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Improvement in simultaneous processing through metacognitive instruction

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This study presents the improvement generated in simultaneous processing by the application of metacognitive instruction to 3rd grade primary education students. A pre-post-follow-up test design was used. The sample consisted of 30 students from one classroom. Two groups were formed; an intervention group comprising students in the classroom who presented difficulties in simultaneous processing, showing a cognitive weakness that compromises reading comprehension, and a comparison group comprising the rest of the students in the class. The instruments used were the Das-Naglieri Cognitive Assessment System (DN CAS), Assessment of Reading Comprehension (ACL) test and the Reading Awareness Scale (ESCOLA). The groups were equivalent in socioeconomic and cultural status and in successive processing. Reading and study variables were used as differentiators: simultaneous processing and reading awareness. A metacognitive training program based on the *Planning Facilitation* method was applied to the intervention group. The comparison group followed the usual curricular activities of the classroom and for the education level, according to the traditional teaching model. The program was implemented in 48 sessions over 12 weeks. After the intervention, the group with weakness improved significantly in simultaneous processing and reading awareness; the comparison group did not show any change in their initial scores. The metacognitive instruction that facilitates discussion between students and reflective verbalization about reading tasks promotes improvement in reading awareness and in the simultaneous processing necessary for reading comprehension.

KEYWORDS

simultaneous processing, facilitation of planning, metacognitive instruction, cognitive evaluation, PASS theory

Introduction

Reading means not only decoding but also understanding and interpreting what has been read (Georgiou et al., 2020). In the process of comprehension, two aspects stand out: the meaning of the text and the meaning of the cognitive processes that underlie the meaning. Comprehension requires extracting a mental representation of the increasingly elaborate and abstract text that integrates a large amount of information. Mental models integrate what is literally expressed in the text with previous knowledge (Van Dijk, 2001; Oakhill et al., 2003; Perfetti et al., 2005; Cain and Oakhill, 2011; Sánchez Miguel and García-Rodicio, 2014). The comprehension of a text implies the construction of a mental model in which the reader

integrates explicit linguistic information in the text with previous knowledge derived from his or her experience. However, the reader must go beyond the text to understand and must infer from the text knowledge of their experience to achieve good comprehension. Developing a mental model activates different reading processes and underlying mental operations. Reading processes begin with access to the lexicon or word recognition, syntactic or grammatical analysis between words, semantic representation or meaning relations between the words and ideas different from the text and the mental model of the situation evoked by what was read (García-Madruga, 2006). Cognitive processes of successive or simultaneous encoding of information support reading process activities (Das et al., 1994a; Georgiou and Das, 2014; Georgiou et al., 2020).

Access to the lexicon or word recognition requires deciphering the meaning that a group of letters represents, identifying them, converting them into phonemes, giving meaning to words and pronouncing them (García-Madruga, 2006). The decoding of words requires the use of the rules of grapheme transformation in phonemes. This process is carried out through grapheme-phoneme correspondence, which allows the recognition of isolated words and access to their meaning stored in memory (Andrés et al., 2010; Martinez et al., 2011). In word recognition, lexical frequency is a measure of how often a word is used in a language. Studies such as those by Verhagen et al. (2022) and Berglund-Barraza et al. (2019) have found that lexical frequency has a significant impact on lexical processing. In general, high-frequency words are processed more quickly and accurately than low-frequency words. This effect is relevant to reading and reading comprehension. In reading, high-frequency words are read more quickly than low-frequency words, and in comprehension, high-frequency words are understood more easily than low-frequency words. This occurs because high-frequency words are more consolidated in the lexical memory, making them easier to access and process (Berglund-Barraza et al., 2019). The organization of words in a sentence is achieved through syntactic processes, which require the reader to establish relations between words, that is, to determine its grammatical structure, successively applying the functions of subject-action-object to the noun-verb-noun sequences (Cuetos et al., 2014). This strategy allows recognizing the role of words in a sentence, determining the agent of the action (the cat), the object of the action (the mouse) and the action (ate). Once the syntactic structure of a phrase is established, it is possible to extract the meaning of that structure: "the cat ate the mouse." The structure could have another form (the mouse, the cat ate, the mouse was eaten by the cat) but have the same meaning. The message that is obtained can be constructed with different syntactic structures, but once the sentence is read, the structure is forgotten, and only the meaning is maintained (Cuetos et al., 2014).

To extract meaning from a sentence, reading comprehension must go beyond the sentence that was provided. Semantic processes (García-Madruga, 2006) require integrating ideas of sentences with each other and previous ideas of the reader about the phrase, constructing a mental or referential model. Understanding meaning is essential for reading (Nation, 2019).

The PASS (Planning, Attention, Simultaneous, and Successive) theory of intelligence, originating from the work of Luria (1966, 1973) on the functional organization of the brain, organizes human cognitive functioning into three systems and four processes (Das and Misra, 2015). The first is the planning system, which involves executive functions (EFs) responsible for controlling, organizing, searching, establishing goals, selecting, constructing and executing plans or strategies, regulating performance, assessing courses of action and making decisions. It is a higher-order cognitive process, a synthesizer of all intellectual operations and, therefore, the essence of human intelligence (Das, 1999). The second is the attention system, which is responsible for maintaining levels of alertness and excitement and ensuring focus on relevant stimuli, excluding irrelevant stimuli. The third system is an information processing system that uses the simultaneous and/or successive process to encode, transform and retain information.

PASS processes are carried out in three functional units of the brain (Luria, 1966, 1973). Attention is located in the first functional unit, which involves the brainstem, the diencephalon, and the medial regions of the brain. Coding involves the second unit, which includes the parietal, occipital and temporal lobes. Planning is carried out in the third functional unit, which involves the frontal areas, especially the prefrontal areas of the cerebral cortex (Das and Misra, 2015).

Research conducted within the framework of the PASS theory has established that planning, attention, simultaneous and successive processes are important in reading in reading and academic achievement (Das et al., 1994b; Papadopoulos et al., 2003; Papadopoulos, 2013; Kendeou et al., 2015; Kroesbergen et al., 2015; Parrila and McQuarrie, 2015; Kumar and Darolia, 2016; Mahapatra, 2016).

Planning allows the adoption of appropriate strategies to read and understand text and use the information at the right time (Gayo et al., 2014). Different levels of planning determine different levels of reading comprehension (Georgiou and Das, 2015; Das and Georgiou, 2016). Attention helps the reader to focus on relevant information, excluding irrelevant information, and opens the way for efficient coding of information that can be simultaneous, successive or both.

Successive processing consists of processing serially organized information. Successively applying the functions of subject-action-object to the sequences noun-verb-noun requires successive processing. These tasks require the student to use the information presented in a specific order, which is necessary to understand the meaning (Georgiou and Das, 2014). Simultaneous processing helps to create a deeper level of semantic analysis of information, to see the interrelation between separate units of information and to integrate them into broader information units. Comprehension, which requires the processing of semantic information, depends on this process at any level (Oliveira et al., 2023). Simultaneous processing involves the integration of separate elements in an interrelated set using both verbal and nonverbal content (Georgiou and Das, 2014). It also integrates information and synthesizes and reduces it to a single information unit (Das et al., 1994a), interrelating the meanings of the words that compose it and the ideas that compose the sentences in the text. This simultaneous processing activity allows extracting the meaning of the text and facilitating the process of representing the meaning, going from the most specific to the most general and meaningful for the reader (Georgiou and Das, 2014; Das and Georgiou, 2016).

Students with reading difficulties experience difficulties in simultaneous and successive processing (Das et al., 2000; Papadopoulos et al., 2004; Deng et al., 2011). The cognitive process most involved in reading comprehension is the simultaneous process (Kirby and Das, 1977; Das et al., 1982; Kirby and Gordon, 1988;

Naglieri and Das, 1988; Das et al., 1990; Georgiou et al., 2020), which is used to integrate a set of items and produce a new one. Simultaneous processing is directly related to the integration of words or phrases in a totality. Research has confirmed its importance for reading, showing that measures of simultaneous processing are a good predictor of achievement in reading comprehension (Das et al., 1982; Kirby and Gordon, 1988; Naglieri and Das, 1988; Das et al., 1990).

A deficit in simultaneous processing, underlying reading comprehension, will impede integrating the set of words read in a totality and understanding the meaning of the text by not giving meaning to the relation between the words, as well as to the ideas of the text, by not being able to integrate them into a totality. Studies reveal that weakness in simultaneous processing in boys and girls is related to difficulties in reading comprehension (Das et al., 1994a; Mahapatra, 2016). This weakness would indicate difficulty in relating the words of a sentence to obtain its meaning and to integrate words in phrases or ideas into other words (Kirby and Gordon, 1988; Das et al., 1994b).

The PASS intervention model (Das, 1999), based on the PASS theory, implements the prescription of the theory to support students in establishing the relation that words have in a sentence and to integrate all those words in an idea to understand and establish the meaning. It also aims to match the cognitive profile of students with related educational interventions beyond cognitive instruction (Ashman and Conway, 1997). This model (Das et al., 1994a) also trains students in the control of reading strategies used to solve reading tasks directed at the goal, facilitates awareness of its effectiveness, and favors its spontaneous and controlled use and its transferability. At the same time, it guides reading intervention, favoring the development of strategic knowledge of reading and the metacognitive control of specific strategies. It is argued that unless the cognitive processes that underlie reading are the focus of the intervention, through an interactive and mediated approach, there will be no success in promoting the transfer to broader aspects of reading (Das et al., 1994b).

Two types of methods have been developed based on the PASS model (Naglieri and Gottling, 1995, 1997; Das, 1999). Both encourage discovery learning instead of direct instruction, and both seek explicit knowledge of specific reading strategies, the conditions of application, their progressive control and transfer of learning to new situations.

The *PASS Reading Enhancement Program* (PREP; Das, 1999) is structured to promote inductive inference rather than deductive inference and the internalization of learning strategies (Das et al., 1995). Such a procedure fosters "ownership" of the strategies used by the students, thus ensuring transfer. On the other hand, it uses "reflexive verbalization" that promotes awareness of the strategies used (Cormier et al., 1990; Kar et al., 1993). Reflexive verbalization allows students to progressively control the execution of efficient cognitive strategies through a discussion group without direct instruction from a teacher. The use of reading strategies is facilitated instead of being taught. Ultimately, the PREP is an intervention that focuses on the cognitive processes that underlie reading so that retrieval in promoting transfer to broader aspects of reading comprehension is successful (Das et al., 1994b). Its reflexive and regulated practice promotes the internalization of strategies through mediation and interaction. PREP has shown its effectiveness in several reading programs (Das, 1999; Mahapatra et al., 2010; Ramos et al., 2014; Mahapatra, 2016).

The *Planning Facilitation* method (Naglieri and Gottling, 1995, 1997; Naglieri and Johnson, 2000), based on the PASS theory and on mediated learning concepts, has shown the value of strategies without direct teacher instruction, guiding the students in facilitating the control of efficient cognitive strategies. Cormier et al. (1990) examined the effect of infant verbal indications on the strategies used to solve items in progressive matrices. The experimenter facilitated discussion with the other children through questions to describe what was done and to verbalize their thoughts on the strategies used. The results showed that participants who identified as poor planners significantly improved their strategic performance on the matrices than those who identified as good planners. Kar et al. (1993) extended the study by Cormier et al. (1990), examining the effects that strategic facilitation had on tasks of pairing numbers in good and poor planners. The participants were asked to verbalize the strategies used to complete the tasks and explain why they were chosen. The researchers encouraged the participants to talk about what they did and why. The results demonstrated, as in the previous study, that poor planners improved their strategic performance more than the good planners in this process.

Naglieri and Gottling (1995, 1997) and Naglieri and Johnson (2000) extended the results of research to mathematical calculation tasks in good and poor planners through CAS (cognitive assessment system) scores. Their results demonstrated that poor planners improved substantially more than good planners in mathematical calculations. Through a single case design, examined the effects of planning facilitation on fluency and reading accuracy and found that this intervention had a positively consistent effect on both variables. Haddad et al. (2003) evaluated whether an instruction designed to improve planning would have a differential benefit over reading, according to the PASS characteristics of each student. The results showed that students with cognitive weaknesses in planning benefited substantially from a reading intervention designed to facilitate planning. Ares-Ferreirós et al. (2017) reported the effect of planning facilitation on reading comprehension.

In short, instruction reviewed from the PASS intervention model focuses on knowledge and metacognitive control of specific strategies and is linked to the transfer of gradual control of learning strategies and metacognitive instruction. The teacher guides the cognitive and metacognitive activity of the student, scaffolding their learning to bring it to a level of increasing competition, gradually withdrawing the support until the control of the learning process is in the hands of the student (Martinez et al., 2011).

The present study

The purpose of this study was to examine the effectiveness of the *Planning Facilitation* strategy (Naglieri and Gottling, 1995, 1997; Naglieri and Johnson, 2000; Haddad et al., 2003) in the improvement of simultaneous processing, measured by the DN CAS battery (Naglieri and Das, 1997), which underlies the reading comprehension activities of 3rd grade elementary students when solving reading tasks. If *Planning Facilitation* improves reading performance in poor planners (Haddad et al., 2003), it seems appropriate to evaluate the effect of this facilitation of planning on improving the cognitive activity of simultaneous processing that underlies the tasks of initial reading comprehension to articulate the meaning of a phrase.

The PASS theory (Georgiou and Das, 2014) has shown that a weakness in simultaneous processing is related to difficulty in reading

comprehension. The explanation of the difficulty in reading comprehension is due to the deficit in the process of integrating information into larger units for the extraction of meaning. When this happens, the prescription best suited to the educational needs, derived from the PASS theory itself, is that reading comprehension difficulties are produced by a cognitive weakness in simultaneous processing, making improvement in the process necessary for reading improvement and for transfer of what was learned. Planning controls the use of strategies employed to solve reading tasks and cognitive activity. This control requires a certain awareness of the value of the use of strategies to solve tasks and the reflexive verbalization offered by instruction with *Planning Facilitation*. When this method is used to solve reading tasks, planning aims to integrate meanings of words into a specific or general idea, using a simultaneous cognitive activity to determine the meaning. In this sense, *Planning Facilitation* in early reading comprehension should produce an improvement in awareness of the value of the use of strategies and simultaneous cognitive activity to control strategic cognitive reading activity.

The first objective of this study is to analyze the effect of the instructional method *Planning Facilitation* (independent variable) on improving the cognitive activity of simultaneous CAS (dependent variable), which underlies the initial reading comprehension of texts. It is expected that the groups of participants, who in the preintervention measure differ in their simultaneous processing cognitive activity, will not be different from the postintervention or follow-up measures.

The second objective is to establish the effect of planning facilitation on the improvement in reading awareness. It is expected that the intervention group will show an increase in their metacognitive awareness (ESCOLA) as a result of the intervention and that there will be no significant differences in their scores postintervention or at follow-up with respect to the comparison group.

If intervention training is generalized to the improvement of reading awareness (ESCOLA) and simultaneous processes (CAS), then the processes used for this training will have been effective. This would show a transfer of learning to improve reading awareness and simultaneous processing, providing evidence of "far" transfer.

The present study expands the results of previous research with the *Planning Facilitation* strategy in the context of metacognitive instruction in reading in several ways: (i) it is carried out in a primary education setting; (ii) it is applied, for the first time, to 3rd grade primary education students; (iii) it extends the effects of improvement to the simultaneous processing of the PASS theory of intelligence and to the reading awareness of those students at risk of reading difficulty who progressively are differentiated from their peer group in reading performance; and (iv) the results are obtained using a pre-post intervention and follow-up design.

Methods

Participants

The sample was formed with 30 students from a 3rd grade classroom in the city of Ourense (Spain). The economic activities in the vicinity of the center belong to the tertiary sector [Instituto Galego de Estatística (IGE), 2018], providing a mean monthly income of 1,680 euros (Instituto Galego de Estatística (IGE), 2018) to the families of the participants, indicating a middle-income level. The education level of the parents was mostly secondary (54%; IGE, 2011a), 51% of the families had a computer at home, and 40% of the households had an internet connection (IGE, 2011b). By sex, 13 were girls and 17 were boys. Their ages ranged from 7 years and 5 months to 8 years and 4 months (*Mdn* = 8 years).

The sample was divided into two groups. One of the criteria used for the division was the level of reading delay that some students were acquiring in relation to the other student in the classroom, according to the classroom teacher. The other criterion was the low results obtained from standardized reading tests [The *Assessment of Reading Comprehension* (ACL) test by Català et al., 2001]. A group ($n = 8$) was formed with the students who had difficulty in reading comprehension, constituting the intervention group. The other students in the classroom ($n = 22$) formed the comparison group.

Both groups were equivalent regarding the socioeconomic and cultural backgrounds of the parents. These were students of urban origin and families of middle socioeconomic status. No significant differences were found by sex or group [$\chi^2(1) = 0.454$; $p = 0.501$]. The sample had homogenous characteristics in terms of social, economic and cultural variables. The groups were also homogenous regarding scores for successive cognitive processing [$F(1,29) = 0.871$, $p = 0.359$] and in the subtests that evaluate it: series of words [$F(1,29) = 0.505$, $p = 0.483$]; repetition of phrases [$F(1,29) = 1.888$, $p = 0.180$]; and questions about phrases [$F(1,29) = 1.335$, $p = 0.258$].

For the cognitive variables, simultaneous processing and its subtest, the intervention and comparison groups were significantly different; the comparison group had a significantly higher mean score than did the intervention group in simultaneous processing [$F(1,29) = 12.991$, $p = 0.001$]; nonverbal matrices [$F(1,29) = 6.818$, $p = 0.014$]; spatio-verbal relations [$F(1,29) = 5.029$, $p = 0.033$]; and figure memory [$F(1,29) = 8.113$, $p = 0.008$]. The groups also initially differed in their scores for awareness [$F(1,29) = 4.037$, $p = 0.047$] and reading comprehension [$F(1,29) = 9.501$, $p = 0.005$], where the comparison group had a significantly higher mean score than did the intervention group.

Instruments

Cognitive processes

For the measurement of cognitive processes, the Das-Naglieri Cognitive Assessment System (DN CAS; Naglieri and Das, 1997, Spanish adaptation by Deaño, 2005) battery was used. This battery comprises four Scales: Planning, Attention, Simultaneous and Successive. The Simultaneous and Successive Processing scales were used.

Simultaneous scale

Simultaneous processing involves interrelating component parts to arrive at a correct solution. The three tasks designed for the Simultaneous Scale require verbal and nonverbal synthesis of separate components into an organized group. (i) Nonverbal Matrices was designed using the standard progressive matrix format. The child is presented with interrelated geometric shapes, must determine the relationships present, and then choose the multiple choice selection that correctly completes the analogy presented. (ii) Verbal-Spatial Relations requires the individual to answer questions describing the

spatial relations of a specific drawing that been presented to the child with five distracter drawings. (iii) Figure Memory is the final simultaneous task presented to the child. The examinee is shown a geometric figure for 5 s. From memory, the child is required to recall and draw that figure in a more complex manner. Its reliability index calculated using Cronbach's alpha is 0.93 (Naglieri and Das, 1997).

Reading processes

The *Assessment of Reading Comprehension* (ACL) test by Català et al. (2001) was used. The ACL consists of six tests, corresponding to each of the six courses of primary education. The ACL 3 was used for the evaluation of this study. Each text is composed of several multiple-choice questions, with only one correct answer. They are aimed at broadly assessing reading comprehension, with texts of different types (narrative, expository, poetic, graph interpretation, and data interpretation) and with topics related to the different curricular subjects. These tests collect information on four relevant dimensions of reading comprehension: *literal*, which focuses on the ideas and information that are explicit in the text; *reorganization*, where the student must analyze, synthesize and/or organize the ideas explicitly expressed in the text; *inferential*, which is executed when the student is able to simultaneously use the information specified in the text and the prior knowledge he or she possesses, for developing conjectures and hypotheses; and *critical*, in which the student must issue answers that indicate that he or she has made an evaluative judgment, confronting the ideas expressed in the text with an internal (personal) or external criterion (the teacher, other sources, etc.). The evaluation of reading comprehension of the text is always provided to the evaluated student. The reliabilities of the test for each of the levels established from 1st to 6th grade, by means of the KR-20, were, respectively, 0.80, 0.83, 0.80, 0.83, 0.82, and 0.76.

Reading awareness

To evaluate reading awareness, the *Reading Awareness Scale* (Escola; Puente et al., 2009), in its long version with 56 items, was used. The scale evaluates the planning, regulation and assessment processes that children from 8 to 13 years of age perform when reading situations posed as dilemmas. Planning is measured through items related to the process of seeking information, the reader's attitude to tasks, the selection of appropriate strategies for reading tasks according to the objective to be achieved, the effort of the task itself and the type of text. Regulation is assessed with items related to the attention and cognitive effort made by the student when faced with a reading task, the use of strategies to select the relevant information from the text, and the perseverance and self-efficacy of the reader to achieve the proposed goal. Assessment involves the control executed by the reader when faced with a reading task, verifying the use and adequacy of the strategies used in the task and identifying the results achieved.

The described processes are evaluated according to three variables: person, task and text. The person variable responds to the knowledge that the student has about his/her own abilities to face a reading task. The task variable has to do with the knowledge that the reader has about the importance of the reading task and its degree or level of difficulty. The text variable refers to the characteristics of the text presented to the reader, such as vocabulary, syntax, and structure.

The scale allows, through direct scoring, obtaining the corresponding percentile according to age and subject year. Its reliability index calculated using Cronbach's alpha is 0.81.

Measurement procedure

It was explained to each student what was to be done before beginning the individual administration of the DN CAS battery. It was applied according to the rules of administration and recording outlined in the manual. The duration was approximately 40 min per participant. The evaluator was trained in applying this battery, and the same evaluator administered the battery for all participants. The administration of the test was performed in an appropriate room of the school and in a relaxed environment.

Administration of the ESCOLA was as a group and adjusted to group rules of application and recording. The approximate duration of the test was 30 min. This group application was performed by an evaluator different from the previous one, trained in the use of this test and in group administration.

The tests were performed in different sessions and days in the order described. Appropriate permits were granted for its implementation and with the collaboration of teachers for both group and individual application.

Intervention program

The program consisted of texts for reading, of different levels, extracted from the ACL. These texts were used to answer questions directed to students about each of the texts at a given level. The levels of the texts used for this program were ACL-1, ACL-2, ACL-4 and ACL-5. ACL-3 texts were excluded from the intervention because they were used for the evaluation. The program consists of eight to ten texts per level. Each text has five questions. The level at which the program for 3rd grad students began was ACL-2, followed by ACL-1, ACL-4 and, finally, ACL-5.

Intervention procedure

The intervention was conducted in a small-group setting. Each group was composed of four participants. The tasks of the reading program were implemented using the Naglieri and Gottling (1995, 1997) *Planning Facilitation* method, which consists of three moments.

In Moment 1, the teacher gives the students an ACL text (levels 2, 1, 4 and 5) with five questions that they have to answer individually, after reading it, in ten minutes. In Moment 2, with the questions answered by the students in view, the mediator starts a debate by asking questions such as (Das, 1999, p. 159): *Can someone tell me something about this problem? What is it about? What is it telling us, and what is the purpose of the question? What question can be formulated? What else was done in this text? Why did you do it this way? How will you do it next time? How did you solve the problem? Could you have done it in a different way? Someone did not do what was important, what do you think?* The mediator does not exhaust the repertoire of questions about the chosen text or ask the questions for all students. The text allows contextualizing the dialog. If this happens through the initiative of the group, the

mediator stops asking questions; if the group initiative runs out, the mediator continues to foster the discussion with new questions. After ten minutes, the discussion is considered closed. Moment 3. The mediator collects the completed pages of all students and hands the students the same text and the same questions (moment 1) so that they solve the task for ten minutes.

The time allocated was a half-hour, two times per week and per group. The number of texts used was 24, which, implemented at two sessions per week, resulted in 12 weeks of intervention for each group. A total of 48 sessions were conducted throughout the second trimester of school.

The four participants per session who were in the program left the classroom to work with a mediator. Leaving the classroom was scheduled in advance. They had no set time or day. For the whole week, the hours and the day were planned, ensuring that the participants did not miss the same subject during the two weekly sessions. The working groups were fixed except for exceptions of schedule, attendance or other inconveniences that arose for any of the participants of the program.

The comparison group continued their learning of reading in a conventional manner. They read a text with conceptual notions about language, grammar, syntax and spelling and resolved conceptual questions raised in the text.

Design and data analysis

A pre/intervention/post/follow-up design was used, contrasting the intervention and comparison groups for each measure. The intervention program was implemented three weeks after the pretest. At the end of the intervention program, the posttest was applied. Three months passed between these two measures. Three more months later, the follow-up measure was applied. To evaluate the effectiveness of the training program in 3rd grade students, one-way repeated measures multivariate analysis of variance (MANOVA) was performed for simultaneous processing, its subtest (nonverbal matrices, spatio-verbal relations, figure memory; DN CAS) and reading awareness (ESCOLA).

The analysis was conducted based on the results of the Box test, which ensured that the observed covariance matrices of the dependent variables were equal across all groups F_{Box} (75, 3237.750) = 0.797, p = 0.898. The Levene test was also used, which contrasts the univariate variance for each of the variables across the groups. The only variable that did not meet this assumption was figure memory [$F_{nonverbalmatrices}$ (5,84) = 0.369, p = 0.868; $F_{spatio\text{-}verbal\ relations}$ (5,84) = 0.506, p = 0.771; $F_{figurememory}$ (5,84) = 2.862, p < 0.05; $F_{simultaneous}$ (5,84) = 0.849, p = 0.519; $F_{readingawareness}$ (5,84) = 1.174, p = 0.329]. Greenhouse–Geisser correction was used for degrees of freedom, given the violation of the sphericity assumption (Mauchly test). The analyses were performed using the Statistical Package for the Social Sciences (SPSS) version 18.0.

Since the tests applied to the study sample (n = 30) showed reliability indexes lower than 0.70 (calculated with Cronbach's Alpha; Conroy, 2016), where only between one (ESCOLA) and three items (D.N.: CAS) were used from each scale for its calculation (recommended between four and six; Hinkin et al., 1997) We opted to use the sensitivity to change in participants' measures of simultaneous processing, its subtests, and reading awareness. That sensitivity was examined by means of the standardised response mean ratio (SRM; Stratford and Riddle, 2005), calculated using the aggregated scores of the mean change in the items of the scales applied in the pre-post and follow-up measures divided by the standard deviation of the change. The SRM statistics are interpretable on the basis of Cohen's benchmarks (Cohen, 1988) reference values: values of 0.20, 0.50 and 0.80 indicate small, moderate and large effect sizes.

Results

The results obtained showed a main effect of the measures for simultaneous processing, its subtest and reading awareness [F(4.63,194.564) = 8.469, p < 0.001, $\eta^2_{partial}$ = 0.168]. In the posttest and follow-up measures with respect to the pretest, there was a significant increase in the mean scores for simultaneous cognitive process [M_{pre} = 97.34, M_{post} = 103.71, $M_{follow\text{-}up}$ = 108.52; F(2,84) = 5.367, p = 0.006, $\eta^2_{partial}$ = 0.113; SRMpre-post = 0.93, SRMpost-follow = 0.20, SRMpre-follow = 0.77] and for the figure memory subtest [M_{pre} = 7.68, M_{post} = 10, $M_{follow\text{-}up}$ = 10.71; F(2,84) = 4.719, p = 0.011, $\eta^2_{partial}$ = 0.101; SRMpre-post = 0.87, SRMpost-follow = 0.12, SRMpre-follow = 0.81] and a substantial significant increase in the mean scores for reading awareness [M_{pre} = 62.17, M_{post} = 76.32, $M_{follow\text{-}up}$ = 79.13; F(2,84) = 23.244, p < 0.001, $\eta^2_{partial}$ = 0.356; SRMpre-post = 1.84, SRMpost-follow = 0.50, SRMpre-follow = 2.88].

A large main effect of group size on simultaneous processing, its subtest and reading awareness was also observed [F(2.32,194.564) = 15.350, p < 0.001, $\eta^2_{partial}$ = 0.155]. The comparison group showed higher mean scores than those for the intervention group for all of the variables involved in the study: simultaneous [$M_{intervention}$ = 95.04, $M_{comparison}$ = 111.34; F(1,84) = 33.976, p < 0.001, $\eta^2_{partial}$ = 0.288], nonverbal matrices [$M_{intervention}$ = 10.20, $M_{comparison}$ = 13.39; F(1,84) = 15.653, p < 0.001, $\eta^2_{partial}$ = 0.157], spatio-verbal relations [$M_{intervention}$ = 9.05, $M_{comparison}$ = 11.90; F(1,84) = 17.505, p < 0.001, $\eta^2_{partial}$ = 0.172], figure memory [$M_{intervention}$ = 8.21, $M_{comparison}$ = 10.72; F(1,84) = 8.899, p = 0.004, $\eta^2_{partial}$ = 0.096] and reading awareness [$M_{intervention}$ = 70.31, $M_{comparison}$ = 74.77; F(1,84) = 4.184, p = 0.044, $\eta^2_{partial}$ = 0.047].

There was no significant interaction of measure × group for simultaneous processing, its subtest and reading awareness [F(4.63,194.564) = 1.029, p = 0.399, $\eta^2_{partial}$ = 0.024]. However, comparisons between groups for each of the measures did show statistically significant differences in the mean scores. Taking into account the initial differences in the groups in the variables analyzed, after the intervention, the differences were matched according to their performance in reading awareness (Table 1). In the follow-up measure, the intervention group had the same mean scores as those of the comparison group in simultaneous processing and maintained the same reading awareness (Table 1).

The evolution demonstrated by each group from pretest to follow-up showed that the intervention had a modest significant effect on simultaneous processing [ΔM = 15.125, p = 0.035; F(2,84) = 3.508, p = 0.034, $\eta^2_{partial}$ = 0.077; SRMpre-follow = 0.90]. For reading awareness, the improvement in the mean score from the pretest to the posttest (ΔM = 16.750, p = 0.001; SRMpre-follow = 2.45) and the pretest to follow-up (ΔM = 19.438, p < 0.001; SRMpre-follow = 3.10) was also significant, with a large effect size [F(2,84) = 10.642, p < 0.001, $\eta^2_{partial}$ = 0.202]. The comparison group had no significant increase in mean score for any of the study variables from one measure to another.

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TABLE 1 Descriptive statistics and results of the analysis of variance of mixed repeated measures for the intervention and comparison group in the pretest, posttest and follow-up measures in simultaneous processing, its subtest and reading awareness.

Variables	Measures	Groups				
		Intervention	Comparison			
		n = 8	*n* = 22	*n* = 30		
		M (SD)	*M (SD)*	*F (df)*[a]	*p*	$\eta^2_{partial}$[b]
Simultaneous	Pretest	88.50 (11.64)	106.18 (11.96)	13.334	<0.001	0.137
	Posttest	93 (9.26)	114.41 (12.97)	19.548	<0.001	0.189
	Follow	103.63 (8.40)	113.42 (11.90)	4.092	0.051	0.046
Nonverbal matrices	Pretest	9.25 (3.37)	12.82 (3.29)	6.504	0.013	0.072
	Posttest	9.88 (3.14)	13.91 (3.79)	8.313	0.005	0.090
	Follow	11.47 (2.67)	13.45 (3.36)	2.014	0.160	0.023
Verbal-spatial relations	Pretest	8.88 (2.17)	11.23 (2.65)	3.987	0.049	0.045
	Posttest	7.87 (3.27)	12.18 (3.20)	13.365	<0.001	0.137
	Follow	10.41 (2.29)	12.28 (2.90)	2.541	0.115	0.029
Figure memory	Pretest	6 (2.27)	9.36 (3.03)	5.321	0.024	0.060
	Posttest	8.50 (2.45)	11.50 (4.34)	4.233	0.043	0.048
	Follow	10.13 (2.70)	11.30 (3.97)	0.644	0.424	0.008
Reading awareness	Pretest	58.25 (11.49)	66.09 (8.67)	4.325	0.041	0.049
	Posttest	75 (13.61)	77.64 (8.54)	0.489	0.486	0.006
	Follow	77.69 (8.21)	80.57 (7.57)	0.584	0.447	0.007

[a]df = 1.84.
[b]Effect size: small, 0.01; medium, 0.06; large, 0.14 (Cohen, 1988).

Discussion and conclusion

The first objective of the study was to analyze the effect of *Planning Facilitation* on improving the simultaneous processing of information underlying reading comprehension. This objective was achieved. The significant main effect that was obtained for the follow-up measurement on simultaneous processing and its subtests means that the scores for simultaneous processing and subtests varied from the pretest to the follow-up with sensitivity to change in the moderate-character measure. The other significant main effect on simultaneous processing and its subtests obtained for the group means that the scores that varied significantly were those of the intervention group, which were matched to those of the comparison group.

These results confirm, as expected, that there were no statistically significant differences in the scores for simultaneous processing in the follow-up measure in the intervention group compared to the comparison group. *Planning Facilitation* improved simultaneous processing in the group that followed the program. The comparison group, which did not benefit from the instruction, barely changed its average scores from the pretest to the follow-up. The improvement seems to arise from the metacognitive control (planning) of cognitive activity (simultaneous) in reading comprehension tasks.

The second objective was to analyze the effect of metacognitive instruction on improvements in reading awareness. This objective was also achieved. A significant main effect of the measure for reading awareness from pretest to posttest was produced with a large sensitivity to change in the measure. There was also a significant main effect for the group in reading awareness, which means that the scores that varied significantly were those of the intervention group, which were matched to those of the comparison group in the posttest. *Planning Facilitation* improved reading awareness in the group that followed the intervention program with a large sensitivity to change in the measure. The comparison group, which did not benefit from the instruction, barely modified its average scores from the pretest to the follow-up. The improvement occurs in the awareness of the strategies used (metacognitive knowledge) to understand the text. The benefit arises from the metacognitive knowledge of cognitive activity in reading tasks.

These results confirm, as expected, that there were no statistically significant differences in reading awareness scores in the posttest measure or follow-up of the intervention group compared to the comparison group.

The intervention group improved their reading awareness and simultaneous processing to match the comparison group. The improvement obtained by the intervention group occurred at different measurement moments with a large sensitivity to change in the measure. The sequence of effects seems to indicate that awareness of cognitive reading strategies favors the control of underlying reading tasks.

The weak functioning of simultaneous processes was improved by *Planning Facilitation*. This method of intervention, using discussion groups without direct instruction from a professor, also improves reading awareness, which allows students to realize efficient cognitive strategies, the need for others or the adjustment of those strategies used (Rodriguez et al., 2023). Verbalization helps students develop strategies to solve reading tasks with a purpose and to regulate cognitive activity through language itself (Cormier et al., 1990). Verbalization, as part of explicit metacognition, makes it possible to share their own experiences with others, fostering reflective discussion

(Das and Misra, 2015). In seeking a solution to a task, verbalization promotes the recognition and identification of the aspects of simultaneous processing of the task, the anticipation of the limitations inherent to its solution and the development of awareness to resolve it (Kar et al., 1993). The intervention fosters a careful analysis of self-regulation and self-correction of the task (Cormier et al., 1990).

Reading awareness and simultaneous processing were improved with questions directed and guided by mediated intervention and student collaboration to learn to solve. *Planning Facilitation* led participants to become aware of the effectiveness of their strategies and to use or modify them. It also facilitated its generalization. That is, what seems to have happened, regarding the measurement moments, is awareness of the use of the strategies and then the use of the strategies, controlling them.

The program produced a transfer of learning, which can be interpreted as far transfer achieved by the effects of training. The program produced a transfer of what was learned to improvement in the PASS simultaneous process, as well as in reading awareness, showing far transfer (Perkins and Salomon, 1989; Schunk, 2013). The procedures used by the students in the training program were transferred to improving the variables analyzed. The knowledge and metacognitive control of the strategies seems to be favored by an instruction not direct from the teacher but collaborative, mediated and guided toward the transfer and control of the competence. These results show that the skills that were used in the instruction were effective; therefore, these results can be interpreted as supporting the validity of the program.

This result is important because it is difficult to show improvement in cognitive functioning in tasks in which the participants have not received training (Das et al., 1995). This result is also important because it shows the maintenance of improved reading awareness. Finally, it is important because it shows improvement in the control of simultaneous cognitive activity.

The results obtained expand those of Haddad et al. (2003) in the sense that 3rd grade is a good time to address emerging difficulties in learning to read that have not manifested in previous grades, resulting from weakened simultaneous processing. Planning facilitation benefits not only poor planners but also poor simultaneous processors. Its manifestation in 3rd grade seems to be presented by the new academic requirements (complex reading comprehension) and by the activity required for the simultaneous process and the participation of complex cognitive skills (thinking, reasoning, inference, comprehension).

Metacognitive instruction has been useful for students who have followed it to solve their reading difficulties. The mental activity performed by the students and the transfer of knowledge need to be manifested with evidence. Follow-up measurement seems to be essential to demonstrate outcomes, which requires more time, further development and more automation. This necessary automation seems contrary to the need for conscious control at the time of awareness, after which the effective performance of simultaneous cognitive activity was manifested.

This study has limitations that should be resolved in future research. This is a study with an intentional sample to address a specific situation in a classroom with students at risk of learning disabilities and in which metacognitive instruction was provided to subjects who needed an educational response. This has caused a second limitation: the number, balance and assignment of participants to the groups. In terms of the number of participants, it would be necessary to considerably increase the sample size. This would be done, on the one hand, to achieve greater statistical validity of the conclusion for the test used (MANOVA). This would be supported by the use and *a priori* calculation of the sample size using the GPower 3.1 program (Faul et al., 2009). On the other hand, it would be necessary to increase the sample size to improve the internal validity of the study. This would be done by trying to achieve greater reliability in the tests used, as well as greater consistency and reliability in the results obtained by trying to minimize type I and II errors. In addition to increasing the number of participants, the randomization of the sample and its random assignment to groups would have a positive impact on the internal and external validity of the study so that the results could be generalized to other samples of students with reading difficulties.

A representative random 3rd grade sample, with cognitive weakness in simultaneous processing and low reading comprehension, should be trained with the *Planning Facilitation* strategy and contrasted with the results obtained from several comparison groups to demonstrate the validity of effectiveness of this method.

In summary, *Planning Facilitation* has proven to be especially effective in helping 3rd grade students who were at risk of reading difficulty when they were unable to cope successfully with age-appropriate reading tasks. The help provided produced a significant improvement in the students who implemented the instructional strategy in reading awareness and in the simultaneous cognitive process. This allowed them to finish 3rd grade at the expected level of reading performance. The improvement in reading awareness has manifested itself in the postintervention measure and continued in the follow-up measurement. The improvement in simultaneous processing required more time to manifest in the student's knowledge and in their metacognitive control of the cognitive activity, which was observed in the follow-up measurement. All this has allowed students to continue subsequent courses with typical functioning and performance.

Data availability statement

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

Author contributions

MA: Writing – original draft. SA: Data curation, Writing – review & editing. MR: Supervision, Writing – review & editing. ÁC: Supervision, Writing – review & editing. MD: Validation, Writing – original draft.

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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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