Scales of Children's Abilities (MSCA; McCarthy, 1972), for instance, the Draw-A-Child task requires only one human figure drawing, with the gender of the figure adjusted to match that of the child. The accompanying checklist includes just 10 items with possible scores of 2, 1, or 0 for each, yielding a maximum possible score of 20 points. The central aim was to measure non-verbal abilities within a battery of tasks that would be quick to administer and score for a practitioner. Despite its simplicity, McCarthy's Draw-A-Child measure is highly correlated with both the longer Goodenough-Harris drawing test, $r = 0.89$ and the Full-Scale IQ measure of the Wechsler Intelligence Scales for Children, $r = 0.68$ (WISC-R; Wechsler, 1974; Naglieri and Maxwell, 1981). More recently, a variant of McCarthy's system using a 12-point checklist

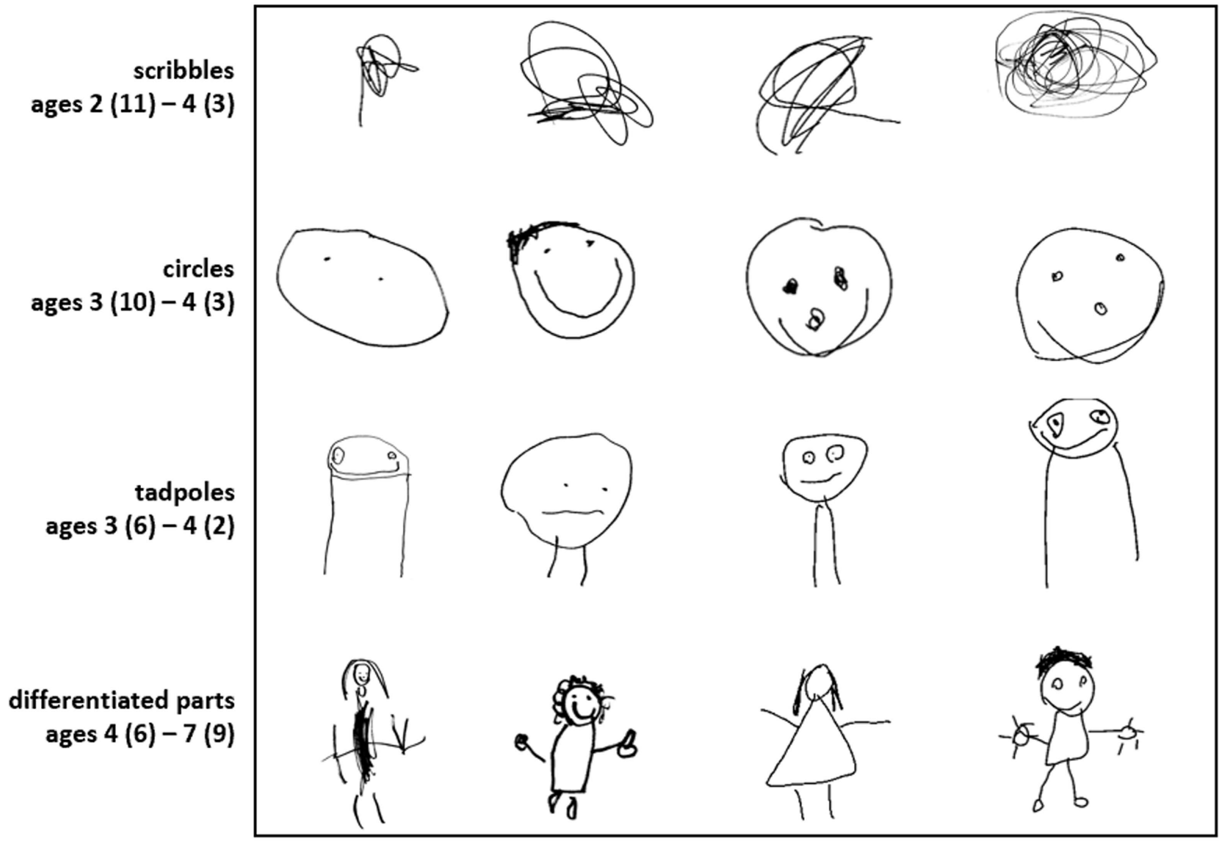

FIGURE 1
Patterns in human figure drawings across development. Examples of images produced in the drawing-across-media dataset, showing four common patterns previously identified in the literature.

(head, eyes, nose, mouth, ears, hair, body, arms, legs, hands, feet, clothes; see Arden et al., 2014) has been incorporated within a broad set of assessment tools used by the Twins' Early Development Study (TEDS)—a large-scale longitudinal study of twins born in the United Kingdom between 1994 and 1996 and assessed at 2, 3, 4, 7, 9, 10, 12, 14, 16, 18, and 21 years of age (Saudino et al., 1998; Oliver and Plomin, 2007; Rimfeld et al., 2019). Researchers working on this study found that Draw-A-Child scores on the 12-point checklist taken at age 4 predicted a remarkable amount of variation in standard general IQ (*g*) measured in the same participants 10 years later ($r = 0.20$; Arden et al., 2014).

Yet for anyone who has skimmed through the various collections of children's drawings that have accumulated over the years (Kellogg, 1969; Goodnow, 1977; Cox, 1993), it is clear that they possess more interesting structure than can be captured by checklists. Figure 2 shows several examples. In scoring the figure in panel A, the rater must decide whether it has fingers. Are the lines radiating out of each hand fingers, and if so, how does the rater indicate that there are more than five per hand? In panel B, both figures receive the same Draw-A-Child checklist score, but one is subjectively more accomplished than the other. In panel C, the drawings possess similar parts, but one has been rendered in much darker strokes than the other, indicating greater pressure on the writing implement that might in turn relate to the participant's motor control. In panel D, the head is out of proportion to the body, which itself is out of balance, potentially reflecting difficulty in spatial reasoning or planning. Where checklists reduce the information in a drawing to a single number, in fact the latent information it contains may be multi-factorial and richer than pre-determined feature checklists can characterize (Beltzung et al., 2021; Sueur et al., 2021).

The central question we ask in the current work is whether new computational methods can improve on checklist-based measures by finding latent structure in children's human figure drawings that relates reliably to their cognitive, motor, and demographic characteristics. The approaches we develop rely on two different innovations from recent years: (1) deep neural-network image classifiers, which learn complex features for representing visual images including sketches, and (2) techniques for exploiting human perception to embed images in low-dimensional spaces that reflect their overall perceptual similarity. Because these approaches are novel and their use as potential diagnostic tools has not previously been explored, the next section of the paper lays out each in detail. The following section then applies each to the analysis of human figure drawings produced by children and adults, evaluating whether the latent structure the new approaches uncover relates systematically to demographic, cognitive, and motor characteristics of the participants. The general discussion then considers what these results imply about the potential for more extensive use of children's drawings in measuring aspects of cognitive, motor, and behavioral development.

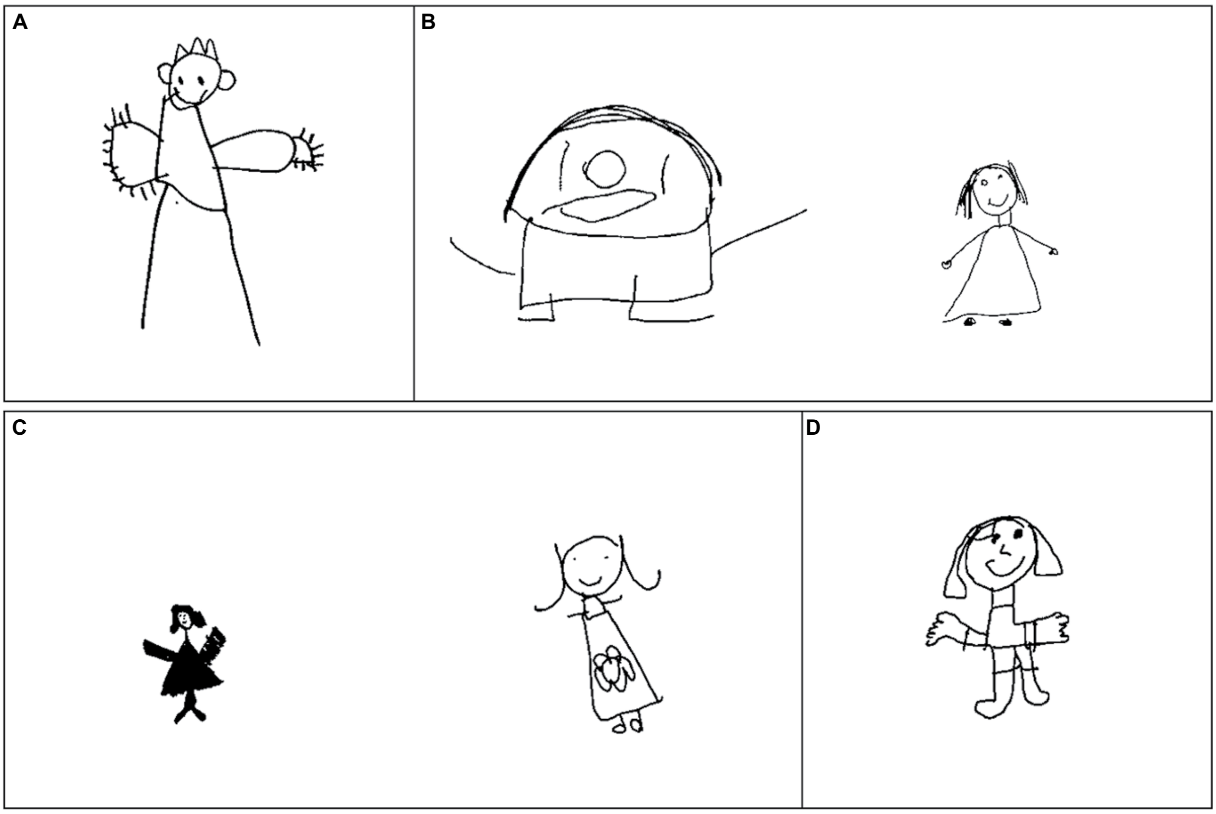

FIGURE 2
Limitations of the Draw-A-Child 12-item checklist. Examples of children's drawings that demonstrate the limitations of the Draw-A-Child 12-item checklist. **(A)** Figure with lines that may suggest fingers extending from shapes that may constitute hands, but the Draw-A-Child checklist includes no way to indicate that there are too many fingers; **(B)** Two figures that each score a 9 on the Draw-A-Child checklist where the participant's ability appears unequal; **(C)** Two figures that suggest different levels of pressure applied when making drawing; **(D)** Figure that presents with out of proportion features.

Section 1: Two novel techniques for measuring structure in drawings

Approach 1: Machine-derived latent feature vectors

The first approach uses deep convolutional image classifiers to find latent structure in drawings. Such classifiers are neural network models that take bitmap images of objects as input and output an estimate of the semantic category to which the object belongs. Models of this type now routinely show human-level performance at categorizing color photographs of objects (Krizhevsky et al., 2012; Yu et al., 2022), and in learning to do so they acquire a complex set of *latent features* useful for representing the visual structure of objects. These representations are remarkably effective: though models are typically trained only on color photographs of real objects, the features they acquire capture the visual similarity existing between human-produced sketches and photographs of a given item (Fan et al., 2018). Indeed, prior work has shown that the feature-vectors from drawings produced by children at different ages trace out a reliable pattern: as children mature, the network-generated features grow increasingly similar both to those generated from adult drawings and those generated by photographs of corresponding objects (Long et al., 2018).

Inspired by this work, we used a well-known convolutional image classifier to extract visual features of sketches for use in cognitive/behavioral assessment. A full exegesis of convolutional neural networks is beyond the scope of this paper (see Kriegeskorte, 2015; Battleday et al., 2021; Li et al., 2022; for detailed surveys), but we provide a brief overview here before explaining how we have used the model.

In convolutional image classifiers, each bitmap pixel is represented by three input units encoding, as real-valued numbers, the amounts of red, green, and blue characterizing the pixel's color. The input bitmap is divided into multiple overlapping "patches," similar to spatial receptive fields in visual neuroscience. The input units within each patch project to a bank of feature-detectors or *filters*, with the activation of each filter indicating how strongly the corresponding feature can be detected in the input patch. The same filters get applied to each input patch, so that every patch in the image is recoded as an activation pattern across the same set of filters. This general structure is then repeated several times, with each successive layer receiving inputs from a spatially contiguous patch of earlier units, encoding the presence of increasingly complex features within increasingly broad regions of the input. The deepest such convolutional layer then projects to one or more "flat" layers that discard spatial/topographic information about features. The deepest flat layer in turn projects to an output layer in which each unit corresponds to a single category label. Activations of output units are positive and constrained to sum to one, so the activation pattern across units can be viewed as a probability distribution over the various possible categories. The model's "job" is to take an image of an object as input, pass it through all model layers, and generate output activations that correctly indicate the probability that the depicted object belongs to each possible category.

Critically, the features detected at each model layer, and the activation pattern generated across units in the "flat" layers, are not pre-specified. Instead they are learned through error backpropagation by training the model to correctly categorize photographs from very large corpora of labelled images. Such training allows convolutional networks to classify new photographs with remarkable accuracy, and to learn visual features at each convolutional layer that express the visual structure of natural images and resemble, in some respects, neural responses to visual stimuli measured in human and non-human primate brains (Cadieu et al., 2014; Yamins et al., 2014; Güçlu and van Gerven, 2015; Cichy et al., 2016; Bao et al., 2020; Storrs et al., 2020).

We used the well-known VGG-19 model, a fully trained neural-network from the Visual Geometry Group at Oxford (Simonyan and Zisserman, 2014). This model has 16 convolutional layers and 3 fully connected "flat" layers intervening between input and output. It was trained to assign each of ~14 M ImageNet images to one of 1,000 possible mutually-exclusive categories. We selected VGG-19 because prior work has shown that its penultimate layer captures important similarity relations amongst sketches of objects (Fan et al., 2018), and because it has been studied extensively in visual cognition and neuroscience (Jha et al., 2020). The approach we describe here can, however, be easily extended to other visual neural network models.

Our goal was to use VGG-19 to extract visual feature vectors characterizing the complex visual structure of a given drawing, and to then assess whether these features reliably predict cognitive, behavioral, and demographic characteristics of the participant. To this end we devised the following procedure. Each drawing in a dataset was scanned and converted to a black-and-white bitmap of the appropriate dimensions (i.e., those of the VGG-19 input layer). The bitmap was fed into the trained network, which computed activation patterns across all units in each model layer. Following Fan et al. (2018), we extracted the activation pattern across the penultimate model layer (i.e., the last hidden layer before the outputs), and took this as a vector-based representation of the drawing.

The resulting vectors are very high-dimensional, since the corresponding layer has 4,096 units. Rather than using these activation vectors directly, we instead applied matrix decomposition methods to reduce the dimension. After extracting the VGG-19 vectors for each of k drawings in a dataset, we computed the *cosine similarity* between each vector pair, yielding a symmetric k by k matrix indicating the degree to which pairs of drawings are represented similarly by the model. We then used classical multidimensional scaling to compute d coordinates for each image, such that the pairwise similarities between all images in the d-dimension space approximate as closely as possible those in the original matrix.

The full procedure effectively re-represents each image as a *machine-derived latent feature vector* that captures similarities amongst VGG-19's internal representations. The latent feature vectors can then be used in regression models to predict characteristics of the participant. The full workflow is shown in Figure 3A.

Approach 2: Mining human perception to find structure in drawings

The second approach is motivated by the intuition that human perception of drawings can be sensitive to varieties of structure not captured by machine-vision techniques like VGG-19. For instance, people possess conceptual knowledge about items depicted in drawings; can easily decompose these into component parts; understand the structure and function of different drawing elements (for instance that limbs are jointed and can move around, or that hands can grasp); can interpret very simple features such as straight lines or circles as depicting more complex object parts like legs or heads; comprehend common drawing conventions such as the use of stick figures to represent the human form; and can easily evaluate overall quality of a drawing. All of this rich knowledge is absent in image classifiers and may inform the similarity judgments that people generate.

Prior work described in the introduction uses human raters to explicitly evaluate the presence of many pre-defined features in a drawing, a procedure that (a) requires expert knowledge of the checklist tool, (b) is laborious and time-consuming and (c) relies on the particular features chosen for inclusion on the checklist. Our approach instead makes use of the ability of non-experts to quickly and reliably judge the perceptual similarity and quality of drawings, in two related ways.

First, we employ a *triadic judgment task* to situate images within a low-dimensional space that expresses human perceived similarity (Jamieson et al., 2015). On each of many trials, human raters must judge which of two images is most perceptually similar to a third (Figure 4A). Judgments for triplets generated from a set of k images are collected online from many human workers (for instance, Amazon Mechanical Turk or [AMT] workers), and these are compiled to create a k by k matrix indicating, for any two items, the probability that they are selected as "most similar" relative to other images. In this way, we obtain discrete, forced-choice similarity judgements that can approximate continuous estimates of perceptual similarity. For the AMT worker, the task is simply to choose which of two images presented at the bottom of their screen is most similar to a third image presented at the top.

We then apply a multi-dimensional scaling algorithm suited to triplet judgements to embed the k items in a d dimensional space (Figure 3B). Specifically, we used the *crowd kernel* approach to ordinal embedding, which situates each drawing within an n dimensional space in such a way that items frequently selected as similar to one another across triplets are nearby (i.e., have low Euclidean distance) in the space. Just as with the VGG-19 workflow, this approach re-represents each image as a *human-derived latent feature vector*, with the similarity between vectors indicating the likelihood the two corresponding images are judged to be perceptually similar. As with VGG-19, these vectors can be used in regression to predict characteristics of the participant.

Second, we use a similar approach to evaluate the overall quality of a drawing as perceived by a non-expert human judge. On each trial a rater on AMT views two images depicting a human figure and must choose which is "the better drawing of a person" (Figure 4B). Many such judgments are collected from the crowd of AMT workers for random pairs of drawings, and for each we compute the proportion of trials for which a drawing was chosen as the best from among all trials where the image appeared. Using this forced-choice approach, high-quality drawings are those often chosen as the "best" compared to other images—that is, drawings selected on a high proportion of trials where they appear. Thus the "proportion selected" value provides an estimate of the true ranking of images by human-judged quality—we therefore refer to this metric as the *quality-rank score*. Like the checklist approach, this method produces a single number

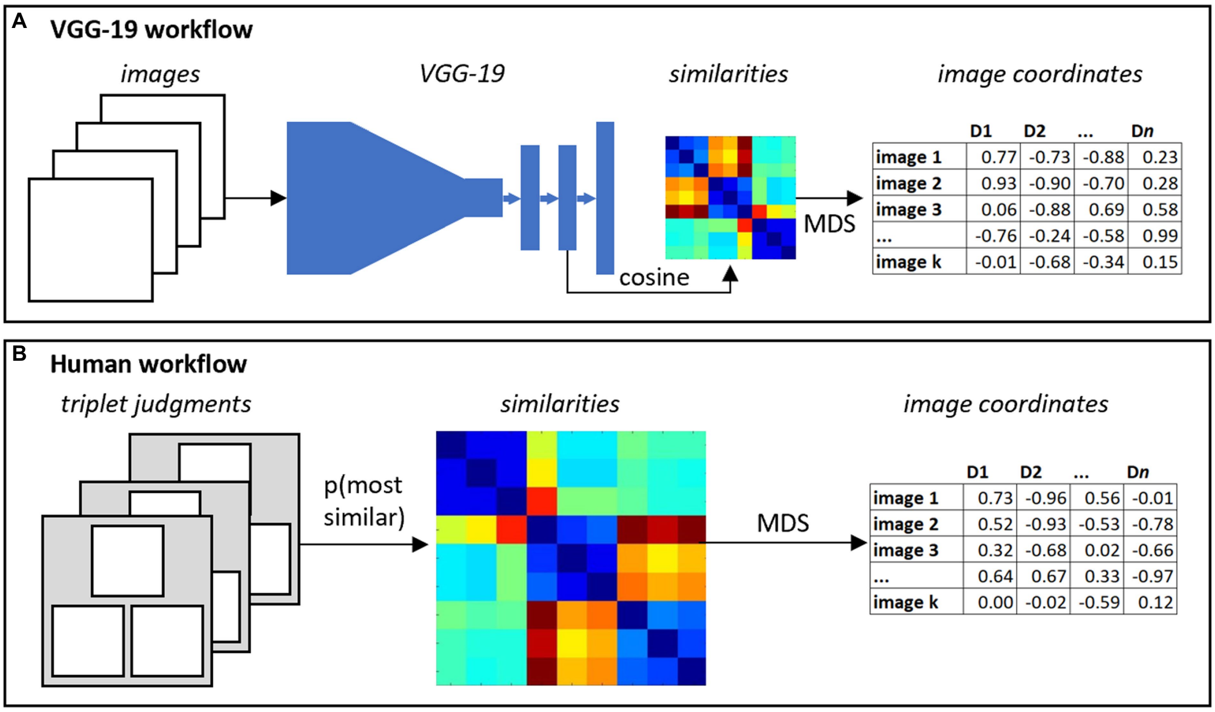

FIGURE 3
Two methods for capturing latent structure in sketches. **(A)** The VGG-19 workflow feeds each image into the neural network, extracts high-dimensional vectors from the penultimate layer, computes pairwise cosine similarities amongst all images, and reduces these to a small number of coordinates for each image using multidimensional scaling (MDS). **(B)** The human workflow collects most-similar judgments for a large set of triplets, computes pairwise probabilities that two images are chosen as most similar, and again uses MDS to reduce the similarity matrix to a small number of coordinates for each item.

evaluating the perceived quality of the drawing, but unlike the standard method, it does not rely on presence/absence of pre-selected features, or any expert training or knowledge: the resulting measure instead reflects non-expert human judgements about the quality of each drawing.

Together the application of these methods to a set of drawings yields, for each image, (a) a machine-derived latent feature vector (b) a human-derived latent feature vector, and (c) a human-derived estimate of perceived drawing quality. These numeric descriptions of the images do not correspond to explicit, identifiable features of the kind appearing in checklists, but may capture underlying structure in drawings that nevertheless relate cognitive, behavioral, and demographic characteristics of the participant. The next section empirically tests this possibility.

Section 2: An empirical proof-of-concept

We used these techniques to analyze a dataset recently collected as part of an unrelated project designed to understand how the introduction of touchscreen tablets into children's homes might influence the quality of drawings they produce (Kirkorian et al., 2020). As part of the original study, the authors collected human figure drawings from 129 children aged 3–9 years and 29 young adults. Children completed an assessment of motor function (grip and pinch strength) and were additionally evaluated on the age-appropriate level of the 3rd edition of the Ages and Stages Questionnaire (ASQ; Squires and Bricker, 2009), a parental-report based screening assessment that includes subscales for fine and gross motor control, problem solving, personality, and social behaviors. Parents also completed a demographic survey.

Our goal was to conduct a proof-of-concept analysis to determine whether the latent structure of drawings expressed by machine vision and/or human perception captures reliable information about the demographic, motor, or other characteristics of the participant as measured through the corresponding standard assessments. To this end, we applied each of the procedures previously described to generate coordinate vectors for each drawing from machine vision and human perception as well as human-judgment-based quality scores. We then used these metrics to predict the participant's demographic characteristics (age and gender), motor capabilities, and other Ages and Stages subscores, focusing on three key questions:

1. Do the new metrics based on machine vision and/or human perception reliably predict variance in the outcome measures (participant age, gender, ASQ scores, etc.)?
2. Do metrics from machine vision and human perception account for similar or different characteristics of the participant?
3. Do the new metrics account for significant variance over and above the Draw-A-Child checklist score?

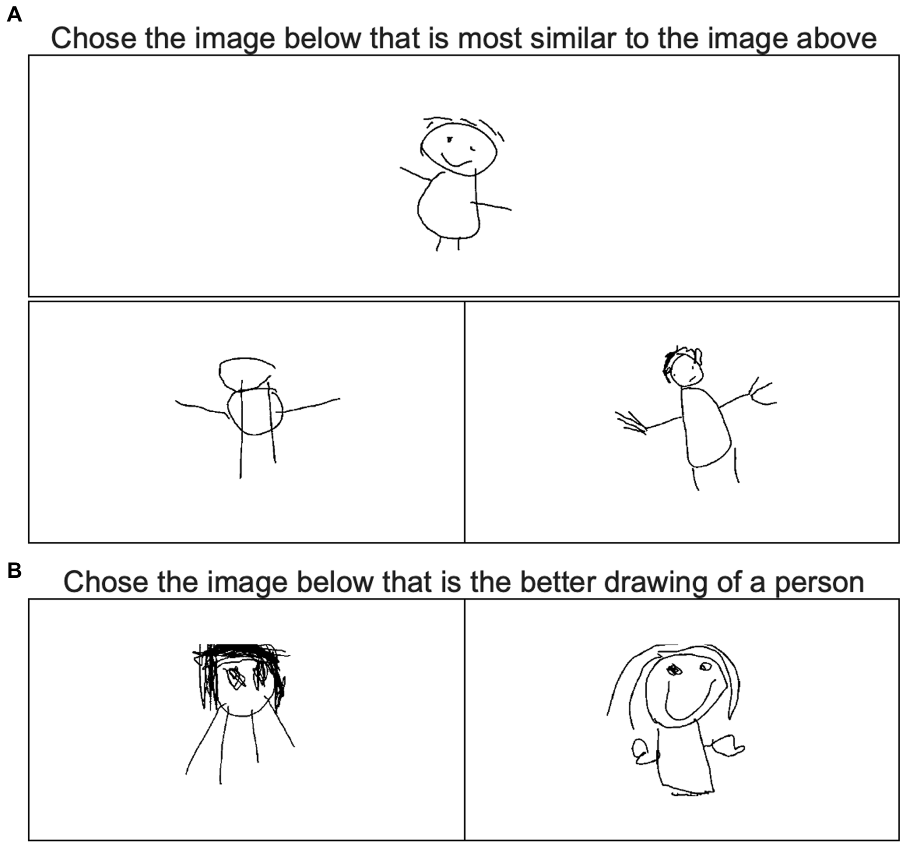

FIGURE 4
Examples of trials in human-judgment tasks. **(A)** One trial of the triadic judgement task where participants must decide which of the two bottom images is most perceptually similar to the top image. **(B)** One trial of the drawing quality judgment task, in which participants must decide which of two images is a better drawing of a person.

Method

Participants

The data come from prior studies of human-figure drawings conducted by several of the co-authors, approved by the Institutional Review Board for Education and Social/Behavioral Science at the University of Wisconsin-Madison (Protocol no. 2015–0564, "Children's Drawing Across Media"). Data were collected between July and November 2015.

Children for these studies were recruited through preschools and a children's museum in Madison, WI, a medium-sized city in the Upper Midwestern United States. Adults were recruited through personal contacts and snowball sampling from within the undergraduate population at UW-Madison. The sample included 129 children, ages are stated in year;month (age range = 1;10–8;10, *M* = 4;4, *SD* = 1;6, 53% female, 47% male) and 25 adults (age range = 19;1–22;0, *M* = 20;7, *SD* = 0;10, 76% female, 24% male). Parents of 85 children (66%) completed a brief demographic survey. The majority (*n* = 66, 77%) identified their child as White and non-Hispanic; other children were identified as Hispanic (*n* = 7, 8%), Asian/Pacific Islander (*n* = 5, 4%), Black/African American (*n* = 3, 2%), or other/mixed race (*n* = 4, 3%). For the parents, the mean years of education was 18;4 (*SD* = 2;10, range = 12–25), a level that is roughly equivalent to a master's degree. Parents were also asked to place themselves on a Socioeconomic Status (SES) continuum derived from the MacArthur Scale of Subjective Social Status (Goodman et al., 2001). Respondents are asked to place themselves on a 10-point continuum with one anchor representing individuals who have the least money, least education, and either no job or a low-status job (rating of 1 out of 10) and the other anchor representing individuals who have high levels of money, high education, and a high-status job (rating of 10 out of 10). The average subjective SES for our sample was 7.15 (*SD* = 1.36, range = 4–10).

Data collection procedure

Human figure drawings

Participants were prompted to draw a human figure following a script adapted from the Draw-A-Child protocol (McCarthy, 1972). Fifty-six children provided three drawings: one with marker on paper, one with finger on tablet, and one with stylus on tablet. Fifteen children contributed two drawings across the three media. The remaining fifty-seven children produced one drawing each, in one of the three media. Taken together, there were 255 drawings by children. The twenty-five adult participants each produced two drawings, one with marker on paper and one with finger on tablet, for a total of 50 drawings.

Grip and pinch strength

These measures were used to obtain an assessment of motor function. As the production of a drawing with an implement on a surface must compensate for frictional forces on the surface, both grip and pinch strength can be viewed as functional measures related to both gross and fine motor control. The full procedure for assessing grip and pinch strength can be found in Kirkorian et al. (2020). Briefly, a Preston Jamar hand dynamometer and pinch meter (Patterson Medical, Warrenville, IL) were used for these assessments. For grip strength, the smallest handle position was used for all participants. Participants were asked to attempt three assessments for each hand, alternating between both hands. The maximum grip and pinch measurements across all trials were used in the analyses, as recommended by Roberts et al. (2011).

Ages and stages questionnaire

Finally, parents of 45 children (56% of sample) completed the ASQ-3, a parent-report evaluation of developmental milestones across five domains: fine motor skill, gross motor skill, problem solving and personal/social skill. Parents completed the specific ASQ questionnaire that corresponded to their child's chronological age in months by responding: Yes, Sometimes, or Not Yet, to questions about their child's behaviors. For example, Gross Motor: "Does your child climb the rungs of a ladder of a playground slide and slide down without help?"; Fine Motor: "When drawing, does your child hold a pencil, crayon, or pen between her fingers and thumb like an adult does?." For each domain, scores range from 0–60, with higher scores indicating increased developmental achievement.

Image processing and rating procedure

Image pre-processing

Original drawings were produced with a black marker on white paper, or on a tablet computer using black script on a white background. Paper drawings were scanned, and screen shots were taken for tablet-based images. All drawings were digitized to a common format and cropped to remove identifying information (e.g., participant IDs) and unintended markings (e.g., borders, scanning artifacts) while maintaining the aspect ratio. The images were then contrast normalized so that all pixels were either black or white to ensure minimal low-level visual differences between scanned versions of paper images and drawings produced on tablets. All drawings were also centered and padded with white pixels to a uniform size.

Machine-derived latent feature vectors

All code for replicating our analyses is available at https://github.com/ClintJensen/DrawingsProject. We used a standard implementation of the VGG-19 architecture pre-trained to classify photographs of real objects within the ImageNet database (Deng et al., 2009; Simonyan and Zisserman, 2014). The model is coded in Python 3.6 using TensorFlow (1.13.1) libraries. Each pre-processed image was rescaled to the dimensions of the model input layer (3x224x224) and presented as input to the model. Activation patterns were computed at each layer in a feed-forward pass, and the resulting vectors from the penultimate layer for each image were extracted.

We next computed cosine similarities for all vector pairs, then decomposed the resulting matrix into a small number of components using classical multidimensional scaling. For purposes of data exploration and visualization, we computed embeddings in both two dimensions (each image represented with two coordinates) and five dimensions (each represented with five coordinates).

Human-derived latent feature vectors

Human-derived latent feature vectors were estimated from a large set of triplet judgments collected from 218 workers on Amazon Mechanical Turk (AMT). All workers had a HIT approval rating greater than 97%, completed a reCAPTCHA verification procedure before beginning, and worked from computers with IP addresses within the US.

Data were collected using NEXT, a software package that enables easy deployment of simple forced-choice experiments in the cloud (Jamieson et al., 2015). On each trial of the triadic judgments task, workers viewed a sample image above two option images and pressed the left or right arrow key to indicate which option was most similar to the sample (Figure 4A). Workers were asked to judge 200 randomly-selected triplets, a task designed to take 10 min given an average response time of 2.5 s per selection, but were permitted to exit at any time. For those exiting early, all data collected to that point were included in the analysis. For the triadic judgments task, out of our total 218 workers, the average number of selections made was 146 (51 workers completed all 200 image pairs). A total of 31,832 judgments were collected. AMT workers were paid $1.00 for participation.

From these data, 10% of trials were selected at random as hold-outs to evaluate the quality of embeddings. Embeddings were then estimated in 1–5 dimensions from the remaining data using Crowd Kernel, an algorithm designed specifically to learn non-metric embeddings from discrete comparative judgments of this kind (Tamuz et al., 2011). We computed the quality of each embedding by tabulating how often inter-item distances correctly predicted human decisions in the set of held-out triplets. Embeddings in 2-dimensions were found to have the best accuracy and were retained for the regression analyses. These same 2D embeddings were used within the visualizations that follow.

Drawing quality

Overall drawing quality was measured in two ways. First, we scored all drawings using the same 12-item Draw-A-Child checklist employed in the TEDS study described in the introduction (Saudino et al., 1998; Oliver and Plomin, 2007; Arden et al., 2014). Two trained raters independently scored all drawings, indicating which of the 12 features they detected in the image. This procedure yielded a total score from 0 to 12 for each image. Inter-rater reliability across drawings showed a by-item Pearson's product–moment correlation of 0.93. The final score for each drawing was taken as the mean of the two raters.

The second approach used pairwise judgments to define each drawing's perceived quality-rank score using the forced-choice method described earlier, again crowdsourced from AMT workers, using the same recruitment procedures and controls. On each trial of this procedure a worker saw two drawings and was asked to decide which was a better drawing of a person by pressing the left or right arrow key (Figure 4B). A total of 58 workers were asked to judge 200 pairs but were permitted to stop at any point. The average number of selections per participant was 174 (25 participants completed all 200 image pairs). As with the triadic judgements task, all data from all respondents were included in the analysis. A total of 10,107 judgments were collected. Each worker was paid $1.00. The quality score for each drawing was then computed as the number of times the image was chosen as the better drawing divided by the total number of times it appeared in the dataset, a proportional value ranging from 0 to 1.

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Results

Exploratory analyses

Before tackling the questions laid out in the introduction, it is useful to get an initial qualitative sense of the structure expressed by machine-and human-derived latent feature vectors, and to evaluate whether the two approaches capture distinct information about the similarity relations among drawings. We began by plotting the 2D embeddings for a subset of drawings as shown in Figure 5. By visual inspection, the two approaches each capture discernible but somewhat different structure across drawings. Embeddings from human judgments lie along a curve in the 2D embedding space, with an ordering that appears to reflect the developmental progression from scribbles to circles to fully differentiated body parts. This organization is more difficult to see in the VGG-19 embeddings, which nevertheless clearly capture some elements of similarity amongst the drawings. For instance, by visual inspection, the VGG-19 embeddings appear to group together larger circular drawings composed of light strokes, including both circular faces and scribbles. These can be seen in the lower left of the figure. Larger drawings with many light horizontal strokes, including a human figure with arms outstretched and horizontal scribbles are grouped in the top left of the figure. Images that are smaller in relative height and width on the drawing surface, with dense strokes and a vertical orientation, appear clustered toward the right middle of the figure. Note that human embeddings group together round and horizontal scribbles that are widely separated in the VGG-19 plot, while VGG-19 embeddings group tadpoles and fully-differentiated figures when these are similar in size, vertical orientation and stroke weight.

To understand whether the apparent differences between machine-and human-derived embeddings are an artifact of compression to just two dimensions, we also considered 5D embeddings generated from both human judgments and VGG-19 representations. We first visually inspected the five nearest neighbors in each 5D space for a set of reference images. Figure 6 shows a representative set of images. The nearest neighbors are completely non-overlapping in the two spaces, suggesting that they capture different similarity relations. The human-derived embeddings again appear to capture the developmental "stage" of the participants: the scribble in the top left is near other images that fit within the category of "scribbles"; circle-faces are near other circle-faces; full figures are near other full-figures; etc. In contrast, the same scribble is near images recognizable as human figures in the machine embeddings; the tadpole in the middle is near fully-articulated figures; and the well-rendered figure in the bottom left is near drawings highly variable in quality.

To test whether the differences arising in this small set of sample images are more broadly characteristic of the two spaces, we computed, for each image, how often the nearest neighbor in one embedding space appeared in the *top ten closest items* for the same referent in the other space. In both cases, for over 90% of the images, the nearest neighbor in one space was *not* among the top ten nearest images in the other. Thus even in this broader space, the embeddings capture different similarity relations amongst the images.

Finally, we used regression to quantify how similar the 2D machine-and human-derived embedding spaces are to one another. Each of the two embeddings situates drawings in two dimensions, so we fit and evaluated four regression models, each using one embedding dimension in a given space as the dependent variable. All four models accounted for significant variance in the dependent measure, showing that the two spaces are not completely independent (see Table 1). Yet neither are they identical: in all four regressions, more than half the variance in a drawing's location along one dimension in a given space remains unexplained by its joint coordinates in the other space. Thus the machine-and human-derived embeddings, though not completely

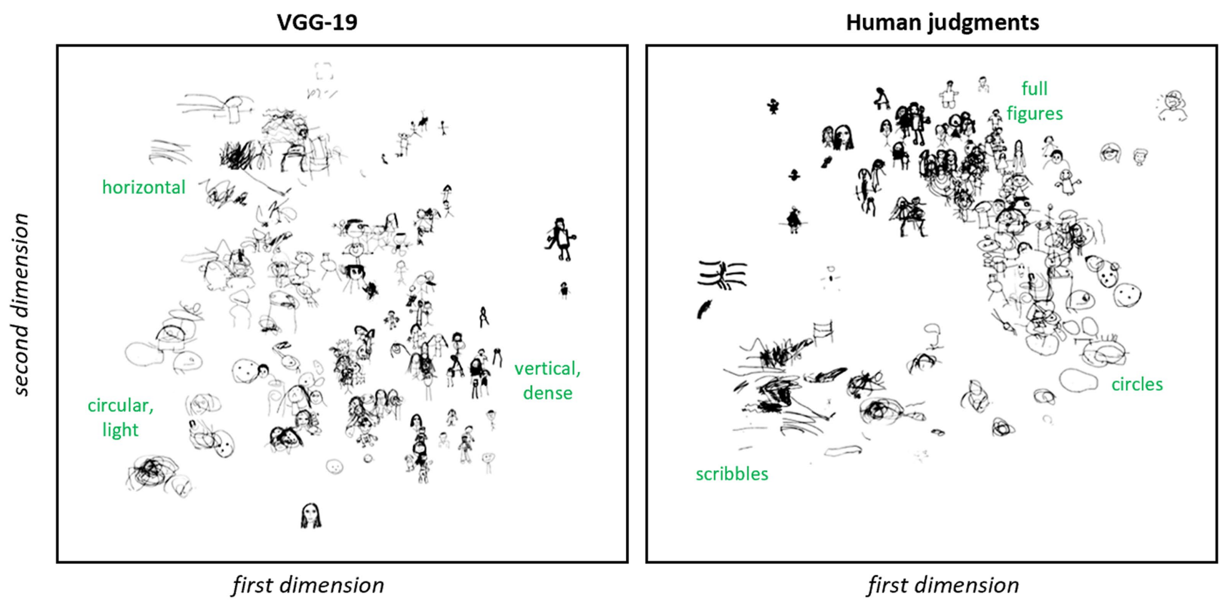

FIGURE 5
Two-dimensional embeddings of drawings. Two-dimensional embeddings for a subset of human figure drawings based on VGG-19 vectors (left) vs. human judgments of similarity (right). By inspection, each technique captures some aspects of structure. For VGG-19, circular shapes composed of light strokes are grouped in the bottom left, images with many horizontal strokes appear near the top, and drawings with dense strokes oriented vertically appear toward the right. For human judgments, sketches trace out a manifold reminiscent of a common developmental trajectory, with scribbles in the bottom left transitioning to circles toward the right and then to fuller depictions of the whole figure toward the top middle.

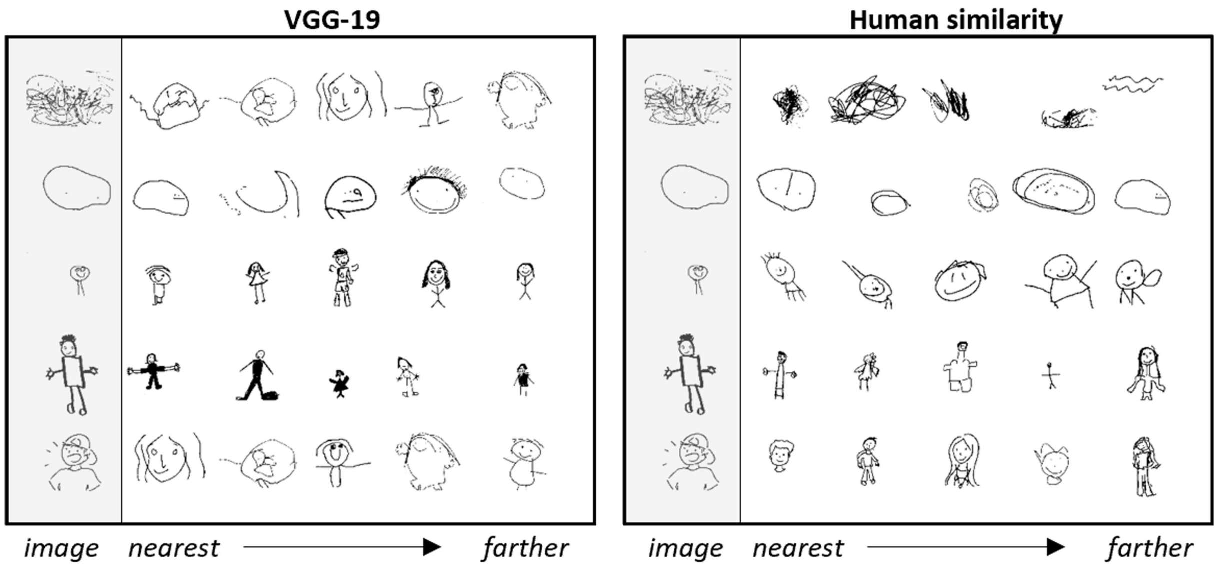

FIGURE 6
K-nearest neighbors of five-dimensional embedding spaces. Nearest neighbors for five reference items in the 5D embedding space for machine- (left) or human- (right) derived latent feature vectors. Rows show the five closest neighbors to the reference item (gray column) in order of proximity. The same reference items are used in each space, but the two spaces capture different neighborhood relations.

TABLE 1 Regressions predicting coordinates of embedding in one space from those in the other.

Model	R^2	p
$X_{human} = X_{machine} * Y_{machine}$	0.21	<0.001
$Y_{human} = X_{machine} * Y_{machine}$	0.46	<0.001
$X_{machine} = X_{human} * Y_{human}$	0.48	<0.001
$Y_{machine} = X_{human} * Y_{human}$	0.23	<0.001

Each model predicts the coordinates of drawings along a given dimension in the human- or machine-derived embedding from both coordinates and their interaction in the other space. X and Y indicate the first and second dimensions of the human- or machine-derived embedding.

independent, nevertheless express quite different structure amongst the drawings.

Note that, whereas the human embeddings appear to capture structure expressing the developmental trajectory of human-figure drawing, it is less clear what information governs the structure of the machine embeddings. While our qualitative observations hint at some possible characteristics that the network may be exploiting (e.g., stroke density, size of the drawings on the surface, vertical/horizontalness, etc.), these may or may not correctly reflect the information guiding the model representations. One potential advantage of using neural network feature vectors to characterize the structure of drawings is that, precisely because of their opacity, such models may discern structure beyond what the human eye naturally detects that is difficult to analytically extract through simpler means. The analyses in this section demonstrate that machine-based representations capture similarity relations that are quite different from those governing human perceptual judgments—so regardless of the driving image characteristics, it is an empirical question whether the machine-perceived structure captures cognitive, motor, or behavioral characteristics of the participant.

We next considered how the crowd-sourced quality-rank score relates to the conventional Draw-A-Child 12-point checklist score. Recall that the quality-rank score is based on many non-expert forced-choice evaluations of comparative drawing quality, while the checklist score is based on evaluating the presence of 12 key features by trained raters. Nevertheless, the two metrics were highly correlated [$r(303) = 0.91$, $p < 0.001$, CI (0.88–0.92); see Figure 7], though items receiving the same checklist score varied nontrivially in their quality score and vice versa. Figure 7 shows some examples in callouts: two drawings both receiving a checklist score of 5 clearly differ in drawing quality, while two drawings receiving a quality-rank score near 0.65 appear to be of similar quality but differ in the parts included. Thus, the checklist and quality-rank, despite their high correlation, capture somewhat different information about each rendering. If the features appearing in the checklist are especially important for understanding aspects of development beyond just capturing image quality, the checklist metric should better predict individual variability on those aspects than does the quality-rank score. If, however, the main utility of the checklist for understanding some component of cognition is to capture overall drawing quality, the quality-rank metric should account for as much or more variance on that component as does the checklist score.

To better characterize the extent to which the new metrics express structure similar or different to that captured by the checklist score we tested these relationships in two ways. In the first analysis, we fit regression models to predict a drawing's checklist score (averaged across the two raters) from each of the new metrics (quality-rank score, human-derived embedding coordinates, and machine-derived embedding coordinates) taken independently and in combination. The results are shown in Table 2. Both human-derived measures independently accounted for over 80% of the variance in checklist scores, and in combination they accounted for significantly more variance than either considered alone (86%, $p < 0.0001$ in contrast against best independent model). Machine-derived embeddings accounted for just 36% of the variation in checklist scores when considered independently, though this rose to 84% when quality rank and its interactions were added to the model. When all new metrics and

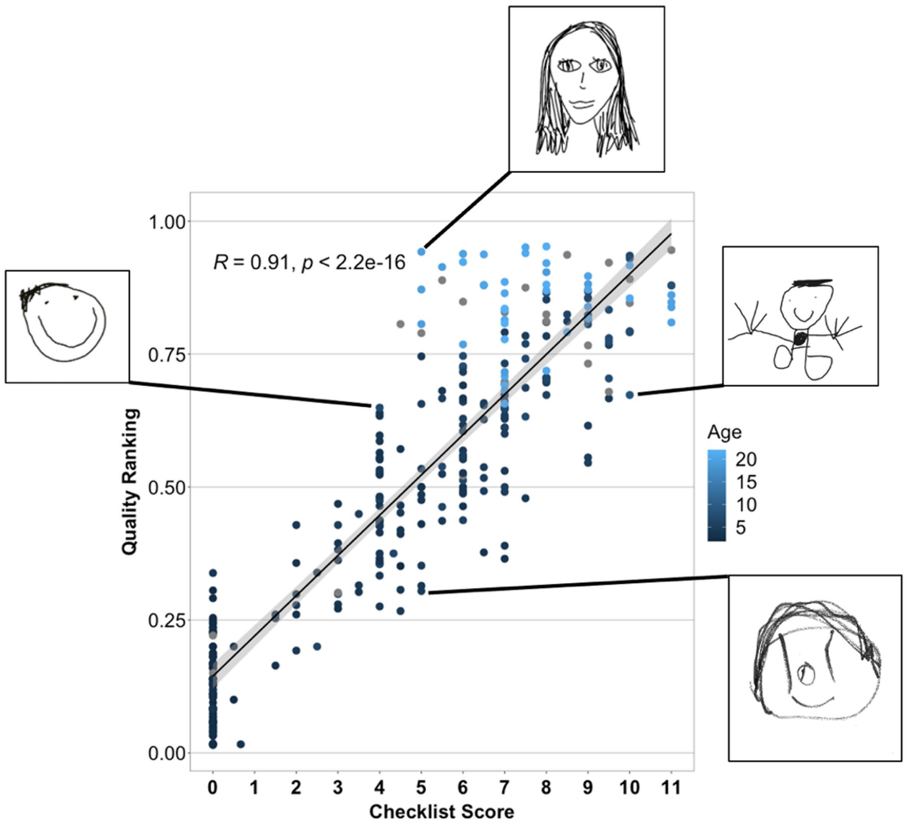

FIGURE 7
Relation between the crowd-sourced quality-ranking and the Draw-A-Child checklist score. The top and bottom callouts show drawings that received the same checklist score but differ in quality-rank, while the two middle callouts show drawings that received similar quality-rank scores but different checklist scores.

TABLE 2 Adjusted r^2 and model-comparison *p* values for regressions predicting a drawing's checklist score from the new metrics.

Predictors	Adj. r^2	Contrast to alternative H
Quality Ranking (QR) only	0.82	$p < 0.0001$ vs. null
Human Embedding (HE) only	0.84	$p < 0.0001$ vs. null
Machine Embedding (ME) only	0.36	$p < 0.0001$ vs. null
QR * Human embedding	0.87	$p < 0.0001$ vs. HE only
QR * Machine embedding	0.84	$p < 0.0001$ vs. QR only
QR * HE * ME	0.89	$p < 0.0001$ vs. QR * HE

their interactions were added to the model, model fit rose significantly, accounting for 89% of the variance in checklist scores ($p < 0.0001$ for fit contrast to next-best model). Thus the bulk of the information captured by the checklist score is also expressed jointly by the new metrics.

In the second analysis we assessed whether human- and machine-derived estimates of pairwise similarities amongst drawings (expressed as distances between points in the corresponding embeddings) capture structure distinct from the similarities in their checklist scores. For each embedding space and for the checklist scores, we computed the Euclidean distances between all drawing pairs. For the checklist, each entry was simply the absolute value of the difference in checklist scores. Across all unique pairs, we then computed the correlations of these distances for each pair of metrics. For the checklist and human-derived embedding distances, the correlation was $r = 0.70$, suggesting that the two measures capture related but non-identical information (49% shared variance) about similarities amongst drawings. The correlation between human- and machine-derived embedding distances was smaller ($r = 0.31$, 10% shared variance) and between checklist and machine-derived embedding distances smaller still ($r = 0.22$, 4% shared variance). Although it is evident that each metric captures distinct information about similarities existing amongst the various drawings, exactly where and how those differences arise is less clear. One way to explore what may underlie both differences and similarities that define these metrics is to consider the predictive ability of each approach on measured attributes of the participants that produced the drawings.

Predicting demographic characteristics of the participants

The preceding exploratory analyses show that the new metrics each express aspects of structure in drawing different from that captured by the standard scoring metric, and different from each other. The next question is whether these varieties of structure in turn reliably capture information about the participant. As an initial proof of concept, we first considered the participant's age and gender, focusing on these demographic factors for several reasons. First, they represent two different prediction problems of key interest for assessment, that is, prediction of a continuous (age) and a categorical (gender) dependent measure. Second, age and gender data are available for all study participants, providing good power for a proof of concept analysis. Third, by analyzing the fits of different predictive models we can assess whether the three new metrics capture any information beyond that already expressed in checklists, and whether they capture similar or different components of variation in these dependent measures. Fourth, some prior work has suggested that DAP-style tests may show reliable sex differences, with girls generally producing more detailed drawings at an earlier age than boys (Goodenough, 1926; Goodenough and Harris, 1950; Harris, 1963; Naglieri, 1988; Cox, 1993; Lange-Küttner et al., 2002). Finally, the demonstration on these simple demographic characteristics provides a blueprint for the subsequent analyses.

In all analyses, age data were log-transformed to better approximate a normal distribution, while gender data were coded as a discrete binary factor. Models predicting age were fit using linear least-squares regression and evaluated using the r^2 metric, while those predicting gender were fit using logistic regression and evaluated using the area under the ROC curve (AUC or area-under-curve) estimated on held-out items from the fitted classifier. For these latter assessments, models were fit to 90% of the data and AUC was computed for the remaining 10%, held out at random. This procedure was run 100 times, with a different set of random hold-outs each time, and model performance was taken as the mean estimated AUC across these folds.

Otherwise, prediction of age and gender followed the same stepwise procedure. Step 1 first fit a "baseline" model predicting the dependent measure from the checklist score and including the other sociodemographic factor as a covariate of no interest. To assess whether the quality-ranking score carries information beyond that captured by the checklist score, a second model was fit including both checklist and quality-rank and their interaction. Any resulting change in model fit was evaluated using ANOVA. Step 2 then evaluated whether the addition of image coordinates from the machine-and human-derived 2D embeddings, considered separately, reliably improved model fit relative to the best-performing model of Step 1. We focused on 2D embeddings rather than higher-dimensional embeddings simply due to power considerations: since the number of terms in the regression increases exponentially with the number of predictors (when interactions are included), and given the size of our dataset and the required covariates in each model, two additional predictors beyond age, gender, and checklist/quality-rank were the most we could include. There is no principled reason, however, why higher-dimensional embeddings could not be included for analyses of larger datasets. Finally, Step 3 evaluated whether machine-and human-derived coordinates account for unique variance in the dependent measure by adding embedding data from both methods and comparing change in model fit to the best-performing model from Step 2.

The results are shown in Table 3. The checklist score predicted 49% of the variance in log age, but this increased to 64% when checklist score was replaced with the quality-rank score, when both models covaried out gender. A comparison of the model with both metrics to the model with checklist alone showed that quality-rank accounted for significant additional variance beyond that explained by the checklist score. Further, adding either the human- or the machine-derived embedding coordinates significantly improved model fit, and by an equal amount, with both models showing an adjusted r^2 of 0.69. Including both human- and machine-derived embeddings did not reliably improve fit compared to either of these alone, $r^2 = 0.69$, suggesting that both embeddings capture the same additional variation after taking quality-rank into account.

Next, the baseline model showed reliable above-chance classification of the participants gender, with higher scores on the checklist measure predicting a greater likelihood that the drawing was made by a female participant after covarying out effects of age (see Table 3), consistent with prior work (Goodenough, 1926; Goodenough and Harris, 1950; Harris, 1963; Naglieri, 1988; Cox, 1993; Lange-Küttner et al., 2002). This predictive accuracy again improved reliably when the checklist score was replaced with the quality-rank score. Both human- and machine-derived embedding coordinates significantly improved model's predictive accuracy compared to the quality-rank alone, and the incorporation of both embeddings together produced significantly better classification accuracy compared to either alone. The model including all three metrics (and including age as a covariate of no interest) showed a remarkable AUC value of 0.87—that is, 87% accuracy discriminating males from females solely based on overall quality and latent structure in the drawings. Interestingly, the relationship between the drawing quality-rank score and the probability of being female remained positive in all models—suggesting, again consistent with prior work, that girls produce drawings perceived as higher quality than those produced by boys, even taking other aspects of drawing structure into account.

Predicting motor and cognitive characteristics of the participants

Finally, we evaluated whether the new metrics carry information about aspects of cognition and behavior measured by the ASQ and about motor abilities as measured through both the parental report within the ASQ, and the practical measures of pinch and grip strength. As already noted, these measures were collected for only a subset of child participants, yielding a total of 109–115 drawings from participants whose parents contributed ASQ responses, and 198 from participants who completed the pinch/grip measures. We also note that the ASQ typically serves as a screening measure for which most children will perform near ceiling, yielding comparatively little variance and a corresponding lack of power for regression. Nevertheless, the inclusion of these measures is useful for several reasons. First, should reliable effects be observed despite the narrow variance, this provides strong evidence that latent structure of drawings can contain information useful for developing a cognitive/behavioral profile of the developing child. Second, the ASQ includes subscales assessing different aspects of behavior, allowing us to determine whether latent structure in drawings carries more information about some components than others. Third, the comparison of fits for models with new metrics to models including just the checklist score allows us to evaluate whether the new metrics carry information beyond that already captured by standard checklist measures. Fourth, the comparison of models with human- versus machine-derived embeddings allows us to evaluate whether the structure captured by these techniques express similar or different aspects of the child's cognitive, motor, and behavioral makeup.

Our analysis followed the same stepwise plan from the demographic study, with three minor changes. First, age was not log-transformed since participants were all children and age was approximately normally distributed; similar results were obtained with log-transformed age data. Second, all models included age, gender, and their interactions as covariates of no interest. Third, we did not complete step 3 of the

TABLE 3 Model fits predicting demographic characteristics of participants.

Dependent variable	Metric	*n*	Baseline	Quality ranking	Human embedding	Machine embedding	Both embeddings
Age	Adj. r^2	280	0.49*** < 0.64***		0.69***	0.69***	0.69
Gender	AUC	287	0.62*** < 0.67***		0.74*	0.74*	0.87***
Comparison model:			Null	Null	QR	QR	QR * HE

Age models include gender and its interactions with other variables as regressors of no interest, and vice versa for Gender models. The Baseline model includes checklist only, while the Quality-Ranking models replace this with the quality-rank (QR) score. Significance tests for these are against the null hypothesis, while the comparison signs (greater/less than) indicate whether one metric accounts for reliably more/less variance than another. Asterisks indicate significance levels at *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

TABLE 4 Model fits predicting cognitive/behavioral and motor characteristics of participants.

Dependent variable	*n*	Baseline	Quality ranking	Human embedding	Machine embedding
ASQ total	115	0.12** = 0.07*		0.15	0.15
ASQ communication	115	0.04* > 0.00		0.04	*adj* = 0.18*
					mult = 0.41*
ASQ gross motor	115	0.27*** > 0.19***		0.25	0.26
ASQ fine motor	115	0.33*** > 0.27***		*adj* = 0.43*	*adj* = 0.49**
				mult = 0.59*	*mult* = 0.63**
ASQ problem solving	109	0.05 = 0.07*		0.00	0.02
ASQ personal/social	109	0.33*** = 0.30***		0.40	*adj* = 0.48**
					mult = 0.63**
Pinch	198	0.56*** = 0.54***		0.57	*adj* = 0.63***
					mult = 0.69***
Grip	198	0.65*** = 0.66***		0.68	*adj* = 0.70**
					mult = 0.74**
Comparison model:		Null	Null	Model with higher r^2 Baseline or QR	

Values are adjusted r^2; multiple r^2 is also reported for models where embedding coordinates significantly improve model fit. All models include age and gender and their interactions as covariates of no interest. Baseline models additionally include the checklist score while Quality Ranking models replace this with quality-rank (QR) score. All models include all interactions. For baseline and QR, significance tests are against the null hypothesis while equal/greater-than signs indicate whether either metric accounts for significantly more variance than the other. Models with embedding coordinates were evaluated against the better-fitting model in the comparison of baseline and QR. Asterisks indicate statistical significance at *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

regression in which both human- and machine-derived embeddings and their interactions were added jointly to all other terms, since these models had a very large number of parameters relative to the number of data points. Otherwise the comparison of baseline and quality-rank models, and the further addition of embedding coordinates from human- and machine-derived data, proceeded as described for the demographic analysis.

The results are shown in Table 4. Several observations are of interest. First, for three ASQ subscales (Communication, Gross Motor, and Fine Motor), the standard checklist score accounted for significantly more variance than did the quality-rank score, in contrast to our analysis of demographic factors (*adj* r^2 values of 0.04, 0.27, and 0.33, respectively). This suggests that checklists may indeed capture some important information beyond overall image quality, especially as regards parental evaluations of the child's motor abilities. For the remaining subscales and for the ASQ total score the two measures captured comparable variation. Second, the addition of embedding coordinates to predictive models significantly improved model fit for 5 of the 8 measures, including some measures clearly relevant to drawing (Grip, Pinch, and ASQ Fine Motor) but also some measures with no transparent relationship to drawing (the Communication and Personal/Social subscales of the ASQ). It is worth noting the large amount of variance explained by all drawing measures for both Grip and Pinch strength. This finding underscores the interrelationship between the structure of the drawing and the child's physical abilities. Third, in all five cases this additional variance was captured by the machine-derived embeddings; in only one case (ASQ Fine Motor) was the additional variance also captured by the human-derived embeddings. Fourth and finally, where embedding coordinates helped prediction, the models captured a remarkable amount of variance—between 41 and 74%—in the dependent measure.

Discussion

A long tradition of research has endeavored to use children's drawings of the human figure to better understand their cognitive and behavioral development. A key challenge has been to develop methods for quantifying the structure that appears in such drawings. We introduced three new metrics derived from recent innovations in machine vision and crowd-sourcing of human judgments, and showed that these capture a wealth of information about the participant beyond that expressed by standard measures, including age, gender, motor abilities, personal/social behaviors, and communicative skills. Machine-and human-derived metrics captured somewhat different aspects of structure across drawings, and each were independently useful for predicting some participant characteristics; however, only the machine-derived metrics explained significant additional variation in the motor and ASQ subscales. Since the human embeddings reflect perceived similarity, this difference must arise because the neural network representations capture informative structure that is non-obvious to human perceivers (or at least does not prominently drive human similarity judgments) and is related to characteristics measured by the ASQ subscales and motor tasks. The contrast shows why the machine representations are useful over and above metrics based solely on structure that people readily perceive: they may express varieties of structure that do not occur to human raters.

A central goal of this work was simply to evaluate whether it is possible to mine information from children's drawings relevant to understanding their cognitive, motor, and behavioral makeup, in ways that go beyond standard checklist measures. The question is important because of the special role that drawing can potentially play in developmental assessment. Where most assessment tools require children to perform unfamiliar and potentially unmotivating tasks encountered only during the assessment itself, drawing is a common activity that most children enjoy and pursue in daily life. Like language, drawing requires coordination of many faculties typically studied independently, including perception, conceptual knowledge, planning, sequencing, and motor control—yet because it relies minimally on language competency, it provides a means of understanding interactions amongst these abilities independent of linguistic skill. Our positive results suggest that drawings carry information far beyond that recognized in prior work, paving the way for more comprehensive use of drawings in future evaluative work.

Beyond this proof of concept, the current results also suggest some specific relationships between qualities of drawings and characteristics of participants. Perhaps most obviously, the new metrics predicted aspects of motor control with remarkable accuracy, including pinch and grip strength as well as the ASQ Fine Motor subscale. Though it seems clear that motor abilities should influence drawing, the use of drawing as an assessment has primarily focused on other factors such as intelligence (Goodenough, 1926; Harris, 1963; Naglieri, 1988), personality (Machover, 1949; Hammer, 1958), and social/emotional disturbance (Koppitz, 1968; Naglieri et al., 1991). Indeed, assessments of supposed "higher order" aspects of cognition often ignore or downplay potential contributions of motor function to the measured behavior. The current results show that the same behavior known from prior work to predict intelligence can also predict significant variance in motor function, raising the possibility that these are not independent but linked. Future work with larger samples and richer measures is needed to assess, for instance, whether latent structure in drawings predicts different characteristics independently, or whether motor functioning mediates predictive relationships with intelligence and other measures (or vice versa).

The new metrics also reliably predicted variation on two ASQ subscales not transparently related to drawing, specifically those for Communication and Personal/Social development. It is possible that these relationships result from the reliance of the associated subscales on motor function. For example, children demonstrate reciprocal communication skills in the ASQ by correctly moving a book after a verbal request, or by successfully using a zipper based on demonstration and instruction. Likewise, tasks that are recorded as personal/social achievements in the ASQ include the use of a spoon and fork when eating, unscrewing a lid from a jar, and by copying behaviors children have witnessed like drinking from a glass or combing one's own hair. It may be that motor functioning revealed by characteristics of drawings likewise influence behavior on these measures—an important possibility since research on human figure drawing often views drawings as providing a window into the mind without regard for the physical demands of the task itself. Alternatively, the predictive relationship with Communication and Personal/Social subscales may reflect other characteristics of the child not mediated by motor function. For instance, since the task requires rendering of a human figure, it may reflect differences in the child's interest, ability or experience interacting with others—factors that may lead to better or just different renderings when the child is asked to draw another person. Again, further work with larger and more diverse samples and richer metrics can adjudicate these possibilities.

The pattern of female participants scoring higher on checklist-based measures of human figure drawing, which Goodenough (1926) noted in the original Draw-A-Man scale, was replicated in our sample on the 12-item TEDS adaptation of the Draw-A-Child checklist. However, our new metric of drawing quality better predicted participant gender compared to the checklist, while inclusion of both machine-and human-derived latent feature vectors further boosted predictive accuracy. In all models, better drawing scores—whether checklist or quality-rank—predicted a larger probability that the participant was female. This phenomenon, and the remarkable predictive accuracy of models that incorporate human- or machine-based latent features, may reflect the Draw-A-Child test's instruction for participants to draw a child of the same gender, coupled with cultural norms about how gender is depicted. Western conventions often depict girls as having long hair and triangular bodies to denote dresses. Presence of hair and clothing constitute two items on the TEDS variant of the drawing checklist, potentially leading to higher scores for girls on this basis—though it is worth noting that girls still score higher in studies that attempt to control for such confounds, for instance by asking that female figures be depicted in a swimsuit (Lange-Küttner et al., 2002). Likewise, it may be that drawings possessing these or other culturally gendered details are judged to be higher in quality than those that do not, influencing the quality-rank score; and that the tendency to share such features impacts the organization of drawings in both human- and machine-derived embeddings, explaining their contribution to gender prediction. Alternatively, it may be that the gender phenomenon represents something more intrinsic to a child's cognitive, social, or motor makeup, beyond just the differences in how boys and girls are conventionally depicted. Future work could address this question by applying comparable techniques to other kinds of drawings that are not intrinsically gendered, such as 3D shapes (Lange-Küttner, 2000; Lange-Küttner and Ebersbach, 2013).

Our novel measures did not reliably predict the overall ASQ-total score, nor scores on Gross Motor and Problem Solving subscales. As the ASQ is primarily a measure of developmental delays and our sample included only typically developing children, it is perhaps not surprising that our measures did not predict the ASQ total score, a general indicator of developmental delay. Though Kirkorian et al. (2020) did not conduct a formal assessment beyond the ASQ-3 for developmental delays, none of the parents reported that their children had any diagnosed conditions. The absence of reliable prediction for the Gross Motor subscale is more interesting, as it suggests that latent structure in drawings may not characterize overall motor ability generally, but may be more informative about aspects of fine manual motor control required for drawing. With regard to Problem Solving, the null result may arise for either of two reasons. First, this subscale more than any other in the ASQ measures aspects of development not directly related to drawing (e.g., verbal skills, including color identification, counting as well as pretend play). Second, this subscale showed the least variation in our sample, with 73% of respondents receiving the maximal possible score—thus the null result may reflect a large number of ceiling responders.

One limitation of the current research is that it is not entirely clear what features of the human figure drawings influence the new human- and machine-derived metrics. The regression results show that each approach can capture distinct information from one another and from the checklist score—for instance, the quality-rank score explains more variation than the checklist in age (*adj* r^2 = 0.64 vs. *adj* r^2 = 0.49) and gender (*adj* r^2 = 0.67 vs. *adj* r^2 = 0.62), but less in the ASQ motor subscales (see Table 2); and, while human-derived embeddings did not predict variation beyond machine-derived embeddings for any measure, nevertheless the two spaces identified measurably different structure amongst the various drawings as evidenced by the regression fits in Table 1: regression models predicting coordinates of a drawing in one space from those in the other accounted for less than half the variance on each dimension, both predicting machine-derived embeddings from human-derived embeddings and vice versa. Understanding precisely what kinds of structure each measure captures, and connecting these to features and characteristics expressed by checklist measures, will facilitate integration of this new work with the long history and rich literature on children's drawings. Nevertheless, the current results suggest that our novel metrics have some diagnostic specificity relevant for characterizing different aspects of cognition and behavior even in healthy, typically-developing populations.

Final thoughts and future directions

Given the commonality and enjoyment of children sitting down to draw, it is not surprising that there is a long history of curiosity about what a drawing can tell us about a child's inner life. Our results suggest that human figure drawings are not a direct window into the child's mind, but are best viewed as artifacts that reflect the joint operation of many different factors, including perceptual and cognitive skills, motor factors, and possibly social and communicative abilities. In the current study we found that both machine-learning and human-similarity judgements could be used to capture underlying structure related to each of these participant characteristics, even among typically-developing children and using screening metrics that limit individual variation. Prior research incorporating devices such as pressure sensitive tablets has demonstrated that both age and the task demands can impact both the pressure applied when drawing but also the number of pauses and line breaks within a shape or figure (Lange-Küttner, 1998, 2000; Tabatabaey-Mashadi et al., 2015). Our results suggest that computational methodologies, especially machine vision, may likewise provide a useful path to identify how related features like stroke density and smoothness of the contour of a drawing may serve as indicators of participant attributes that lie outside of checklist-based measures. Of note, the sample of images used in this study were not collected using technology to monitor the pressure applied by participants when drawing, and so our novel approaches may provide an alternative solution to consider the physical nature of drawing within image collections that were not collected using such media. A key goal for future research will be to assess whether similar metrics, collected in a larger and more diverse sample, and using richer cognitive/behavioral measures, can reshape our understanding of typical and typical patterns of development.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving human participants were reviewed and approved by Institutional Review Board for Education and Social/Behavioral Science at the University of Wisconsin-Madison. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

Author contributions

DS was involved in related work. HK, BT, and KR collected the initial data and contributed to the manuscript revision, TR contributed to both statistical analysis and to the framing of the original manuscript. All authors approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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What do mathematics lessons look like? Analyses of primary students' drawings

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The use of student drawings to assess their experiences and beliefs about teaching and learning of mathematics has become almost a regular research method – especially when working with young students who may not express themselves well, for example, in self-report questionnaires. These methods, nevertheless, need to be improved regarding their objectivity and validity. By building on the existing research, in this study, we focus on objectivity and validity issues in drawing-based methods. We use a drawing-based instrument: *Draw A Mathematics Classroom* (DAMC) and present 104 fourth-grade students to draw a picture of their regular mathematics lessons. We especially aim to develop and validate a data coding manual with low-inferent categories; that is, well-operationalizable categories that can be used with high interrater-reliability like the presence of teachers, the arrangement of student desks, and teacher-student interactions. The results reveal that almost half of the participating students perceive their lessons as teacher-centered. The results also confirm the reliability and validity of the methodological approach. For example, in pictures where the teacher is depicted larger than the students, the teacher is also depicted in the center, and students are pictured working alone. Classroom observations support students' perceptions, and all these show that the manual used in this study is useful to getting insights into young students' perceptions of their mathematics classroom.

KEYWORDS

drawings, draw a mathematics classroom, mathematics lessons, primary students, beliefs

1. Introduction

There are many factors that influence the learning gains of students in mathematics classrooms in addition to students' abilities. One of these factors—that is the focus of the present study—is the students' experiences and beliefs regarding the teaching and learning of mathematics (e.g., Schoenfeld, 1989; Mapolelo, 2009; Sullivan, 2011) as students' learning largely depends on their interactions with the teacher over learning objectives (Ball and Forzani, 2011). For example, whether doing mathematics is a singular versus group activity, or whether such learning environments are dominated by teacher instructions versus students' explorations—such activities and interactions shape learners' experiences and their beliefs about mathematics.

Experiences and beliefs regarding the teaching and learning of mathematics are shaped early in students' careers. Therefore, it is important that research in this field addresses primary grades. Although there are established methods to assess beliefs, "there is considerable scope for the development of new methods and the wider use of established methods for qualitative studies" (Fraser, 2014, p. 116). We endeavor to contribute to the methodological discussions by exploring and validating the research method of interpreting students' drawings, as common methods and instruments used to investigate experiences and beliefs—like interviews and self-report questionnaires—are less suitable for children who often struggle with understanding interview questions or questionnaire items and are not yet able to reflect upon their experiences and beliefs (cf. Rolka and Halverscheid, 2011; Döring and Bortz, 2016). Additionally, interviews are unlikely to be useful to conduct data from large samples (Döring and Bortz, 2016) and self-report questionnaires suffer from validity problems (Safrudiannur and Rott, 2020).

Our research goal is to better understand the method of analyzing and interpreting primary students' drawings in the context of their experiences and beliefs regarding teaching and learning of mathematics. Specifically, we use self-drawn pictures of primary students (grade 4). Compared to more commonly used research methods, the coding and interpretation of drawings still needs methodological development. Therefore, in addition to the results of our study regarding the students' beliefs, we especially focus on validating the methodological approach.

2. Theoretical background

2.1. Students' experiences and beliefs

To date, certain student affect outcomes including students' attitudes, feelings, or beliefs relating to mathematics, and their views about mathematicians have been widely investigated (e.g., Picker and Berry, 2000; Rock and Show, 2000; Dahlgren and Sumpter, 2010; Aguilar et al., 2016; Hatisaru, 2020a). Yet, the research in this area lacks information on the perceptions of students relating to their mathematics teaching and learning experiences. Large-scale assessments such as Trends in International Mathematics and Science Study (TIMSS) and Program for International Student Assessment (PISA) have identified important aspects of perceived school and classroom experiences of both students and teachers. Some researchers have used the TIMSS (e.g., O'Dwyer et al., 2015) or PISA (e.g., Echazarra et al., 2016) data to examine perceived teaching and learning practices in mathematics classrooms, and how particular teaching practices are related to student performance. The findings from these studies, however, are limited to responses obtained from questionnaire items as they did not include observational and/or interview data (Vieluf et al., 2012). Research shows that the statements used in questionnaires are not necessarily understood by young students in the way researchers mean (Bragg, 2007). More research and especially alternative research methods are needed not only exploring perceived mathematical experiences in the classroom but also to fill some of gaps in the existing literature.

Doing research on students' beliefs and experiences regarding teaching and learning of mathematics is important, as such beliefs may affect the learning of mathematics. For example, students who mostly know routine exercises from their mathematics classes will most likely stop working on non-routine problems after just a few minutes and wait for the teacher to present them the "correct procedure" (cf. Schoenfeld, 1992, p. 358f.). More generally, teacher-centered approaches or lecture-style teaching, as well as emphasizing the repetition of problems and correct use of procedures, can negatively impact students' attitudes (Hasni and Potvin, 2015), making it difficult for students to remain engaged and be successful in STEM (science, technology, engineering, mathematics) subjects (Cooper and Carter, 2016) including mathematics.

As mentioned earlier, there is an abundance of research on students' beliefs; however, most common methodologies rely on (closed) questionnaires or interviews, which can lack validity and are less suitable for primary students (see Section 1). Therefore, we utilize *drawings* as the research tool and explore the validity and reliability of using them to address beliefs. Additionally, as a research tool, student drawings have been less used in the field of mathematics education in Germany, and we were interested in providing additional evidence with respect to students' perceptions of the teaching and learning of mathematics in their classroom. The results contain valuable insights into the classroom mathematical practices in Germany and beyond.

2.2. Learner- vs. teacher-centered learning environments

Learning environments can be characterized regarding different dimensions, one of which being learner- vs. teacher-centeredness, ranging from very open project- and problem-based environments to environments in which the teachers almost always step in and do the work for the students (Hiebert and Stigler, 2004; Dole et al., 2016). The discussion about such learning environments is similar to the debate between psychologists Bruner and Ausubel who favored discovery and receptive learning, respectively (e.g., Legge and Harari, 2000).

Per se, none of the two teaching styles is "better" or "more effective" (by any definition of these terms) then the other. However, research has shown that some teaching practices often associated with learner-centered environments, are more favorable than others in leading to desirable learning outcomes, for example having mathematical communications, varying teaching approaches, and involving non-routine problems (Anthony and Walshaw, 2009; Bobis et al., 2011; National Council of Teachers of Mathematics [NCTM], 2014). On the one hand, compared to learner-centered environments, teacher-centered environments often rely on direct knowledge transfer, resulting in students to prefer surface instead of deep approaches to learning (Trigwell et al., 1999). On the other hand, student-centered learning can improve students' achievement (Parker and Gerber, 2000; Hatisaru and Kucukturan, 2011; Baeten et al., 2013), motivation (Baeten et al., 2013), and attitudes (Parker and Gerber, 2000; Erdemir, 2009). It is more often related to a constructivist approach of teaching in which students are enabled to construct their own information and the teacher's role is that of a facilitator rather than an instructor (Aktas, 2010). Learner centeredness can help students to develop their inquiry and collaboration (Hatisaru, 2014) and flexible understandings and lifelong learning skills (Hmelo-Silver, 2004).

It is noteworthy that (1) In this article, we do not intend to compare the effectiveness of different teaching approaches and learning environments and will not measure learning outcomes. (2) Some, or even most of the mentioned qualities associated with learner centeredness do not directly result from the role of the teacher, but from the use of tasks that foster cognitive activation, from student collaboration, etc. However, empirical research has shown that such qualities often are related to the role of the teacher. Thus, it is a simplification to speak of teacher vs. learner centeredness, but a reasonable one. Additionally, it is much easier to observe the role of the teacher than to assess the quality of tasks, group works, etc.—especially for young children who cannot reflect upon such qualities. Therefore, we aim to explore whether we can access students' experiences and beliefs regarding such environments via their drawings by focusing on the role of the teacher.

2.3. Drawing as a research tool

Young children start to draw from infancy and many of them continue to draw because it is enjoyable, it produces beautiful representations, and it allows them to express feelings, emotions, and ideas that words alone cannot describe.

Drawing is independent of language-based methods and is non-textual, hence as a research method, it can provide researchers with an alternative and versatile way of knowing (Pehkonen et al., 2016; Hatisaru, 2022). Researchers use drawing and/or multimodal research methods (e.g., drawing; text; or verbal responses) to explore participants' understandings of different phenomena. Thus, drawing has become an important tool for researchers interested in image-based research methods. Literat (2013) argues that its lack of dependence upon linguistic proficiency makes drawing particularly suited for working with children, and others argue that it helps bridge the gap between children and adults (Søndergaard and Reventlow, 2019).

In this research, we are interested in exploring how school children experience mathematics classrooms and especially if analyzing their drawings is a valid method to assess their experiences and beliefs. We have drawn upon previous work in mathematics and science education to help us to address the perceived experiences of them on how mathematics is taught in their classrooms.

Drawings have been found to be valid indicators of classroom experiences (Gulek, 1999) and have the potential to provide rich and valid information (e.g., Laine et al., 2020). They allow school or classroom environments to be documented from the perspective of students, "the most assiduous observers of school and classroom life" (Haney et al., 2004, p. 243). Drawings "can provide a valuable catalyst to document, change, and improve what goes on in schools" (Haney et al., 2004, p. 243). For some time, therefore, drawings have been used to evaluate classroom teaching and learning in school subjects including mathematics (e.g., Pehkonen et al., 2016).

For decades now, the "Draw A Mathematician Test" (DAMT) (Picker and Berry, 2000)—which had been adopted from Chambers's (1983) "Draw A Scientist Test"—as well as variations of the test have been widely used to elicit data from students about their perceptions of mathematics (e.g., Rock and Show, 2000), mathematics and mathematics education with a focus on motivation (e.g., Dahlgren and Sumpter, 2010), mathematicians (e.g., Picker and Berry, 2000; Aguilar et al., 2016; Hatisaru, 2020a), and mathematics teaching (e.g., Pehkonen et al., 2011; Hatisaru, 2020a).

In the following section, we present perceived experiences for teaching and learning of mathematics found in student drawings.

2.4. Previous research regarding drawings

In one of the ground-breaking studies in this field, Picker and Berry (2000) investigated the perceptions of mathematicians held by lower secondary school students (12 to 13 years old) in the United States, the United Kingdom, Finland, Sweden, and Romania by using the DAMT, and compared students' images in these countries. With small cultural differences, certain stereotypical images of mathematicians were found to be common among students. Mathematicians quite often were pictured as people having special powers, and sometimes as foolish people. As also found in Rock and Show (2000), many students seemed to believe that mathematicians do the same work as students do in their own mathematics classes such as arithmetical computations, area and perimeter, and measurement. Mathematicians and their work were invisible for those students. According to Picker and Berry (2000), school-related factors such as often experiencing direct teaching methods through which students do not see the applications of mathematics enough, is one of the sources of students' images of mathematicians.

In another study in the United States, most students' drawings of mathematicians were shown in the classroom. Young respondents (kindergarten—grade 8) named tools they were familiar with from their own classrooms (e.g., paper, pencils, whiteboards, etc.) as tools of mathematicians, second and third grade respondents mentioned calculators, rulers, geometric shapes, while fourth grade and middle school students expanded their responses to include computers, calculators, and protractors (Rock and Show, 2000).

Pehkonen et al. (2011) used drawings to reveal young students' (8–9 years old) conceptions on mathematics and its teaching in Finland. Among 153 student drawings, every second drawing included indications to attitudes towards mathematics such as mathematics is nice, easy, dull, or difficult. As opposed to findings in Picker and Berry (2000), no negative views about the teacher were found in student drawings. The depicted mathematics lessons contained many activities. Two thirds of the participating students pictured a classroom environment where students in the picture were in action such as thinking, speaking, or discussing. Laine et al. (2013) further analyzed these drawings to study the kind of emotional atmosphere in a mathematics lesson that could be seen in students' depictions. Mostly a positive emotional atmosphere was found in the pictures. Pehkonen et al. (2016) were curious about what could be found in the same drawings relating to mathematics teaching, and they examined the drawings to find out the types of work experienced in mathematics lessons through the eyes of students. The most frequent work experienced in students' pictures was found to be 'Independent work' (students work individually for solving problems at textbooks or given by the teacher) and 'Work with the teacher in charge' (the teacher teaches the whole class, or all students work on the same task). 'Group work' (students work with classmates on a task) was less common. In this set of research studies, Pehkonen and his colleagues found drawings as an efficient way of collecting data to explore students' experiences in mathematics lessons and offered the drawing tasks to practitioners as a possible way to obtain and evaluate information about students' perceptions pertaining to mathematical experiences.

In Spain, Remesal (2009) used drawings to explore how primary school students (7 to 8 years old) perceived assessment practices in the classroom, and how students' conceptions might be shaped by their actual classroom experiences. In a case study design, two practicing teachers and their twelve students (six from each teacher's class) participated in the research. Data were collected through semi-structured interviews with teachers and their students, classroom observations, artefacts used in the assessment of mathematics learning, and students' drawings of mathematics classrooms. Remesal (2009) reported that:

> The main common result of these cases is the identification of young primary pupils' capability of perceiving assessment practices as ruled by distinctive norms and conventions in the classroom among other classroom routines: 'someone is to ask and someone is to respond,' 'someone is to show the work and someone is to mark the work,' 'grades are given and the parents are informed.' This awareness develops even though the teachers themselves might not believe 8-year-olds are capable of such insights (p. 47).

In her study investigating the image of mathematics held by a large group of middle school students in Turkey through examining students' drawings, Hatisaru (2020a) found that students associated mathematics narrowly with only numbers and arithmetic, and the work of mathematicians with solving textbook questions or performing calculations. Some of the students depicted great mathematicians in the past (e.g., John Nash, Ali Qushji, or Pythagoras), and they thought that the main activity of even those mathematicians is studying to solve algebra, numbers, or geometry practice questions (Hatisaru, 2020a). A further investigation into the same student drawings (Hatisaru, 2019) revealed that in the drawings the most common mode of instruction was highly teacher-directed. No evidence of group work or student-oriented mode of instruction existed. A whiteboard and/or books were the most observed teaching resources in classroom portrayals. Technological tools appeared the least often in these drawings. An important part of the teacher's activity in the classroom were lecturing, explaining, solving exercises, and disciplining. When present, students' desks were in orderly rows. The interactions among students and between the teacher and the students were limited.

Associating mathematics predominantly with calculations or operations was also evident in another study implemented in Turkey. In that study, Ucar et al. (2010) implemented interviews and used drawings to investigate the beliefs about mathematics and mathematicians of nineteen elementary school students (grades 6 to 8) attending a supplementary school, where students are instructed out of their school times. Both student interview responses and pictures revealed that students viewed mathematics as numbers, formulas or computations, and believed that mathematicians could be needed, for instance in the industry, for their computational skills. To students, being good at mathematics meant finding a correct answer to questions quickly. For several students, in mathematics learning, finding a correct answer to a question was sufficient, understanding the question was not that important.

In her research exploring drawings of learning in the classroom depicted by a group of 6- to 7 year-old students in a primary school in the United Kingdom, Lodge (2007) stated that when children draw, they make decisions and choices about what to include or not in the drawing. The main sources of their decisions might be affected by cumulative cultural text, the current or past experiences, and individual preferences. The author found that all these three sources were seen in the students' drawings analyzed. However, as the students' drawings showed some disparity, she made a warn against the assumption that we 'know' how a young child views their learning, or that children in the same class share 'a common view' of learning.

Aktas (2010) analyzed drawings and semi-structured interviews of 41 fourth-grade students from a Turkish school. In that study, the vast majority of students depicted their teacher as an "instructor-informant" inferring that most students see themselves as passive receivers. The author concludes that the intended change of the Turkish curriculum towards more student-centered and constructivist learning environments has not been successful at the time of the study.

Kanyal and Cooper (2010) compared drawings, as well as interviews, and photographs of 12 children from England and 15 children from India being asked about their "actual" and their "ideal" school experience. Students liked being with their friends in school, but wanted to spend more time outside in both countries.

In a 2 year study, Streelasky (2017) observed 35 Canadian primary students' perceptions of their learning experiences. Several methods were used, including interviews, group discussions, photographs, and drawings. A major finding was the importance of the outdoors, that is outside activities and a high value placed on peers as well as other living things such as animals.

Together, the reviewed literature has shown that drawings of students contain rich information on their thoughts about teaching and learning of mathematics, and sometimes about what is happening in the classroom. However, identifying students' beliefs in their drawings "is related to a large amount of subjectivity in interpretation and will certainly not allow for an unambiguous classification" (Rolka and Halverscheid, 2011, p. 522), which is why we are going to thoroughly analyze this method.

2.5. Criticizing the analyses of students' drawings

In many studies that analyze students' drawings, this method is either taken for granted—that is not reflected upon and questioned regarding its validity—, and/or used in conjunction with other data—most often interviews. Both could imply that the method has some unexplored flaws or is not seen as a reliable and valid method that can be used on its own. In this study, therefore, we want to explore whether the analysis of drawings can be used on its own in a valid way. But first, we shortly discuss possible flaws of interpreting students' drawings.

Even though "[p]upils' drawings seem to be a powerful method to gather information from small children" (Pehkonen et al., 2016, p. 167), gathering such information relies on interpretations of the drawings. For example, Pehkonen et al. (2016) used the "[facial expressions of] pupils' and teacher's faces in drawings […] to conclude how the pupil who did the drawing has experienced the emotional atmosphere in class" (p. 172). They used two reviewers who reexamined and discussed their classifications when they did not agree (Pehkonen et al., 2016, p. 173). But still, those classifications rely—amongst others—on the children's abilities to depict facial expressions in such a way that they can be interpreted validly and on the reviewers' interpretations. Especially the latter makes such a coding high-inferent, that is depending on interpretations, but not on operationalizations, or on countable or measurable objects.

Another example is the study of Rolka and Halverscheid (2011), in which fifth graders' drawings were coded for the mathematical world views by Ernest (1989): the instrumentalist, the problem-solving, and the Platonist view. Even though the authors report interrater-reliability scores (Cohen's kappa) between 0.21 and 0.58, such codes still imply a lot of interpretation, especially keeping in mind that fifth graders might not fully comprehend the philosophical background of the world views.

Finally, we discuss the study by Gulek (1999) in which "a rating from 1 to 4 was assigned to each drawing for each of the two classroom constructs/traits" (p. 44). These four ratings are 1: Highly, and 2: Moderately teacher-directed mode of instruction, as well as 3: Moderately, and 4: Highly student-centered mode of instruction. For each of these ratings, Gulek developed indicators to help him decide which rating to apply to a drawing. For example, in a highly teacher-directed classroom, "only the teacher [is] depicted, students are not present in the picture" or "if depicted, student desks are in rows" (p. 124). Such indicators make it easier to code with sufficient interrater agreement, yet, still, there is interpretation in some codes, for example whether "teacher talk, if any, is lecturing or disciplining" (Gulek, 1999). Also, decisions like whether a classroom is highly or moderately teacher-directed depend on the fact whether students are depicted in the drawing or not. However, it is easily imaginable to have a drawing of a highly teacher-centered classroom in which students are depicted.

In the present study, we address the mentioned problem with high-inferent codes that heavily rely on interpretations by suggesting a coding manual with highly operationalized coding instructions, resulting in a low-inferent coding.

3. Methodology

3.1. Participants

We collected data in four 4th-grade classes (coded as A–D to assign students' drawings to the classes; that is, Class A, Class B, etc.) from two primary schools in central Germany. In total, 104 students (9–10 years old) participated in the study. The research was approved by the ethics committee of the relevant university, and prior to collecting data, the teachers, school principals, and parents in participating schools gave written consent for the study. Data collection took place in February and March of 2020. In Germany, first contact restrictions because of the COVID-19 pandemic had been introduced in mid-March—at this point, the restrictions were mostly self-imposed with no "official lockdown" being implemented, yet. The second author had already collected data in three of the four classes (one in February, two in March) before restrictions were initiated. In the fourth class, Class A, the drawings were collected by the teacher shortly after restrictions had been implemented, because the researcher was not allowed to enter the school anymore. At that time, restrictions applied only to people outside of the school; there were no restrictions regarding student interactions, group work, etc., yet.

The curriculum for 4th-grade students in the respective federal state of Germany defines (i) process- and (ii) content-related competencies. The process-related competencies are (i.1) problem solving/being creative, (i.2) modeling, (i.3) reasoning, and (i.4) representing/communicating; the contents, which should be taught, are organized into (ii.1) numbers and operations, (ii.2) space and form, (ii.3) size and measure, and (ii.4) data, frequencies, and probabilities (MSW, 2008).

3.2. Methods

To assess our students' experiences and beliefs, we used a variation of the DAMT (Picker and Berry, 2000) (please see Appendix A) with the following instruction: *Draw your mathematics lessons with your teacher. The picture should show what you know about his or her work.* (German original: *Male deinen Mathematikunterricht mit deiner Lehrerin/deinem Lehrer. Das Bild soll zeigen, was du über sie und ihre Arbeit weißt.*)

We chose this instruction to draw the students' attention to a usual classroom environment. This way, we intended to get insight into the environments that shape their experiences regarding mathematics lessons.

Students' pictures were scanned and converted into a PDF file. The first two authors then independently coded all pictures according to the manual that is described below. Interrater agreement was good at Cohen's Kappa = 0.88, cases of disagreement in coding individual drawings have been discussed and then recoded consensually.

In addition to collecting the pictures, the second author (a) spoke with the children about their drawings and (b) observed teaching practices in the participating classes.

(a) The second author had 10% of the children explain their pictures to check whether our interpretations of depicted persons and objects were correct, which they were in all cases. She also asked the children how they proceeded in drawing their pictures and what was important to them. The children's answers regarding their classroom experiences were all in line with the observations, confirming, for example, whether teaching was mostly organized in teacher–student conversations or in small-group work, or whether teachers focused on arithmetic compared other topics like geometry or data and chances.

(b) For 12 weeks, the second author visited three of the four classes (all but Class A) and took notes on teachers' and students' classroom routines. On the basis of these observations and notes, the classroom environments were interpreted with regard to the distinction between a teacher- or student-centered environment. Of note, in one of the classes, guests were not allowed because of restrictions in the course of the COVID-19 pandemic.

3.3. Coding the pictures

Aiming to improve the existing coding schemes for students' drawings from the literature (see Section 2.5), we developed a coding scheme focusing on aspects that are operationalizable, for example whether students are depicted or what mathematical content is shown. The process of developing the categories of the manual can be described as an application of Qualitative Content Analysis (Mayring, 2000), using a deductive-inductive approach. Deductively, we took inspiration from existing coding schemes (especially Gulek, 1999 and Hatisaru, 2020b); inductively, we recorded every detail of the drawings that seemed to be interesting but were not covered by categories, yet.

The full coding manual is given in Appendix B, examples and explanations are given in the section "Data Analysis and Results" (Section 4).

4. Data analysis and results

To give readers an impression of our data, we start with describing and showing typical students' drawings (Section 4.1). We then evaluate the coded pictures more thoroughly (Section 4.2), and finally

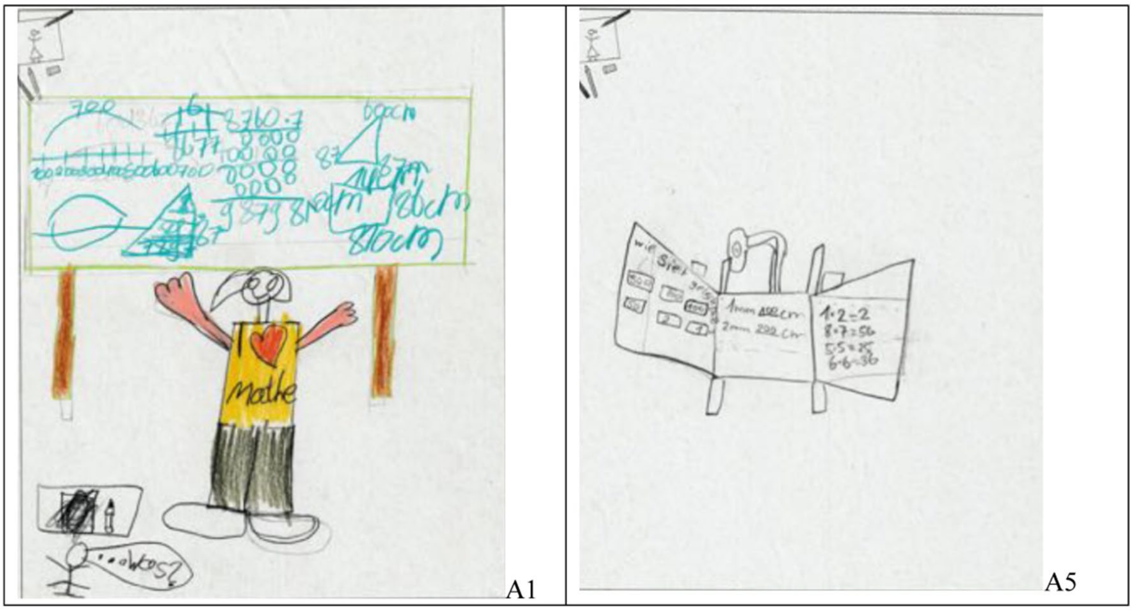

FIGURE 1
Examples of students' drawings with a board at the center and with (left, student A1) or without persons (right, student A5).

focus on analyzing the data with regard to validity and reliability (Section 4.3). Please note, we aim at using well operationalized codes, not holistic interpretations of the pictures. Therefore, we show several pictures, focusing on observable details.

4.1. First impressions

Looking at the students' pictures, we often see the board (i.e., blackboard, whiteboard, or smartboard) in the center, sometimes with and sometimes without persons (see Figure 1).

There are pictures with students seated in rows as well as seated in clusters (see Figure 2).

Most pictures show arithmetic tasks (see Figures 1, 2), but others depict specific actions like "counting peas" (Figure 3, left). A few papers do not show a single classroom situation but several in a "comic strip"-like way (Figure 3, right).

4.2. Coding the pictures

In coding the pictures, we tried to get a better overview of what is depicted in the students' drawings, make them comparable, their attributes countable, and get insight into the students' experiences and beliefs. We present our findings under the themes "teachers" (Section 4.2.1), "students" (Section 4.2.2), and "classes" (Section 4.2.3).

4.2.1. Teachers

The first thing we did was looking at the teachers as they are most often positioned prominently in the drawings. More specifically, we (1) looked at the teacher's size compared to their students' sizes and (2) at the teacher's position within the pictures. Regarding analysis (1), taking into account that adults are taller than children, teachers can be depicted as bigger (e.g., Figure 1, left), about the same size (e.g., Figure 2, left), or smaller than the students. When no teachers or students are shown, "no comparison" is possible. Regarding analysis (2), we divided the pictures equally into 9 areas (see Figure 4). When a teacher was mostly shown in area 5 (could extend into other areas), we coded "center"; we coded "left" or "right" for the areas 1, 4, and/or 7 or 3, 6, and/or 9, respectively (even though we allow for the upper and lower corners, most "left" or "right" teachers are shown in areas 4 or 6, respectively); finally, we coded "upper or lower edge" for the areas 2 or 8. Results of this coding are shown in Table 1.

The relative size of the teachers (considering that teachers as adults are larger than children) is most often bigger than the students' size, twice as often as equal size; and the teachers are almost never depicted smaller than the students. The teacher is often positioned in the middle row (left, center, or right) of the picture (73.1%, or 88.4% if you do not count pictures without teachers and comics). Both—position and size—indicate that the teachers have a very important, maybe even dominant role in the depicted classrooms as also inferred by Picker and Berry (2000).

4.2.2. Students

Next, we examined the depicted students, more specifically (3) their position in the classroom and (4) the arrangement of their desks. Regarding analysis (3), we coded whether they were shown at their places or somewhere else in the classroom (e.g., at the board or in the center of the depicted room). Regarding analysis (4), the desks, we identified whether none or only a single desk is drawn or if there are multiple desks, whether they are depicted in rows or clustered for group work. Findings were mostly in consistent with the literature (e.g., Dahlgren and Sumpter, 2010; Pehkonen et al., 2016; Hatisaru, 2019, 2020b).

In Table 2, we see that more than 40% of the pictures do not include students, which is at least to some degree surprising, as the

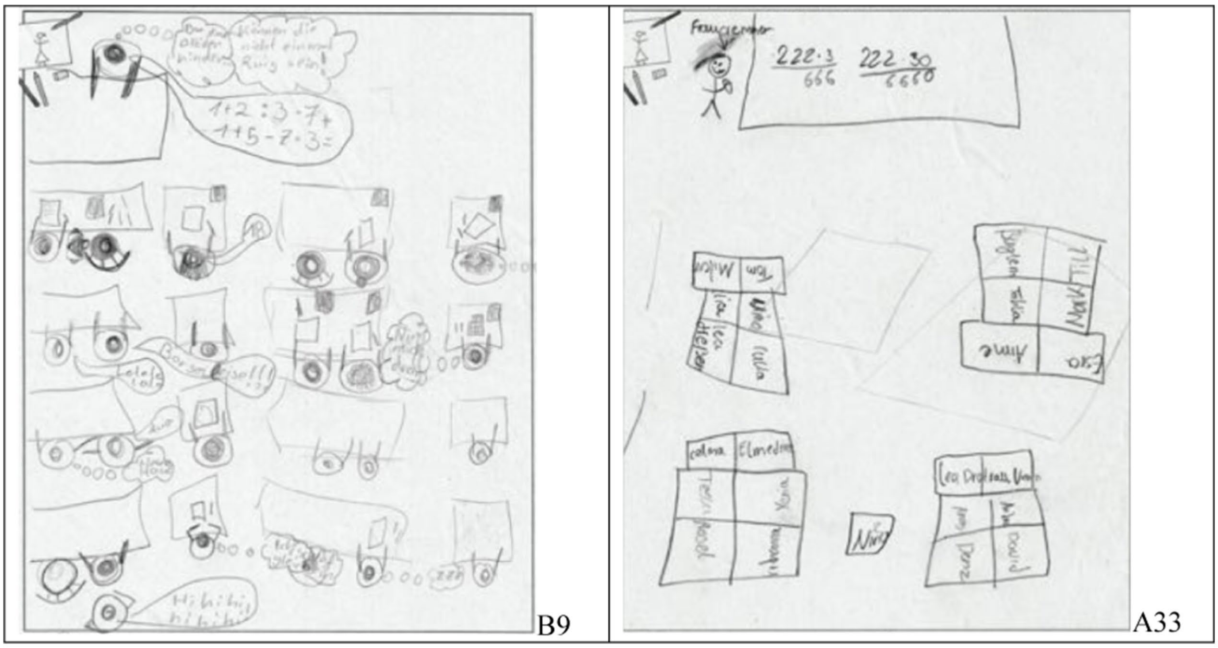

FIGURE 2
Examples of students' drawings with students drawn and seated in rows (left, student B9) or written and seated in clusters (right, student A33).

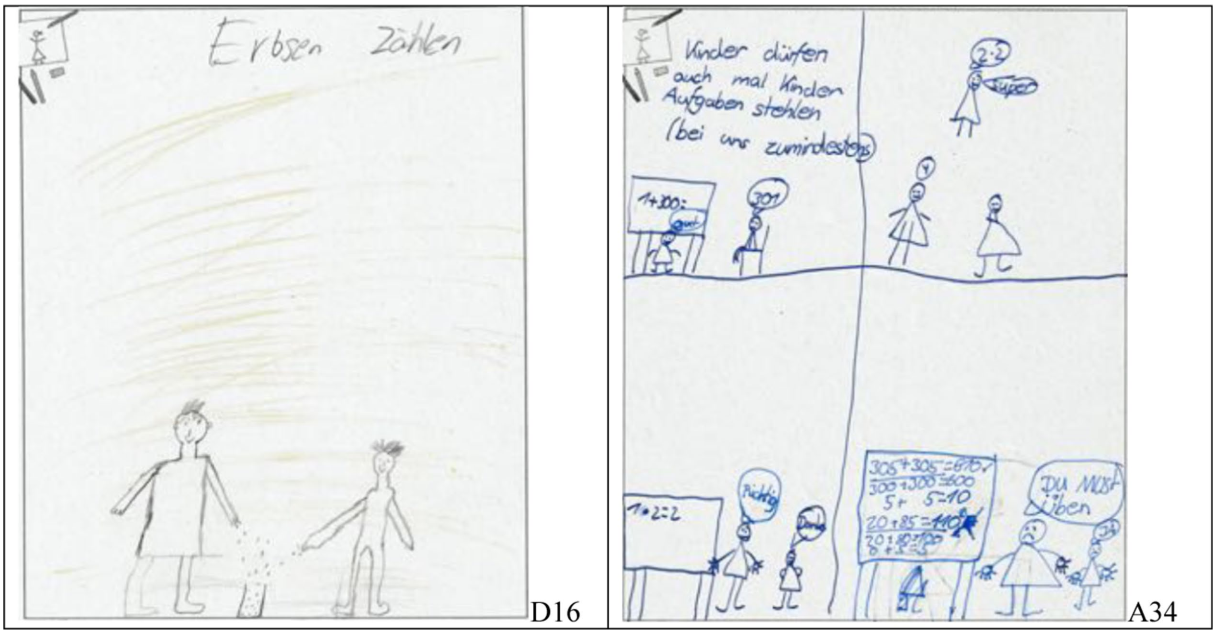

FIGURE 3
Examples of students' drawings; students shown in an activity named "Erbsen zählen" which translates to "counting peas" (left, student D16) and a "comic strip" (right, student A34).

pictures were drawn from students' perspectives.[1] Most of the pictures with students show them at their places, ready to write and/or work. Only less than 9% of the pictures show arrangements of the desks that are suited for group work; most pictures show students sitting alone at their desks (like observed in, e.g., Pehkonen et al., 2016 and Hatisaru, 2019).

In addition to the position of the students and their desks, we decided to code some additional aspects in the drawings to give a complete picture of students' perceived experiences and beliefs. For

1 The students were asked to "Draw your mathematics lessons with your teacher," drawing students was not required; however, it is hard to imagine a teacher working without students.

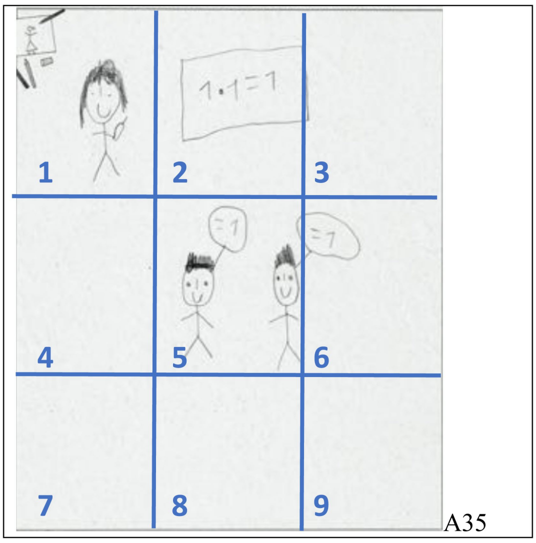

FIGURE 4
Determining the position of drawn persons and objects (like the teacher) by dividing the drawings equally into 9 areas (student A35).

TABLE 1 Teachers' sizes and positions in the students' drawings.

(1) Teacher size (compared to students)			(2) Teacher's position		
Smaller	2	1.9%	Centre	19	18.3%
Same	23	22.1%	Left	25	24.0%
Bigger	45	43.3%	Right	32	30.8%
No comparison	34	32.7%	Upper or lower edge	10	9.6%
			Comics	7	6.7%
			No teacher	11	10.6%
Sum	104	100%	Sum	104	100%

TABLE 2 Students' position in the classroom and the arrangement of their desks.

(3) Students' position			(4) Students' desks		
At their place	38	36.5%	Single	22	21.2%
Not at their place	17	16.4%	Rows	24	23.1%
Both (multiple s.)	4	3.9%	Clustered	9	8.7%
No students depicted	45	43.3%	None	49	47.1%
Sum	104	100%	Sum	104	100%

TABLE 3 Students' activities and teacher–student conversation.

(5) Students' activities			(6) Teacher–student conversation		
Working alone	35	33.7%	Only teacher	14	13.5%
Working in group	2	1.9%	Only students	5	4.8%
Other	22	21.2%	Teacher and students	16	15.4%
No students	45	43.4%	No conversation	66	63.5%
			Not applicable	3	2.9%
Sum	104	100%	Sum	104	100%

TABLE 4 Mathematical activity and representation modes of relevant activities.

(7) Mathematical tasks (on the board)			(8) Representation mode		
Simple arithmetic	82	78.8%	Enactive (E)	4	3.8%
S.A. and lengths	2	1.9%	Iconic (I)	1	1.0%
S.A. and geometry	3	2.9%	Symbolic (S)	85	81.7%
Geometry	3	2.9%	EIS	1	1.0%
None	10	9.6%	IS	3	2.9%
Undecidable	4	3.8%	None	10	9.6%
Sum	104	100%	Sum	104	100%

example, we coded: (5) the students' activities—working alone, working in groups, or other (e.g., talking to the teacher, walking through the classroom)—and (6) the conversation between the teacher and students, giving particular attention to who is shown speaking ("not applicable" is coded when there are neither teachers, nor students depicted).

The data in Table 3 indicates that students are often shown at their place or desk and working alone (about 60% in both cases if pictures without students are not counted). This indicates that students do not work often in groups but mostly alone which is supported by the depicted activities as no group-based, open tasks are shown (see below). This impression is supported by the arrangements of the students' desks (see Table 2). Also, there are only very few pictures in which only students speak, and even fewer in which students speak with other students.

We also (7) analyzed the mathematical tasks that are shown on the black-, white-, or smartboards and (8) the representation modes (according to Bruner, 1966) which are shown in the pictures (distinguishing between the enactive, iconic, and symbolic modes as well as combinations of those modes). The results are presented in Table 4.

Being asked to draw a usual mathematics lesson, the majority of the students depicted simple arithmetic in a symbolic form (i.e., formulas, equations) as the content of the lesson as also observed in Hatisaru (2020b).

Finally, we recorded the (technological) tools drawn by the students. Only 4 out of the 104 pictures show a computer in the classroom, even though three of the four classrooms had a computer in them, whilst only one of those computers had been used during the time in which the classes were observed by the second author. In one picture, an overhead projector was seen. Four pictures show compass, ruler, and set square in a size that fits the board; and another two pictures show a pointing stick for the teacher, even though no classroom had such a stick. This shows, sometimes students show preference to what to include or not include in their pictures (Lodge, 2007). Regarding the board, six pictures do not show any board, nine show a smartboard (with a visible projector attached to it) and the other 89 pictures show a black- or whiteboard (without visible technology attached).

All codes presented are deliberately low-inferent, meaning that they are well-operationalized and easy to code with high interrater agreement. We are now going to interpret those codes with regard to their validity, that is whether we can get meaningful information regarding the students' classroom experiences.

4.2.3. Classes

In the previous sections, the results give insights into the whole group of 104 students and their experiences. In this section, we sort the pictures by the students' classes. Taking into account previous research (see Section 2.3) and the considerations from the previous sections, we make the following assumptions regarding teacher- versus student-centered classroom experiences (see Table 5).

As the four classes were of different sizes, in Tables 6, 7, only relative numbers are given. In each row, the maximum value is marked. The data suggests that especially Class B is regularly taught in a teacher-centered way, whereas Class D is often taught in a student-centered way.

4.3. Reliability and validity of the coding regarding students' classroom experiences

In this section, we further analyze the coded data to explore its internal consistency, reliability, and validity with regard to the students' classroom experiences. To check the internal consistency (comparable to measures like Cronbach's alpha) and validity of the codings, we look at selected subsamples of our data.

4.3.1. Individual pictures

Above, we listed the (technological) tools depicted in the students' drawings. One of the most trustful ways to check the reliability of the drawings (and, therefore, the drawing method) is to compare the drawn tools to the real-world classrooms. For example, 9 pictures show a smartboard (a digital whiteboard) and all of those pictures have been drawn by students from class A, which is the only classroom of our sample that actually contained a smartboard. The other tools also are in line with the actual environments; thus, indicating reliable information in the drawings (e.g., Gulek, 1999; Lodge, 2007; Remesal, 2009).

4.3.2. Teacher size

A majority of the teachers is depicted "bigger" than the students (in relation to normal size differences between children and adults, see above), which can be seen in Table 1. This could mean that teachers in the drawn classrooms play a more important role than the students, implying teacher-centered learning environments. To investigate this hypothesis, we analyze this subgroup of pictures with "bigger" teachers. To do so, we use the same codings as above to produce another six analyses that refer to the analyses (1)–(6) presented in Tables 1–3—now with an additional "b," which stands for "bigger (teacher)," in the numbering.

As seen in Table 8, analysis (1b) shows the relevant numbers of drawings. In this subgroup of drawings, we see (2b) even more teachers are depicted in the center of the picture (29.0% vs. 18.3%; but about the same number in the middle row). Also (3b), more students are depicted at their place (53.3% vs. 36.5%) and (5b) working alone in this subgroup (48.9% vs. 33.7%). There are (4b) slightly larger percentages of single student's desks and students' desks in rows (60% vs. 44.3%; see Table 9) as well as (6b) only teacher speaking (17.8% vs. 13.5%; see Table 10); however, the latter should not easily be compared to the whole group as in the subgroup, "not applicable" is impossible as there are no pictures without persons. In summary, the data suggest that "bigger" teachers are well related to teacher-centered routines. As this is not a quantitative study, we refrain from arguing statistically at this point. However, interested readers find the results of chi-square tests that confirm these results in Tables 11–15 in Appendix C.

4.3.3. Classes

We can validate the impressions from results regarding the classes via a comparison with classroom observations. In addition to the pictures, we have observation notes from the second author who visited the classes for a period of several weeks. Her impressions were:

- The teacher of Class B was originally trained to be a secondary, not a primary teacher; and he was not trained to be a mathematics teacher. He mostly used tasks from the official textbook and sometimes handed out copied tasks from another textbook. The chosen tasks were mostly closed with no room for interpretation or discussion. He structured the lessons in very small steps and gave solutions after every step; especially in reflection phases, he made sure that all students got "the one, right answer." Often, he seemed to be uncertain about how to react to students' questions. This way of teaching was interpreted as "teacher centered" in this study.
- The teacher of Class C was also not trained to be a mathematics teacher at primary schools, but as a special education teacher. She was also adhered to the textbook and mostly followed the textbook scripts, explanations, or examples in designing her lessons. Her teaching style was interpreted to be teacher-centered, but not as clearly as the style of teacher B as teacher C sometimes encouraged cooperative forms of learning (especially when it was recommended by the textbook script).
- The teacher of Class D used many action-oriented and cooperative forms of learning. The rhythm of her lessons was often the same: after a short introduction, the children would work independently on open-ended problems and they presented the results to each other with an open discussion following the presentations. Teacher D never highlighted her solution to be the right one; sometimes, there were so many ideas, that the discussion had to be continued in the next lesson. The students were encouraged to use research notebooks to gather their observations. In our interpretation, this teacher showed the most student-centered ways of teaching.

The data fit well to the observations with Class B showing the most maximum values in Table 6 and Class D showing the most maximum values in Table 7.

5. Discussion and conclusion

Analyzing students' drawings is an emerging research method that enables insights into students' experiences and beliefs that other methods can hardly provide. For example, compared to commonly used (self-report) questionnaires, drawings can be used even with very young students and compared to classroom observations or interviews, drawings are cost-effective as drawing-based data can be collected from a large number of students. Additionally, drawings suffer less from limitations like issues with validity and social desirability that questionnaires are faced with (Di Martino and Sabena, 2010; Safrudiannur and Rott, 2020). However, the objectivity and validity of analyzing drawings still needs to be thoroughly explored as sometimes findings are based on assumptions and interpretations by the respective researchers. In this study, we have addressed these methodological issues (See Tables 11–15 in Appendix C).

The topic of our study is observable instructional arrangements and teaching methods, namely teacher-centered vs. student-centered teaching approaches. Whilst such "sight structures" (as termed by Kunter and Voss, 2013) do not have the same power for explaining student learning progress as others such as classroom management, cognitive activation, or individual learning support (i.e., "deep structures," Kunter and Voss, 2013), some instructional arrangements are correlated with unfavorable learning approaches. They are, therefore, important for empirical research. Previous studies have shown that this especially occurs in teacher-centered environments (Trigwell et al., 1999).

Methodologically, in this study, we asked students to draw their typical classroom environments, as their "perceptions about the role of their teachers and how they might contribute to their learning begin to be formed once they start school" (Taylor et al., 2005, p. 728). Specifically, we were interested in assessing learning environments that shape students' experiences regarding their usual mathematics classes by making them tell—or rather show—us their perspectives of their mathematics lessons. To do so, we used a variation of the *Draw A Scientist Test* (DAST) (Chambers, 1983) and the *Draw A Mathematician Test* (DAMT) (Picker and Berry, 2001): the *Draw A Mathematics Classroom Test* (DAMC) (Hatisaru, 2020b) (see Appendix A). Such an assessment can generate rich data (see also Hatisaru, 2022); yet compared to interviews, data collected by using DAMC or alike instruments from a large number of participants can easily be generated and evaluated.

Compared to quantitative methods (like using questionnaires), the interpretation of drawings—especially when focusing on students' beliefs—can be subjective or high-inferent (cf. Rolka and Halverscheid, 2011). We, therefore, developed a low-inferent coding manual focusing on observable characteristics of the drawings that are well-operationalizable and can be used with high interrater agreement—with codes like whether teachers or students are depicted, whether students' desks are shown in rows or clustered, and so on. To address the validity of our codings, we compared them to classroom observations.

TABLE 5 Attributes of the students' drawings indicating rather teacher-centered (left) or student-centered (right) learning environments.

Teacher-centered learning environments are rather associated with	Student-centered learning environments are rather associated with
Teacher bigger than students	
No students depicted	Students are depicted
Only one student depicted	More than four students are depicted
Only a single student's desk is depicted	
Students' desks are shown in rows	
Students are working alone	Students are working in groups
Only the teacher speaks	Only students are speaking
	Teacher and students are speaking

TABLE 6 Distribution of attributes that hint at teacher-centered learning environments.

Code/class	Class A (*n*=45)	Class B (*n*=20)	Class C (*n*=20)	Class D (*n*=19)
Teacher bigger than students	33.3%	45.0%	60.0%	47.4%
No students depicted	48.9%	50.0%	45.0%	26.3%
Only one student depicted	28.9%	25.0%	10.0%	21.1%
Only a single student's desk is depicted	20.0%	35.0%	25.0%	5.3%
Students' desks are shown in rows	4.4%	45.0%	35.0%	31.6%
Students are working alone	22.2%	30.0%	45.0%	52.6%
Only the teacher speaks	24.4%	5.0%	0.0%	10.5%

TABLE 7 Distribution of attributes that indicate student-centered learning environments.

Code/class	Class A (*n*=45)	Class B (*n*=20)	Class C (*n*=20)	Class D (*n*=19)
Students are working in groups	0.0%	0.0%	0.0%	10.5%
Students are depicted	51.1%	50.0%	55.0%	73.7%
More than four students are depicted	15.6%	15.0%	15.0%	10.5%
Only students are speaking	4.4%	5.0%	10.0%	0.0%
Teacher and students are speaking	15.6%	25.0%	5.0%	15.8%

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TABLE 8 Analysis of drawings depicting a teacher that is larger than the students: teacher's position.

(1b) Teacher size (compared to students)			(2b) Teacher's position		
			Centre	13	29.0%
			Left	10	22.2%
Bigger	45	43.3%	Right	13	29.0%
			Upper or lower edge	4	8.9%
			Comics	2	4.4%
Other	59	56.7 5	Other	3	6.7%
Sum	104	100%	Sum	45	100%

TABLE 9 Analysis of drawings depicting a teacher that is larger than the students: students' positions and the positions of their desks.

(3b) Students' position			(4b) Students' desks		
At their place	24	53.3%	Single	13	28.9%
Not at their place	9	20.0%	Rows	14	31.1%
Both (multiple s.)	4	8.9%	Clustered	5	11.1%
No students[a]	8	17.8%	None	13	28.9%
Sum	45	100%	Sum	45	100%

[a]In these cases, teacher size was compared to students' desks.

TABLE 10 Analysis of drawings depicting a teacher that is larger than the students: students' activities and teacher–student conversation.

(5b) Students' activities			(6b) Teacher–student conversation		
Working alone	22	48.9%	Only teacher	8	17.8%
w. in group	0	0.0%	Only students	3	6.7%
Other	15	33.3%	Teacher and students	8	17.8%
No students	8	17.8%	No conversation	26	57.8%
			Not applicable	0	
Sum	45	100%	Sum	45	100%

The results of our study—analyzing 104 drawings of 4th grade students—highlight the possibilities of the chosen research method. That is, coding drawings with the manual presented in Appendix B allows analyzing data from mid- to large-sized groups, getting insights into individual experiences as well as experiences of groups like classmates. Especially when combining the coding of students, we see patterns that confirm the validity and reliability of the methodological approach. For example, drawings with teachers that are larger than the depicted students also show other signs of teacher-centered learning environments; and with regard to classes, we see patterns regarding learner- or teacher-centeredness that matched with the observational notes taken in those classes.

Whilst a sample of 104 collected drawings is relatively an ideal sample size, it is worth noting that a *limitation* of this study is its sample and sample size. It would be favorable to have a larger and importantly more diverse sample (e.g., students of different grades from different schools; or even students from different countries). Researchers in this field are encouraged to further explore the possibilities of drawing tasks for assessing beliefs and experiences with larger and diverse groups.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving human participants were reviewed and approved by University of Cologne. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

Author contributions

BR did most of the data analyses (including the development of the coding manual, together with LB) and manuscript writing (especially the Methodology, Results, and Discussion sections). LB gathered the data and did most of the data analyses (including the development of the coding manual, together with BR). VH helped with writing the manuscript, especially the Theoretical Background section. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyg.2023.1019299/full#supplementary-material

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Learning in the forest: environmental perception of Brazilian teenagers

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The idea of separation between person and nature, accentuated by current production and consumption models, has generated unthinkable impacts, causing an unprecedented loss and degradation of the global environment. Occupying 13% of the Brazilian territory, the Atlantic Forest is the second-largest tropical rainforest on the American continent; however, it is one of the most threatened biomes in the world, with only 12% of the original cover. In this study, we consider that enabling young people to experience direct contact with nearby natural environments can positively influence their knowledge and feelings about the biodiversity that occurs there, contributing to its protection and conservation for current and future generations. In this study, we explore how teenagers (n = 17) aged between 13 and 17 years old describe and perceive the nearby natural environment before and after an interpretive trail in Una, Bahia, Brazil. Participants were asked to draw the Atlantic Forest with colored pencils on white paper and, based on the drawing, they answered the following questions: "What is in your drawing? and "What is happening in your drawing?," in addition to other information such as the title of the drawing, difficulty of the activity, and sociodemographic aspects. Content analysis was used to analyze the information collected. From the drawings and responses of the participants, categories related to knowledge, experiences, and types of relationships with the visited place emerged. We count the frequency of drawing elements before and after the visit, together with a qualitative analysis of the descriptions of their feelings and meanings attributed to the visit, highlighting the different elements and their relationships. The results showed that, after the trail, the participants manifested bonds of proximity with the visited environment and the organisms protected there, evidencing expressive changes in their perceptions of the person-nature interaction, in the specific knowledge of the visited ecosystem, and in the different forms of relationship provided by the visitation itinerary.

KEYWORDS

environmental perception, environmental knowledge, interpretative trail, person-nature, drawings analysis

1. Introduction

Nowadays, the interaction between people and nature has been approached from different perspectives. The most evident, especially during the Covid-19 pandemic but even before that, is linked to mental health, mostly for children and teenagers (Louv, 2005; Aydogdu, 2020). Recent studies allow us to state that environmental, political, and socio-economic crises constitute a real threat to children's development and education (Hickman et al., 2021). The negative consequences of quarantine during the Covid-19 pandemic have reactivated the theme both in common sense and in the scientific field: people need nature. Beyond the direct impact on physical and mental health, studies have pointed that the isolation from nature makes people less aware and insensible to current environmental problems, such as of the loss of the planet's biodiversity and climate emergencies, with further commitment to human well-being (Artaxo, 2020). Studies in this direction already viewed human well-being and conservation as two sides of the same coin that could not be treated independently. In fact, several initiatives seek to preserve nature for human well-being and protect other threatened beings, processes, and ecosystems. Examples of these initiatives are the practices in the field of environmental education.

The experiences in nature as a strategy for environmental awareness have been the keynote of these initiatives, with the "interpretative trails" or "interpretation trails" being one of the main instruments used. The first author to address the interpretative aspects of nature trails was Freeman Tilden (2007), for whom the interpretation is an educational activity of dignification and practical affiliation with an environment, aiming to reveal meanings of the interactivity between different physical, biological, and anthropic environmental factors (De Lima-Guimarães, 2010). Thus, interpretation is an educational instrument capable of adding value to the visitor's experience, contributing to the formation of close relationships with the natural environment, its beings, and its processes (Ikemoto et al., 2009).

Therefore, direct contact with natural surroundings can affect how children and teenagers interact with nature, influencing their willingness to conserve biodiversity (Zhang et al., 2014; Soga and Gaston, 2016; Barthel et al., 2018). These studies also reinforce the hypothesis that experiences of this type can influence pro-environmental attitudes and behaviors during adulthood (Wells and Lekies, 2006; Collado et al., 2015; Chawla, 2020), emphasizing the importance of close experiences with natural beings and processes since childhood (Broom, 2017) to promote environmental actions. A more specific approach to changing environmental attitudes highlights the process of acculturation and the formation of a global mindset as important counterpoints to an eco-deficit culture (Vuong and Napier, 2015). In this sense, acculturation and global mindset absorbs and integrates changes, rejecting cultural aspects that are not compatible with the situation of the person or group, while breaking with traditional behaviors and practices that are inappropriate at the time, making room for the assimilation of new values, beliefs and attitudes. This global sponge mindset works proactively by gradually solving acculturation challenges in the direction of a new cultural core value centered around environmental conservation (Vuong, 2021).

Since the first research on the factors that contribute to the adoption of a new environmental paradigm from a gender perspective, a more pronounced pro-environmental tendency has always been observed in the female group (Zelezny et al., 2000), even among girls and teenagers (Corraliza et al., 2013). While there seems to be a consensus on the greater pro-environmental inclination on the part of girls and women, cultural differences and variations are also considered (Xiao and Hong, 2010), through risk perception (Xiao and McCright, 2012), and the influence of peers and parents on child environmentalism (Collado et al., 2017). In this regard, all studies involving person-environment are attentive to variations in results between genders.

In order to better access environmental perception and knowledge, drawing is a successful technique in research to identify the perception of children and teenagers (Barraza, 1999; Profice et al., 2021). In environmental studies, drawing has been used in studies on climate change (Pellier et al., 2014), basic botanical knowledge (Bartoszeck et al., 2015), perception of the natural environment, and attachment to the place (Profice et al., 2015) and the concept of biological reserve and nature conservation (Eckert et al., 2017), or even on ways of interacting with nature (Bolzan-de-Campos et al., 2018; Grenno et al., 2021). Initiatives and programs of education and environmental awareness with children and teenagers also use drawings to evaluate their activities, although in a less structured and controlled way than in the academic field, both in their collection and in the interpretation of their results. The subject presented here concerns the perception and knowledge that young people and children in rural areas have about the Atlantic Forest, based on an intervention carried out in 2018. Using drawing as a research tool, we explore how teenagers aged between 13 and 17 years old describe and perceive the nearby natural environment before and after an interpretive trail in Una, Bahia, Brazil.

2. Materials and methods

2.1. BioBrasil and environmental awareness

BioBrasil is a conservation project developed by the Center for Research and Conservation at the Zoological Society of Antwerp, in partnership with Bicho do Mato Research Institute, focusing on the golden-headed lion tamarin (*Leontopithecus chrysomelas*), an endemic and endangered primate species in southern Bahia. In its environmental education program, BioBrasil coordinates actions aimed at raising environmental awareness, environmental education, agroecology, and environmental communication to involve the local community in the forefront of the conservation of the golden-headed lion tamarin and its habitat. One of its strategies consists of an activity that begins with an interpretive nature trail, as well as other interactive experiences in more anthropized environments, as detailed further on.

In this context, it was possible to build a common goal for the academy and the environmental education program capable of meeting the expectations of the research groups involved, while also providing the BioBrasil team with an assessment of the impacts of nature experiences on the participants' environmental knowledge and perception. The main objective of this work was to quantitatively and qualitatively evaluate the impacts of an environmental awareness activity in nature on the participants' knowledge and perception of the environment. In the present study, we used drawing as a data collection tool to visualize the effect of the experience, addressing the following question: to what extent do experiences in interpretive trails and planned natural spaces alter the knowledge and perception of nature among teenagers in rural areas?

2.2. Study area

The Gameleira interpretive trail is one of the environmental awareness and perception tools used by BioBrasil to disseminate information about the Atlantic Forest and the golden-headed lion tamarin. The trail is located at Fazenda Santo Antônio, a private family-owned rural property located in the district of Colônia de Una, municipality of Una, State of Bahia, Brazil. In this area, BioBrasil also develops its research activities by monitoring 4 groups of golden-headed lion tamarins. The farm area is 1.6 miles long, with predominantly Dense Ombrophilous Forest vegetation in secondary, medium, and advanced stages of regeneration (Figure 1).

The trail has 7 interpretation points to observe the difference in vegetation structure, ecosystem services, presentation of some species of flora, and interaction of fauna and flora. Thus, point 1 is used to monitor groups of golden-headed lion tamarins and their interaction with the ecosystem's fauna and flora. Point 2 focuses on the perception of flora species and how they interact with the environment, showing characteristics of the climate and soil. Point 3 shows the constant transformation of the forest and its structure, while point 4 shows the importance of fauna for forest recovery (e.g., seed dispersal). At point 5 (the highest point of the trail), there is a centenary-old Gameleira with a hollow of the tamarin, where participants can reflect and observe the forest canopy and perceive climate change (Figure 2). In terms of the forest and its life and decomposition processes, point 6 invites participants to observe details of the forest floor through magnifying glasses. Finally, point 7 represents "The Celebration of Life," a moment of contemplation, gratitude, and honor of the forest, remembering and re-signifying the path to reach there. The activity ends with a visit to the seedling nursery of native Atlantic Forest species, where participants are invited to plant a tree (seedling) in the agroforestry system implemented on the farm. Agroforestry has been adopted as a strategy that associates forest conservation with food production in diversified cultures (Nair, 2011).

2.3. Participants

The sample was composed of 17, teenagers aged between 13 and 17 years (Mean = 13.88; Standard Deviation = 0.96; 52.94% girls and 47.05% boys) eighth-grade students from Colégio Municipal Alice Fuchs de Almeida, in the city of Una (Bahia, Brazil). This study was approved by the Research Ethics Committee of the Universidade Estadual de Santa Cruz, Bahia, Brazil (C.A.E N° 01517618.8.0000.5526).

2.4. Research procedures

The teenagers completed the interpretive Gameleira Trail (Figure 2), guided by educators from the BioBrasil project. Before starting the trail, they watched a brief presentation about the objectives and activities developed by the project in the region, and received instructions on the day's activity, but without details of the experience itself. Moreover, the guide in charge presented information about the monitoring work carried out by BioBrasil with groups of golden-headed lion tamarin (*Leontopithecus chrysomelas*). The Gameleira Trail is located in an area of Atlantic Forest, close to the Una Biological Reserve. This forest remnant cut by the trail concentrates a great biological richness.

In order to deepen the experience, the participants were accompanied by research assistants to learn more about the work of monitoring the lion tamarins, observe the species in the wild, and handle the radio telemetry equipment to find the animals in the forest. After the two activities (i.e., the trail itself and accompanying the monitoring of lion tamarins in the wild), participants were invited to share their experience on the banks of the Aliança River, while continuing contemplation of the environment and ending with a swim in the river.

On days and times previously coordinated by school authorities, the participants were invited to draw the Atlantic Forest with colored pencils on a square sheet of white paper (21 × 21 cm) in the classroom, 1 week before the trail. Subsequently, each participant was asked to answer individually and orally a semi-structured questionnaire with open and closed-ended questions to obtain sociodemographic information (name, age, gender) and

FIGURE 1
Location and route of the Gameleira Interpretive Trail located at Fazenda Santo Antônio, district of Colônia de Una, municipality of Una, state of Bahia, Brazil.

FIGURE 2
Participants during the interpretive visit to the Gameleira Trail.

information about the drawing, namely "What did you draw?," "What is in your drawing?," "What is happening in your drawing?," "Is there any relation/function between the drawing elements?," "Did you find it easy or difficult to draw?"; "Is there anything else you would like to say about your drawing?" and "If you had to put a title on it, what would it be?" to understand the elements, interactions, and meanings through the eyes and voice of the author. This procedure was performed twice, 7 days before and 10 days after the experience.

2.5. Classification of the elements represented in the drawings

The elements in the drawings were classified following the categories suggested by Grenno et al. (2021) and Profice et al. (2015), with adaptations. Those categories were validated by a panel of judges' techniques with scientists from biology, anthropology, and psychology, and intensively discussed to overcome disagreements before the content analysis. Thus, we first classified the drawing elements into two major categories: natural elements and artificial elements (constructions and structures). The broad category of natural elements was divided into five subcategories: botanical elements, animals, people, geographic elements (e.g., river, mountain, and sea), and celestial (e.g., cloud, sun, or rain). Finally, the botanical and animal elements of the non-human category were subdivided into types: (i) generic plants, (ii) exotic plants, (iii) native plants; (iv) vertebrate animals, (v) invertebrates animals and (vi) lion tamarin (Figure 3). The lion tamarin was considered separately from the other vertebrates, as it is the focus species of the BioBrasil project on which the students received more information, and which can be observed during the interpretative trail. For each drawing, the number of elements was quantified in each of the categories, subcategories, and types.

2.6. Quantitative analysis of drawings

Quantitative analyses were conducted to identify differences in groups of elements (category, sub-category, and type) drawn by different genders (boys vs. girls) and between the two moments: before and after the experience on the Gameleira Trail. We identified the groups of elements represented in at least 5 drawings (>14% of the drawings). We counted the total number of elements represented in each drawing and calculated the median and interquartile range for: (1) boys and girls and (2) before and after the experience (Table 1).

2.7. Qualitative analysis of drawings

Following the steps proposed by Bardin (2011), namely exploration of the material, treatment of inference, and interpretation of results, the qualitative analysis was oriented towards the interpretation and comparison of the meanings given both to the drawing activity and to the perception and aesthetics of nature before and after the experience. Consequently, the data were tabulated after a thorough examination of the material (drawings and comments) to build overviews that allowed a problematization of the theme addressed, especially the relevance of the experience for the articulation between the cognitive and the affective, both for the expansion of previous knowledge and for the aesthetic expressions of the portrayed nature.

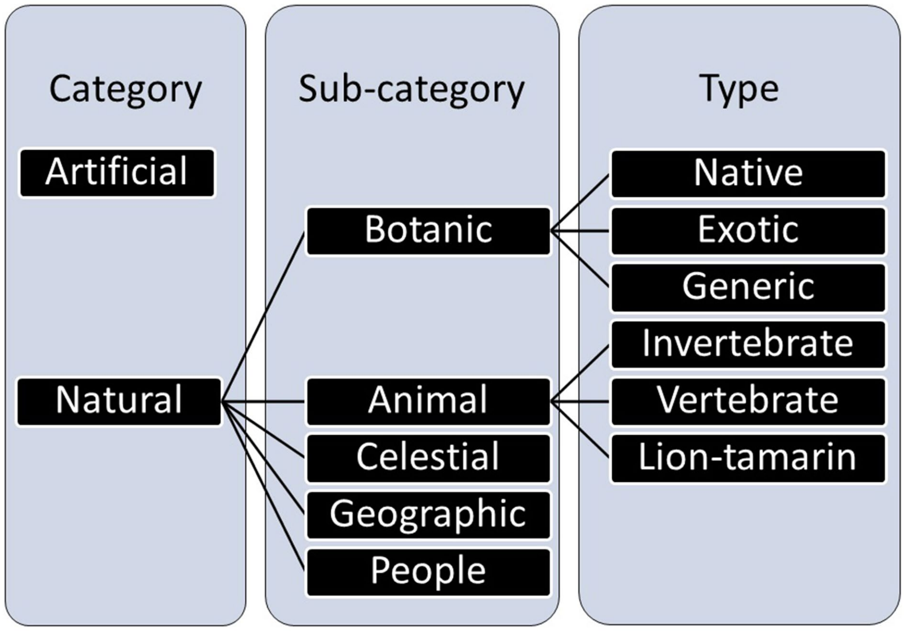

FIGURE 3
Classification of the elements represented in the drawings into categories, sub-categories, and types for quantitative analysis.

TABLE 1 Total number of elements (N), minimum, quartiles (Q1, Q2 and Q3) and maximum of elements per drawing, and number of drawings with representations in each category, sub-category, and type.

Category	Elements														Drawing	
Sub-category	Before							After							Before	After
Type	*N*	Min	Q1	Q2	Q3	Max	IQR	*N*	Min	Q1	Q2	Q3	Max	IQR	*N*	*N*
Artificial	3	0	0	0	0	1	0	23	0	0	1	3	5	3	3	9
Natural	326	5	13	17	26	31	3	370	9	16	19	25	68	3	17	17
Botanical	122	2	3	4	12	24	3	206	2	6	10	13	61	4	17	17
Native	5	0	0	0	0	4	0	22	0	0	0	1	8	1	2	5
Exotic	15	0	0	1	1	3	1	16	0	0	0	2	4	2	9	6
Generic	102	1	2	3	11	24	9	168	0	4	5	10	60	6	17	16
Animal	136	1	3	7	9	25	3	96	0	2	6	7	15	3	17	14
Invertebrate	4	0	0	0	0	4	0	13	0	0	0	0	10	0	1	4
Vertebrate	125	1	3	7	9	23	6	63	0	1	4	4	12	3	17	14
Lion tamarin	7	0	0	0	0	3	0	20	0	0	1	1	4	1	4	12
People	5	0	0	0	0	4	0	4	0	0	0	0	2	0	2	3
Celestial	43	0	1	3	4	6	3	28	0	0	1	2	13	2	13	10
Geographic	20	0	1	1	1	5	0	36	0	0	0	1	16	1	14	8
Total general	329							393							17	17

*Rightmost column represents the number of drawings containing each category and sub-category.

3. Results

3.1. Quantitative results

Altogether, 722 elements interpreted in the drawings of the 17 participants were quantified: 329 elements were represented before, and 393 elements were represented after the experience (Table 1). All results are reported as the total number of elements (per category, sub-category, and type) represented in each drawing before and after the experience. The information regarding the total number of elements drawn by both boys and girls (before/after) will be presented in a narrative format. Median (Q2) and interquartile range for each category, sub-category and type of element before and after the experience are presented in Table 1. For more information about the median and interquartile range by gender see Supplementary Table 1.

3.2. Categories, subcategories, and types

The major categories of natural and artificial elements comprised 696 and 26 items, respectively. In the first, most of the elements represented were botanicals and animals. In the post-visit drawings, aspects of the experience were represented, such as the trail itself or, even, the swing and soccer field, which were present in the recreational space used at the end of the trail (Figure 4). Considering all the elements drawn by each participant, before and after the visit ($N = 34$), 326 natural elements were represented before, and 370 after the experience. The artificial elements were represented 3 and 23 before and after the experience, respectively (see Table 1). Regarding the gender of the participants, 141 and 185 natural elements were represented, respectively, by boys and girls before the experience, and 160 and 210 after the experience. Corresponding numbers for artificial elements were 3 and 0 before the experience and 11 and 12 after the experience.

The sub-categories of botanical and animal elements were the most represented, with 328 and 232 representations, respectively. These were followed by the sub-categories of celestial, geographic, and people elements, with 71, 56, and 9 representations. Regarding the botanical elements, 122 and 206 were represented, respectively, before and after the experience, and the frequency of animal representations was 136 before, and 96 after. Among the abiotic elements (geographic and celestial), rivers, lagoons, and the sea stood out. In total, 20 geographic elements were represented before and 36 after the experience, while celestial elements were represented 43 before and 28 after the experience (Table 1). People were poorly represented in both moments, with 9 representations in 5 drawings only. Regarding the gender of the participants, 28 and 94 botanical elements were represented, respectively, by boys and girls before the experience, and 58 and 148 after. Corresponding numbers for animal elements were 71 and 65 before and 48 and 48 after the experience.

Among the botanical elements, students mainly represented generic plants (270 representations in 33 drawings), followed by exotic plants (especially fruits, which had 31 representations in 15 drawings) and native plants (27 representations in 7 drawings). In total, 102 generic botanical elements were represented before and 168 after the experience, while the representation of exotic botanical elements was 15 and 16 after. Regarding the gender of participants, 17 and 85 generic botanical elements were represented, respectively, by boys and girls before, and 34 and 134 after the experience. Corresponding numbers for exotic botanical elements were: 7 and 8 before the experience and 10 and 6 after the experience.

In the animal elements, vertebrates, in general, were more frequent (188 representations in 31 drawings), followed by the lion tamarin (27 representations in 16 drawings) and invertebrates (17 representations in 5 drawings). The most represented vertebrates were birds, with many generic representations (line style), although there was a diversity of species such as toucans, parrots, and herons (Figure 5). Mammals were represented exclusively by the lion tamarin, jaguar (2 drawings), and domestic dog (1 drawing). In total, 125 vertebrates were represented before the experience and 63 after the experience. Lion tamarin was represented: 7 before the experience, and 20 after the experience (see Table 1; Figure 6). Regarding the gender of the participants, 69 and 56 vertebrates were represented, respectively, by boys and girls before the experience, and 34 and 29 after the experience. Corresponding numbers for lion tamarin were 2 and 5 before the experience, and 4 and 16 after the experience.

FIGURE 4
Beatriz (13 years old). Before the visit **(A)**: "The Free Farm." After the visit **(B)**: "Knowing the lion tamarin."

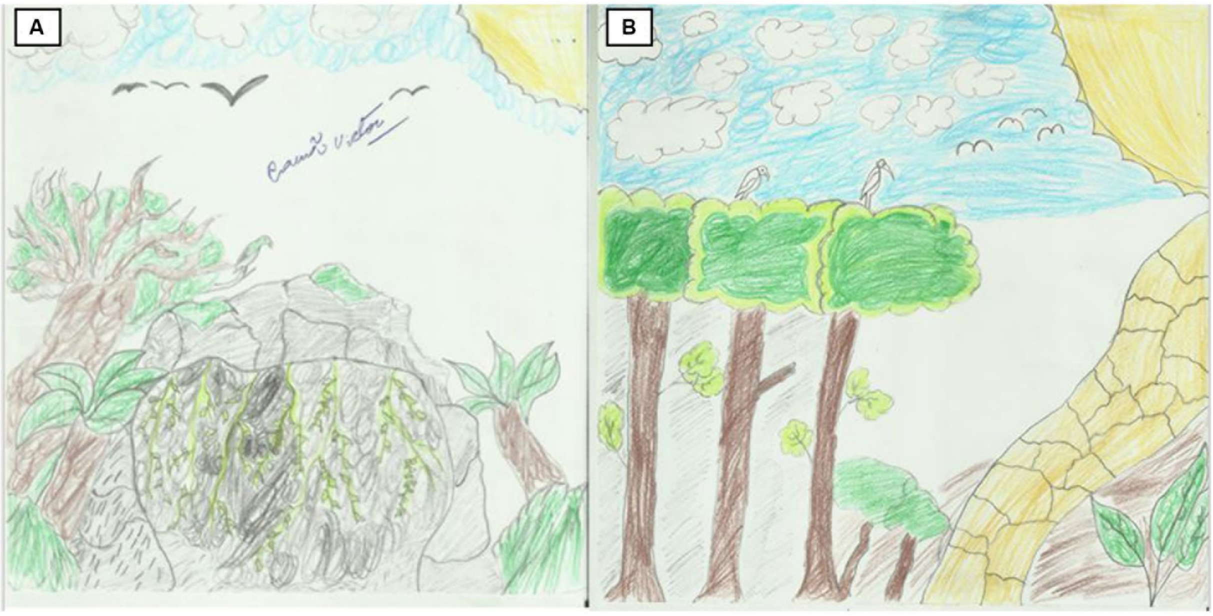

FIGURE 5
Cauã (14 years old). Before the visit **(A)**: "The Unknown Cave." After the visit **(B)**: "Pine Forest."

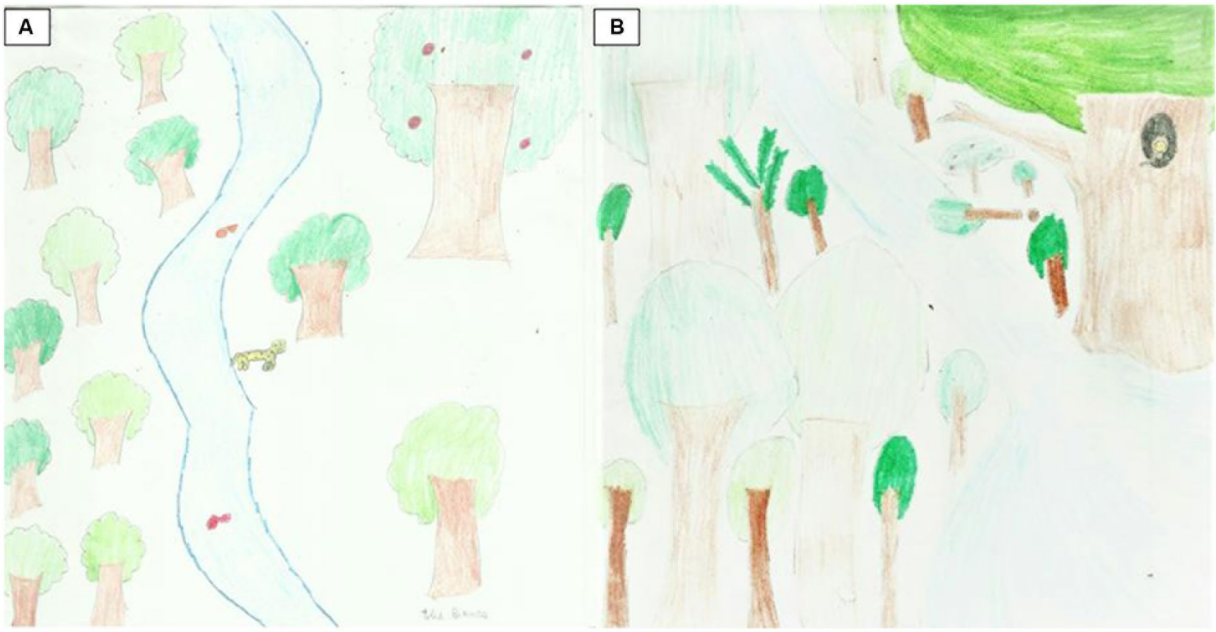

FIGURE 6
Ellis (13 years old). Before the visit **(A)**: "Atlantic Forest." After the visit **(B)**: "Diversity of the Atlantic Forest."

3.3. Qualitative results

This section provides an overview of the drawings made before and after the trail and time with the research assistants, with some examples and statements that guided our reflections. The first constant that stands out in the drawings and statements of the participants is a feeling of greater ease in drawing the Atlantic Forest after completing the trail. Many participants stated that the first drawing was difficult to execute because they had the self-perception of not knowing the subject, despite living in this environment and frequenting the woods in their daily lives. Notably, the experience of the trail was fundamental for the participants to consider what they had learned about the subject based on the newly acquired knowledge and affections and the knowledge they already had.

"It was easier because, before the trail, I did not know what to draw, after the trail, things are clearer in my mind" (Emily, 13 years old).

"Easier than before because I had drawn thin trees and not thick ones like I saw in the woods" (Yami, 13 years old?).

We also identified an expressive difference both in the knowledge of the functioning of the Atlantic Forest and its configuration and aesthetics, with landscapes where the color of the drawn elements is mostly green. In the drawings by Elis (13 years old), we can observe a change in the structure of the forest between the activities before and after the trail (Figure 6). She found the first drawing difficult since she believed her knowledge of the Atlantic Forest was almost non-existent. In the drawn scene, we observe a jaguar looking for food in a very open area and an apple tree among the trees that are far from each other. It is worth mentioning that the apple tree is not found in this region. For this teenager, it was easier to draw a forest after the trail. In the second scene, the forest is more diversified and closed, with only native plant species such as the gameleira and the presence of the golden-headed lion tamarin. A fallen tree indicates deforestation and its risk to animals. She declared that humans are absent because they harm the forest and named her drawing "Atlantic Forest Diversity."

Likewise, when interviewed after the visit and after her second drawing, Emily (13 years old) stated, "It was easier because, before the trail, I did not know what to draw, after the trail things are clearer in my mind." Cauã, 14 years old, named his first drawing "The Unknown Cave" and declared that it was difficult and that he could not draw properly because he does not know how to draw well. In the image, we see a cave with bushes on top and an apple tree together with other local animal species such as toucans and parakeets. A change of landscape is perceptible between the first and second drawings, which is more alive, green, organized, and careful than in the previous drawing. He declared, "This time it was easy," and in his "Pine Forest," we find coconut trees and branches, the herons looking for the flock to migrate, and the jaguar following the wild boar in the forest (Figure 5).

Jaivan, aged 14, made skilled drawings (Figure 7), the first of which he portrayed wild animals and local trees such as the avocado tree. He commented that he did not draw the blue macaw because it is from another biome. In "The Snack Time," he sought to produce a scene in which "everyone was doing something." He said the first drawing was a little difficult because it is full of details and things to paint. The drawing after experiencing the trail is also very beautiful, with more emphasis on vegetation, and the presence of the golden-headed lion tamarin, ants, and bats. Although he declared that he liked the result, he found the execution difficult again due to the many details he saw in the trees. He named his drawing "Fauna and Flora of BioBrasil." Here the teenager started from a well-structured knowledge and expanded it, thus demonstrating his skill in graphic production and focusing on its elements and retraction.

4. Discussion

Our results showed some changes in the way teenagers perceive and get to know the Atlantic Forest, reflecting the participants' connection with the visit and the importance of direct experiences with aesthetic manifestations of nature that highlight the lived experience, with drawings more in tune with the local reality.

In the representations and frequencies by each category, the results highlight an Atlantic Forest inhabited mainly by natural botanical and animal elements and with little human presence, evidencing a mostly common perception of nature among children and teenagers already pointed out in other studies (Dai, 2017; Bolzan-de-Campos et al., 2018; Grenno et al., 2021). However, the higher presence of constructed elements in the post-visit drawings seems to contrast with their previous perception, perhaps due to the influence of media, films, or cartoons (Barraza, 1999). Thus, we observed that most of the elaborations after the experience are illustrative of the visited place, revealing interconnections between the affective-sensory and the lived experience (Barthel et al., 2018).

Although the great frequency of botanical and animal elements may have been influenced by the request to the participants to draw "the Atlantic Forest," the fact that they accompany the activities carried out by the community in the forest in their daily lives contributes to their repertoire. In this regard, although we have not observed an increase in the identification of native botanical elements of local origin, the increase in the total number of botanical elements after the experience suggests some implications for teenager's conservation attitude, according to other studies which show a concern of adolescents with environmental problems (Barros and Pinheiro, 2020; Keith et al., 2022). In addition, the post-visit drawings show a view that is relatively more consistent with the visited place, where floristic exuberance and diversity are predominant (Figure 7), stimulated and expanded by the activities proposed during the experience, which included, for example, planting a seedling in the agroforestry system (Figure 2).

As previously mentioned, in addition to observing an increase in generic botanical elements, the presence of vertebrates increased in the drawings after the visit. These vertebrates, in agreement with other studies (Profice et al., 2015; Grenno et al., 2021), are mostly represented by birds, which were more than half of the simple line drawing type, suggesting a low difficulty in the execution and, consequently, relative success in the elaboration.

In contrast, the fact that mammals are represented almost exclusively by the golden-headed lion tamarin, and its frequency seems to increase considerably in the drawings after the experience, shows the assimilation of the natural elements when they are experienced through direct contact with the environment (Kellert, 1993, 2002; Payne, 1998). Additionally, the importance of the two educators during the activity is highlighted to raise awareness among the participants, enriching and amplifying the experience. Activities in interpretative trails are powerful educational tools (Ikemoto et al., 2009), but environmental educators should carefully plan what to present and emphasize to impact youth perceptions, considering what are key learnings and understandings that are important to share with the participants.

Although it was not our main intention, we could not fail to observe the gender differences related to the expressive increase in the representation of the golden-headed lion tamarin in the drawings and comments after the visit, reinforcing the idea, already pointed out in previous studies, that suggests greater environmental awareness among girls than boys (Ramstetter and Habersack, 2020).

The fact that some participants expressed their difficulty in representing what they wanted through the language of drawing can be attributed to the few opportunities for artistic expression offered by conventional schools, as well as the age group characterized by a lack of interest in drawing as a form of expression (Profice et al., 2021). However, the results also reinforce the relevance of the use of drawings

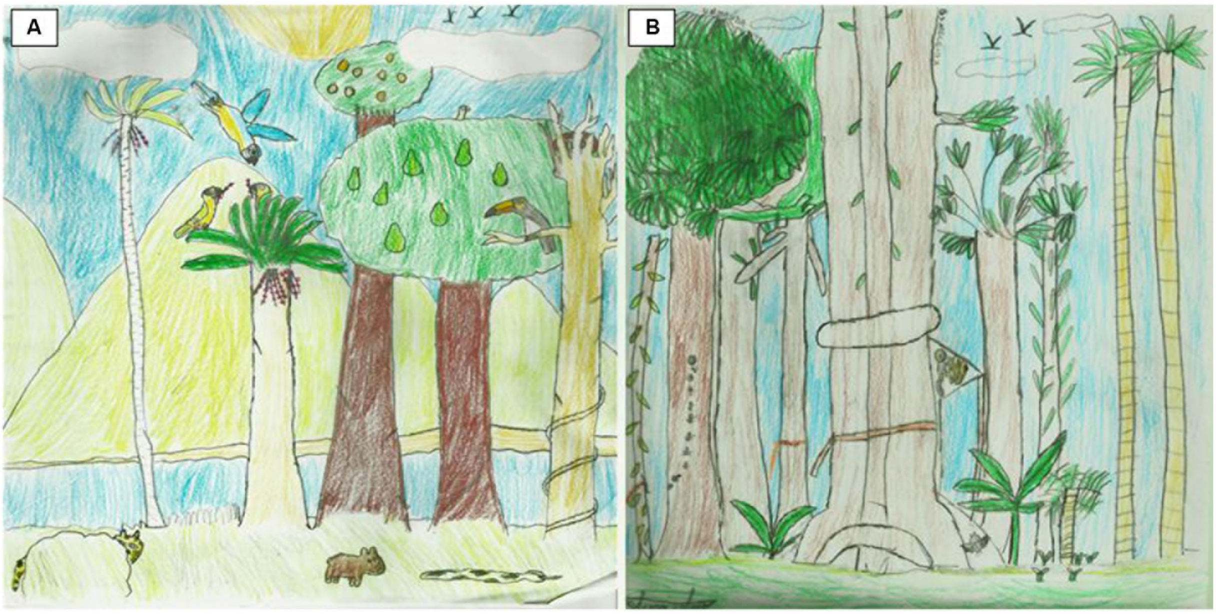

FIGURE 7
Jaivan (14 years old). Before the visit **(A)**: "The Snack Time." After the visit **(B)**: "Fauna and Flora of BioBrasil."

as a research tool with children and young people, in line with previous studies (Barraza, 1999; Profice et al., 2015; Bolzan-de-Campos et al., 2018), and the importance of accompanying written or oral descriptions (Bland, 2018).

Regarding issues of awareness and expansion of knowledge of the trail (differences and vegetation structure, ecosystem services, species of native flora, and characteristics of the climate and soil), although our analysis was not carried out to verify whether all of them changed, our results indicate a positive impact regarding these factors.

5. Final considerations

One of the limitations of this research was that the drawing and questionnaire activities were carried out 10 days after the visit, which did not allow a long-term impact perspective. In this regard, we encourage future studies to use the drawing activities and questionnaires on different occasions — 3, 6 months, or 1 year after the trail — and to determine if perceptions remain altered by the experience.

Despite living in and seeing the forest daily, its resignification, which was the objective of the trail, can generate a new environmental perception. The visit to the trail can improve and consolidate prior knowledge, and the experience can expand this knowledge. Living in nature, besides increasing knowledge and perception, contributes to our ability to represent it. In this regard, the self-perceived lack of mastery of graphic skills may indicate that the arts and drawing are not common practices in schools and homes.

In summary, our results show that, regardless of gender, experiences of interpretive trails in direct contact with the natural environment can be a powerful instrument for the consolidation of knowledge and close links with the visited environment and the beings protected there. We also observed the importance of this type of contact for triggering aesthetic manifestations of nature, in which the lived experience stands out, with drawings that are more in line with the local reality. Our research supports the idea that children are aware of environmental problems and demand guidance from the adult and institutional world for their solution. It is imperative to meet this demand towards environmental commitment and allow the new generations to do better than the previous ones (Sousa et al., 2021). In terms of open-mindedness, our research points to childhood as the period when human plasticity to overcome beliefs and values and adopt new attitudes towards reality is at its fullest, that is, it is when acculturation encounters less resistance (Vuong and Napier, 2015).

Beyond the resignification and consolidation of knowledge and perception of the visited environment and the beings protected there, the pleasurable experiences provided by interpretative trails are likely to enhance physical and mental health. Altogether, the benefits of this type of activity in the open environment have a great potential to enhance human well-being and increase nature conservancy. Finally, we would like to highlight that the combination of research objectives between academia and environmental awareness programs points to a production of knowledge based on the current reality that can support future actions with the communities involved.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving human participants were reviewed and approved by Comitê de Ética em Pesquisa-Universidade Estadual de Santa Cruz/UESC. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin. Written informed consent was obtained from the individual(s), and minor(s)' legal guardian/next of kin, for the publication of any potentially identifiable images or data included in this article.

Author contributions

AF, SM, CP, and CS conducted the fieldwork. FG analyzed the data and wrote most of the manuscript. CC participated in fieldwork logistics and contributed to writing and discussion. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyg.2023.1046405/full#supplementary-material

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