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The role of parent-child interactions in developmental psychopathology: Methodological and intervention challenges and opportunities, 2nd edition

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Published in
Frontiers in Child and Adolescent Psychiatry
Frontiers in Public Health

ISSN 1664-8714
ISBN 978-2-8325-5960-4
DOI 10.3389/978-2-8325-5960-4

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The role of parent-child interactions in developmental psychopathology: Methodological and intervention challenges and opportunities, 2nd edition

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Citation

Pearson, R., Rochat, T. J., Coetzee, B., eds. (2025). *The role of parent-child interactions in developmental psychopathology: Methodological and intervention challenges and opportunities, 2nd edition*. Lausanne: Frontiers Media SA. doi: 10.3389/978-2-8325-5960-4

Publisher's note: In this 2nd edition, the following article has been updated:

Pearson RM, Coetzee B and Rochat TJ (2025) Editorial: The role of parent-child interactions in developmental psychopathology: methodological and intervention challenges and opportunities. Front. Child Adolesc. Psychiatry 3:1489804. doi: 10.3389/frcha.2024.1489804

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frontiers | Frontiers in Child and Adolescent Psychiatry

TYPE Editorial
PUBLISHED 27 January 2025
DOI 10.3389/frcha.2024.1489804

OPEN ACCESS

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RECEIVED 01 September 2024
ACCEPTED 24 December 2024
PUBLISHED 27 January 2025

CITATION
Pearson RM, Coetzee B and Rochat TJ (2025) Editorial: The role of parent-child interactions in developmental psychopathology: methodological and intervention challenges and opportunities.
Front. Child Adolesc. Psychiatry 3:1489804.
doi: 10.3389/frcha.2024.1489804

Editorial: The role of parent-child interactions in developmental psychopathology: methodological and intervention challenges and opportunities

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KEYWORDS

parenting, mental health, interventions, development, method

Editorial on the Research Topic
The role of parent-child interactions in developmental psychopathology: methodological and intervention challenges and opportunities

Our research topic called on the field of developmental psychology to update the current status quo on the role of parent-child interactions in children's development. The field answered in robust and creative ways. That said, the collection still reflects historical challenges; an overrepresentation of research in early parenthood relative to the other developmental stages, the use of small observation studies, and a focus on mothers as compared to other caregivers was still apparent.

We summarize and discuss the edition and suggest next steps.

Global representation

The diversity of submissions in the collection reflects a global interest in the topic; it also demonstrates the progress made in ensuring diverse populations are able to contribute knowledge to a field which has long been dominated by research from only a few ethnic groups in mostly high-income settings. The papers include studies from 17 countries representing both high-income and low- and middle-income contexts: Argentina, Belgium, Brazil, Canada, Finland, France, India, Israel, Italy, Japan, Kenya, Netherlands, Norway, Singapore, South Africa, the United Kingdom, and the United States of America.

Developmental time periods

Most papers focused on infancy or early childhood and on interactions with mothers (12 out of 14), which reflects an imbalance in the broader understanding of the value of

interaction and relationships across childhood and into adolescence and adulthood. This limits our understanding of the complex tapestry of relationship dynamics that emerge as children grow and, in particular, as their relational capacities develop with and through interactions with multiple family members including fathers (which only two papers focused on) and siblings. Children develop their capacities to contribute to interactions as they grow through developmental transitions which should develop their independence and autonomy. The current focus on the early years leaves several gaps in our understanding of how interaction develops alongside other socio-emotional and cognitive capacities, as well as how interactions shift and shape beyond the mother-child dyad. In addition, studies that map parenting to developmental growth and specific needs as and when they occur rather than time period would advance the field further.

This focus on the early years limits the potential to innovate in how we intervene at different developmental stages and contexts. It also introduces methodological vulnerabilities because the existing methodologies used for infancy research do not necessarily translate to older age groups. For example, concepts robust in infancy are taken as the gold standard, but we should not assume that concepts such as sensitivity and attachment present in the same way or have the same role in adolescence, a time in which successful developmental transitions would require greater autonomy and in which it may be adaptive to have "de-attach". Studies included in the collections offer considerations of this and present potential methodological approaches that could inform observational research in middle childhood and adolescence (Wright et al., Lekhuleni et al.).

Much as looking forward to later development is important, considering pre-conception (including previous intergenerational pathways) and the prenatal period is key. While the pre-natal period is recognized biologically as having an impact on fetal and thus child development, its psycho-social influence on parent-child interactions is often overlooked. One study looked at the role of BMI in pre-pregnancy on later peer problems (Dow et al.), recognizing both biological and social pathways. No papers came forward looking at multi-generational influences or the role of new reproductive methods to conceive and the role of fertility treatment, which is a key change in contemporary pre-conception parenting journeys.

Parents are always parents, and their role and influence likely extend beyond the dependent years even into many generations after their death. Similarly, modern and complex ways of experiencing and contrasting the context of parent-child relationships were not extensively explored in this collection; for example, no studies captured the complexities of half, step, adoptive, and single parents or same-sex parenthood.

Methodological advances

We specified that we were interested in interactions, and this was considered by authors in many ways. Some studies examined interactions in their simplest forms, exploring well known constructs like "responsiveness", while others explored more complex coding matrices on mutual affect and what can be learned from micro-coding, emotional recognition, and the use of Artificial Intelligence (AI) and how these technologies may support an openness to new understandings not limited by historical knowledge and standards. In addition, more global assessments of interactions were included, such as concepts of sensitivity or attachment that re not taken from one moment alone. Rather, concepts such as sensitivity are taken as greater than the component micro moments and, in some ways, rely on a subjective sense by the observer. Greater periods of time were generally assessed by self-reports of perceptions; these included simple proxies of interactions based on working hours in Japan, the use of routines during lockdown, or the recall of childhood events such as neglect or emotional trauma in parent-child relationships.

The collection does suggest researchers are beginning to grapple with this and expand methodologies to include bio-psycho-social processes as a means to engage with the potential multiple and competing pathways that may be involved in outcomes (see for example Braithwaite's examination of interactions and their biological signals embedded in DNA methylation). These different ways of "knowing" or gaining insights into the parent-child interaction or relationship were exciting to see and the next steps may include triangulation and understanding.

Other exciting methodological developments presented as part of the collection include the richness of new tasks and protocols. These explored creative approaches in protocol development to observe parent-child interactions, such as using free play, structure, attachment protocols, and specific games in research "labs" or at home (1). These also extend to the use of new technology such as wearable cameras and AI, which offer exciting opportunities for future research. Similarly, a refreshing theme of co-production and creativity in engagement emerged from the papers as a new norm and foundation to challenge ideas and develop methodology. Such co-production included art (Culpin et al.), mobile pop-up events (Wright et al.), and new ways of engaging in "talk" with adolescents in groups (Lekhuleni et al.).

In addition, to gain statistical power to reach a larger sample size, it is key that more work is done in collaboration and that data sharing and harmonization is *a priori*ty. Some important examples are found in this collection, with studies designing aligned protocols in multiple settings (Bornstein et al.) or protocols being developed to harmonize data from consortiums of cohort studies that followed different protocols and did not initially aim to be brought together (e.g., Dream Big Consortium) (2).

Intervention advances

Only one study investigated the role of interventions (Braithwaite et al.). However, many more provided evidence.

For example, the use of wearable cameras to enhance video-feedback via first person perspective was noted in three of the

included papers in this topic. This is important as a recent meta-analysis of 59 randomized controlled studies found that psycho-educational advice alone is not effective in reducing later mental health disorders (3). Rather, relational support at home, in practice, is the key causal ingredient in parenting interventions in preventing mental health risk and increasing parents' self-efficacy.

Wearable camera devices for both children and babies are described in this topic (Skinner et al.); as they capture the same moment for both parties, the devices enable the viewing of shared emotions and how the interaction was different from different viewpoints, aiding introspection and reflective functioning. The co-production development work highlighted in this topic (Wright et al.) reports that parents notice more mental state signals when viewing first-person perspective footage and can more easily re-live the moment when it is viewed back "through their eyes".

In addition, some of the AI discussed in this issue, such as face-reader, could support interventions. Finding moments of strength is key to video-feedback but is limited by practitioners scanning through lots of footage and hampered by natural human subjectivity/error. Face-reader technology, described in this topic, records intensity of emotions (such as sadness or happiness) concurrently in parent and child on a scale between 0 and 1, every 0.02 s, allowing statistical modelling of subtle transitions in emotion. Face-reader processing systems could automatically indicate key moments, drastically saving time and potentially standardizing the selection of footage alongside personalized input, where AI and therapists work together.

Interventions in context

Finally, studies in this collection looked at the role of previous contexts on later outcomes (Hill et al.), demonstrating that when trauma happens (in this case exposure to violence) the child's attachment history is relevant. This is also seen in trauma-informed care. How trauma may interact with mindfulness to predict later eating disorders was also explored (Royer et al.). In combination, these papers support more personalized and systemic approaches to parenting interventions, considering a developmental lens.

Author contributions

RP: Conceptualization, Writing – original draft. BC: Conceptualization, Writing – review & editing. TR: Conceptualization, Writing – review & editing.

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 author(s) declared that they were an editorial board member of Frontiers, at the time of submission. This had no impact on the peer review process and the final decision.

Funding

The author(s) declare financial support was received for the research, authorship, and/or publication of this article. This work was supported by European Research Council (ERC) under the European Union's Seventh Framework Programme (grant FP/2007-2013), European Research Council Grant Agreements (grant 758813; MHINT) held by RP.

Publisher's note

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frontiers | Frontiers in Child and Adolescent Psychiatry

TYPE Original Research
PUBLISHED 28 October 2022
DOI 10.3389/frcha.2022.971743

OPEN ACCESS

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SPECIALTY SECTION
This article was submitted to Developmental Psychopathology and Mental Health, a section of the journal Frontiers in Child and Adolescent Psychiatry

RECEIVED 17 June 2022
ACCEPTED 17 August 2022
PUBLISHED 28 October 2022

CITATION
Dow C, Lorthe E, Galera C, Tafflet M, Marchand-Martin L, Ancel P-Y, Charles M-A and Heude B (2022) High maternal pre-pregnancy BMI is associated with increased offspring peer-relationship problems at 5 years. *Front. Child Adolesc. Psychiatry* 1:971743.
doi: 10.3389/frcha.2022.971743

High maternal pre-pregnancy BMI is associated with increased offspring peer-relationship problems at 5 years

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Background: Peer relationships are an important aspect of child development that are often overlooked. Maternal pre-pregnancy body mass index (BMI) may influence peer relationships through intrauterine mechanisms affecting fetal neurodevelopment or through postnatal mechanisms including social discrimination of the obese mother/child. This study aimed to determine the relationship between maternal pre-pregnancy BMI and child peer-relationship problems around 5 years old, including preterm and term-born children.

Methods and findings: Maternal BMI and offspring peer-relationship problems were assessed in participants of three French birth cohorts: EDEN (n = 1,184 children born at term), ELFE (n = 10,889 children born ≥33 weeks of gestation) and EPIPAGE-2 (n = 2,646 children born 23–34 weeks of gestation). Reported or measured pre-pregnancy weight (kg) and height (m) were collected from mothers and used to calculate BMI (kg/m²). Offspring peer-relationship problems were assessed using the Strengths and Difficulties Questionnaire at 5.5 years. Logistic regression was used to estimate odds ratios (OR) of a high peer-relationship problem score (≥3) in EDEN and ELFE, and generalized estimated equations were used in EPIPAGE-2 to account for the large number of multiple births. Paternal BMI was used as a negative control in sensitivity analyses. Maternal pre-pregnancy obesity was associated with increased odds of a high peer-relationship problem score in all three cohorts, independent of confounding factors [adjusted OR 2.27 (1.32, 3.88); 1.52 (1.29, 1.78); 1.44 (1.04, 1.99); for EDEN, ELFE and EPIPAGE-2, respectively]. Additional analysis based on negative controls (i.e., adjusting for paternal BMI) showed the same pattern of associations.

Conclusion: High maternal pre-pregnancy BMI is associated with greater likelihood of a high peer-relationship trouble score in offspring around 5 years of age in both children born preterm and at term.

KEYWORDS

maternal obesity, behavioral problems, pre-pregnancy, peer problems, lifecourse

Introduction

The perinatal period is an extremely important timeframe for neurodevelopment, sensitive to both environmental and biological stressors. Such stressors are believed to impair normal growth and development and create the basis for the Developmental Origins of Health and Disease (DOHaD), an approach in public health research focused on the role of the pre- and perinatal environment in determining the development of diseases in adulthood [1]. Maternal pre-pregnancy obesity is a potential stressor on fetal development that has been exponentially increasing in prevalence worldwide [2]. The exact mechanisms through which maternal obesity may cause insults to the developing fetus remain to be elucidated. However, metabolic changes, inflammation, variations in the steroid or hormonal environment and induced epigenetic changes (that may occur as a consequence of the previous factors) have been identified as likely culprits [3]. In particular, large epidemiological studies have linked maternal pre-pregnancy obesity to a host of neurodevelopmental issues for the offspring including autism spectrum disorder, schizophrenia, cognitive impairment, attention deficit hyperactivity disorder (ADHD), depression and anxiety [3]. Nevertheless, whether maternal obesity affects the development of peer-relationship problems in childhood has not been studied in detail, despite the significance of peer relationships in healthy development.

Peer relationships are an important aspect of child development that often seems to be overlooked. Yet, they represent an "absolute necessity for healthy cognitive and social development and socialization" [4]. Studies show that early peer relationships affect early adulthood social adjustment. Correlations have been observed between early relationships and externalizing symptoms such as aggressive, suicidal, and illegal behavior [5–7] and internalizing problems such as anxiety and depression [8]. Children with good peer relationships also tend to accomplish more academically, have greater emotional wellbeing, and value prosocial behavior more strongly than children with troublesome peer relationships [5, 9].

Though several studies have examined the role of maternal pre-pregnancy obesity on child behavior in general, many do not discriminate between domains. Yet, in the few that have examined different aspects of behavior separately, the associations observed are usually far from uniform across domains [10–12]. With regards to peer-relationship problems, some prospective cohort studies have noted a positive association between maternal pre-pregnancy obesity and peer problems in childhood with up to twofold increased odds [10, 13], while others have observed no association [12, 14, 15] and in one, the association varied depending on the reporter (parents or teacher) [11]. All of these studies were quite limited in the confounding factors they accounted for, some of which have been quite consistently linked to child neurodevelopment, such as the maternal diet and maternal alcohol intake [16, 17]. Other factors are likely important candidates for confounding, such as maternal physical activity and maternal mental health [18, 19] and were also not taken into account. In addition, none of these studies were able to evaluate the same children across time, yet the severity of symptoms may vary with time and depend strongly on the types of environments children are exposed to at different ages. Finally, to our knowledge, there are no studies that have examined the impact of maternal pre-pregnancy obesity on the development of peer problems in preterm offspring, who represent a developmentally unique group already at increased risk of neurodevelopmental deficits, including behavioral problems, compared to children born at term [20, 21].

Thus, the objective of our study was to determine whether maternal pre-pregnancy body mass index (BMI) was associated with peer-relationship problems in children between the ages of 3–8 years in three French birth cohorts, one of which is a large cohort of infants born moderately to extremely preterm (<34 weeks gestation) while simultaneously adjusting for important potential confounders of the relationship such as maternal lifestyle behaviors (diet, exercise, alcohol and tobacco consumption) and maternal mental state during pregnancy.

Materials and methods

Study populations

EDEN

EDEN is a mother-child cohort initiated in the French cities of Nancy and Poitiers in 2003 [22]. Its goal was to study both pre- and post-natal determinants of child health and development. A total of 2002 expecting mothers (<24 weeks of gestation) agreed to participate in the study and were recruited from two maternity clinics if they had singleton pregnancies, no known diabetes before pregnancy, were French literate and had no plans to move out of the region in the following 3 years. During pregnancy, 95 of these mothers withdrew from the study (Supplementary Figure 1a). Data collection was *via* questionnaires, clinical examinations and cognitive assessments from pregnancy to 12 years of age and is still ongoing. At study enrollment, written informed consent was obtained from parents.

ELFE

ELFE (French Longitudinal Study since Childhood) is a nationwide mother-child cohort that was initiated in 2011 to study the determinants of child health, development and socialization from birth and throughout the lifecourse [23]. Maternities throughout metropolitan France were randomly selected and 320 (92%) agreed to participate. Recruitment took place over 25 days divided into four periods during the year. Mothers were approached after delivery if they had: birth(s) ≥33

weeks of gestation, were at least 18 years old, and had no plan to leave metropolitan France in the following 3 years. Consent was obtained from parents or the mother alone (with the father informed of his right to oppose) at enrollment and all documents were available in French, English, Arabic and Turkish.

A total of 18,040 mothers agreed to participate in ELFE and gave birth to 18,329 babies (Supplementary Figure 1b). Since enrollment, 59 women asked to withdraw from the study, giving rise to an initial study population of 18,270 children. Data collection was *via* phone interview, internet and paper questionnaires with one or both parents, home visits and physician-filled questionnaires. Biological samples were also collected, school medical examination records were obtained and nursery schoolteachers completed questionnaires.

EPIPAGE-2

EPIPAGE-2 is a population-based French cohort of infants born preterm designed to study the determinants of preterm birth, short and long-term outcomes and the impact of changes in provided care and practices on preterm infants [24]. Participants were recruited from March to December 2011 in all maternities throughout 25 of 26 regions of France. Live born, stillborn, and terminations of pregnancy between 22 and 34 weeks of gestation were eligible. Participants were classified into one of three gestational age groups: extremely preterm (22–26 weeks of gestation), very preterm (27–31 weeks), or moderately preterm (32–34 weeks) and longer recruitment periods were undertaken for smaller gestational age groups. A total of 7,804 were enrolled in EPIPAGE-2, of these, 4,467 infants were discharged from neonatal care alive and 177 withdrew (family refused or child died), resulting in 4,290 infants eligible for follow-up (Supplementary Figure 1c).

Data were collected at birth and during the neonatal period by questionnaires completed by the obstetrical and neonatal teams or extracted from medical records. Information in the follow-up period was collected through questionnaires completed by parents, physicians, and/or health assessments at regional exam centers.

Ethics

Ethics approval for data collection in ELFE and EPIPAGE-2 was obtained from the French National Commission on Informatics and Liberty (CNIL), the Advisory Committee on Information Processing in Maternal Research in the Field of Health (CCTIRS) and the Committee for the Protection of People (CPP). The EDEN cohort was approved by the Bicêtre Hospital ethics committee and the CNIL.

Exposure assessment

In EDEN, maternal height was measured by midwives and pre-pregnancy weight was self-reported between 24 and 26 weeks of gestation. In ELFE, information on pre-pregnancy weight and height were collected in face-to-face interviews or self-administered questionnaires at the time of delivery. In EPIPAGE-2, information about pre-pregnancy weight and height were extracted from medical records. Pre-pregnancy BMI was calculated and classified as: underweight ($<18.5 kg/m^2$), normal (18.5–24.9 kg/m^2), overweight (25.0–29.9 kg/m^2) and obese ($\geq 30 kg/m^2$).

Outcome assessment

The Strengths and Difficulties Questionnaires (SDQ) is a validated tool used to assess behavioral difficulties in children [25]. It includes five domains: peer-relationship troubles, hyperactivity-inattention, emotional symptoms, conduct problems and prosocial behavior. Each domain is comprised of 5 items, the following are the items included in the peer-relationship domain: (1) rather solitary, tends to play alone; (2) has at least one good friend; (3) generally liked by other children; (4) picked on or bullied by other children; (5) gets on better with adults than other children. The responses vary on a 3-point Likert scale from "Not true (0 points)" to "A little true (1 points) to "Very true (2 points)." This results in a score ranging from 0 to 10 for each domain.

The SDQ was administered to parents when children were aged 3, 5.5 and 8 in the EDEN cohort, and 5.5 years in ELFE and EPIPAGE-2. In ELFE, SDQ data were collected for 11,247 children and after excluding the small number of twins, the study sample was comprised of 10,889 children. In EPIPAGE-2, SDQ data were collected for 2,646 children. The mean scores were: 1.2, 1.2 and 1.5 for EDEN, ELFE and EPIPAGE-2, respectively. A score $\geq$90th percentile in EDEN and ELFE was considered "high-risk" for all three cohorts, which corresponded to a score $\geq$3. This threshold corresponded to the 88th percentile in EPIPAGE-2 and is consistent with the classic SDQ cut-off, which considers the extreme 10% of the population as the "high-risk" group [25].

Covariates

Covariates collected from parents in all cohorts included parental: age, level of education, country of birth, employment status, household income or socioeconomic status, cohabitation and region of residence. Variables related to the pregnancy were: folic acid intake before conception, parity, gestational weight gain (GWG; EDEN/ELFE), gestational diabetes (GDM), pre-existing diabetes (ELFE), hypertension in pregnancy,

pre-eclampsia, psychiatric problem before or during pregnancy (EDEN/ELFE) or anxiety score during pregnancy (EPIPAGE-2), maternity center, cause of prematurity (EPIPAGE-2), type of delivery, and duration of breastfeeding. Maternal lifestyle covariates encompassed: smoking in pregnancy, alcohol intake in pregnancy (EDEN/ELFE), dietary profile score during pregnancy (EDEN) [26]/score of adherence to the National Nutrition guidelines for pregnant women (ELFE) [27] and physical activity score [EDEN: *ad-hoc* from principal component analysis; ELFE: score derived from the Pregnancy Physical Activity Questionnaire = metabolic equivalents $(METS)_{activity} \times$ time (hours) $\times$ 7 days] [28]. Lastly, variables related to the child were: gestational age at birth, sex, birth weight, childcare from birth to 5 years, sleep duration at 2 years (EDEN/ELFE), night waking at 2 years (EDEN/EPIPAGE-2), difficulty falling asleep (ELFE only, at 2 years), duration of weekly screentime at 2 years (ELFE) and the HOME (Home Observation Measurement of the Environment) questionnaire (5.5 years) which measures the level of stimulation in the child's home environment (EDEN/EPIPAGE-2) [29].

Statistical analyses

Missing data and weighting

Missing data were imputed using multiple imputation with chained equations, generating 60 datasets in EDEN, 45 in ELFE and 65 in EPIPAGE-2. The number of imputed datasets was chosen based off the fraction of missing information in the parameters included in the procedure. The variables included in the multiple imputation were all those listed previously. To impute categorical variables, the discriminant function method was employed, and predictive mean matching was used to impute quantitative variables.

We previously observed differences in attrition by baseline characteristics in EDEN [30]. Inverse probability weighting was used to correct this bias due to loss to follow-up. Logistic regression (EDEN and ELFE) or generalized estimating equations (GEE; to take into account the large proportion of multiple births; EPIPAGE-2) were fit for baseline data associated with not having available data for the SDQ ($p < 0.20$) to calculate stabilized weights. The best models were chosen based on parsimony and by comparing Akaike information criterion (AIC) between nested models.

Data analysis

Descriptive analyses were performed on all populations to describe the overall distribution of characteristics. In EPIPAGE-2, the descriptive statistics were weighted to account for the recruitment scheme. Characteristics of participants with low and high ($\geq$3) peer-relationship trouble scores were compared using ANOVA or chi² test, as appropriate.

A thorough review of the literature and the construction of a DAG identified potential confounding factors. Logistic regression was then used to analyze the association between maternal pre-pregnancy BMI and either a high score on the peer-relationship trouble domain (EDEN, ELFE, EPIPAGE-2) or a high peer-relationship trouble score trajectory (EDEN) for all children with follow-up. Models were adjusted for all potential confounding factors identified in the literature review and confounders were retained if they contributed to lowering the AIC, if they modified the beta coefficients (>10%) or if they were considered essential to adjust for (i.e., sex). All statistical analyses were completed in SAS 9.4 (SAS Institute Inc, Cary, NC).

Sensitivity analyses

First, linear regression was conducted in all cohorts between maternal pre-pregnancy BMI and the continuous score on the SDQ peer-relationship problem domain. Next, complete case analyses were conducted using only mother-child pairs with no missing data for the exposure, outcome or covariates. Third, we tested for interactions with sex, gestational age, singleton pregnancy (ELFE and EPIPAGE-2) and cause of prematurity (EPIPAGE-2).

Fourth, paternal BMI can provide valuable information as a negative control. Using paternal BMI could provide support for a direct, causal association of maternal BMI if paternal BMI does not have a similar magnitude as maternal BMI with child peer-relationship problems [31]. We both adjusted for paternal BMI in the same model with maternal pre-pregnancy BMI, as well as ran analyses with paternal BMI separately, considered as the main exposure. Due to the high amount of missing data for paternal BMI in ELFE (31.0%) and EPIPAGE-2 (64.9%) we also ran complete-case analyses using only observations for which paternal BMI was not imputed.

Fifth, as we had SDQ data available at three time points in EDEN [3 (n = 1,307), 5.5 (n = 1,184), and 8 years (n = 875)], we conducted group-based trajectory modeling, which allowed the identification of specific clusters of children with similar developmental patterns over the time period. These clusters were not based on a set of pre-defined characteristics, but rather the scores of the SDQ [32]. Each child with at least one SDQ assessment was included, resulting in a study population of 1,428 children. The procedure used to derive the trajectories has been detailed previously [33]. Briefly, trajectories were derived using semi-parametric mixed models with censored-normal distributions. To identify the best models, the Bayesian Information Criterion was used to single out the ideal models with respect to the number of groups and polynomial order. The quality of the model was evaluated by maximizing the posterior probability of group membership according to recommendations ($\geq$0.7) [32]. Three groups of peer-relationship problems were derived: low (17.7%), medium

(75.5%), and high (6.8%), which were subsequently classified into high vs. other. We also conducted individual analyses in children at 3 and 8 years.

Results

Descriptive

The descriptive characteristics of the EDEN population are shown in Table 1A. Children with higher peer-relationship trouble scores were more likely to be the first born, to have mothers with psychological problems during pregnancy and to have a smaller gestational age. The descriptive characteristics of the ELFE and EPIPAGE-2 populations are displayed in Tables 1B,C. In both cohorts, children with higher peer-relationship problem scores at 5 years had slightly younger mothers, who were more likely foreign-born, with lower socioeconomic status, and primiparous. In ELFE, children with more peer-relationship problems were more likely born to underweight or overweight/obese mothers, who were more likely to have GDM, hypertension, psychological problems, smoke during pregnancy and have worse diet quality. The children were also more likely to have their parents care for them than professionals and to have a higher weekly duration of screentime and more sleep difficulties. In EPIPAGE-2, higher scores were observed more often in children with lower birthweight, who were born more premature, in mothers without normal BMI, in mothers without hypertension, and mothers with higher anxiety scores during pregnancy. The children were more often cared for by parents, had more frequent night waking at 2 years, and had less stimulating home environments.

Maternal BMI and offspring peer-relationship problems

In unadjusted logistic regression, maternal pre-pregnancy obesity was associated with more than two-fold increased odds of a high peer-relationship problem score at 5.5 years in EDEN and two-fold increased odds of a high score at 5.5 years in ELFE (Table 2). The magnitude of the unadjusted relationship in infants born premature was relatively smaller [OR 1.62 (1.19, 2.20)]. In all three cohorts, adjustment for covariates slightly attenuated the magnitude of the association, however, the association remained statistically significant in the final models.

Maternal pre-pregnancy overweight was not associated with high offspring peer-relationship problem scores in EDEN or EPIPAGE-2 [aOR 1.06 (0.66, 1.69); aOR 1.03 (0.77, 1.38), respectively]. In ELFE, maternal overweight was associated with 20% increased odds of a high peer-relationship problem score at 5.5 years in adjusted analyses.

Maternal pre-pregnancy underweight was not associated with peer-relationship problem scores in EDEN [aOR 1.14 (0.61, 2.13)], but it was associated with 30% increased odds of a high peer-relationship problem score in ELFE and near the limit of statistical significant in EPIPAGE-2 [aOR 1.51 (0.98, 2.31)].

Sensitivity analyses

Linear analyses in both EDEN and ELFE supported a positive association between maternal pre-pregnancy obesity and high offspring peer-relationship problem scores around 5 years of age (Supplementary Table 1). In EPIPAGE-2, a positive relationship between maternal obesity and increasing peer-problem scores was observed in univariate analyses but attenuated below the threshold of statistical significance after adjustment for confounders [$a\beta$ 0.19 (−0.04, 0.41)]. Maternal overweight was not associated in linear analyses with increasing peer-relationship problem scores in any of the three cohorts. But, maternal underweight was associated with increasing peer-relationship problem scores in ELFE [$a\beta$ 0.12 (0.02, 0.23)] and showed a higher, though non-statistically significant magnitude in EPIPAGE-2 [$a\beta$ 0.24 (−0.06, 0.52)].

In complete-case analyses the associations observed changed little from those observed in the main results (Supplementary Table 2). None of the interactions tested were significant in EDEN or ELFE ($p > 0.10$). On the other hand, in EPIPAGE-2, we observed a significant interaction between maternal BMI and the cause of prematurity ($p = 0.04$; Supplementary Table 3). When the cause of prematurity was due to a vascular pathology, isolated placental abruption or isolated intrauterine growth restriction (IUGR) the odds of an increased peer problem score in offspring of both underweight and obese mothers was much higher [aOR 3.16 (1.22, 8.91); 2.57 (1.57, 4.21) for underweight and obese, respectively]. There was no association between maternal pre-pregnancy BMI and offspring peer-relationship problems in women with preterm labor [aOR 1.06 (0.58, 1.94); 1.37 (0.78, 2.41) for underweight and obese, respectively]. On the other hand, we observed an inverse, though non-statistically significant, association between pre-pregnancy obesity and offspring peer-relationship problems when the cause of prematurity was preterm premature rupture of the membranes [PPROM; aOR 0.50 (0.23, 1.06)].

Adjustment for paternal BMI did not change estimates in any cohort (Figure 1). When paternal BMI was modeled separately without maternal BMI it was not associated with offspring peer-relationship problems [aOR 1.40 (0.69, 2.88); aOR 1.20 (0.96, 1.51); aOR 1.13 (0.70, 1.82); for paternal obesity in EDEN, ELFE, and EPIPAGE-2, respectively].

Similar relationships between maternal obesity and underweight with offspring peer-relationship problem score trajectories (3–8 years) were observed as those at 5.5 years in EDEN (Supplementary Table 4). The magnitude of the

TABLE 1A Descriptive characteristics of the EDEN study population overall and by SDQ peer-relationship score at 5.5 years ($n = 1,184$).

Variable	Study population $N = 1,184$	SDQ peer-relationship problem score N (%) or mean [STD]		p-value[a]
		"Low-risk" $n = 1,014$	"High risk" $n = 170$	
Socioeconomic factors				
Center ($n = 1,184$)				
Poitiers	629 (53.1)	540 (53.3)	89 (52.4)	0.83
Nancy	555 (46.9)	474 (46.7)	81 (47.6)	
Mother's age at delivery (years) ($n = 1,184$)	30.1 [4.7]	30.2 [4.6]	29.9 [5.1]	0.58
Maternal education (birth) ($n = 1,180$)				
High	715 (60.6)	632 (62.5)	83 (49.1)	<0.01
Medium	414 (35.1)	339 (33.5)	75 (44.4)	
Low	51 (4.3)	40 (4.0)	11 (6.5)	
Parental lifestyle/health characteristics				
Parity (including stillbirths) ($n = 1,182$)				
0	549 (46.4)	458 (45.3)	91 (53.5)	0.08
1	415 (35.1)	370 (36.6)	45 (26.5)	
2	162 (13.7)	136 (13.4)	26 (15.3)	
≥3	56 (4.7)	48 (4.7)	8 (4.7)	
Maternal BMI category ($n = 1,164$)				
Underweight (<18.5 kg/m^2)	91 (7.8)	77 (7.7)	14 (8.3)	<0.01
Normal (18.5–24.9 kg/m^2)	763 (65.5)	666 (66.9)	97 (57.7)	
Overweight (25–29.9kg/m^2)	207 (17.8)	176 (17.7)	31 (18.5)	
Obese (≥30 kg/m^2)	103 (8.8)	77 (7.7)	26 (15.5)	
Paternal BMI category ($n = 1,109$)				
Underweight (<18.5 kg/m^2)	9 (0.8)	7 (0.7)	2 (1.3)	0.43
Normal (18.5–24.9 kg/m^2)	574 (51.8)	491 (51.7)	83 (52.2)	
Overweight (25–29.9 kg/m^2)	425 (38.3)	370 (38.9)	55 (34.6)	
Obese (≥30 kg/m^2)	101 (9.1)	82 (8.6)	19 (11.9)	
Smoking during pregnancy ($n = 1,179$)				
No	926 (78.5)	799 (79.0)	127 (76.0)	0.40
Yes	253 (21.5)	213 (21.0)	40 (24.0)	
Alcohol intake during pregnancy ($n = 1,184$)				
No	565 (47.7)	480 (47.3)	85 (50.0)	0.52
Yes	619 (52.3)	534 (52.7)	85 (50.0)	
Exercise during pregnancy (score) ($n = 1,142$)	0.0 [1.0]	0.1 [1.0]	−0.1 [1.0]	<0.01
Western diet during pregnancy (score) ($n = 1,028$)	−0.1 [0.9]	−0.1 [0.9]	0.0 [1.0]	0.05
Gestational weight gain (kg) ($n = 1,161$)	13.1 [4.8]	13.2 [4.6]	13.1 [5.5]	0.8
Any psychiatric disorder (during pregnancy) ($n = 1,184$)				
No	1,112 (93.9)	954 (94.1)	158 (92.9)	0.56
Yes	72 (6.1)	60 (5.9)	12 (7.1)	
Child characteristics				
Gestational age ($n = 1,184$)				
<37 weeks (preterm)	68 (5.7)	54 (5.3)	14 (8.2)	0.26
37–38 weeks (early term)	215 (18.2)	182 (18.0)	33 (19.4)	
≥39 weeks (term)	901 (76.1)	778 (76.7)	123 (72.3)	
Birth weight (g) ($n = 1,184$)	3,292 [515.7]	3,289 [501.6]	3,315 [594.1]	0.54
Sex of the child ($n = 1,184$)				

(Continued)

TABLE 1A (Continued)

Variable	Study population $N = 1,184$	SDQ peer-relationship problem score N (%) or mean [STD]		p-value[a]
		"Low-risk" $n = 1,014$	"High risk" $n = 170$	
Male	626 (52.9)	532 (52.5)	94 (55.3)	0.49
Female	558 (47.1)	482 (47.5)	76 (44.7)	
Childcare (2 years) ($n = 1,165$)				
Parents	293 (25.2)	244 (24.5)	49 (29.2)	<0.01
Relatives	151 (13.0)	118 (11.8)	33 (19.6)	
Professional/childcare center	226 (19.4)	207 (20.8)	19 (11.3)	
Maternal assistant	495 (42.5)	428 (42.9)	67 (39.9)	
Age at 5 years follow-up (months) ($n = 1,184$)	67.1 [1.9]	67.1 [1.9]	67.2 [2.0]	0.45

[a]Difference among BMI categories, by ANOVA or by chi² test.

relationship with maternal overweight was higher but statistically non-significant with the 3–8 year peer-relationship problem score trajectories. In individual analyses at 3 years in EDEN, none of the maternal pre-pregnancy BMI classes were associated with high offspring peer-relationship problem scores. At 8 years, none of the estimates reached statistical significance but were similar in magnitude to those estimated in ELFE at 5.5 years.

Discussion

Using data from three French birth cohort studies, including a large study of infants born premature, we found that children whose mothers were obese before pregnancy were much more likely to have adverse peer-relationship problems at 5 years of age than children whose mothers had a healthy pre-pregnancy BMI. The fact that we observed this relationship in three separate cohorts with children around the same age, using both clinically significant thresholds and continuous scores further strengthens our results. Our findings were also robust to adjustment for a variety of important confounding factors that previous studies did not take into account, such as maternal diet, physical activity, and alcohol intake. Paternal BMI was not associated with peer-relationship problem scores and did not change our estimates when it was included in the model, in favor of a direct intrauterine effect of maternal BMI on the offspring rather than residual confounding by genetics or the postnatal environment.

Our findings are consistent with previous studies that also observed an increased risk of social problems in children born to mothers with pre-pregnancy obesity [10, 11, 13]. However, not all of these studies are completely in accordance. Jo et al. [10] only observed this relationship among mothers in obesity class II/III (≥35 kg/m²) and the relationship showed no association with obese class I [OR = 1.01 (0.57, 1.78)]. On the other hand, Mikkelsen et al. [13] observed a significant association in both overweight and obese mothers. Menting et al. [11] only reported a significant association between teacher-rated peer-relationship problems and maternal pre-pregnancy obesity, but not mother-rated social problems. Finally, several other studies did not observe any relationship with maternal obesity and peer-relationship problems in offspring [12, 14, 15]. One reason for the variability in the results could be the age of evaluation, ages ranged from 4 to 8 years and a child at ages 3/4 vs. 5/6 or 7/8 years old are at very different developmental stages with regards to social and emotional development [34]. Indeed, we observed no association at 3 years in EDEN, despite observing a non-statistically significant association at 8 years of similar magnitude to that of ELFE and EPIPAGE-2 at 5 years. There may also be disparity in the results due to the wide range of countries across these studies, as the impact of maternal obesity may differ across ethnic groups [35].

In EDEN, we observed the strongest association between high maternal pre-pregnancy BMI and offspring peer problems at 5.5 years. Peer problems may not yet be as evident in children as young as 3 years old, as social development is still quite immature. To our knowledge, the youngest age that peer problems have been examined in association with maternal pre-pregnancy BMI is around 4 years old [12]. This study did not observe a relationship between mothers with severe pre-pregnancy obesity (≥40 kg/m²) and offspring peer-relationship problems, however, the cohort was relatively small. On the other hand, at 8 years, our results suggest a tendency toward increased peer-relationship problems that was not statistically significant. This could be due to a lack of statistical power in our 8-year population, but Robinson et al. [14] did not observe a relationship between obesity or severe obesity and child-relationship problems in children at 7–8 years. Conversely, Menting et al. [11] observed increased likelihood of teacher-reported peer-relationship problems in children between 5 and

TABLE 1B Descriptive characteristics of the overall population and by SDQ peer-relationship trouble score in ELFE ($n = 10,889$).

Variable	Study population $N = 10,889$	SDQ peer-relationship problem score N (%) or mean [STD]		p-value[a]
		"Low-risk" $n = 9,309$	"High risk" $n = 1,580$	
Sociodemographics				
Maternal age at child's birth ($n = 10,849$)	30.9 [4.7]	31.0 [4.6]	30.6 [5.1]	<0.01
Maternal education (birth) ($n = 10,887$)				
High	7,374 (67.7)	6,497 (69.8)	877 (55.5)	<0.001
Medium	3,036 (27.9)	2,470 (26.5)	566 (35.8)	
Low	477 (4.4)	340 (3.7)	137 (8.7)	
Monthly revenue ($n = 10,399$)				
1st quartile (lowest)	1,719 (16.5)	1,529 (17.1)	190 (12.9)	<0.001
2nd quartile	2,534 (24.4)	2,224 (24.9)	310 (21.0)	
3rd quartile	3,575 (34.4)	3,114 (34.9)	461 (31.3)	
4th quartile (highest)	2,571 (24.7)	2,058 (23.1)	513 (34.8)	
Parity ($n = 10,749$)				
0	4,963 (46.2)	4,146 (45.1)	817 (52.4)	<0.001
1	3,919 (36.5)	3,449 (37.5)	470 (30.2)	
2	1,400 (13.0)	1,212 (13.2)	188 (12.1)	
≥3	467 (4.3)	384 (4.2)	83 (5.3)	
Parental health/lifestyle				
Maternal BMI category ($n = 10,743$)				
Underweight (<18.5 kg/m²)	755 (7.0)	638 (6.9)	117 (7.5)	<0.001
Normal (18.5–24.9 kg/m²)	7,244 (67.4)	6,304 (68.6)	940 (60.4)	
Overweight (25–29.9 kg/m²)	1,774 (16.5)	1,481 (16.1)	293 (18.8)	
Obese (≥30 kg/m²)	970 (9.0)	763 (8.3)	207 (13.3)	
Paternal BMI category ($n = 9,379$)				
Underweight (<18.5 kg/m²)	72 (0.8)	61 (0.8)	11 (0.9)	0.10
Normal (18.5–24.9 kg/m²)	5,221 (55.7)	4,540 (56.1)	681 (52.9)	
Overweight (25–29.9 kg/m²)	3,371 (35.9)	2,900 (35.8)	471 (36.6)	
Obese (≥30 kg/m²)	715 (7.6)	590 (7.3)	125 (9.7)	
Gestational weight gain (kg) ($n = 10,676$)	13.2 [5.2]	13.2 [5.1]	13.0 [5.7]	0.11
Any psychiatric disorder (during pregnancy) ($n = 10,791$)				
No	9,479 (87.8)	8,168 (88.5)	1,311 (83.8)	<0.001
Yes	1,312 (12.2)	1,058 (11.5)	254 (16.2)	
Smoking in pregnancy ($n = 10,786$)				
No	9,006 (83.5)	7,752 (84.0)	1,254 (80.3)	<0.001
Yes	1,780 (16.5)	1,473 (16.0)	307 (19.7)	
Alcohol intake in pregnancy ($n = 10,147$)				
None	6,097 (60.1)	5,154 (59.3)	943 (64.5)	<0.001
Light (<3 units)	3,966 (39.1)	3,465 (39.9)	501 (34.3)	
Moderate/heavy (≥3 units)	84 (0.8)	67 (0.8)	17 (1.2)	
Pregnancy diet quality score ($n = 9,791$)	7.7 (0.8)	7.7 (0.8)	7.6 (0.8)	<0.001
Physical activity score in 3rd trimester ($n = 9,848$)	174.5 (84.7)	173.6 (81.9)	179.6 (99.9)	0.01
Child characteristics				
Gestational age ($n = 10,580$)				
<37 weeks (preterm)	771 (7.1)	664 (7.1)	107 (6.8)	0.36
37–38 weeks (early term)	2,082 (19.1)	1,798 (19.3)	284 (18.0)	

(Continued)

TABLE 1B (Continued)

Variable	Study population $N = 10,889$	SDQ peer-relationship problem score N (%) or mean [STD]		p-Value[a]
		"Low-risk" $n = 9,309$	"High risk" $n = 1,580$	
≥39 weeks (term)	8,036 (73.8)	6,847 (73.6)	1,189 (75.3)	
Birth weight (g) ($n = 10,526$)	3,339 [478.7]	3,339 [480.7]	3,339 [466.9]	0.99
Sex of child ($n = 10,639$)				
Male	5,519 (51.9)	4,733 (52.0)	786 (50.9)	0.39
Female	5,120 (48.1)	4,361 (48.0)	759 (49.1)	
Childcare at 2 years ($n = 10,399$)				
Parents	2,628 (25.3)	2,141 (24.0)	487 (32.7)	<0.001
Relatives	779 (7.5)	669 (7.5)	110 (7.4)	
Professional	4,592 (44.2)	4,004 (44.9)	588 (39.5)	
Childcare center	2,400 (23.1)	2,096 (23.5)	304 (20.4)	
Child's age at 5 years follow-up ($n = 10,889$)	66.5 [1.8]	66.5 [1.8]	66.4 [1.8]	0.04

[a]Difference by peer-relationship trouble score, by ANOVA or by chi^2 test.

7 years. In preterm children, socio-emotional or internalizing problems evaluated at 2 years old have been found to predict peer relationship problems at 5 years and psychiatric diagnoses at 11 years [21]. More studies are required to examine the longitudinal effects of maternal pre-pregnancy BMI on peer-relationship problems.

Only one other study that found a link between maternal obesity and offspring peer-relationship problems was able to use paternal BMI as a negative control. In this large Danish cohort, an association of similar magnitude was observed with both maternal and paternal BMI and peer-relationship problems [13]. We found that adjustment for paternal BMI did not change the association between maternal BMI and offspring peer-relationship problems nor was paternal BMI independently associated with peer-relationship troubles in our imputed and weighted models, in favor of a direct intrauterine effect of maternal BMI rather than residual confounding by genetics or the environment. Other studies have not observed a significant association between paternal BMI and offspring behavior [14, 36, 37] but one found a stronger, though non-significant, relationship with paternal than maternal BMI [38]. A recent Mendelian randomization study supports the hypothesis the link between maternal obesity and offspring hyperactivity-inattention symptoms may have both genetic and environmental origins [39], however the association with peer-relationship problems has not been investigated using genetic markers.

In ELFE, maternal underweight was associated with increased odds of high peer-relationship problem scores. There exists little literature on the role of maternal underweight in offspring peer problems as many studies do not analyze the role of maternal underweight at all [11, 12, 36, 37] or group it with normal BMI [14]. However, maternal underweight has been associated with twofold increased odds of teacher-rated difficulties in group situations at 5 years in one study [15], though not with peer-relationship problem scores at 6 years in another [10]. Results are also conflicting concerning other behavioral outcomes. In other studies, it has not been associated with problem behaviors in children 8–9 years old [35] but has been associated with externalizing problems in boys at 9–11 [40]. The results are equally contradictory concerning the association of maternal underweight with cognitive or psychomotor developmental outcomes. In some studies, there is no association between maternal underweight and cognitive or psychomotor development in offspring [38], but others find it associated with decreased cognitive scores and suggest there may be a U-shaped association between BMI and cognitive outcomes [41, 42]. Maternal underweight may be an indicator for inadequate prenatal micronutrient status and has been linked with fetal growth restriction, preterm birth, low birth weight, and increased risk of undernutrition in offspring, all of which are strong risk factors for adverse neurodevelopment [43, 44]. The role of maternal underweight represents an important avenue for future studies to investigate.

To our knowledge, this is the first study analyzing the relationship between maternal pre-pregnancy BMI and child peer-relationship problems in preterm infants. However, one previous study has analyzed the relationship between maternal pre-pregnancy BMI and offspring hyperactivity-inattention symptoms in children born preterm. In a population of 10-year-old children born extremely preterm (<28 weeks gestation), Van der Burg et al. [45] observed an increased risk in parent-rated, but not teacher-rated, hyperactivity-inattention symptoms for children whose mothers were overweight or obese before pregnancy. Children born preterm are a unique

TABLE 1C Descriptive characteristics of the overall population and by SDQ peer-relationship trouble score in the EPIPAGE-2 study ($n = 2,646$) weighted by gestational age group.

Variable	Study population $N = 2,646$	SDQ peer-relationship problem score N (%) or mean [STD]		p-Value[a]
		"Low-risk" $n = 2,056$	"High risk" $n = 590$	
Sociodemographics				
Maternal age at child's birth ($n = 2,646$)	30.6 [0.14]	30.7 [0.15]	30 [0.33]	<0.01
Maternal education (birth) ($n = 2,569$)				
High	1,351 (54.0)	1,102 (57.7)	249 (39.5)	<0.001
Medium	528 (20.4)	407 (20.0)	122 (22.4)	
Low	690 (25.6)	490 (22.3)	197 (38.1)	
Household SES ($n = 2,541$)				
Managerial	661 (27.3)	553 (29.4)	107 (18.7)	<0.001
Intermediate	632 (25.8)	504 (27.4)	128 (19.5)	
Administrator, director, civil servant, student	647 (25.2)	496 (24.1)	151 (29.5)	
Domestic or sales employee	309 (11.3)	218 (10.1)	90 (16.3)	
Laborer	249 (8.7)	176 (7.9)	73 (12.1)	
Without profession	43 (1.7)	26 (1.1)	17 (4.0)	
Parity ($n = 2,622$)				
0	1,502 (56.8)	1,159 (56.2)	341 (58.7)	0.72
1	632 (25.4)	503 (25.9)	130 (24.2)	
≥2	488 (17.8)	376 (17.9)	111 (17.1)	
Parental health/lifestyle				
Maternal BMI category ($n = 2,465$)				
Underweight (<18.5 kg/m^2)	180 (6.7)	130 (6.4)	50 (8.0)	<0.01
Normal (18.5–24.9 kg/m^2)	1,430 (58.8)	1,148 (60.6)	281 (51.7)	
Overweight (25–29.9 kg/m^2)	488 (20.1)	384 (20.3)	105 (19.8)	
Obese (≥30 kg/m^2)	367 (14.3)	257 (12.7)	108 (20.6)	
Paternal BMI category ($n = 975$)				
Underweight (<18.5 kg/m^2)	5 (0.4)	2 (0.4)	3 (0.7)	0.18
Normal (18.5–24.9 kg/m^2)	545 (56.7)	435 (58.6)	110 (49.6)	
Overweight (25–29.9 kg/m^2)	323 (30.7)	237 (30.1)	86 (33.1)	
Obese (≥30 kg/m^2)	102 (12.1)	73 (10.9)	28 (16.6)	
Maternal smoking in pregnancy ($n = 2,556$)				
No	2,080 (83.2)	1,621 (83.4)	457 (82.1)	0.58
Yes	476 (16.8)	362 (16.6)	114 (17.9)	
Anxiety score in pregnancy (STAI-T) ($n = 1,781$)				
Weak	1,409 (81.7)	1,135 (84.3)	275 (70.6)	<0.001
Moderate	222 (11.0)	162 (9.5)	59 (17.3)	
High	150 (7.3)	106 (6.2)	44 (12.1)	
Pregnancy/delivery				
Gestational age ($n = 2,646$)				
>32–34 weeks	658 (64.3)	536 (26.1)	123 (20.8)	<0.01
27–31 weeks	1,659 (31.2)	1,280 (62.3)	378 (64.1)	
23–26 weeks	329 (4.6)	240 (11.7)	89 (15.1)	
Birth weight (g) ($n = 2,646$)	1,712 [12.5]	1,724 [13.7]	1,666 [29.5]	0.02
Cause of prematurity ($n = 2,415$)				
Preterm labor	1,086 (48.4)	856 (48.6)	229 (47.1)	0.46
PPROM	592 (23.5)	464 (23.9)	127 (21.5)	

(Continued)

TABLE 1C (Continued)

Variable	Study population $N = 10,889$	SDQ peer-relationship problem score N (%) or mean [STD]		p-value[a]
		"Low-risk" $n =$ 9,309	"High risk" $n =$ 1,580	
Vascular pathology, isolated placental abruption or isolated IUGR	737 (28.2)	561 (21.1)	176 (31.3)	
Child characteristics				
Sex of child ($n = 2,646$)				
Male	1,421 (55.5)	1,085 (54.9)	336 (58.2)	0.30
Female	1,225 (44.5)	971 (45.1)	254 (41.8)	
Childcare at 2years ($n = 2,490$)				
Parents	1,022 (38.9)	758 (37.2)	265 (46.3)	<0.001
Relatives/employee at home	173 (6.9)	135 (7.2)	38 (5.8)	
Professional/childcare center	423 (18.0)	336 (18.4)	86 (16.2)	
Maternal assistant	626 (27.9)	523 (29.8)	103 (20.3)	
Other	246 (8.2)	186 (7.4)	58 (11.4)	
Child's age at 5 years follow-up ($n = 2,646$)	67.3 [0.1]	67.3 [0.1]	67.4 [0.1]	0.39

[a]Difference by peer-relationship trouble score, by ANOVA or by chi² test.
PPROM, preterm premature rupture of the membranes; STAI-T, State-Trait Anxiety Inventory; IUGR, intrauterine growth restriction.

group already at increased risk of neurodevelopmental deficits compared to children born at term [20]. It is pertinent to determine whether high maternal pre-pregnancy BMI confers an additional, preventable risk to an already high-risk group. The risk of neurodevelopmental deficits appears to increase in a dose-response manner with decreasing gestational age [20]. However, with regards to peer-relationship problems, we did not find any interactions with gestational age in either EPIPAGE-2 or ELFE. This phenomenon could be explained by the fact that maternal obesity is also associated with increased neonatal mortality, which also rises with decreasing gestational age [46]. The competing risk of neonatal mortality may diminish the observed magnitude of association between maternal obesity and offspring behavioral deficits in preterm infants. As obese women are also at increased risk of preterm birth [47], the observed association maybe greater than what we have estimated.

We observed an interaction between the cause of prematurity and maternal pre-pregnancy BMI in EPIPAGE-2, suggesting that the positive association observed with the extremes of maternal BMI are driven by premature births caused by vascular pathologies, isolated placental abruption, or isolated IUGR. The association with premature labor was not statistically significant and conversely, PPROM showed a non-significant negative association. We are unsure how to explain this negative association, as infants born PPROM usually show similar risks of neonatal morbidity as those born due to spontaneous preterm labor and higher risks of acute antenatal complications and infections [48, 49].

It is believed that maternal obesity may directly affect the developing fetus through inflammation. Obese women have higher levels of proinflammatory factors than women of normal weight, and proinflammatory cytokines have been linked to oxidative stress in the placenta, placental inflammation and changes in fetal gene expression [3]. Inflammation has been found to disturb brain development and evidence suggests that multiple or sustained intermittent episodes of perinatal inflammation are more damaging to the brain than a single episode [50]. However, there are other mechanisms through which maternal obesity may influence behavioral development in offspring, including changes in the steroid or hormonal environment and behaviourally induced epigenetic modification [3, 51]. High paternal BMI may also contribute to increased risk of neurodevelopmental problems through epigenetic modification, though our results did not support this mechanism [52]. A few studies have attempted to determine the mechanisms of action. Both cytokine levels in cord blood and at 5 years old have been associated with behavioral problems, including peer-relationship issues, in children at 5 years in the EDEN cohort [53, 54]. In extremely preterm infants, levels of proinflammatory cytokines were higher in infants born to obese or overweight mothers in babies with induced preterm birth than infants delivered spontaneously [55]. This could indicate a contribution of maternal BMI to an inflammatory state, but possibly represents another competing risk situation [55]. Finally, one study observed an association between increasing cord blood leptin and decreased hyperactivity-inattention symptoms at 5 years, but no

TABLE 2 Association between maternal pre-pregnancy body mass index and high peer-relationship problem scores at 5.5 years in the EDEN, ELFE, and EPIPAGE-2 cohorts.

Variable	Unadjusted OR [95%CI]	Model 1[a] [95%CI]	Model 2[b] [95%CI]	Model 3[c] [95%CI]
EDEN (n = 1,184)				
Obese (≥30 kg/m²)	2.30 [1.38, 3.82]	2.28 [1.35, 3.84]	2.25 [1.33, 3.81]	2.27 [1.32, 3.88]
Overweight (25–29.9 kg/m²)	1.13 [0.72, 1.77]	1.08 [0.68, 1.71]	1.09 [0.69, 1.73]	1.05 [0.66, 1.67]
Normal (18.5–24.9 kg/m²)	REF	REF	REF	REF
Underweight (<18.5 kg/m²)	1.25 [0.70, 2.21]	1.18 [0.65, 2.13]	1.10 [0.60, 2.00]	1.15 [0.63, 2.11]
ELFE (n = 10,889)				
Obese (≥30 kg/m²)	1.93 [1.65, 2.25]	1.57 [1.34, 1.85]	1.53 [1.30, 1.80]	1.52 [1.29, 1.78]
Overweight (25–29.9 kg/m²)	1.36 [1.19, 1.56]	1.22 [1.07, 1.41]	1.21 [1.05, 1.39]	1.20 [1.05, 1.39]
Normal (18.5–24.9 kg/m²)	REF	REF	REF	REF
Underweight (<18.5 kg/m²)	1.40 [1.16, 1.69]	1.29 [1.06, 1.56]	1.30 [1.08, 1.58]	1.30 [1.08, 1.58]
EPIPAGE-2 (n = 2,646)				
Obese (≥30 kg/m²)	1.62 [1.19, 2.20]	1.45 [1.06, 1.99]	1.44 [1.05, 1.98]	1.44 [1.04, 1.99]
Overweight (25–29.9 kg/m²)	1.07 [0.81, 1.42]	1.01 [0.75, 1.35]	1.00 [0.75, 1.33]	1.03 [0.77, 1.38]
Normal (18.5–24.9 kg/m²)	REF	REF	REF	REF
Underweight (<18.5 kg/m²)	1.67 [1.08, 2.57]	1.46 [0.95, 2.24]	1.48 [0.96, 2.28]	1.51 [0.98, 2.31]

[a]Adjusted for study center (EDEN), maternal education, household monthly income (ELFE), household socioeconomic status (EPIPAGE-2), parity, sex, psychological problems during pregnancy (EDEN+ELFE), maternal age at birth, singleton pregnancy (EPIPAGE-2).
[b]Additionally adjusted for maternal physical activity during pregnancy (EDEN + ELFE), maternal diet in pregnancy (EDEN + ELFE), maternal alcohol intake during pregnancy (EDEN +ELFE), maternal smoking during pregnancy, maternal anxiety during pregnancy (EPIPAGE-2).
[c]Additionally adjusted for gestational age, child age at evaluation, childcare at 2 years, cause of prematurity (EPIPAGE-2).

association with inflammatory cytokines such as TNF-α and IL-6 [56]. Further investigation into the roles of possible mediating factors is warranted, especially as the results concerning leptin are contrary to expected.

Other mechanisms of action between maternal obesity and child peer-relationship problems may not be as biological in nature. Social stigmatization of obese parents may play a role, and mothers may be subject to more stigma than fathers [57]. Social stigma may act by inducing psychological stress and consequently impacting fetal development in utero [58, 59] or maladaptive social networks and supports experienced by the parents may also be experienced by the offspring. The maternal social network has been significantly associated with offspring cognitive development at 2 years and thus may extend to child social development [60], possibly by providing more opportunities for playdates or social activities. In addition, as children of overweight mothers are more likely to be overweight themselves [61] they may be directly subject to increased social stigma by their peers [62]. Future studies are needed to quantify the role of child BMI as a potential mediator.

Our study has some limitations. Pre-pregnancy weight was self-reported in EDEN and ELFE and may have induced measurement error. However, weight is more likely to be under-reported than over-reported and would have attenuated our estimates rather than inflate them [63]. Ascertainment of peer-problems relied on parental reporting and teacher input may be valuable as they tend to observe children in much different social settings than parents. Indeed, poor/fair agreement between parent and teacher ratings have been reported for the SDQ [64]. However, the highest agreement between parents and teachers were observed for the peer-relationship problem and hyperactivity-inattention scales and the SDQ has proven a validated and reliable tool to distinguish behavioral problems [64, 65]. Finally, despite our adjustments we cannot rule out residual confounding.

Our study also has several strengths. We were able to evaluate an important aspect of behavioral development across three large birth cohorts, using the same tool, and around the same age, while adjusting our models for a wide range of important confounding factors not previously available to other studies. To our knowledge, this was the first study to evaluate the role of maternal BMI on social development in preterm infants and we were able to use paternal BMI as a negative control. Multiple imputation and inverse probability weighting also allowed us to increase efficiency, statistical power, and reduce bias due to attrition.

In conclusion, we observed that maternal pre-pregnancy obesity was associated with increased peer-problem scores at 5 years in three large birth cohorts, including a large cohort of infants born preterm. This association was not influenced by adjustment for maternal lifestyle or psychological problems. However, residual confounding by the postnatal environment

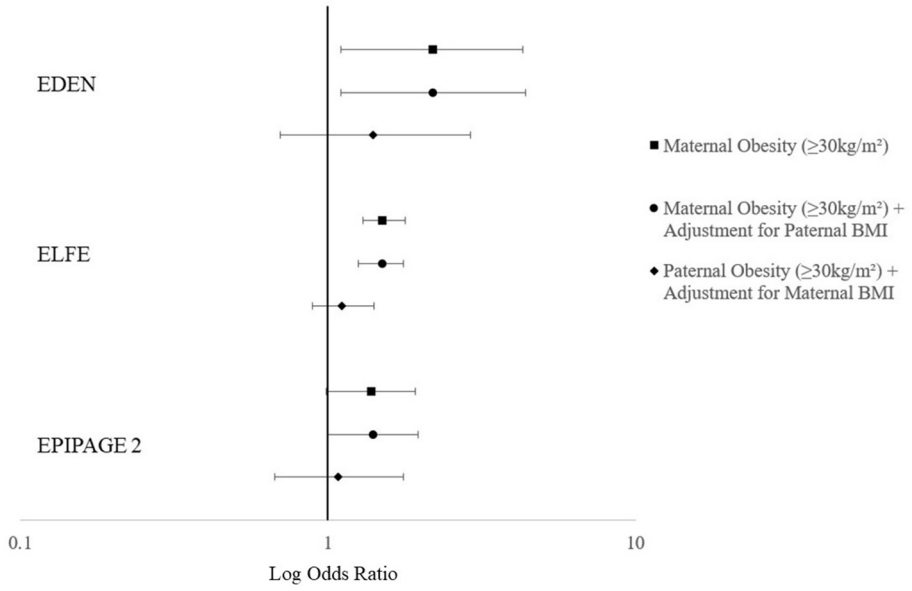

FIGURE 1
Adjusted[a] odds ratios for a high peer-relationship score trajectory from 3 to 8 years (EDEN, $n = 1,428$), a high peer-relationship score at 5.5 years (ELFE, $n = 10,889$) and a high peer-relationship score at 5 years in EPIPAGE-2 ($n = 2,646$). [a]Adjusted for study center (EDEN), maternal education, household monthly income (ELFE), household socioeconomic status (EPIPAGE-2), parity, sex, psychological problems during pregnancy (EDEN + ELFE), maternal age at birth, singleton pregnancy (EPIPAGE-2), maternal physical activity during pregnancy (EDEN + ELFE), maternal diet in pregnancy (EDEN + ELFE), maternal alcohol intake during pregnancy (EDEN + ELFE), maternal smoking during pregnancy, maternal anxiety during pregnancy (EPIPAGE-2), gestational age, child age at evaluation, childcare at 2 years, cause of prematurity (EPIPAGE-2) and paternal BMI.

or genetics may explain part of the association we observed. Given the current body of evidence, potential mediating factors and Mendelian randomization could support whether this association is causal in nature.

Efforts should be strengthened to ensure women of childbearing age have healthy weights before pregnancy, both with respect to reproductive counseling and with respect to more general healthy weight-based public health interventions. As randomized controlled trials have shown that behavioral and social skills of children can be ameliorated with intervention, healthcare providers should also be made aware of the potentially increased risk of pre-pregnancy obesity on child peer-relationship problems [21]. This could allow more timely identification of children at risk of behavioral problems and can provide more opportunities to improve their social skills during what may be the most modifiable period of their lives.

Data availability statement

The datasets generated during and analyzed during the current study are not publicly available due to privacy laws set by the Commission nationale de l'informatique et des libertés (CNIL). Anonymized data may be made available upon reasonable request to any public or private research team and with permission of the EDEN, ELFE and EPIPAGE 2 scientific committees Requests to access the datasets should be directed at: Data requests concerning EDEN can be made through the website: http://eden.vjf.inserm.fr/en/page/25/submit-a-research-project. Data requests concerning ELFE can be made through the website: https://pandora-elfe.inserm.fr/public/index.php. Data requests concerning EPIPAGE 2 can be made using through the email: accesdonnees.epipage@inserm.fr by using information provided on the data access website: https://epipage2.inserm.fr/index.php/en/related-research/265-data-access-and-questionnaires.

Ethics statement

The studies involving human participants were reviewed and approved by French National Commission on Informatics and Liberty (CNIL), and/or the Advisory Committee on Information Processing in Maternal Research in the Field of Health (CCTIRS), Committee for the Protection of People (CPP), or the Bicêtre Hospital Ethics Committee. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

Author contributions

Conceptualization: CD, EL, CG, M-AC, and BH. Data curation: CD, MT, and LM-M. Formal analysis and writing original draft: CD. Funding acquisition: CD, P-YA, M-AC, and BH. Investigation and methodology: CD, EL, M-AC, and BH. Writing (reviewing and editing): CD, EL, CG, MT, LM-M, P-YA, M-AC, and BH. All authors contributed to the article and approved the submitted version.

Funding

CD's salary was funded by a grant from the *Fondation pour la Recherche Médicale* (the French Foundation for Medical Research): SPF201909009122. The EDEN study acknowledges the following sources of funding: Foundation for Medical Research (FRM), National Agency for Research (ANR), National Institute for Research in Public Health (IRESP: TGIR cohorte santé 2008 program), French Ministry of Health (DGS), French Ministry of Research, Inserm Bone and Joint Diseases National Research (PRO-A) and Human Nutrition National Research Programs, Paris–Sud University, Nestle', French National Institute for Population Health Surveillance (InVS), French National Institute for Health Education (INPES), the European Union FP7 programmes (FP7/2007–2013, HELIX, ESCAPE, ENRIECO, Medall projects), Diabetes National Research Program [through a collaboration with the French Association of Diabetic Patients (AFD)], French Agency for Environmental Health Safety (now ANSES), Mutuelle Générale de l'Education Nationale (MGEN), French National Agency for Food Security, and the French-speaking association for the study of diabetes and metabolism (ALFEDIAM). Funders had no influence of any kind on analyses or result interpretation. The Elfe survey is a joint project between the French Institute for Demographic Studies (INED) and the National Institute of Health and Medical Research (INSERM), in partnership with the French blood transfusion service (Etablissement français du sang, EFS), Santé publique France, the National Institute for Statistics and Economic Studies (INSEE), the Direction générale de la santé (DGS, part of the Ministry of Health and Social Affairs), the Direction générale de la prévention des risques (DGPR, Ministry for the Environment), the Direction de la recherche, des études, de l'évaluation et des statistiques (DREES, Ministry of Health and Social Affairs), the Département des études, de la prospective et des statistiques (DEPS, Ministry of Culture), and the Caisse nationale des allocations familiales (CNAF), with the support of the Ministry of Higher Education and Research and the Institut national de la jeunesse et de l'éducation populaire (INJEP). Via the RECONAI platform, it receives a government grant managed by the National Research Agency under the Investissements d'avenir programme (ANR-11-EQPX-0038 and ANR-19-COHO-0001). EPIPAGE 2: The French National Institute of Public Health Research (IRESP TGIR 2009–01 programme)/Institute of Public Health and its partners [the French Health Ministry, the National Institute of Health and Medical Research (INSERM), the National Institute of Cancer, the National Solidarity Fund for Autonomy (CNSA)], the National Research Agency through the French programme of investments for the future (grants no. ANR-11-EQPX-0038 and ANR-10-COHO-0001) and the PremUp Foundation. Additional funding was obtained from the Fondation pour la Recherche Médicale (SPF 20160936356) and Fondation de France [00050329 and R18202KK (Grand Prix)].

Acknowledgments

The authors would like to thank the participants and the families of the EDEN, ELFE, and EPIPAGE-2 cohorts for their continued contribution in these studies.

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/frcha.2022.971743/full#supplementary-material

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frontiers | Frontiers in Child and Adolescent Psychiatry

TYPE Original Research
PUBLISHED 17 April 2023
DOI 10.3389/frcha.2023.1143125

OPEN ACCESS

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SPECIALTY SECTION
This article was submitted to Developmental Psychopathology and Mental Health, a section of the journal Frontiers in Child and Adolescent Psychiatry

RECEIVED 12 January 2023
ACCEPTED 07 March 2023
PUBLISHED 17 April 2023

CITATION
Hill J, Wright N, Sharp H, Pickles A and Steele H (2023) On the risks of secure attachment in infancy: Childhood irritability and adolescent depression predicted by secure attachment and high approach behaviours at 14-months towards a caregiver living with inter-parental violence.
Front. Child Adolesc. Psychiatry 2:1143125.
doi: 10.3389/frcha.2023.1143125

On the risks of secure attachment in infancy: Childhood irritability and adolescent depression predicted by secure attachment and high approach behaviours at 14-months towards a caregiver living with inter-parental violence

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Introduction: The secure infant turns to a caregiver for comfort when distressed or threatened. Does this level of openness create vulnerability where the caregiver is unsupportive or aggressive? In this study we examined prospectively whether secure attachment in infancy, and approach behaviours on reunion with a parent, were associated with childhood emotional dysregulation (irritability) and adolescent depression among children exposed to inter-parental violence.
Methods: We followed 219 families recruited from the general population during pregnancy (members of the Wirral Child Health and Development Study; WCHADS), with attachment assessments (Strange Situation Procedure; SSP) at 14 months, maternal interviews about inter-parental violence at 2.5, 5 and 7 years, and parent and teacher rated irritability at 9 years (CBCL). At age 13 years, 199 young people rated their levels of depression (SMFQ). In addition to the standard SSP classification, a latent variable reflecting approach behaviours during reunions was generated from the SSP dimensional scores and a factor score extracted. Analyses used path analysis using the gsem command in Stata.
Results: There were interactions between attachment security and inter-parental violence for age 9 irritability ($p = .084$) and age 13 depression ($p = .039$) which arose from greater levels of psychopathology among secure children exposed to inter-parental violence. Similarly, higher approach behaviours during SSP reunions among children exposed to inter-parental violence were associated with irritability (interaction term $p = .004$) and depression (interaction term $p < .001$). Among children who were not exposed to partner violence higher approach behaviours in the SSP were associated with lower irritability and depression.
Conclusion: Infant behaviours characteristic of attachment security in the Strange Situation Procedure may not equip children to deal with exposure to inter-parental violence and associated parental negativity.

KEYWORDS

attachment, strange situation procedure, interparental violence exposure, irritability, adolescent depression, inter-partner violence

Introduction

Secure attachment has been conceptualised as good expectations on the infant's part, and trust in the caregiver and the wider world. This is consistent with evidence of robust links between security of attachment to mother and later social competence with peers (1). Groh et al. (1) assembled meta-analytic evidence from 80 independent samples and 4,441 children, reporting a small to moderate effect size of secure attachment ($d = .39$). These effects were unrelated to age of child suggestive of continuity of maternal sensitive responsiveness, in these mostly low-risk families. But what of those circumstances where infants who have developed a secure attachment subsequently experience adverse family conditions?

As long ago as 2002, Belsky et al. (2) argued that although the case can be made that secure attachment will confer resilience in the face of adversity, "…we would be remiss if we did not observe that reasoned arguments could be made for just the opposite predictions. For example, only when ecological conditions are supportive of development will early security predict enhanced functioning in the future" (2). Independent evidence that secure attachment may represent risk came from the pioneering study of maternal depression undertaken by Radke-Yarrow et al. (3) in the 1980s which showed that the children most resilient at 4-year follow-up were the children who had been insecure-avoidant with their depressed mothers. Those who had been secure, had the most problematic behaviour later (3). Further evidence that secure attachment may confer risk in the presence of unsupportive ecological conditions comes from a study of maternal and child anxiety disorders (4). Maternal social anxiety disorder was strongly associated with child internalising symptoms at ages 4–5 years, but only among children who had been rated secure in the Strange Situation Procedure (SSP) at 14 months. Similarly mothers' higher interpretation of threat when reading a story with their children was associated with child anxiety disorder, but only in secure children.

The possibility that secure attachment confers risk in the presence of inter-parental violence (IPV) and conflict has not previously been examined. Inter-parental violence and conflict pose major threats to children's emotional and physical welfare and are associated with emotional and behavioural problems in children. Studies dealing with genetic confounds have demonstrated environmental effects (5, 6). Some of these effects are mediated *via* the parent-child relationship. A parent who is in a hostile and conflicted partner relationship is likely to be more hostile and aggressive toward their children and less sensitive and emotionally responsive to their children's needs (7). In addition to an impact on the parents' behaviours with their children, conflict and violence in the home are likely to be frightening for a young child, and to pose fundamental questions as to whether their parents are people they can turn to for their own needs (8). This in turn raises a question regarding the way children cope in such a threatening family environment. On the one hand this may be through the preservation of a supportive relationship with a parent, in spite of the conflict (9) or with a sibling (10). On the other, the child may have to find their own individual coping strategies in regulating emotions and finding sources of relief from fear, anger or sadness (11). Davies et al.'s (11) Emotional Security Theory (EST) brings out the complexity and challenge for the child. In their operationalisation of the theory, less adaptive patterns of responding include "mobilizing" comprising high levels of vigilance and emotional arousal together with continued attempts to gain comfort from parents, "dominant" in which the threat is countered by the child through attempts to control, sometimes aggressively, the parental behaviours, and "demobilizing" responses such as freezing or withdrawal. Their characterisation of the "secure" pattern is of particular relevance to the study described here. It is conceptualised as reflecting the child's, "…underlying confidence that interparental disputes will be effectively managed and regulated in a way that maintains family harmony" (11). Behaviourally this is evidenced in only brief expressions of distress, and a limited concern for parents. Davies et al. (11) have reported promising findings showing associations between the secure pattern and better child adjustment in the face of inter-parental violence and conflict.

This detailed and sophisticated conceptual and empirical framework helps to bring out key questions in relation to parent-child attachment in the presence of high levels of within family threat. First the secure pattern of responding is thought to be characterised by a degree of disengagement from the conflict, in contrast to the behavioural and emotional engagement of the child with the parent which characterises the "secure" infant in the SSP (12). Second, the framework focuses on the child's adaptation to the parental conflict and not the child's orientation to the parent when themselves worried, anxious or sad, which is the focus of the assignment of the infant to an attachment category. Based on the EST we might predict that the "secure" pattern of behaviours would entail a degree of caution in expressing distress with, and seeking comfort from, a parent. In other words the "secure" organisation of behaviours seen in the SSP, may be different from the "secure" organisation of behaviours of the child shown towards parents in conflict with each other. Similarly at the representational level, if security in the SSP reflects trust in the caregiver, and confidence that they can provide relief in the face of threat, this may be poorly matched to the reality of the child whose parents are physically aggressive towards each other. On the other hand, if early secure attachment reflects a capacity to revise interpretations and expectations in the light of experience, then it may be associated with a subsequent revision of the child's representation of the trustworthiness of their parents' caregiving. This would be consistent with evidence that adverse experiences during childhood may lead to a change from early secure to later insecure attachment, referred to as "lawful discontinuity" (13).

Most commonly the SSP is used to assign infants to secure and insecure categories based on rater judgements of a range of infant behaviours mainly at the second reunion. The strength of this method is that it reflects a combination of the infant's approach behaviours with the caregiver and the effectiveness of the reunion in leading to a reduction in distress. However dimensional ratings are also made in the SSP of specific

behaviours which, if they were to persist during childhood, may be expected to put children exposed to parental violence and conflict at risk (proximity seeking and contact maintenance) or confer protection (avoidance). While the question of whether or not a dimensional characterisation of attachment has advantages over categorical assignments has been debated for a long time (14), these behavioural dimensions have received relatively little attention. However a recent study using multimodal measures of attachment-related behaviour such as dyadic contact duration and infant velocity of approach toward the mother, showed that these detailed observations were strongly associated with the SSP dimensions, supporting their validity (15).

Establishing targets for early intervention requires evidence of associations between early child or family characteristics and later psychopathology. The promotion of secure attachment has been a common target for early intervention, and so addressing questions discussed earlier regarding attachment security in the presence of inter-parental violence and discord, in relation to mental health outcomes in the long term is important (16). Similarly more needs to be known about the long term consequences of early exposure to inter-parental violence (17).

Depression in adolescence is common, with a prevalence of 23.4% in girls and 8.6% in boys (18). It is a major source of suffering and impairment, and commonly recurs through adolescence and into adult life. Identifying targets for early intervention to reduce adolescent depression is therefore a key goal. There are probably several pathways to adolescent depression, one of which is *via* childhood irritability (19–21). Irritability is commonly identified as a subset of externalizing behaviours characterised by a low threshold for getting angry, and frequent or intense angry responses. In view of the evidence for an environmental effect of inter-parental violence on childhood externalising behaviours, this may represent a pathway from exposure to domestic violence to adolescent depression. In this study we therefore examined both child irritability at age 9 years and depression at age 13 years. As outlined earlier directional hypotheses for the role of early attachment, could be based on risk arising where a child shows attachment behaviours towards physically aggressive parents, or on resilience arising from a child's ability to revise their representations based on experience. For this study, given that the SSP is behavioural rather than representational, we hypothesised that secure attachment and high approach behaviours in the SSP would be associated with increased child irritability and adolescent depression specifically in children exposed to inter-parental violence.

Materials and methods

Procedure and sample

The participants were members of the Wirral Child Health and Development Study (WCHADS), a prospective epidemiological longitudinal study in the North West of England, United Kingdom. It was designed to investigate vulnerability and resilience in the face of environmental stressors and their role in child and adolescent psychopathology. Families were recruited in pregnancy and followed over several assessment points during infancy up to when the children were mean age 12.88 (s.d. = 0.53) years (referred to as "age 13"). This uses a two-stage stratified design in which a consecutive general population sample (the "extensive" sample) is used to generate a smaller "intensive" sample stratified by psychosocial risk (psychological abuse in the partner relationship) and both are followed in tandem. The extensive sample was identified from consecutive first-time mothers who booked for antenatal care at 12 weeks gestation between 12 February 2007 and 29 October 2008. The booking clinic was administered by the Wirral University Teaching Hospital which was the sole provider of universal prenatal care on the Wirral Peninsula, a geographical area bounded on three sides by water. Socio-economic conditions on the Wirral range between the deprived inner-city and affluent suburbs, but with very low numbers from ethnic minorities.

The study was introduced to the women at 12 weeks of pregnancy by clinic midwives who asked for their agreement to be approached by study research midwives when they attended for ultrasound scanning at 20 weeks gestation. Ethical approval for the study was granted on four occasions covering the assessment points reported here, by the Cheshire North and West Research Ethics Committee on 27 June 2006 (reference no. 05/Q1506/107), 7th June 2010 (reference no. 10/H1010/4) and on 22nd December 2014 and 8th June 2020 (reference no. 14/NW/1484). At each assessment point written informed consent was obtained before administration of measures. Of those approached by study midwives, 68.4% gave consent and completed the measures, yielding an "extensive" sample of 1,233 mothers (mean age = 26.8 years, S.D. = 5.8 years, range 18–51 years) with surviving singleton babies who were available for postnatal follow-up. In the extensive sample 41.8% were in the most deprived quintile of UK neighbourhoods (22), consistent with high levels of deprivation in some parts of the Wirral. A total of 48 women in the extensive sample (3.9%) described themselves as other than white British. Details of recruitment to the study are shown in Sharp et al. (23). Maternal responses to questions about psychological abuse in their current or recent partner relationship (23, 24) were used to generate the stratified "intensive" sample of mothers and children for more detailed study. These intensive sample children were assessed at two prenatal time points, and postnatally on eleven occasions up to age 13. Assessments for this study were made at 14 months (infant attachment), at 2.5, 5 and 7 years (inter-parental violence), 9 years (irritability), and at 13 years (depression).

Of the 316 recruited to the intensive sample at 32 weeks gestation, 268 mothers and children attended for assessment of infant attachment status at 14 months. Of these, 238 mothers reported on inter-parental violence at three time points from age 2.5 to 7 years, data on age 9 years irritability were gathered from 219, and on age 13 depression from 199.

Measures

Infant attachment status

Infant-mother attachment was assessed at 14 months using the Strange Situation Procedure (SSP) (12) in a purpose built room at the WCHADS centre, with filming through a one-way mirror and with cameras in the room. The SSP is a widely used laboratory procedure for the assessment of the attachment relationship between infants aged 12–20 months and their primary caregiver. The procedure was designed to capture the balance of the activation of the attachment and exploratory systems under conditions of increasing stress. The full assessment consists of 8 episodes, which involve a standardized sequence of separations and reunions between infant and mother (12). Five 7-point scales are rated to assess the infant's attachment behaviour during the reunion episodes: (1) Proximity seeking; (2) Contact maintenance; (3) Resistance to interaction; (4) Avoidance of contact and (5) Disorganization. Following the protocol outlined in Ainsworth et al. (12), infants are classified in three "organised" groups, as insecure-avoidant (A), secure (B), or insecure-resistant (C). Disorganized attachment (D) was coded using the Maine and Solomon criteria (25). For these analyses the secure-insecure contrast was used. The proximity seeking, contact maintenance and avoidance of contact scales were used to generate an approach factor as described in the "Statistical analyses" section.

All assessments of infant-mother attachment were rated by reliable, trained coders in Steele's attachment research lab. In the current sample, one trained rater who was blind to all other study data coded all infant-mother SSPs. To evaluate inter-rater reliability, 53 assessments (20%) were selected randomly for coding by a second trained rater who was also blind to the study details. The two coders achieved inter-rater reliability for both three-way (87% exact agreement; kappa = 0.79) and four-way classification (81% exact agreement; kappa = 0.72) coding schemes, and for the behavioural dimensions all ICCs $\geq$ .80.

Inter-parental violence

Inter-parental violence (IPV) was measured using the Partner Conflict Calendar (26) administered at the age 2.5 years, age 5 and age 7 interviews with mothers. The respondent is presented with a prompt card which displays a series of violent acts and is asked to report whether any of these have occurred between themselves and their partner, and if so, provide the date at which it occurred. Responses provided were categorically coded for the presence of IPV, with a single presence/absence (0/1) variable reflecting whether or not there had been an episode of violence between the 14 months assessment of attachment status and age 7 years.

Irritability age 9 years

Maternal reports of child symptoms were obtained at 9 years using the Child Behaviour Checklist (CBCL), which has been extensively employed in studies of child and adolescent emotional and behavioural disorders. It has 99 items each scored 0 (not true), 1 (somewhat or sometimes true), and 2 (very true or often true). Teacher reports of child symptoms were obtained using the Teacher Report Form (TRF), also a widely used measure of child and adolescent symptomatology. Where both parent and teacher scores were available ($N = 201$) the highest value was used in data analyses. If only one report from either the parent ($N = 13$) or the teacher ($N = 5$) was available, then that was used as the outcome variable. The ODD (oppositional defiant disorder) dimension of irritability was generated based on the items previously identified by confirmatory factor analyses (CFA) in adolescents (27), and on CFA with data collected at ages 2.5, 3.5 and 5.0 years in this study (28). Cronbach's alpha for parent and teacher irritability scales were .73 and .78.

Depression age 13 years

Adolescent depression was assessed using child report on the Short Mood and Feelings Questionnaire (SMFQ), which includes 13 items assessing DSM depression symptoms over the prior 2 weeks. The SMFQ is a widely used self-report measure which has been validated against other depression questionnaires and diagnostic interviews (29).

Confounds

Socioeconomic status was determined using the revised English Index of Multiple Deprivation (IMD) (22) based on data collected from the UK Census in 2001. According to this system, postcode areas in England are ranked from most deprived (i.e., IMD of 1) to least deprived (i.e., IMD of 32,482) based on neighbourhood deprivation in seven domains: income, employment, health, education and training, barriers to housing and services, living environment, and crime. All mothers were given IMD ranks according to the postcode of the area where they lived and assigned to a quintile based on the UK distribution of deprivation. Age of mother and the age they left full time education were recorded at the first assessment. Child sex was recorded at birth.

Statistical analyses

Bivariate associations were examined using Spearman's correlations. All analyses were conducted in Stata version 17 (30). Child irritability and depression scores were highly skewed with a mode of zero so not suitable for transformation. Several of the SSP scores were also highly skewed. Therefore, the gsem command in Stata was used to generate the approach factor score and to test the main study hypotheses, with scores treated as ordinal or count variables. Confirmatory factor analysis was conducted in gsem on the six SSP variables treated as ordinal scores to generate a factor representing approach-avoidance behaviours in the SSP. A latent variable factor score was extracted for analysis. The study hypotheses were tested in path analysis using the gsem command in Stata with scores modelled as Poisson counts. All models included the covariates, variables reflecting stratification, main effects of attachment/approach variables and violence, and the interaction terms between

attachment/approach and violence. Variables were standardised prior to generating interaction terms. Separate models were estimated for age 9 irritability and age 13 depression symptom outcomes, and for attachment classification and approach score. Interactions were plotted using the margins command in Stata, showing the association between approach score and child outcome in violence exposed and unexposed groups.

Results

The factor loadings for the six SSP scores on the single approach latent variable are shown in **Supplementary Table S1**. A factor score was extracted for all subsequent analyses. Of the 219 children included in the analyses of irritability at age 9 years, 106 (48%) had been rated secure in the SSP at 14 months, and 50 (23%) were exposed to inter-parental violence between the ages of 14 months and 7 years. There was no association between the rate of secure attachment in the unexposed (83/169 = 49%) and in the exposed (22/50 = 44%) groups, $c^2 = 0.334$, $p = .563$). In **Table 1** showing bivariate associations among study variables it can be seen that there was a small association between attachment security and approach to the caregiver in the reunions in the SSP.

Comparison of mean approach scores in the secure ($N = 106$), avoidant ($N = 23$), resistant ($N = 19$) and disorganized ($N = 71$) groups highlighted the variability in approach behaviours in the insecure group. In pairwise comparisons of mean approach scores in one-way ANOVA (model F 3,215 = 27.747, $p < .001$) the avoidant group mean was lower than the secure group mean ($p < .001$) and the disorganised group mean ($p < .001$), but the resistant group mean was higher than the secure ($p = .008$) and the disorganized ($p < .001$). The difference in approach behaviours between secure and disorganized groups was small and non-significant. Thus the secure-insecure demarcation does not provide a discriminating measure of approach behaviours on reunion in the SSP. Also shown in **Table 1** there were small, but statistically significant associations between inter-parental violence and socio-economic deprivation, leaving school at age 18 or younger, and young maternal age at the birth of the first child, illustrating co-occurrence of family risks. Attachment security was not associated with age 9 irritability nor with age 13 depression. Higher approach behaviours in the SSP were associated with lower irritability at age 9 but not with young adolescent depression.

After accounting for the planned confounders, deprivation, leaving school at 18 or under, maternal age at first child, child sex, and variables reflecting the sample stratification there was an attachment security by exposure to partner violence interaction in the prediction of age 9 irritability (unstandardised estimate = .45 95% CI −.06 to.97, $p = .086$). There was also an approach to caregivers by exposure to partner violence interaction (unstandardised estimate = .50, 95% CI .16 to.84, $p = .004$) which is shown in **Figure 1**. Increasing approach was associated with increasing irritability in exposed children and with decreasing irritability in the unexposed group. The plots represent linear effects of log symptom scales.

There was an attachment security by exposure to partner violence interaction in the prediction of age 13 depression (unstandardised estimate = .30, 95 CI .01 to .59, $p = .039$). There was also an approach to caregivers by exposure to inter-parental violence interaction in the prediction of age 13 depression (unstandardised estimate = .52, 95% CI .32 to .73, $p < .001$) which is shown in **Figure 2**.

We examined the size of the effects reflecting vulnerability associated with secure attachment and high approach behaviours in children exposed to inter-parental violence, and reflecting a protective role for secure attachment and high approach behaviours in children brought up without exposure up to age 7 years. This was done by comparing the proportional differences in symptoms in the attachment groups, either secure compared with insecure, or approach behaviours 1.s.d. above the mean compared with 1.s.d below the mean. The smaller exposed ($N = 50$) compared to unexposed ($N = 169$) groups accounted for substantial differences in 95% confidence intervals in the two groups. In each of the four analyses, with secure-insecure and approach-avoidance, age 9 irritability and age 13 depression, there was a greater vulnerability effect of secure or high approach in the exposed children, than protective effect in unexposed children. In line with the models for the interaction terms, this was more evident for approach/avoidance than for secure/insecure.

In the exposed group the proportional increase in irritability associated with secure attachment was 38% (95% CI −24% to 99%) while the proportional decrease in the unexposed group

TABLE 1 Bivariate associations (Spearman's rho) among study variables.

	Attachment security	Approach factor	IPV before child age 7	Left school ≤age 18	Deprivation	Child sex	Maternal age	Irritability child age 9
Approach	.145 (.031)							
IPV	−.038 (.578)	−.154 (.022)						
Left school ≤age 18	.021 (.765)	−.065 (.335)	.137 (.042)					
Deprivation	−.087 (.197)	.053 (.436)	.188 (.005)	.204 (.003)				
Child sex	.004 (.952)	.063 (.354)	.025 (.707)	.076 (.258)	.064 (.344)			
Maternal age	.058 (.407)	.060 (.372)	−.186 (.005)	−.292 (<.001)	−.300 (<.001)	.041 (.546)		
Irritability age 9	−.005 (.946)	−.116 (.085)	.181 (.007)	.143 (.034)	.021 (.751)	−.019 (.784)	−.142 (.035)	
Depression age 13	.007 (.918)	−.088 (.590)	.008 (.914)	.023 (.747)	.083 (.246)	.353 (<.001)	.083 (.246)	.259 (<.001)

For all independent variables and for age 9 irritability $N = 219$, for age 13 depression $N = 199$. Values of p are shown in brackets. IPV, interparental violence.

10.3389/frcha.2023.1143125

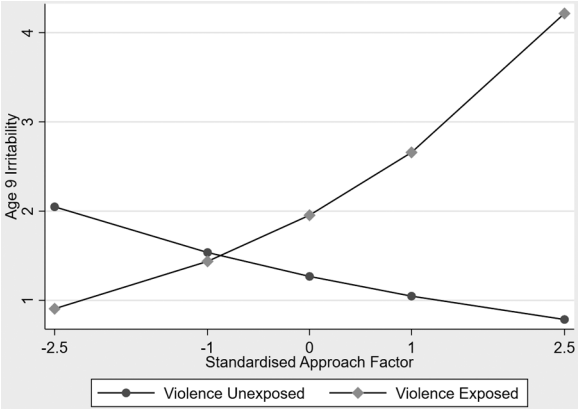

FIGURE 1
Associations between increasing approach and age 9 irritability contrasting children exposed to interparental violence and unexposed children.

was 12% (95% CI −36% to 11%). In analyses using the approach-avoidance variable both the proportional increase associated with high approach (85%, 95% CI −31% to 201%) in the exposed group and the proportional decrease in the unexposed group (32%, 95% CI −50% to −14%) were greater than for the secure-insecure comparison.

For age 13 depression in the exposed group the proportional increase in depressive symptoms associated with secure attachment was 29% (95% CI −5% to 63%), while the proportional decrease in the unexposed group was 4% (95% CI −16% to 7%). By contrast in analyses using the approach factor, in the exposed group the proportional increase in depressive symptoms associated with high approach was much larger than for secure attachment, 150% (95% CI 53% to 247%), while the proportional decrease in the unexposed group was 12% (95% CI −23% to −2%), also larger than for secure attachment.

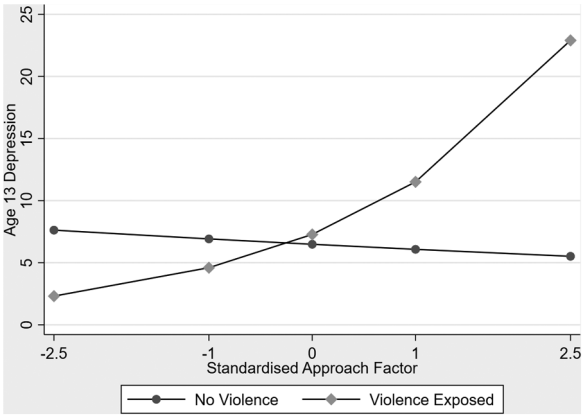

FIGURE 2
Associations between increasing approach and age 13 depression contrasting children exposed to interparental violence and unexposed children.

Discussion

Based on our hypothesis that the emotional and behavioural openness of the secure infant will increase their vulnerability to the conflict and hostility commonly found in homes with inter-parental violence, we predicted that the combination of secure attachment and exposure to partner violence will be associated with higher levels of later dysregulated emotions and depressive symptoms than in unexposed children. This prediction was supported in analyses of attachment security in the SSP at 14 months, and of parent and teacher ratings of child irritability at age 9 years, and adolescent self-reported depression at age 13 years. We also hypothesised that the vulnerability may arise specifically from the child's tendency to approach their parent when distressed or threatened in spite of the negative environment of a home with inter-parental violence. We found that this tendency is not tracked precisely by attachment security. While as expected, approach scores based on SSP dimensions during the reunions were higher in the secure than the insecure groups, they were lower in the insecure-avoidant infants, but higher in the insecure-resistant infants, compared to those with secure attachment. We therefore hypothesised that increasing approach behaviours seen in the SSP would provide a more specific index of vulnerability than attachment security and so would show a stronger moderator effect with inter-parental violence. Using a high approach-low avoidance factor generated from the six SSP reunion dimensions, we found that children with high approach scores exposed to interparental violence, had elevated irritability and depression scores, and this was in marked contrast to children who had not been exposed to inter-parental violence. The strength of associations using the approach factor were somewhat greater than those for the secure-insecure difference, suggesting that the vulnerability may arise specifically from the tendency to seek comfort from a parent in a violent relationship.

Our findings add further to the evidence that children exposed to inter-parental conflict and violence face a formidable challenge in finding adaptive responses. As Davies and Martin (11) have indicated, the adaptation may entail a degree of emotional and behavioural caution, very different from the openness of the secure infant in the SSP. As we outlined earlier we do not know whether, behaviourally there is homotypic continuity of attachment behaviours in the face of major adversity, whereby children seek comfort even in the face of parental negativity, or heterotypic continuity with attachment security evidenced in changing behaviours. We have described evidence consistent with there being a pathway characterised by persistence of attachment behaviours even in the face of inter-parental violence, creating child and adolescent vulnerability.

Our findings bear on the broader question of whether there is an association between attachment security assessed in the SSP and later emotion dysregulation and depression as a main effect. Meta-analyses have reported small effect sizes for of attachment security and internalising symptoms but these are difficult to interpret in relation to this question because of considerable heterogeneity in

sampling, attachment measures, ages of children, and cross-sectional vs. longitudinal design (31). The extent of this heterogeneity is highlighted in a recent meta-analysis in which associations between attachment security and adolescent depression were weaker in longitudinal than cross-sectional designs, for males than for females, and for attachment measures other than questionnaires (32). Once these were accounted there was a statistically significant, but very small ($b = .047$) association between insecure attachment and adolescent depression. Taken together, the findings of the meta-analyses and the evidence presented here imply that at least in respect of attachment status assessed behaviourally in the SSP, there are context dependent, rather than main effects of attachment security on child and adolescent emotion dysregulation and depression.

The marked differences in approach behaviours on reunion between the resistant and avoidant infants suggested that for investigations of the developmental implications of attachment behaviours the insecure category is a blunt tool. This was to some degree supported by our findings. For both the age 9 and age 13 years outcomes, while the pattern of findings were the same for the secure/insecure categories and the approach factor, the effects were somewhat stronger with the latter. There are wider implications of two kinds. First the existing coding system for the SSP includes a dimensional richness and specificity which has rarely been explored and which could enable novel developmental questions to be examined using data which are readily available. Second the dimensional approach to the attachment relationship lends itself to a more complex characterisation than the categorical approach permits. This is exemplified in studies which view attachment as a multidimensional control system accounting for exploratory as well as approach behaviours, and parental as well as infant behaviours (33).

The strengths of the study include the prospective measurement over substantial periods of time, using a range of methods, observational, interview, and parental, teacher and self-report questionnaire. The sample was recruited from the general population in a defined geographical area and stratified sampling allowed us to use time intensive observations with a subsample of known elevated psychosocial risk. Associations between younger age at first pregnancy, higher deprivation, IPV, and childhood irritability, were consistent with available evidence for co-occurrence of these risks and poor outcomes (34), supporting generalisability from this sample. Ratings of the SSP were made blind both to subsequent exposure to inter-parental violence and child and adolescent mental health outcomes. However statistical power for two-way interactions was limited by the size of the group of children exposed to inter-parental violence further divided into two roughly equal groups according to attachment status. In view of the associated risks of Type 2 errors reported values of "p" and the range of 95% confidence intervals may be less important than the pattern of findings which was very similar across two indices of attachment status, and across theoretically related outcomes at time points separated by four years.

The implications of the findings are far reaching. They imply that secure attachment, and the propensity to display attachment behaviours, are not straightforwardly positive or advantageous. Rather they contribute to development in a context dependent manner. Furthermore, in the extremely negative family environment of inter-parental violence, behaviours which under other circumstances are positive, can create vulnerability. This clearly requires further investigation, of the reproducibility of the findings, and also of the role of attachment assessed using different methods at different ages, and of other adverse family environments. The possibility has to be considered that interventions which aim to promote secure attachment in infants and young children, without assessing and aiming to reduce inter-parental violence or discord, may inadvertently increase their vulnerability to later emotional and behavioural problems.

Data availability statement

Due to ethical constraints supporting data cannot be made openly available. Supporting data are available to bona fide researchers on approval of an application for access. Further information about the data and conditions for access are available at the University of Liverpool Research Data Catalogue: https://doi.org/10.17638/datacat.liverpool.ac.uk/564.

Ethics statement

Ethical approval for the study was granted on four occasions covering the assessment points reported here, by the Cheshire North and West Research Ethics Committee on 27 June 2006 (reference no. 05/Q1506/107), 7th June 2010 (reference no. 10/H1010/4) and on 22nd December 2014 and 8th June 2020 (reference no. 14/NW/1484). Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

Author contributions

JH designed the study, chief investigator on grants, generated the hypothesis to be tested, wrote the paper. NW conducted the study, analysed the data, reviewed and revised the paper. HSh principal investigator on grants, directed the study, contributed to hypothesis generation and paper writing. AP principal investigator and senior statistician, supervised data analyses, reviewed and revised the paper. HSt coded attachment assessments, reviewed and revised the paper. All authors contributed to the article and approved the submitted version.

Funding

This work was supported by the Medical Research Council (grant numbers: G0400577, G0900654, MR/L022257/1 to JH, HS, AP) Cheshire Wirral Partnership NHS Foundation Trust, a National Institute of Health Research Health Protection Research

Unit in Emerging and Zoonotic Infections, the Centre of Excellence in Infectious Diseases Research (CEIDR) and Alder Hey Charity with support of Liverpool Health Partners and the Liverpool-Malawi-Covid-19 Consortium (to HS), a University of Reading Research Endowment Trust Fund award (to JH), a British Academy Small Research Grant award to (SRG2021\211230 to NW, AP, HS), and a National Institute of Health Research Senior Investigator award (NF-SI-0617-10120 to AP).

Acknowledgments

The authors are grateful to all participating families and research staff who contributed to this work and to Wirral University Teaching Hospital NHS Foundation Trust, Wirral Community NHS Foundation Trust, Cheshire and Wirral Partnership NHS Foundation Trust who supported the recruitment into the study in pregnancy and to the National Institute for Health Research (NIHR) Biomedical Research Centre at South London and Maudsley NHS Foundation Trust and Kings College London.

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/frcha.2023.1143125/full#supplementary-material.

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frontiers | Frontiers in Child and Adolescent Psychiatry

TYPE Original Research
PUBLISHED 26 April 2023
DOI 10.3389/frcha.2023.1175299

OPEN ACCESS

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RECEIVED 27 February 2023
ACCEPTED 04 April 2023
PUBLISHED 26 April 2023

CITATION
Braithwaite EC, Cole J, Murgatroyd C, Wright N, O'Farrelly C, Barker B and Ramchandani P (2023) Child DNA methylation in a randomised controlled trial of a video-feedback intervention to promote positive parenting and sensitive discipline (VIPP-SD).
Front. Child Adolesc. Psychiatry 2:1175299.
doi: 10.3389/frcha.2023.1175299

Child DNA methylation in a randomised controlled trial of a video-feedback intervention to promote positive parenting and sensitive discipline (VIPP-SD)

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Introduction: A major modifiable risk factor for behavioural difficulties is harsh and insensitive parenting, and it has been hypothesised that the biological mechanism by which parenting influences child behaviour is *via* changes in the child's DNA methylation. We attempted to, in part, address the hypothesis that parenting is associated with child DNA methylation and, in turn, behaviour.
Methods: Primary caregivers of young children with behavioural difficulties (children aged 12–36 months) were randomised to receive a video-feedback Intervention to promote Positive Parenting and Sensitive Discipline (VIPP-SD) ($n = 151$), or usual care ($n = 149$). Child buccal samples were collected at a 2-year post-randomisation follow up (children aged 3–5 years, VIPP-SD group $n = 106$, usual care group $n = 117$) and were assessed for DNA methylation at the NR3C1, FKBP5 and OXYR genes. Child behaviour was assessed at baseline, post-intervention and 2-years post-randomisation using the Preschool Parental Account of Children's Symptoms (PPACS). We examined group differences in DNA methylation, associations of DNA methylation with behaviour, and sex differences.
Results: For the NR3C1 and OXYR genes, there were no group differences, sex differences, or associations of DNA methylation with child behaviour, though all non-significant findings were in the hypothesised direction. For FKBP5 DNA methylation, there was a significant interaction between group and sex, such that males in the usual care group had higher DNA methylation than females, but in the intervention group females had higher DNA methylation than males. However, FKBP5 DNA methylation was not associated with behaviour in males or females.
Discussion: We provide the first evidence from a randomised controlled trial focused on improving parenting for sex-specific changes in child DNA methylation at a key gene involved in stress reactivity and psychopathology. This study adds to our understanding of causal mechanisms linking parenting with child behaviour, which is important for developing targeted interventions. A key limitation is that child DNA methylation was only assessed at one time point, so we were unable to assess change in DNA methylation over time. However, we demonstrate that is possible to collect and analyse DNA samples from families with young children receiving parenting interventions in the community, providing impetus for further research on this topic.

KEYWORDS

behavioural problems, developmental psychopatholgy, parenting, DNA methyaltion, intervention

1. Introduction

Enduring behavioural problems in childhood are an important early risk factor for conduct disorders, and other psychopathologies in adulthood such as depression, drug and alcohol misuse and antisocial personality disorder (1), and can present multiple challenges across the lifespan (2). To illustrate, 25%–60% of all adult disorders can be traced back to juvenile disruptive behaviours (3). In childhood, disruptive behaviours are characterised by disobedience, angry or irritable mood, and verbal or physical aggression towards others (Diagnostic and statistical manual (DSM-V); APA (4)). Behaviour problems are a source of immediate distress for children and families as well as having long-term costs for peer relationships (5, 6) and engaging positively in school (7, 8). Most children who exhibit disruptive behaviours experience challenges with regulating their emotions and behaviours; an early marker of impulsivity and low self-regulation capability (9). An inability to self-regulate one's emotions is also associated with heightened risk for later substance abuse, health problems, financial hardship, and delinquency (10, 11). Thus, disruptive behaviours in childhood come at a great cost for both individuals, families and society as a whole; therefore, attempts to tackle disruptive behaviours early could yield huge benefits for families, as well as significant economic gains (12). The current study is nested within a randomised controlled trial (RCT) to promote positive parenting and sensitive discipline, which has been shown to improve behavioural outcomes in young children. The aim of the current study was to examine group differences (intervention vs. control) in child DNA methylation and associations with child behaviour, to attempt to elucidate causal epigenetic mechanisms linking parenting and child behavioural difficulties.

Effective prevention strategies for childhood behavioural difficulties rely on our ability to identify the underlying aetiology, and then apply targeted prevention/intervention strategies. A key modifiable risk for behavioural problems in childhood is the parental care that children receive (13). In particular, harsh and physical disciplinary strategies, and low parental sensitivity and responsiveness, have been associated with an increased risk of externalising behaviours (behavioural difficulties, conduct problems and attention difficulties) (13, 14), and functional physiological changes in the autonomic nervous system (ANS) and hypothalamic-pituitary-adrenal (HPA) axis (15) in children. Alterations in the child's stress response systems may reflect a short-term adaptive response to harsh parenting, but in the long term may lead to increased allostatic load (i.e., the cumulative burden of chronic stress and life events) on the neuroendocrine, immune, metabolic, cardiovascular and respiratory systems (16, 17), resulting in system impairments. For example, children in supportive parenting contexts clearly exhibit a quick stress response followed by a recovery and return to resting state. However, in the context of chronic and severe dysfunctional parenting, children's stress response becomes less flexible in response to acute stress (18, 19) demonstrated by blunted (20, 21), or in some cases exaggerated (22), glucocorticoid responses. In children, dysregulated stress reactivity has also been related to behavioural difficulties and conduct disorders (23, 24). However, a key unanswered question is whether epigenetic mechanisms may mediate associations between dysfunctional parenting and behavioural difficulties/dysregulated stress reactivity in children (25).

Epigenetic modifications are biochemical modifications of the DNA that influence gene expression without altering the DNA sequence itself, and DNA methylation is the most widely studied epigenetic mechanism in humans. Cytosine-phosphate-guanine (CpG) sites within the DNA can become methylated with the addition of a methyl molecule (CH_3), which can occur within the gene sequence or, more commonly, at the promotor region of the gene (26). DNA methylation in the promotor region of a gene, in most cases, prevents DNA transcription, leading to a downregulation or silencing of gene expression (26). This is therefore a biological mechanism by which family experiences, or indeed any experiences or exposures, may become biologically embedded and influence an organism's phenotype.

It has been hypothesised that dysfunctional parenting may lead to the methylation of genes that code for the functioning of children's glucocorticoid stress reactivity system, leading to diminished stress reactivity; a risk factor for behavioural difficulties (25). Initial evidence for this hypothesis is based on pioneering animal research which has robustly demonstrated that low maternal care is associated with altered DNA methylation of the glucocorticoid receptor (GR) gene (*nr3c1*), as well as GR gene expression and HPA stress responses, in offspring (27, 28). Evidence for comparable mechanisms in humans is clear. It is well established in humans that exposure to early life stress is associated with hypermethylation of the NR3C1 gene which encodes the glucocorticoid receptor (29, 30). NR3C1 hypermethylation has also been associated with emotion regulation difficulties and externalising behaviour (31), and altered HPA reactivity (30, 32) in children. There is also evidence for sex differences in DNA methylation of NR3C1 in relation to early life adversity and child behavioural and emotional outcomes (33), with girls at greater risk of developing externalising symptoms and poor emotional outcomes, mediated by changes in DNA methylation.

In addition to NR3C1, other candidate genes which play a role in glucocorticoid stress responses have also been examined in relation to early life stress and child behavioural and physiological outcomes. There is an accumulating literature which has focused on the *FKBP5* gene, which codes for the FK506-binding protein 51 (FKBP5). FKBP5 is a co-chaperone for the GR receptor which modulates its sensitivity and is involved in the HPA-axis negative-feedback loop (34). There are several polymorphisms within the *FKBP5* gene which appear to moderate effects of early life stress on psychopathology (35), with "T" allele carriers more at risk of depression and PTSD (36) and alterations in DNA methylation (37) following early adversity. Maltreatment has been associated with reduced DNA methylation in the promoter region of the FKBP5 gene in children (38). Conversely in adults, reduced DNA methylation at the FKBP5 gene has been associated with a greater response to

psychological therapy for agoraphobia, and reduced anxiety following treatment (39). However, developmental changes in the epigenome are unclear therefore comparing DNA methylation of children to adults is challenging.

Another biological system which has been the target of research concerning mechanisms of how the early environment can impact phenotype is the oxytocin system. The human oxytocin system is essential to the regulation of complex social behaviours and is also implicated in psychopathologies characterised by social deficits (40, 41). Emerging evidence suggests that variation in the epigenetic regulation of the oxytocin receptor gene (*OXYR*) provides the oxytocin system with the flexibility to respond to environmental factors, especially those that occur during childhood (41). Robust evidence from animal studies has demonstrated that poor maternal care in prairie voles is associated with increased DNA methylation at the *oxyr* gene and decreased expression of the oxytocin receptor in the nucleus accumbens (42). Additionally, treatment of mandarin vole pups with an oxytocin antagonist resulted in decreased attachment behaviours of the pups towards the dams (43); providing experimental evidence that reduced oxytocin signalling (which also occurs in the case of OXYR hypermethylation) directly impacts attachment behaviour. In humans, it is evident that oxytocin is important in early parent-infant interactions; elevated parent and child oxytocin is associated with more parent-infant contact, and also elevated parental oxytocin is associated with more responsive parenting (44). Adults, however, who retrospectively reported low levels of maternal care in childhood have elevated OXYR DNA methylation in peripheral blood (45), suggesting long-term impacts of parenting behaviours on the epigenetic regulation of children's oxytocin system. Critically, increased OXYR DNA methylation has been associated with callous unemotional traits and difficulties with affect regulation in children (46).

Accumulating evidence therefore implicates the role of DNA methylation mechanisms at the glucocorticoid stress response and oxytocin systems as a potential mediator of the link between parenting behaviours and child psychopathology. However, longitudinal evidence that directly links parenting with *both* child DNA methylation and behaviour is lacking. Additionally, it is currently unknown whether interventions that target parenting can reverse changes in child DNA methylation, and whether this will lead to long-term reductions in disruptive behaviour. To address this evidence gap, randomised controlled trials where parenting is manipulated are needed.

Here, we present data from a randomised controlled trial of a home-based video-feedback intervention to promote positive parenting and sensitive discipline (VIPP-SD) in parents with the aim of reducing behaviour problems in children aged 12–36 months ($N = 300$). The trial was effective at reducing behaviour problems in the children at the 5-month post-intervention follow up (47). At the two-year follow up, buccal samples ($n = 225$) were collected from the children to examine DNA methylation at the NR3C1, FKBP5 and OXYR genes. The aims of the current study were to examine (A) whether there were group differences (intervention vs. usual care) in DNA methylation, and (B) if child behavioural difficulties were associated with DNA methylation. Because of the evidence of sex differences in effects of early life stress on psychopathology and DNA methylation at the NR3C1 gene, an additional aim was to examine sex differences in all analyses, but these were exploratory, and we did not make specific *a priori* hypotheses concerning sex differences. Our hypotheses were as follows:

H_1: The intervention group will have reduced DNA methylation at the NR3C1 and OXYR genes, and elevated DNA methylation at the FKBP5 gene, compared with the usual care group.
H_2: Behavioural problems will be associated with elevated DNA methylation at the NR3C1 and OXYR genes, and reduced DNA methylation at the FKBP5 gene.

2. Methods

2.1. Participants and procedures

Data derives from a two-arm, parallel group, researcher-blind, randomised-controlled trial (RCT) to test the clinical and cost-effectiveness of a brief video-feedback psychological intervention aimed at improving positive parenting and sensitive discipline [VIPP-SD (48, 49),] for parents of young children (aged 12–36 months) at risk of behavioural difficulties (ISRCTN58327365) (47, 50, 51). VIPP-SD is a manualised, home-based intervention, delivered over six sessions of 1- to 2-hour duration at approximately fortnightly intervals. The intervention was provided in the community and delivered by trained health practitioners. Each session had two parts: the first part involved filming parent-child interactions, and the second part involved giving parents focused feedback based on the filmed interactions from the previous sessions. For more information on the intervention please see O'Farrelly et al. (47).

Participants were 300 families who were randomised to receive either the VIPP-SD intervention ($n = 151$) or treatment as usual ($n = 149$), for details on the sample size calculation and randomisation process please see O'Farrelly et al. (47). Families included young children (aged 12–36 months) who demonstrated emerging behavioural difficulties, and their parents, see O'Farrelly et al. (47) for more information on the recruitment process. Eligibility for inclusion in the trial was as follows: parents aged 18 or over; child aged between 12 and 36 months; child scored in top 20% for behavioural difficulties on the Strengths and Difficulties Questionnaire (SDQ) (52, 53). Families were excluded if: the child or parent had a severe sensory impairment, learning disability, or language limitation that precluded participation in the trial; there were siblings participating in the trial; families were participating in active family court proceedings; parent/carer was participating in another closely related research trial and/or was currently receiving an individual video-feedback-based intervention. Participants in both groups continued to receive their usual care, which was minimal in most cases (there are no standard care pathways in the NHS for early-onset behaviour problems). Some participants received support and advice from a health visitor or

GP, referral to early intervention mental health services linked to a children's centre, or parenting advice and support sessions. Data were collected on the concurrent use of health and social care services.

Assessments were conducted at baseline, and at 5- and 24-months post-randomisation and were completed by researchers who were blind to the family's treatment status (51). Baseline and 5-month follow-up data were collected between July 2015 and April 2017, and 24-month follow-up data was collected between October 2017 and July 2019. The primary outcome was an assessment of severity of behavioural problems using a modified version of the Preschool Parental Account of Children's Symptoms (PPACS), a semi-structured investigator-led interview administered to the child's primary caregiver (54, 55). Child behaviour was also assessed at each time point using the SDQ and the Child Behaviour Checklist (CBCL) (56), as well as the PPACS. Demographic information was collected at baseline. More details of the measures are available in the trial protocol (50) and publication (47).

Buccal samples were collected from the children participating in the trial at the 24-month post-randomisation follow up using the iSwab-DNA-250 collection device (Mawi, UK) ($N = 225$, 75% of the trial sample). We used this method to collect child DNA samples because it allows the storage of DNA samples at room temperature. Attrition in sample size from the full trial sample was because of study drop-out ($n = 14$), because caregivers did not provide consent to the collection of DNA samples from their children ($n = 17$), because children did not provide assent for the collection of the sample ($n = 26$), and because some follow-up assessments were conducted over telephone only so no in-person contact with participants occurred to collect the sample ($n = 18$). Families who provided a child DNA sample were not statistically different to the whole sample on any of the demographic measures used as confounders in the analyses (all p's < 0.05). Samples were stored at room temperature at Imperial College London for 20 months and were then transported to Manchester Metropolitan University for analysis, which was conducted between May and November 2021.

The trial protocol was approved by Riverside Research Ethics Committee (14/LO/2071) as part of the NHS Research Ethics Service for more details see O'Farrelly et al. (47). Parents or caregivers provided informed consent, and the trial followed the Consolidated Standards of Reporting Trials (CONSORT) reporting guidelines. Additional ethical approval was gained from the Manchester Metropolitan University Research Ethics Committee (REF 10452) prior to the transportation of buccal samples from Imperial College London to Manchester Metropolitan University.

2.2. Measures

2.2.1. Demographics

Primary caregivers reported demographic characteristics at baseline. These included: child sex (male/female), date of birth, and race/ethnicity (asian/black/mixed/other/white), and the primary caregivers' sex (male/female), age (in years), race/ethnicity (asian/black/mixed/other/white), employment status (employed/paid parental leave/self-employed/student/looking after home and children) and highest educational qualification (GCSE or lower/A level, NVQ, or BTEC/University graduate or postgraduate degree). For more details please see (47).

2.2.2. Child behaviour

Three parental reports of child behaviour were collected as part of the trial at baseline and at the 5-month and 24-month follow up assessments: the PPACS, the SDQ and the CBCL. In the current analysis we chose to only use data from the PPACS to minimise the number of statistical tests and to reduce the likelihood of reporting a false-positive result. We chose the PPACS because it was the primary outcome used in the trial. The PPACS is a semi-structured researcher-led interview administered to a parent or caregiver (55). Interviews are the criterion standard outcome measure as they provide a more complete picture of children's symptoms that it is possible to measure by questionnaire (57, 58). To determine scores, the primary caregiver provided detailed examples of the child's typical behaviour over the last week in a range of settings (e.g., in the home, with friends, in public). The objective of this approach is to allow the interviewer to rate the child's behaviour based on real examples, rather than the caregiver's global impressions or judgements of whether or not the behaviour is normal. To ensure that the example given is characteristic of the child, caregivers are asked how representative the described behaviour is of the child over the past 4 months. A trained interviewer then rated the severity and frequency of the symptoms based on their professional judgement, following training, and guided by written definitions and thresholds of each of the scored behaviours. The measure comprises two subscales: conduct problems and attention-deficit/hyperactivity disorder or hyperactivity. In this study we used the total score in all analyses. The PPACS has high inter-rater reliability and good construct validity, and has been used in several RCTs assessing intervention effects on child behaviour (55, 59, 60). Interviews were recorded, and 10% (30 out of 300) were randomly selected for double scoring at each time point; high reliability was observed (intraclass correlations 0.93–0.97).

2.2.3. Child NR3C1 1F, FKBP5 and OXYR DNA methylation

2.2.3.1. DNA isolation

DNA from the buccal samples was extracted using DNA extraction kits (Quiagen, UK) in accordance with the manufacturer's protocol, and the salivary DNA was quantified using a Nanodrop 1,000 spectrophotometer (Thermo Scientific, UK). The extracted DNA was in the range 9.3–114.8 ng/µl (mean = 46.12, SD = 20.69). Extracted DNA samples were stored at −20°C.

2.2.3.2. Bisulphite pyrosequencing

DNA methylation at specific CpG sites (see **Supplementary Figure S1**) on the NR3C1, FKBP5 and OXYR genes was analysed using the quantitative bisulfite-pyrosequencing method. The extracted DNA (500 ng) was bisulfite converted using the

EpiTect Bisulphite kit (Qiagen Ltd, UK) according to the manufacturer's instructions and stored at −20°C until PCR processing. PCR was performed to amplify the DNA and label it with biotin for pyrosequencing. A mastermix was prepared for each reaction, including: 4 µl of 5x MyTaq reaction buffer (Bioline, UK), 0.5 µl of forward primer and 0.5 µl of reverse primer (see Table 1 for primer sequences), 0.2 µl MyTaq hot start DNA polymerase (Bioline, UK), and 12.8 µl water to make a total solution volume of 18 µl. This solution was vortexed and 18 µl aliquots were added to each well of a 96 well PCR plate. DNA (2 µl) was added to each well, then placed into an Eppendorf thermocycler (94 °C, 1 min; 60 °C, 1 min; 72°C, 1 min; 50 cycles). Electrophoresis of the PCR products (5 µl) was performed to confirm success of the PCR reaction. Pyrosequencing was performed using a PyroMark Q24 pyrosequencer (Qiagen Ltd, UK) with specific pyrosequencing primers using 20 µl of bisulfite-converted DNA. The average DNA methylation levels of specific CpG sites was quantified using PyroMark Q24 2.0.4 software (Qiagen Ltd, UK).

2.2.3.3. CpG sites

DNA methylation of two CpG cites in the FKBP5 promoter region previously linked to child maltreatment and response to psychological intervention (37, 39, 61, 62) were assessed. Average methylation at FKBP5 CpG1 was 97.47% and 78.68% at CpG2. Mean methylation of the two CpG sites was used in analysis; previous research has shown similar reductions in DNA methylation at both CpG sites in response to maltreatment (38, 62). Supplementary Figure S1 shows the position of the assessed CpG sites in the FKBP5 gene upstream of the coding region.

Four CpG sites on the NR3C1 promoter region previously linked to child adversity and behaviour (29, 63, 64) were assessed for methylation, see locations in Supplementary Figure S1. For analysis, the mean of CpG1 (average = 8.89%) and 2 (average = 4.50%) methylation was used, an approach that has previously been taken (33, 65). Not all bisulphite samples produced clear enough bands to give high enough peaks in the sequencing for the Pyromark software to consider them accurate enough. Therefore, a smaller sample (compared with other genes) with clean PCR bands of $N = 139$ samples were available for the NR3C1 analyses.

DNA methylation was assessed at two CpG sites within the OXYR gene which have previously been linked to child conduct disorders (66, 67) and maternal care (45, 68), see position in Supplementary Figure S1. The mean DNA methylation at CpG1 (47.57%) and CpG2 (69.05%) were used in separate analyses.

2.3. Statistical analysis

Imputation of missing child behavioural data is described in O'Farrelly et al. (47). Analysis was conducted in Stata version 17. Any values on the methylation scores >3 standard deviations (SD) above or below the mean were winsorised to 3 SD above/below the mean. No imputation was conducted for the child DNA methylation data. FKBP5 and NRC31 DNA methylation values were skewed and therefore transformed using log and square root transformation, respectively. The two OXYR DNA methylation variables were approximately normally distributed. All analyses controlled for study site (using Islington as reference), months between randomisation and outcome, age of child at recruitment, number of caregivers participating and baseline PPACS total score. Hypothesis 1 was tested using a 2 (treatment group; intervention/usual care) x 2 (child sex; male/female) analysis of variance with covariates (ANCOVA) models with each of the 4 methylation scores (NR3C1, FKBP5, OXYR CpG1, and OXYR CpG2) as outcomes. Significant interactions were explored and plotted using the margins command to estimate the predicted marginal effects for each combination of predictors (intervention vs. usual care and females vs. males). Main effects of group were then explored using a one-way ANCOVA in males and females separately. Hypothesis 2 was tested using multiple linear regression predicting time 3 PPACS scores from DNA methylation (4 separate models) and infant sex and their interaction term, in the intervention and control groups separately. Bonferroni correction was applied to account for multiple testing, with a threshold of $p < .006$ (0.05/8 statistical tests) set for significance.

3. Results

3.1. Demographics

Demographic statistics of the sample with DNA methylation data are presented in Table 2, split by treatment group. There were no differences between the intervention and usual care groups on any of the demographic measures (all p's < 0.05). Means and standard deviations of the DNA methylation variables are shown in Table 3.

3.2. Addressing hypothesis 1

Hypothesis 1, that treatment group would be associated with methylation, and the exploratory examination of sex differences,

TABLE 1 Forward and reverse primers used for NR3C1, FKBP5 and OXYR, location and sequence size.

Gene	Primers, forward (f), reverse (r)	Location	PCR size (bp)
NR3C1	F-(Biotin)AATTTTTTAGGAAAAAGGGTGG	hg19; chr5:142,783,610–142,783,671	343
	R-AACCCCTTTCCAAATAACACACTT		
FKBP5	F-GGATTTGTTGGGATAATAATTTTGGG	Chr6: 35,558,486–35,558,567	324
	R-(Biotin)TCTTACCTCCAACACTACTACTAAA		
OXYR	F- GGGGGGAGTTAATTTTAGGTT	hg19:Chr:3:8,810,807–8,810,808	330
	R-(Biotin)CTCAATCCCCAAAAATCTTTACAATCT		

was tested using a 2 (treatment group) by 2 (child sex) ANCOVA for each of the 4 methylation scores, accounting for confounders and baseline PPACS symptoms. For OXYR CpG1, OXYR CpG2 and NR3C1 the main effects of group, sex and the interaction term were all non-significant (all p's > 0.006), indicating no association between treatment group, either as a main effect or modified by sex, and DNA methylation at these CpG sites, see Supplementary Table S1. For FKBP5, the main effects of group and child sex were non-significant, but the interaction term was significant [F(13, 202) = 8.42, $p = 0.004$] (see Table 4). The interaction is displayed in Figure 1, which shows the predicted marginal effects for girls and boys in the intervention and usual care groups. The FKBP5 DNA methylation is higher in females in the intervention group (mean = 86.85, SD = 5.91; predicted marginal mean = 82.53, SE = 6.27) than the usual care group (mean = 86.84, SD = 6.81; predicted marginal mean = 79.72, SE = 6.17). Conversely for males, FKBP5 DNA methylation is lower in the intervention group (mean = 87.31, SD = 6.57; predicted marginal mean = 80.16, SE = 6.25) compared to the usual care group (mean = 88.92, SD = 7.13; predicted marginal mean = 82.01, SE = 6.29). The main effect of group was examined in a one-way ANOVA split by child sex. There was a small to medium effect size (partial eta squared = 0.05) for the effect of group in females which was non-significant [F(11,85) = 4.38, $p = 0.039$], and a small effect size in males (partial eta squared = 0.02) which was non-significant [F(11,118) = 1.99, $p = 0.161$].

TABLE 2 Demographic characteristics of the sample, split by intervention and control group.

Characteristic	VIPP-SD Group	Usual Care Group
	n = 106	*n* = 117
Children		
Male, *N* (%)	55 (51.9)	67 (57.3)
Age at baseline, mean (SD) in months	22.92 (6.88)	23.44 (6.51)
Age at 2 year follow up mean (SD) in months	47.58 (7.29)	47.92 (6.91)
Race/ethnicity, *N* (%)		
Asian	8 (7.5)	5 (4.3)
Black	3 (2.8)	10 (8.5)
Mixed	28 (26.4)	20 (17.1)
Other	2 (1.9)	6 (5.1)
White	65 (61.3)	76 (65.0)
Primary caregivers		
Male, *N* (%)	2 (1.9)	5 (4.3)
Age, mean (SD) in years	34.39 (4.98)	34.56 (6.07)
Race/ethnicity, *N* (%)		
Asian	13 (12.3)	12 (10.3)
Black	3 (2.8)	10 (8.5)
Mixed	7 (6.6)	8 (6.8)
Other	7 (6.6)	3 (2.6)
White	76 (71.7)	84 (71.8)
Employment status, *N* (%)		
Employed	47 (44.3)	52 (44.4)
Paid parental leave	5 (4.7)	7 (6.0)
Self-employed	14 (13.2)	9 (7.7)
Student	2 (1.9)	5 (4.3)
Looking after children at home	38 (35.8)	44 (37.6)
Highest qualification, *N* (%)		
GSCE or lower	9 (8.5)	10 (8.6)
A level, NVQ, or BTEC	29 (27.4)	28 (23.9)
University graduate or postgraduate degree	68 (64.2)	79 (67.6)

TABLE 3 DNA methylation (% methylation) variables split by intervention and control group.

	VIPP-SD group		Control group	
	N	Mean (SD)	*N*	Mean (SD)
NR3C1 (mean CpG1 and CpG2)	66	6.15 (6.78)	73	7.16 (9.05)
FKBP5 (mean CpG1 and CpG2)	104	88.30 (6.56)	115	87.84 (7.75)
OXYR CpG1	106	47.32 (5.14)	116	47.80 (5.73)
OXYR CpG2	106	69.41 (5.33)	116	68.73 (5.39)

3.3. Addressing hypothesis 2

The second hypothesis, that methylation would be associated with behavioural difficulties at the 24-month follow up, with the possibility of sex differences, was examined using multiple linear regression predicting PPACS total score at the 24-month follow up from treatment group, child sex, and the interaction term between them, after accounting for confounders and baseline PPACS symptoms. OXTR CpG1, OXTR CpG2, NR3C1 and FKBP5 DNA methylation were not significantly associated with PPACS total behavioural difficulties in the intervention or usual care group, see Supplementary Table S2.

4. Discussion

This study aimed to further scientific understanding of whether parenting can impact children's DNA methylation, which in turn impacts behavioural difficulties. Our first aim was to test whether

TABLE 4 Result of the ANCOVA examining the impact of intervention group, child sex, and their interaction on FKBP5 DNA methylation.

FKBP5 DNA methylation		
Variable	F	p
Intervention group	0.00	0.947
Child sex	0.00	0.967
Intervention group X child sex	**8.42**	**0.004**
PPACS T1	1.77	0.184
Child age	1.98	0.161
Number of caregivers in trial	0.66	0.419
Time since randomisation	7.10	0.008
Location—Camden	1.16	0.282
Location—Hillingdon	5.45	0.021
Location—Oxford	3.28	0.072
Location—Barking	3.13	0.079
Location—Peterborough	3.59	0.059
Location—Hertfordshire	0.05	0.831
Model *N* = 217, R-squared = 0.119		

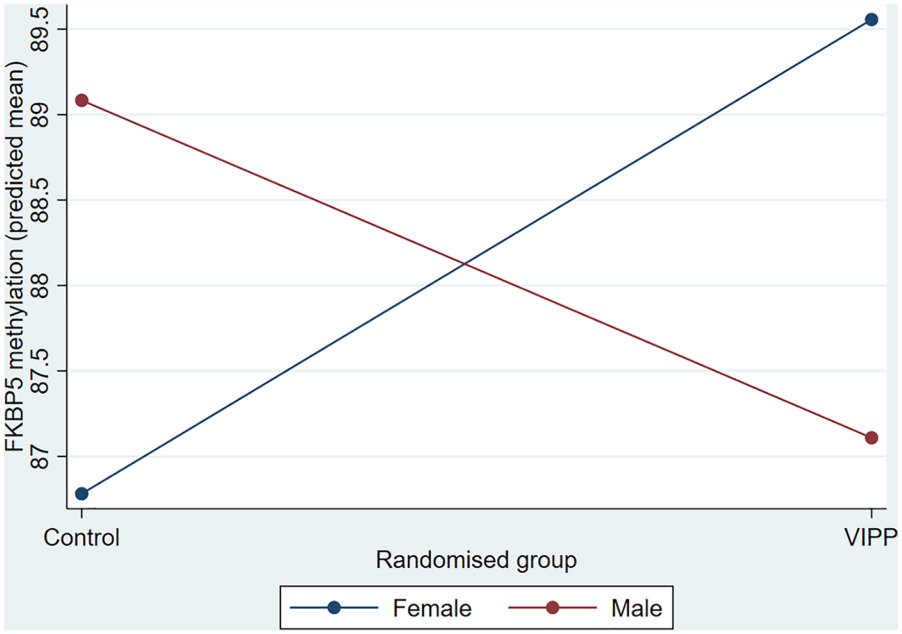

FIGURE 1
FKBP5 DNA methylation predicted mean by intervention group and child sex.

there were group (intervention group vs. usual care group) and/or sex (male vs. female) differences in child DNA methylation at the NR3C1, FKBP5 and OXYR genes. There were no main effects of group, sex, or their interaction on DNA methylation at the NR3C1 and OXYR genes. However, there was a significant interaction between group and sex on FKBP5 DNA methylation, after applying a stringent statistical control for multiple testing. Further analysis established that females in the intervention group had higher DNA methylation than females in the control group, whereas males in the intervention group had lower DNA methylation than males in the control group. There were no associations between child DNA methylation at any genes and child behaviour.

We hypothesised that the intervention group would have higher FKBP5 DNA methylation than the control group. This was based on evidence that child maltreatment has been associated with reduced DNA methylation at this gene (38), therefore we followed the hypothesis that if there were improvements in parenting (and using the intervention group compared to the usual care group as a proxy for this), then the hypomethylation of this gene in children may be reversed. Results are therefore in the hypothesised direction for females, but in the opposite direction for males. Our examinations of sex differences were exploratory, not determined *a-priori*, and based on evidence from studies implicating sex differences in effects of early life stress on DNA methylation at the NR3C1 gene (33, 69). Therefore, the sex difference in effect of treatment group on FKBP5 DNA methylation was not directly hypothesised and should be interpreted with caution. That said, both the glucocorticoid receptor and FKBP5 play a key role in moderating stress responses and mediating risk for psychopathology. As far as the authors are aware, this is the first evidence for the sex-specific impact of parenting on FKBP5 DNA methylation, and it requires replication. There is however evidence from studies of adults of female-specific associations between FKBP5 DNA methylation and bedtime cortisol (70), and between FKBP5 mRNA expression and symptoms of depression and anxiety (70). Our findings, alongside existing research, therefore support the idea that FKBP5 DNA methylation may be of particular importance in stress reactivity and psychopathology in females, and our findings also implicate DNA methylation at this gene as being malleable to changes in parenting. However, it is evident that polymorphisms within the FKBP5 gene moderate effects of environmental stress on psychopathology (35, 36) and DNA methylation (37), therefore future studies should consider the interaction between genotype and DNA methylation in mediating risk. In the current study we were unfortunately unable to determine and control for FKBP5 genotype.

Our second aim was to examine whether DNA methylation at the NR3C1, FKBP5 and OXYR genes was associated with behavioural difficulties 2 years post-intervention, whilst controlling for baseline (pre-intervention) behaviour. We found no evidence to suggest that DNA methylation was associated with change in behavioural difficulties from baseline to 2 years post-intervention. This is in contrast to previous literature which has examined associations between NR3C1 DNA methylation and externalising behaviour (31), and OXYR DNA methylation and callous unemotional traits and affect dysregulation in children (46, 66). Discrepancies could be explained by comparisons with larger cohorts which included severely maltreated children (31), or because of comparisons with a samples of children with severe behavioural disorders

(e.g., callous unemotional traits) (66). The sample of children in the current study were demographically low-risk, and had moderate behavioural difficulties at a very young age, which could explain why there were no associations between DNA methylation and behaviour, as reported in other studies.

Understanding the impact of the early environment on child DNA methylation and psychopathology is an emerging field. There is preliminary evidence that parenting is associated with child DNA methylation (25), and that DNA methylation is associated with child and adolescent psychopathology (71). However, most of the existing work is correlational in nature and few studies have examined DNA methylation in relation to *both* parenting and child behaviour/psychopathology. One very small study of just 23 maltreated children showed that an intervention to enhance caregiving, Attachment and Biobehavioural Catchup (ABC), resulted in genome-wide variation in DNA methylation in those children who received the intervention ($n = 12$) compared with those who did not ($N = 11$) (72). Although promising, these results should be interpreted with caution given the small sample size and the whole-genome approach where issues of multiple-testing are difficult to address. The current study, therefore, extends existing knowledge by examining DNA methylation in children in the context of a fully-powered, randomised controlled trial (RCT) aimed at improving positive parenting and sensitive discipline, and testing associations with child behavioural difficulties. Research of this kind, nested within an RCT, provides the strongest evidence of causal relationships between parenting, child DNA methylation and behaviour. A major strength of this study is the collection of child DNA within an RCT design, which extends existing methodology by demonstrating that it is possible to collect buccal samples from young children to be analysed for DNA methylation within an RCT delivered in the community. If future studies adopt this approach, then more evidence on causal pathways will accumulate to further advance our knowledge. Another strength of this study is that the measure of child behavioural difficulties is based on a parental interview of child behaviour, which allowed the collection of detailed information about symptoms based both on severity and frequency that was not weighted by the parent but by the research team based on strict criteria (55). This measure of child behaviour therefore minimises reporter bias, which is often a limitation of observational research focused on child behaviour.

There were also limitations to the current study that should be considered. First, due to a technical issue with equipment over a period of a COVID-19 lockdown in the UK, the data for the DNA methylation at the NR3C1 gene is incomplete and therefore there is a reduced sample size for analyses of this gene. Thus, power to detect small to medium effects was reduced in this analysis. Overall, the study had a moderate sample size and was underpowered to detect small effects. Second, we did not have data on DNA methylation at the candidate genes prior to the intervention so were unable to assess change in DNA methylation over time. We were therefore unable to directly test the hypothesis that there would be greater changes in child DNA methylation in the intervention compared to the control group, and future work should seek to establish this. Third, assessment of DNA methylation from buccal swabs is limited because it does not necessarily reflect DNA methylation in brain tissue. Fourth, we were unable to control for FKBP5 genotype, as discussed previously. Fifth, we were also unable to directly test the proposed causal mechanism that changes in parenting results in changes in DNA methylation, and ultimately a change in child behaviour. Instead, we used trial group as a proxy for parenting behaviour, with the assumption that those caregivers in the intervention group would show a change in positive parenting and sensitive discipline over time, whereas the caregivers in the control group would show no change in parenting. Future work should seek to assess changes in parenting using observational methods, such as sensitivity and responsiveness, pre- and post-intervention to directly test the proposed causal mechanism. Additionally, replication of these findings using larger, more diverse samples is needed, with rigorous control for confounding variables and potential gene-environment interactions.

In sum, we provide novel evidence, from a fully powered RCT aimed at improving positive parenting and sensitive discipline, that there are impacts of the intervention on child DNA methylation at the FKBP5 gene, consistent with sex-specific effects. We also demonstrate that it is possible to collect and analyse child DNA samples within an RCT delivered in the community to assess levels of DNA methylation; an objective outcome from a parenting intervention that is not subject to the limitations of self-report or observational measures. Research of this type is needed to fully understand causal pathways linking parenting with child DNA methylation and behaviour. Whilst considering the limitations of this study, this work provides impetus for more research on this topic to fully understand how parenting practices may become biologically embedded, resulting in long term consequences for child behaviour and psychopathology.

Data availability statement

The datasets presented in this article are not readily available. All of the individual, de-identified participant data will be available 12 months after publication and for 5 years after date of publication. Data will be made available to researchers who provide a methodologically sound proposal and have the required institutional approvals in place to achieve aims in the approved proposal. Proposals should be directed to the corresponding author to gain access, and requestors will be asked to sign a data access agreement. Requests to access the datasets should be directed to EB, e.braithwaite@mmu.ac.uk.

Ethics statement

The studies involving human participants were reviewed and approved by Riverside Research Ethics Committee (14/LO/2071) and Manchester Metropolitan University Research Ethics Committee (REF 10452). Written informed consent to participate in this study was provided by the parents for themselves and for their child.

Author contributions

EB: conceptualization, methodology, investigation, data curation, writing—original draft, funding acquisition, supervision. JC: methodology, investigation, writing—review & editing. CM: conceptualisation, methodology, investigation, resources, supervision writing—review & editing. NW: formal analysis, writing—review & editing. CO: conceptualisation, methodology, investigation, data curation, writing—review & editing. BB: conceptualisation, methodology, investigation, data curation, writing—review & editing. PR: conceptualisation, methodology, resources, conceptualisation, methodology, investigation, data curation, writing—review & editing, funding acquisition. All authors contributed to the article and approved the submitted version.

Funding

This research was funded by an NIHR HTA programme grant (13/04/33) and the NIHR Biomedical Research Centre based at Imperial College Healthcare National Health Service (NHS) Trust and Imperial College London. The views and opinions expressed therein are those of the authors and do not necessarily reflect those of the HTA programme, NIHR, NHS, or the Department of Health. Analysis of the saliva samples for DNA methylation was funded by an internal research award at Manchester Metropolitan University awarded to Braithwaite.

Acknowledgments

We would like to thank the Healthy Start, Happy Start Project Management Group, Steering group and Patient and Public Involvement Group for their contributions to the design and production of the original study. We are grateful to the families who took part in the study and the study's funders. We also thank the core Healthy Start, Happy Start research team, particularly Ellen Grimås, Charlotte Phillips, Rachel Ryan and Holly Mattock for their contributions to the study and data collection.

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/frcha.2023.1175299/full#supplementary-material.

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frontiers | Frontiers in Child and Adolescent Psychiatry

TYPE Original Research
PUBLISHED 26 May 2023
DOI 10.3389/frcha.2023.1148273

OPEN ACCESS

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RECEIVED 15 March 2023
ACCEPTED 08 May 2023
PUBLISHED 26 May 2023

CITATION
Royer MF, Cosgrove K and Wharton C (2023) Absent mindfulness: mediation analyses of the relationship between adverse childhood experiences and disordered eating among young adults.
Front. Child Adolesc. Psychiatry 2:1148273.
doi: 10.3389/frcha.2023.1148273

Absent mindfulness: mediation analyses of the relationship between adverse childhood experiences and disordered eating among young adults

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Recent evidence has indicated that adverse childhood experiences (ACEs) involving abuse, neglect, and other potentially traumatic occurrences are predictive of disordered eating among young adults. Previous findings have suggested that ACEs and disordered eating were both inversely related to mindfulness. No known studies have examined the extent to which mindfulness mediates the link between ACEs and disordered eating. This study was conducted among a sample of 144 young adults in the U.S. between the ages of 18 and 26 years. Primary study variables included ACEs, mindfulness, and disordered eating. Univariate and multivariable regression analyses assessed the link between ACEs and disordered eating. Mediation analyses examined whether mindfulness mediated the link between ACEs and disordered eating. Multivariable analyses statistically adjusted for the covariates of age, sex, race/ethnicity, and income. Findings suggested ACEs were inversely related to mindfulness ($B = -0.04$, SE = 0.01; 95% CI = −0.07, −0.01; $p < 0.05$), mindfulness was inversely related to disordered eating ($B = -1.27$, SE = 0.23; 95% CI = −1.74, −0.80; $p < 0.0001$), and ACEs were positively related to disordered eating before ($B = 0.17$, SE = 0.04; 95% CI = 0.09, 0.26; $p = 0.0001$) and after ($B = 0.13$, SE = 0.04; 95% CI = 0.05, 0.21; $p = 0.002$) adjusting for mindfulness. Mediation analysis results indicated that the link between ACEs and disordered eating was significantly mediated by mindfulness ($B = 0.05$, SE = 0.02; 95% CI = 0.01, 0.09; $p < 0.05$). Evidence produced in this study confirmed existing findings concerning the positive association between ACEs and disordered eating among young adults, and these outcomes helped fill a knowledge gap regarding whether mindfulness mediates the link between ACEs and disordered eating. Future intervention studies should identify health-enhancing mindfulness approaches and then test whether the adoption of mindfulness practices can alleviate and prevent disordered eating among young adults with high ACEs.

KEYWORDS

disordered eating, young adults, mediation, adverse childhood experiences, mindfulness

1. Introduction

1.1. Background for adverse childhood experiences and disordered eating

Adverse childhood experiences (ACEs) are characterized by abuse (physical, emotional, sexual), neglect (physical, emotional), and household dysfunction (witnessing abuse, divorce, incarceration, substance abuse, mental illness) occurring from the ages of 0–17 years old (1).

ACEs are a major risk factor for the emergence of risky behaviors and poor health conditions in adulthood (2). Among adults with high ACEs, the pairing of persistently high stress levels with unhealthy coping mechanisms further increases the risk for chronic disease (3).

During the 21st century, there have been declines in a variety of ACEs including childhood poverty, exposure to domestic violence, parental divorce, physical abuse, emotional abuse, and sexual abuse in comparison to the late 20th century (4). In contrast, the ACEs that have consistently increased in prevalence since the 20th century have been parental alcohol and drug abuse (4). An examination of data derived from the 2016 National Survey of Children's Health (NSCH) revealed that, among 45,287 U.S. children aged 0–17 years, almost half (45%) had experienced at least one ACE while one in 10 encountered three or more ACEs (5).

Widespread disparities in ACEs exist across sociocultural groups in the United States (6, 7). ACEs are most common among individuals who are low-income (8); female (7); and those who are Black, Indigenous, and people of color (6). Recent reports have highlighted how ACEs were higher among Black (61%) and Hispanic (51%) children than White (40%) and Asian (23%) children (5). Adults with four or more ACEs have significantly worse health outcomes than those with no ACEs (9). Chronic diseases that are associated with high ACEs include obesity (10), asthma (11), heart disease (12), cancer (13), and stroke (12). High ACEs also increase the odds of mental illness and associated symptoms in adulthood including anxiety (14), depression (15), and suicidal behavior (16). Certain unhealthy behaviors contributing to the development of disease among adults with high ACEs involve physical inactivity (17), illicit drug use (18), binge drinking (19), and disordered eating (20).

Disordered eating is characterized by eating behaviors typically exhibited by individuals with eating disorder symptoms in the absence of a clinical diagnosis (21). Specific disordered eating behaviors include restraint, eating concern, weight concern, and shape concern (22). Restraint involves an avoidance of eating, eating concern pertains to a fixation with food, weight concern refers to a preoccupation with one's own bodyweight, and shape concern involves worries about one's own body composition. Since healthy eating is vital for human wellbeing (23), the harmful impact of certain types of disordered eating behaviors pose a threat to both physical health (24) and mental health (25), as disordered eating has been shown to increase the odds of obesity (26), type 2 diabetes (27), and mental health problems including depression (28), and suicidal behaviors (29).

1.2. Adverse childhood experiences and disordered eating among young adults

A positive association between ACEs and disordered eating has been detected in several samples of college students (30–33), while only two known studies have confirmed these findings among young adult samples that are more representative of the general U.S. population (20, 34). Outcomes from recent research among a diverse sample of young adults in the midwestern U.S. ($n = 1{,}647$) highlighted how both emotional abuse (RR = 1.4, 95% = 1.1, 1.8) and emotional neglect (RR = 1.4, 95% = 1.2, 1.8) in childhood were connected to a greater risk of disordered eating during adulthood (34). Findings from a separate study among another diverse sample of young adults in the midwestern U.S. ($n = 1{,}440$) suggested that young adults who experienced household dysfunction ($B = 1.22$, 95% CI = 1.02, 1.47) or household dysfunction and abuse ($B = 1.89$, 95% CI = 1.39, 2.57) during childhood were also at an increased risk of disordered eating (20).

Additional research findings for the relationship between adverse childhood experiences and disordered eating in young adult males have shown that a higher prevalence of those with an adverse family background reported disordered eating ($\chi^2 = 9.11$, DF = 1; $p = 0.003$) compared to those without an adverse family background, while no differences in disordered eating were detected between victims and non-victims of physical abuse and sexual abuse (30). Contrarily, a study among young adult males determined that physical abuse during childhood was correlated with disordered eating in adulthood ($r = 0.26$, $p < 0.01$). In the same study, physical neglect during childhood was also found to be correlated with disordered eating ($r = 0.35$, $p < 0.02$). Mediators were explored in this study, but it was found that neither anxiety nor alexithymia were significant mediators within the relationship between ACEs and disordered eating (31).

Additional outcomes from research that examined the relationship between ACEs and disordered eating among young adults revealed how childhood experiences of sexual abuse [t (1,153) = 2.31, $p = 0.02$] and neglect [t (1,153) = 6.26, $p < 0.001$] were both associated with disordered eating in adulthood. However, results from a mediation analysis in the same study reported that anxiety mediated the relationship between sexual abuse and disordered eating, as it was no longer significant after accounting for anxiety during adulthood [t (1,092) = 0.98, $p = 0.34$] (32). Moreover, other mediation-related findings have indicated that experiences of emotional abuse are linked to an increased likelihood of disordered eating among young adult college students both before ($B = 0.60$, $p < 0.001$) and after ($B = 0.25$, $p < 0.001$) accounting for self-perception as a hypothesized mediator (33).

Young adulthood is a period of life when emerging adults adopt lifestyle behaviors that very often lay the foundation for a certain health trajectory into later adulthood (35). There is a greater prevalence of disordered eating among young adults compared to middle age and older adults (36), which highlights the urgent need to establish a greater understanding of the link between ACEs and disordered eating among young adults. It is therefore essential to identify mediating mechanisms that attenuate the link between ACEs and disordered eating and could eventually be targeted to prevent or alleviate disordered eating among young adults with high ACEs.

Mindfulness is a hypothesized mediator of special consideration, as past study findings suggest that mindfulness is inversely related to ACEs (37–42) and disordered eating (43–46). Mindfulness involves the self-regulation of attention and responses related to internal (thoughts, feelings) and external (bodily senses, environment) stimuli (47). Intervention studies using mindfulness-based approaches have been shown to reduce the risk of poor mental health among individuals with high ACEs (48) and disordered eating symptoms (49–53). Mindfulness has been shown to attenuate the positive association that a high level of ACEs have with unhealthy behaviors like alcohol misuse (39) and domestic violence (38), poor health

outcomes such as psychopathological symptoms (41) and depression (40), and health-related quality of life (37).

A recent study revealed how mindfulness moderated a positive link between depression and disordered eating by mitigating the effect of depression (54). A separate study highlighted how mindfulness was inversely related to both anxiety and disordered eating (55). These findings portray how mindfulness can mitigate the severity of disordered eating despite the presence of problematic circumstances that are linked to increased disordered eating. Additional outcomes from mediation studies have indicated that body dissatisfaction (56), perceived distress (57), anxiety (58, 59), depression (31, 59, 60), and emotion regulation (61–63) mediated the link between ACEs and disordered eating. Some mediators (i.e., perceived distress) were positively related to disordered eating, while others (i.e., emotion regulation) were inversely related to disordered eating.

Despite indications of mindfulness being inversely related to both ACEs and disordered eating, no known studies have explored whether mindfulness mediates this relationship. In being inversely related to ACEs and disordered eating, it is possible that mindfulness could play a mediating role by attenuating the positive relationship between ACEs and disordered eating in adulthood. Therefore, this critical knowledge gap needs to be addressed by determining whether mindfulness plays a mediating role within the relationship between ACEs and disordered eating.

1.3. Research hypotheses

The aims of this research were to address two primary knowledge gaps concerning ACEs and disordered eating among young adults using a cross-sectional observational study. First, research is scant regarding the link between ACEs and disordered eating among young adults who were not sampled from a university population. It is important to expand the knowledge base concerning how ACEs are related to disordered eating among young adults in the general population, as these individuals are in the process of developing and adopting health behaviors that could be sustained throughout their lives. Second, it is critical to identify mediators of the relationship between ACEs and disordered eating that can be tested in future intervention studies. The identification of mindfulness as a significant mediator of the relationship between ACEs and disordered eating would provide evidence that could be utilized for designing an intervention to increase mindfulness that can help address disordered eating among individuals with high ACEs. These study aims informed our two research hypotheses that (1) a positive relationship exists between ACEs and disordered eating among young adults, and (2) mindfulness mediates the relationship between ACEs and disordered eating among young adults.

2. Materials and methods

2.1. Participant recruitment

Study researchers implemented a quantitative, cross-sectional research approach to determine whether mindfulness mediates the link between ACEs and disordered eating among young adults in the U.S. A nationwide sample of 150 young adults in the U.S. were recruited to complete an online Qualtrics survey between May 3rd and May 8th, 2022 using CloudResearch from Amazon Mechanical Turk (MTurk) (64). MTurk is an online crowdsourcing platform offering an array of data collection features (65). A target sample size of 150 was the goal, as this exceeded the estimated sample size of 45 that was required to adequately power a cross-sectional study using multiple linear regression to conduct a two-tailed multiple linear regression analysis with five predictors, an anticipated effect size of 0.30 (31), an error probability of 0.05, and a power of 0.95 to detect a true positive (66). Data collected via MTurk has been found to be as reliable as data collected using more traditional methods (67), while also having the advantage of producing participant samples that are more diverse than other internet-recruited or college student samples (68, 69).

To be eligible for participation in the study, participants were required to be U.S. residents between the ages of 18 and 26 years who had never been clinically diagnosed with an eating disorder. Of the 150 survey responses, six respondents were excluded from the study due to the detection of three duplicate IP addresses, which resulted in a final study sample of 144 participants with no missing data. Three attention-check questions were used during data collection to promote data quality. One question was integrated into each of the ACEs, mindfulness, and disordered eating surveys. The attention-check question instructed respondents to select a certain answer. Data derived from respondents who did not select a correct answer for any attention-check question were excluded. The data collection process was completely anonymous. Participants received $2.00 for completing the 15-minute survey. Ethics approval was provided by the Institutional Review Board (IRB) of Arizona State University (STUDY00015736). All participants provided informed consent before joining the study.

2.2. Data collection measures

A 59-item online Qualtrics survey was used to obtain data on self-reported participant outcomes for ACEs, mindfulness, disordered eating, and personal characteristics.

ACEs were measured using the 11 items included within the Centers for Disease Control and Prevention's 2020 Behavioral Risk Factor Surveillance System Survey (BRFSS) Questionnaire (70). The BRFSS items for ACEs include questions related to the following: fellow household members during childhood who experienced serious mental health problems, substance abuse, interpersonal violence, incarceration, and/or divorce; along with personal childhood experiences involving verbal, physical, and/or sexual abuse. In the BRFSS format, respondents are asked to indicate "Yes", "No", "Don't know/Not Sure", or "Refused" for each item. For this study, respondents were given the options of "Yes" or "No" to preclude missing data. A psychometric evaluation of the ACEs measure used in the BRFSS survey have yielded results which indicated that the ACEs measure

maintained an acceptable level of reliability that passed the threshold of 0.65 for multidimensional measures ($\omega = 0.906$) (71).

Mindfulness was measured with the widely used 15-item Five-Facet Mindfulness Questionnaire (FFMQ) (72). The FFMQ items include statements covering five facets of mindfulness, which include: observing, describing, acting with awareness, non-judging of inner experience, and non-reactivity to inner experience. The FFMQ is answered on a five-point Likert scale, which ranges from "Never or very rarely true" to "Very often or always true". The original FFMQ contains 39 items, so the 15-item FFMQ was developed and is used to minimize respondent burden since the two versions share consistent factor structures and strong correlations between total facet scores (73). Psychometric evaluations of the FFMQ have found that the, across the five facets of mindfulness, the FFMQ sustained an acceptable level of reliability for observing ($\omega = 0.699$), describing ($\omega = 0.0.726$), acting with awareness ($\omega = 0.771$), non-judging ($\omega = 0.777$), and non-reactivity ($\omega = 0.688$) (74).

Disordered eating was measured using the 28-item Eating Disorder Examination Questionnaire (EDE-Q) (22). The EDE-Q contains the following four subscales of disordered eating behaviors: restraint, eating concern, shape concern, and weight concern. Altogether, the four disordered eating subscales can be combined to create the general outcome of global disordered eating. Likert scales with varying point ranges are used in the EDE-Q to gauge either the frequency (e.g., No days, Every day) or intensity (e.g., Not at all, Markedly) of an outcome that contributes to a disordered eating subscale. Examinations of the test-retest reliability of the EDE-Q have concluded that the EDE-Q has strong measurement reliability for the subscales of restraint ($r = 0.81$), eating concern ($r = 0.87$), shape concern ($r = 0.94$), and weight concern ($r = 0.92$) (75).

Participant characteristics measured in the study included age in years (18–26), biological sex (female, male), race/ethnicity (American Indian or Alaska Native, Asian, Black, Hispanic/Latino, White), education (high school, some college, Bachelor's degree, Master's degree, Doctoral degree), and income (<$25,000; $25,000–$49,000; $50,000–$74,999; $75,000–$99,000; ≥$100,000). The full study survey in Qualtrics required that participants provide a response to each ACEs, mindfulness, disordered eating, and personal characteristics item before proceeding to the next item. This approach prevented instances of missing data from occurring throughout data collection.

2.3. Primary variables and covariates

ACEs were the primary predictor variable in this study. A continuous interval variable for ACEs was created by adding responses for each of the 11 ACEs items (no = 0, yes = 1) and then assigning each participant a total ACEs score (0–11). Separately, a dichotomous ACEs variable was created to categorize participants by whether they had experienced four or more ACEs (ACEs < 4 = 0, ACEs ≥ 4 = 1). A cutoff point of ≥4 was chosen because encountering four or more types of ACEs has been recognized as a widely accepted threshold for individuals being at an increased risk of poor health and adverse social outcomes in adulthood when compared to those with less than four ACEs (76). The continuous ACEs score was used to test differences in mindfulness and disordered eating across different levels of ACEs. Separately, the dichotomous ACEs score was used for descriptive purposes and to assess the association between having four or more ACEs and disordered eating.

Mindfulness was the hypothesized mediating variable in the link between ACEs and disordered eating. Scores for each FFMQ item ranged from one to five points with some items being reverse scored. A continuous variable was created for mindfulness by summing the total score for all 15 items and dividing the sum by 15 to assign each participant a mean mindfulness score (0–5). Disordered eating was the primary outcome variable in this study. Continuous variables were created for each of the disordered eating subscales (restraint, eating concern, weight concern, shape concern) by summing the item totals and dividing by the number of items to produce a mean subscale score. The four disordered eating subscale scores were then summed and divided by four to produce a continuous global disordered eating score. Covariates in this study included all participant characteristics. Age was zero-centered when coded as an interval variable. Sex was dichotomously coded as biological female or male. Race/ethnicity was treated as a categorical variable. Ordinal variables for both Education and Income were created, although Education was eventually excluded in statistical analyses due to multicollinearity resulting from a strong correlation with Income.

2.4. Statistical analyses

RStudio packages including "glm", "rmediation", and "stats" were utilized for analyzing the study data (77). Generalized Linear Models were used to perform bivariate and multivariable linear regression analyses to examine cross-sectional relationships between ACEs and disordered eating, ACEs and mindfulness, and mindfulness and disordered eating. Across all analyses, statistical significance was set at $p < 0.05$. Bivariate linear regression models analyzed the link between having ≥4 ACEs and global disordered eating scores. Multiple linear regression analyses were then used to assess the link between having ≥4 ACEs and global disordered eating while adjusting for the potential confounding influences of covariates (i.e., participant characteristics). Multiple linear regression analyses were also conducted to determine the association between ACEs score and mindfulness, ACEs score and global disordered eating, ACEs score and restraint, ACEs score and eating concern, ACEs score and weight concern, and ACEs score and shape concern. All multiple linear regression analyses statistically adjusted for the covariates of age, sex, race/ethnicity, and income.

Mediation analyses were then performed by computing the product-of-coefficients (*ab*) using the unstandardized beta coefficients and standard errors produced from the multivariable linear regression analyses to produce mediating effect size coefficients, standard errors, and 95% confidence intervals (CI) for each disordered eating outcome (78–80). In the mediation

analyses, the *a*-path assessed the link between ACEs and mindfulness, the *b*-path assessed the link between mindfulness and disordered eating, the *c*-path assessed the link between ACEs and disordered eating, and the *c*'-path assessed the link between ACEs and disordered eating adjusted for mindfulness.

Five separate mediation analyses were conducted to model global disordered eating, restraint, eating concern, weight concern, and shape concern as the outcome variable. Coefficients and standard errors for paths *a* and *b* were used to compute *ab* for determining the extent to which mindfulness mediates the link between ACEs and global disordered eating along with the four disordered eating subscales of restraint, eating concern, weight concern, and shape concern. All mediation analyses adjusted for the covariates of age, sex, race/ethnicity, and income.

3. Results

3.1. Participant characteristics

This study included a participant sample composed of young adults between the ages of 18–26 ($n = 144$) who reside in the U.S. and have no previous clinical diagnosis of an eating disorder (Table 1). The mean average age of participants was 23.4 (SD = 2.4). Participants were mostly male (59%), White (66.7%), with an annual income of $25,000–$49,999 (29.9%). Across the study sample ($n = 144$), the mean average number of different types of ACEs that participants experienced in childhood were 2.80 (SD = 2.72). The mean mindfulness score among participants was 3.43 (SD = 0.48). For disordered eating, mean scores were 2.04 (SD = 1.44) for global disordered eating, 1.60 (SD = 1.68) for restraint, 2.56 (SD = 1.11) for eating concern, 1.97 (SD = 1.70) for weight concern, and 2.03 (SD = 1.72) for shape concern.

By descending order, the most prevalent individual ACEs (Table 2) among young adults ($n = 144$) in this study sample included: verbal abuse by an adult in the home (43.8%); parents or guardians separating or getting divorced (41.7%); living with someone who had a mental illness (34.7%); living with someone who was a problem drinker (33.3%); being a victim of physical abuse (28.5%); witnessing physical violence among adults in the home (20.8%); living with someone who abused drugs (19.4%); living with someone who served time in prison or jail (19.4%); and having someone at least 5 years older than them touch them sexually (15.3%), request sexual touching (12.5%), and/or force them to have sex (10.4%).

TABLE 1 Participant characteristics among U.S. young adults ($n = 144$).

Characteristics	Total (%)
Age (years)	$M = 23.4$, SD = 2.4[a]
Sex	
Female	59 (41)
Male	85 (59)
Race/Ethnicity	
American Indian/Alaska Native	2 (1.4)
Asian	9 (6.2)
Black	29 (20.1)
Hispanic/Latino	8 (5.6)
White	96 (66.7)
Income	
<$25,000	36 (25)
$25,000–$49,999	43 (29.9)
$50,000–$74,999	37 (25.7)
$75,000–$99,999	17 (11.8)
≥$100,000	11 (7.6)
Adverse childhood experiences	$M = 2.80$, SD = 2.72
<4	98 (68.1)
≥4	46 (31.9)
Mindfulness	$M = 3.43$, SD = 0.48
Disordered eating	
Global	$M = 2.04$, SD = 1.44
Restraint	$M = 1.60$, SD = 1.68
Eating concern	$M = 2.56$, SD = 1.11
Weight concern	$M = 1.97$, SD = 1.70
Shape concern	$M = 2.03$, SD = 1.72

[a]*M*, mean; SD, standard deviation.

3.2. Univariate and multivariable regression for ≥4 ACEs and disordered eating

A majority of participants encountered fewer than four ACEs (68.1%). Univariate regression analyses (Table 3) yielded results suggesting a significant association between having four or more ACEs and disordered eating status ($B = 1.03$, SE = 0.24; $p < 0.001$). Findings from multivariable regression analyses adjusted for covariates supported the univariate results by indicating a significant positive association between having four or more ACEs and global disordered eating scores ($B = 0.97$, SE = 0.25; $p < 0.001$).

3.3. Mediation via multivariable linear regression and product-of-coefficients

The conceptualized mediation diagram for the relationship between ACEs, mindfulness, and global disordered eating

TABLE 2 Prevalence of adverse childhood experience among U.S. young adults ($n = 144$).

Adverse childhood experiences	No (%)	Yes (%)
Lived with someone who had a mental illness.	94 (65.3)	50 (34.7)
Lived with someone who was a problem drinker.	96 (66.7)	48 (33.3)
Lived with someone who abused drugs.	116 (80.6)	28 (19.4)
Lived with someone who served time in prison or jail.	116 (80.6)	28 (19.4)
Parents or guardians were separated or divorced.	84 (58.3)	60 (41.7)
Witnessed physical violence among adults in the home.	114 (79.2)	30 (20.8)
Was a victim of physical abuse.	103 (71.5)	41 (28.5)
Was verbally abused by an adult in the home.	81 (56.2)	63 (43.8)
Was touched sexually by someone at least 5 years older.	122 (84.7)	22 (15.3)
Someone at least 5 years older requested sexual touching.	126 (87.5)	18 (12.5)
Was forced to have sex with someone at least 5 years older.	129 (89.6)	15 (10.4)

TABLE 3 The relationship between encountering four-or-more adverse childhood experiences and global disordered eating scores among U.S. young adults ($n = 144$).

Model	Statistic	*p*-value
Univariate[a]	$B = 1.03$, SE = 0.24[c]	$p < 0.001$
Multivariable[b]	$B = 0.97$, SE = 0.25[c]	$p < 0.001$

[a]Univariate analysis included linear regression using a generalized linear model.
[b]Multivariable analysis included linear regression using a generalized linear model adjusted for age, sex, race/ethnicity, and income.
[c]B, unstandardized beta coefficient; SE, standard error.

(Figure 1) depicts ACEs as the predictor, mindfulness as the mediator, and global disordered eating as the outcome.

3.3.1. Mediation model for ACEs, mindfulness, and global disordered eating

Findings from the multivariable regression analyses (Table 4) suggest that ACEs were inversely related to mindfulness ($B = -0.04$, SE = 0.01; 95% CI = −0.07, −0.01; $p = 0.01$), mindfulness was inversely related to global disordered eating ($B = -1.27$, SE = 0.23; 95% CI = −1.74, −0.80; $p < 0.0001$), ACEs were positively related to global disordered eating ($B = 0.17$, SE = 0.04; 95% CI = 0.09, 0.26; $p = 0.0001$), and ACEs remained positively related to global disordered eating after adjusting for mindfulness ($B = 0.13$, SE = 0.04; 95% CI = 0.05, 0.21; $p = 0.002$). The product-of-coefficients indicate the link between ACEs and global disordered eating was mediated by mindfulness ($B = 0.05$, SE = 0.02; 95% CI = 0.01, 0.09; $p < 0.05$).

3.3.2. Mediation models for ACEs, mindfulness, and the disordered eating subscales

The conceptualized mediation models for the relationship between ACEs, mindfulness, and either restraint, eating concern, weight concern, or shape concern (Figure 2) depict ACEs as the predictor, mindfulness as the mediator, and each of the four aforementioned disordered eating subscales as the outcome.

3.3.3. Mediation model for ACEs, mindfulness, and restraint

In the mediation analysis with restraint as the outcome, findings suggest ACEs were inversely related to mindfulness ($B = -0.04$, SE = 0.01; 95% CI = −0.07, −0.01; $p < 0.05$), mindfulness was inversely related to restraint ($B = -1.09$, SE = 0.28; 95% CI = −1.65, −0.53; $p = 0.0002$), ACEs were positively related to restraint ($B = 0.16$, SE = 0.05; 95% CI = 0.06, 0.26; $p = 0.002$), and ACEs remained positively related to restraint after adjusting for mindfulness ($B = 0.13$, SE = 0.05; 95% CI = 0.03, 0.22; $p = 0.013$). The product-of-coefficients indicate the link between ACEs and restraint was mediated by mindfulness ($B = 0.04$, SE = 0.02; 95% CI = 0.02, 0.08; $p < 0.05$).

3.3.4. Mediation model for ACEs, mindfulness, and eating concern

The mediation analysis modeling eating concern as the outcome produced results indicating that ACEs were inversely related to mindfulness ($B = -0.04$, SE = 0.01; 95% CI = −0.07, −0.01; $p < 0.05$), mindfulness was inversely related to eating concern ($B = -0.96$, SE = 0.19; 95% CI = −1.33, −0.59; $p < 0.0001$), ACEs were positively related to eating concern ($B = 0.12$, SE = 0.03; 95% CI = 0.06, 0.20; $p = 0.0002$), and ACEs remained positively related to eating concern after adjusting for mindfulness ($B = 0.10$, SE = 0.03; 95% CI = 0.03, 0.16; $p = 0.003$). The product-of-coefficients indicated the link between ACEs and eating concern was mediated by mindfulness ($B = 0.04$, SE = 0.01; 95% CI = 0.02, 0.07; $p < 0.05$).

3.3.5. Mediation model for ACEs, mindfulness, and weight concern

A mediation analysis with weight concern as the outcome produced results indicating ACEs were inversely related to mindfulness ($B = -0.04$, SE = 0.01; 95% CI = −0.07, −0.01; $p < 0.05$), mindfulness was inversely related to weight concern ($B = -1.48$, SE = 0.28; 95% CI = −2.04, −0.93; $p < 0.0001$), ACEs were positively related to weight concern ($B = 0.21$, SE = 0.05; 95% CI = 0.11, 0.31; $p < 0.0001$), and ACEs remained positively

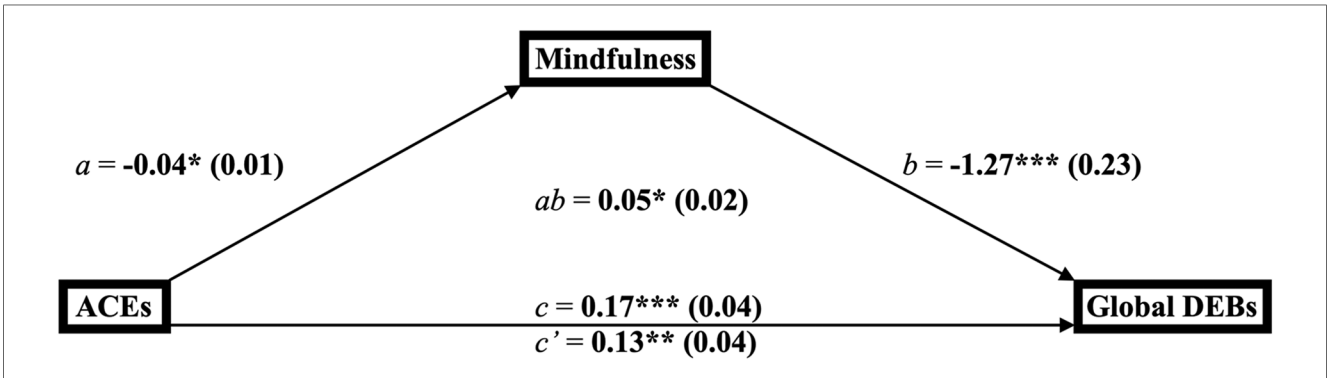

FIGURE 1
Mediation diagram for the link between adverse childhood experiences, mindfulness, and global disordered eating behaviors among young adults ($n = 144$). [a]*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$. [b]ab = product-of-coefficients mediation statistic. [c]a, b, c = direct effect paths; c' = indirect effect path. [d]ACES, adverse childhood experiences; DEBs, disordered eating behaviors.

TABLE 4 Mediation analyses for the link between adverse childhood experiences, mindfulness, and disordered eating behaviors among U.S. young adults ($n = 144$).

	Path	*B*, SE (95% CI)[a]	*p*-value
Global DEBs[a]			
a-path	ACEs → Mindfulness	−0.04, 0.01 (−0.07, −0.01)	$p = 0.01$
b-path	Mindfulness → Global DEBs	−1.27, 0.23 (−1.74, −0.80)	$p < 0.0001$
c-path	ACEs → Global DEBs	0.17, 0.04 (0.09, 0.26)	$p = 0.0001$
c'-path	ACEs → Global DEBs	0.13, 0.04 (0.05, 0.21)	$p = 0.002$
Mediating effect of Mindfulness (ab)[b]		0.05, 0.02 (0.01, 0.09)	$p < 0.05$
Restraint			
a-path	ACEs → Mindfulness	−0.04, 0.01 (−0.07, −0.01)	$p < 0.05$
b-path	Mindfulness → Restraint	−1.09, 0.28 (−1.65, −0.53)	$p = 0.0002$
c-path	ACEs → Restraint	0.16, 0.05 (0.06, 0.26)	$p = 0.002$
c'-path	ACEs → Restraint	0.13, 0.05 (0.03, 0.22)	$p = 0.013$
Mediating effect of Mindfulness (ab)[b]		0.04, 0.02 (0.02, 0.08)	$p < 0.05$
Eating Concern			
a-path	ACEs → Mindfulness	−0.04, 0.01 (−0.07, −0.01)	$p < 0.05$
b-path	Mindfulness → Eating Concern	−0.96, 0.19 (−1.33, −0.59)	$p < 0.0001$
c-path	ACEs → Eating Concern	0.12, 0.03 (0.06, 0.20)	$p = 0.0002$
c'-path	ACEs → Eating Concern	0.10, 0.03 (0.03, 0.16)	$p = 0.003$
Mediating effect of Mindfulness (ab)[b]		0.04, 0.01 (0.02, 0.07)	$p < 0.05$
Weight Concern			
a-path	ACEs → Mindfulness	−0.04, 0.01 (−0.07, −0.01)	$p < 0.05$
b-path	Mindfulness → Weight Concern	−1.48, 0.28 (−2.04, −0.93)	$p < 0.0001$
c-path	ACEs → Weight Concern	0.21, S0.05 (0.11, 0.31)	$p < 0.0001$
c'-path	ACEs → Weight Concern	0.17, 0.05 (0.07, 0.26)	$p = 0.0009$
Mediating effect of Mindfulness (ab)[b]		0.06, 0.02 (0.03, 0.10)	$p < 0.05$
Shape Concern			
a-path	ACEs → Mindfulness	−0.04, 0.01 (−0.07, −0.01)	$p < 0.05$
b-path	Mindfulness → Shape Concern	−1.56, 0.28 (−2.11, −1.00)	$p < 0.0001$
c-path	ACEs → Shape Concern	0.18, 0.05 (0.08, 0.28)	$p = 0.0008$
c'-path	ACEs → Shape Concern	0.13, 0.05 (0.03, 0.22)	$p = 0.01$
Mediating effect of Mindfulness (ab)[b]		0.06, 0.02 (0.03, 0.10)	$p < 0.05$

[a]ACEs, adverse childhood experiences; B, unstandardized beta coefficient; CI, confidence interval; DEBs, disordered eating behaviors; SE, standard error.
[b]Mediation analyses computed with product-of-coefficients using unstandardized beta coefficients derived from multivariable generalized linear models adjusted for age, sex, race/ethnicity, and income.

related to weight concern after adjusting for mindfulness ($B = 0.17$, SE = 0.05; 95% CI = 0.07, 0.26; $p = 0.0009$). The product-of-coefficients indicated the link between ACEs and weight concern was mediated by mindfulness ($B = 0.06$, SE = 0.02; 95% CI = 0.03, 0.10; $p < 0.05$).

3.3.6. Mediation model for ACEs, mindfulness, and shape concern

Lastly, the mediation analysis modeling shape concern as the outcome produced results indicating ACEs were inversely related to mindfulness ($B = -0.04$, SE = 0.01; 95% CI = −0.07, −0.01; $p < 0.05$), mindfulness was inversely related to shape concern ($B = -1.56$, SE = 0.28; 95% CI = −2.11, −1.00; $p < 0.0001$), ACEs were positively related to shape concern ($B = 0.18$, SE = 0.05; 95% CI = 0.08, 0.28; $p = 0.0008$), and ACEs remained positively related to shape concern after adjusting for mindfulness ($B = 0.13$, SE = 0.05; 95% CI = 0.03, 0.22; $p = 0.01$). The product-of-coefficients indicated the link between ACEs and shape concern was mediated by mindfulness ($B = 0.06$, SE = 0.02; 95% CI = 0.03, 0.10; $p < 0.05$).

4. Discussion

4.1. The association between ACEs and disordered eating

Outcomes from this study further confirmed the findings of existing studies that suggested ACEs may contribute to disordered eating behaviors among young adults. Findings from this study supported results from past research that emphasized the positive association between various types of ACEs [e.g., household dysfunction (20), neglect (31, 32, 34), and abuse (32–34)] and disordered eating. Across all participants, high ACEs scores were related to an increased severity of disordered eating. Furthermore, disordered eating was more severe among young adults with four or more ACEs when compared to those with fewer than four ACEs. These results are supported by previous studies among non-college student young adults that reported household dysfunction (20), abuse (20), and neglect (34) during childhood as potent predictors of displaying disordered eating symptoms later in life. Findings among young adult college students further support results in the present study by highlighting the association between physical abuse (31, 32), emotional abuse (31–33), sexual abuse (31, 32), and neglect (31, 32) during childhood and disordered eating in adulthood. The increased risk of habitual disordered eating behaviors among young adults with high ACEs raises concerns about the health trajectories of these individuals across their life course.

4.2. Links between ACEs and restraint, eating concern, weight concern, or shape concern

ACEs were positively associated with the disordered eating subscales of restraint, eating concern, weight concern, and shape concern. The positive link between ACEs and restraint that was detected in this study is discordant with non-significant findings from the only other known study to have analyzed the link between ACEs and restraint among a non-clinical sample of adults (81). Although, these findings could be discordant due to alternative explanations relating to differences in the research methodology, as Wingenfeld et al. recruited an all-female study sample and did not statistically control for the potential confounding variables of age, race/ethnicity, and income. Given the conflicting evidence, the present study offers a new perspective for the risk that ACEs pose to food avoidance behaviors. ACEs were also positively linked to eating concern, which has been posited as an antecedent to binge eating (82), a trait characterized by eating a large amount of food in a short period of time (83).

Moreover, the positive link detected between ACEs and weight concern highlights an increased risk for other eating disorders including binge eating, bulimia, and anorexia nervosa, as these

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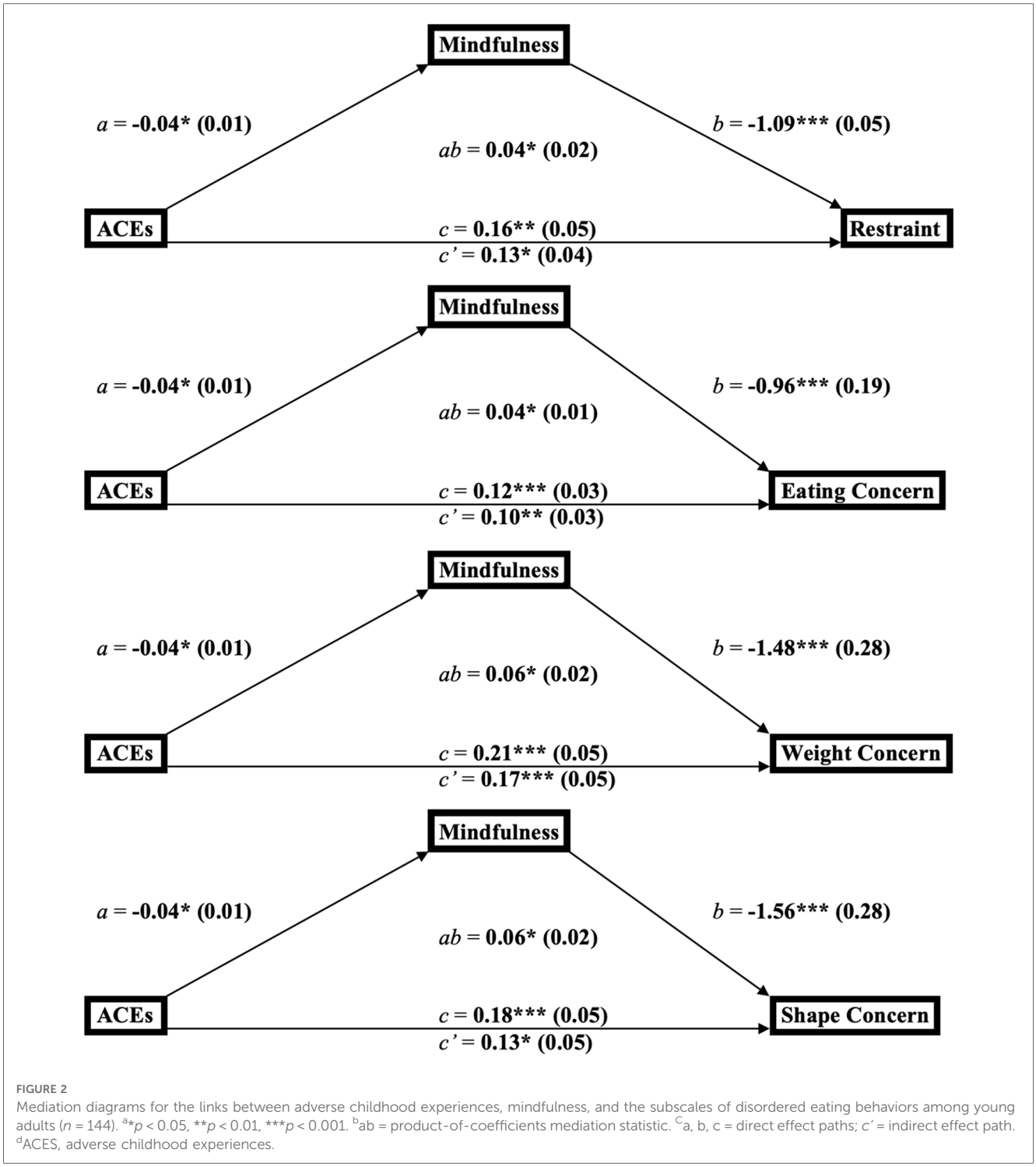

FIGURE 2
Mediation diagrams for the links between adverse childhood experiences, mindfulness, and the subscales of disordered eating behaviors among young adults (n = 144). [a]*p < 0.05, **p < 0.01, ***p < 0.001. [b]ab = product-of-coefficients mediation statistic. [C]a, b, c = direct effect paths; c' = indirect effect path. [d]ACES, adverse childhood experiences.

three eating disorders have been linked to the presence of weight concern (84, 85). Findings detailing the relationships between ACEs and either eating concern or shape concern are supported by recent research emphasizing how individuals with clinically diagnosed eating disorders have significantly higher ACEs than those with no eating disorder diagnosis (86). Moreover, the positive link between ACEs and shape concern supports findings from past studies underscoring the connection between ACEs, body dissatisfaction (87), and body dysmorphia (88). The evidence is consistent across all four subscales of disordered eating in showing the multifarious risk that ACEs pose to the development of these unhealthy behaviors.

4.3. Mindfulness mediating the association between ACEs and disordered eating

Identifying mindfulness as a significant mediator in the relationship between ACEs and disordered eating was key to

answering to the research hypotheses in this study. In five separate statistical models, mindfulness was shown to significantly mediate the link between ACEs and global disordered eating, restraint, eating concern, weight concern, and shape concern. These results raise important considerations concerning the underlying mechanisms that would contribute to mindfulness being a temporal mediator had this been a longitudinal study that tracked the effect of ACEs on mindfulness and the effect of mindfulness on disordered eating over time. Mindfulness involves the self-regulation of personal responses to internal and external stimuli (47), so emotion regulation could be a possible mechanism of mindfulness as a mediator since emotion regulation has been shown to blunt the harmful impact of ACEs on disordered eating.

The significant relationship that existed between ACEs and mindfulness should be perceived with caution, as this cross-sectional study could not determine cause-and-effect results and the coefficient detected for this relationship was small, which could both limit the legitimacy of mindfulness being a treatment target for interventions. Nonetheless, these findings help to tie together evidence from past studies that established links between ACEs and mindfulness (37) and between mindfulness and disordered eating (43) by introducing mindfulness as a potential mediator within the temporal relationship between ACEs and disordered eating. The discoveries made in this study fill an important knowledge gap concerning the relationship between ACEs and disordered eating, as the role of mindfulness in this context was previously unknown. Given that mindfulness is a modifiable personality trait that can be changed over time (89, 90), the evidence from the present study provided a glimpse for whether a mindfulness intervention could be used to alleviate disordered eating among adults with high ACEs.

4.4. Past and future mindfulness interventions

Past studies have successfully implemented a mindfulness intervention that successfully reduced disordered eating symptoms of restraint (50, 52), eating concern (50, 51, 53), weight concern (49, 50), and shape concern (49, 50) among samples of adolescents (49), adult females (52), adults who were overweight or obese (51, 53), and adults with a clinically diagnosed eating disorder (50). Preventing ACEs from contributing to the development and exacerbation of disordered eating throughout adulthood is essential for improving public health outcomes, and mindfulness could play an impactful role in this process. Parenting techniques that incorporate mindfulness through specific parent-child interactions have been shown to supplement traditional approaches to promoting healthy behaviors among children (91). Advocacy has been increasing to also teach mindfulness practices to children in school settings (92), as improved mindfulness in grade school students has been connected to enhanced emotion regulation (93), a more positive outlook (94), increased prosocial behavior (93), better academic outcomes (95), and greater life satisfaction (94). Therefore, future research is needed to identify the most effective mindfulness practices for children and test the extent to which promoting these mindfulness approaches among families and schools can alleviate and prevent disordered eating among young adults with high ACEs.

4.5. Strengths and limitations

This research contained multiple strengths. First, study findings expanded the knowledge base concerning the relationship between ACEs and disordered eating among young adults in the U.S., as most previous studies examining ACEs and disordered eating among this population exclusively sampled college students, while this study was open to all young adults. Second, the cross-sectional mediation models used in this study yielded unique information detailing how mindfulness mediated the link between ACEs and disordered eating, which could be used to rationalize further exploration of whether this significant relationship would be maintained in a longitudinal study. Third, the young adult sample recruited for this study was not exclusively composed of college students, which enhanced the generalizability of these study findings to other young adults in the U.S.

There were also several limitations in this study. First, this study was cross-sectional, which prohibited the assigning of causal inference to the hypothesized effect of ACEs on mindfulness and disordered eating. Temporality in the relationship between ACEs, mindfulness and disordered eating was assumed since data for ACEs are restricted to the ages of 0–17 while data for mindfulness and disordered eating were based on the present day at the time of data collection, but longitudinal data is needed to best determine the truth regarding the relationships that were explored in this study. Second, participants in this study were not randomly selected. A convenience sample of young adults was recruited for this study, which introduced self-selection bias. Third, data for primary variables were obtained from self-report measures, which are limited in their accuracy due to subjectivity, recall bias, and social desirability bias. For example, the 11-item ACEs measure can only subjectively detect occurrences that occurred in childhood through honest answers to closed-ended questions and cannot objectively pinpoint more in-depth family processes that took place. Three attention-check questions were integrated into the study survey that simply asked participants to select a specific answer, which helped to strengthen the validity of survey responses since it could be confirmed that respondents were actually reading the questions before providing their responses Fourth, two-thirds of the participants in the study sample were White, which limits the extent to which these findings can be generalized to racial and ethnic minority groups. Potential implications of this limitation include ongoing uncertainty concerning how the relationship between ACEs and disordered eating differs across racial and ethnic groups. Fifth, the product-of-coefficients approach to estimating the

mediating effects in this study produced results that only indicated whether the findings were significant at the 0.05 level, and did not provide a specific *p*-value despite providing specific effect size coefficients, standard errors, and 95% confidence intervals. For this reason, the information pertaining to *p*-values in the mediation analyses are limited to the findings either being less-than 0.05 or greater-than 0.05. This limitation did not prevent the hypotheses from being answered, as the resulting effect size coefficients, standard errors, 95% confidence intervals, and general (yet not specific) *p*-values provided sufficient information to address the primary research questions. Lastly, while the coefficients for the mediating effect of mindfulness were statistically significant, the effect sizes were small which raise concerns about whether mindfulness plays a clinically significant role within the relationship between ACEs and disordered eating. For this reason, additional studies are needed to confirm whether the small yet significant mediating effect of mindfulness that has been detected among non-clinical sample would still be significant among a clinical sample of young adults with high ACEs.

5. Conclusions

Young adults with high ACEs are at an increased risk of disordered eating. Evidence suggested that mindfulness played an influential role in the relationship between ACEs and disordered eating, but longitudinal research is needed to better estimate the interplay of mindfulness within the relationship between ACEs and disordered eating among young adults. Additional studies among diverse samples of young adults are needed to strengthen the evidence for the relationship between ACEs, mindfulness, and disordered eating by producing findings that are generalizable to wider variety of people groups. Future intervention studies among young adults with high ACEs are needed to evaluate whether mindfulness practices can meaningfully decrease and prevent disordered eating. Such public health efforts could generate effective disease prevention approaches to promote and ensure health equity among vulnerable populations.

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 - Arizona State University. The patients/participants provided their written informed consent to participate in this study.

Author contributions

MR: conceptualization, methodology, project administration, data curation, formal analysis, writing—original draft, writing—review and editing. KC: data curation, resources, writing—original draft, writing—review and editing. CW: funding acquisition, resources, supervision, writing—original draft, writing—review and editing. 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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frontiers | Frontiers in Child and Adolescent Psychiatry

TYPE Original Research
PUBLISHED 26 May 2023
DOI 10.3389/frcha.2023.1124037

OPEN ACCESS

EDITED BY
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RECEIVED 14 December 2022
ACCEPTED 20 April 2023
PUBLISHED 26 May 2023

CITATION
Bornstein MH, Putnick DL, Esposito G and Pearson RM (2023) The nature and structure of maternal parenting practices and infant behaviors in U.S. national and international samples.
Front. Child Adolesc. Psychiatry 2:1124037.
doi: 10.3389/frcha.2023.1124037

The nature and structure of maternal parenting practices and infant behaviors in U.S. national and international samples

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Methods: Twenty maternal parenting practices and 15 behaviors of their 5½-month-old infants in a U.S. national sample ($N = 360$) and 9 international samples ($N = 653$) were microcoded from videorecords of naturalistic interactions at home and aggregated into domains. Altogether, the samples were recruited from Argentina, Belgium, Brazil, France, Israel, Italy, Japan, Kenya, as well as the United States.
Background and Rationale: A previous test of three competing models of the nature and structure of the maternal parenting practices supported a hybrid 2 factor/6 domain model as superior to a 1-factor dimensional model and a multi-factor style model: Maternal parenting practices are structured into nurture, physical, social, didactic, material, and language domains undergirded by dyadic and extradyadic factors. Infant behaviors were organized into physical, social, exploration, nondistress vocalization, and distress communication domains. The current study sought to examine links connecting these previously identified maternal domains and factors with infant behavior domains using structural equation models.
Results: Mothers' dyadic factor is associated with infant social behaviors with mother; and mothers' extradyadic factor and encouragement of infant physical development are associated with infant exploration of their immediate physical environment and physical development. Infant distress communication (and less nondistress vocalization) is associated with more maternal nurturing.
Discussion: Mothers' parenting practices in the middle of the first year of infant life are commonly structured and adapted to specific needs and developmental tasks of infants. Evaluations of mother-infant interactions with national and international samples permit a wide yet judicious analysis of common vs. specific models of mother-infant relationships.

KEYWORDS

culture, parenting, mother-infant interaction, infancy, modeling

Introduction

Parenting and infancy at the beginning of life

As approximately 370,000 babies are born each day, hundreds of thousands of new mothers around the globe experience the joys but also assume the daunting responsibilities of new parenthood (1). Parents are fundamentally invested in their infants' survival and subsistence

as well as their socialization and education. Moreover, infants actively shape their own development, and so parents and infants influence one another bidirectionally and transactionally (2). A compelling tension pervades the dynamic of this foundational human relationship. On the one hand, specific parent-infant dyads have idiosyncratic needs and goals, which are shaped by unique and individual bioecocultural forces. On the other hand, human parents and infants everywhere display many of the same biopsychosocial needs and must succeed at many of the same caregiving and developmental tasks. Indeed, at the end of the day parents everywhere want physical health, mental achievement, social adjustment, and economic security for their children—however those goals may be locally instantiated. At different levels of analysis, then, parenting and infancy likely vary in specific ways faithful to individual and social differences but also share commonalities that transcend those individual and social differences. The main aims of the complementary pair of studies presented here were to assess the nature and structure of maternal parenting practices and infant behaviors as well as commonalities and specificities of mother-infant relationships in U.S. national and 9-country international samples from Argentina, Belgium, Brazil, France, Israel, Italy, Japan, Kenya, as well as the United States.

We report the videorecording, microcoding, analysis, and emergent organization of relationships between maternal parenting practices and infant behaviors as enacted during naturalistic interactions at home in 360 primiparous U.S. European American and 653 primiparous mothers from 9 different countries with their 5½-month-old infants. Undertaking an evaluation of parent-infant relationships in the context of a broad national and international research design permits a comprehensive yet judicious determination of the nature and structure of mother-infant relationships as well as their commonalities and specificities. These studies also contribute information about parenting and infancy in several still relatively underresearched populations and compare it to parenting infants in populations that have been more comprehensively studied.

Maternal parenting practices, infant behaviors, and their interaction: three aims

Maternal parenting practices

Parents endow their offspring with a genetic makeup, and they supply and share experiences with their children and so co-construct the environments in which their children are reared. Indeed, before children are old enough to enter formal social learning situations, like school, or even informal ones, like peer groups, virtually all of children's experiences stem directly from interactions they have within the family. In this light, parents' cognitions and practices directly influence infant development and prepare infants for wider social interactions (3).

A previous report attempted to gain greater purchase on the nature and structure of mothers' parenting in international settings. Individual parenting practices in primiparous mothers with their 5½-month-old infants in one U.S. European American sample and samples from 9 different nations were microcoded from videorecords of naturalistic home-based mother-infant interactions, and three possible models of caregiving were compared (4). Out of the varied repertoire of individual caregiving activities, six parenting domains that meet fundamental developmental tasks of infants were derived. The six domains included, in precis, *nurturant* caregiving that meets the biological, physical, and health requirements of infants through such practices as feeding, thermoregulation, grooming, and clothing. *Physical* caregiving promotes infants' gross and fine psychomotor balance and movement. *Social* caregiving includes visual, verbal, affective, and physical activities that engage infants in interpersonal exchanges, express affection, and involve social play as well as regulate affect and emotions. *Didactic* caregiving draws infants' attention to properties, objects, and events in the environment as well as labels and describes, demonstrates and stimulates. *Material* caregiving provisions and organizes infants' home and local environments, including the number, variety, and composition of inanimate objects available to the infant, level of ambient stimulation, limits on physical freedom, and overall physical components of infants' experiences. *Language* caregiving is a major channel through which mothers maintain contact, interpret infant cues, respond to infants, introduce experiences, and express affection. Taken as a totality, this constellation of parenting domains constitutes a varied and demanding set of caregiving tasks that together encompass virtually all of parents' important activities with their infants. They are likely universal, even if their qualitative instantiation (e.g., meaning) or quantitative emphases (e.g., frequency or duration) vary across cultures. Reciprocally, human infants universally are reared in, influenced by, and adapt to social and physical environments that are characterized by the domains of this parenting taxonomy.

Further analysis determined that these six domains converged on two conceptually independent, developmentally significant caregiving factors (4). Akin to the dimensional school of caregiving, parenting infants was characterized by a *Dyadic* factor which included the nurture, physical, social, didactic, and language domains that optimally engage infants in warm, nurturing, supportive interpersonal exchanges, and by an *Extradyadic* factor which included the didactic, material, and (negatively loading) nurture domains that incorporate properties, objects, and events in the natural and designed environments and stimulate infants to engage and understand their surround. Many investigators have previously theorized and operationally distinguished between dyadic and extradyadic parenting as separate and significant whether they are called animate vs. inanimate, affective vs. informational, or social vs. didactic (e.g., Field, 1981; Goldfield, 1987; Sherrod, 1981; Stern, 1985). This hybrid 2 factor/6 domain model of parenting held for a U.S. sample as well as a sample including 9 international countries and appears to be robust as it obtained for mothers with daughters and sons and over and above variation in maternal age, education, and personality.

Infant behaviors

To complement that study of mothering, here we incorporate infant behaviors. Fifteen individual infant behaviors that are key expressions of early performance and development were also

microcoded from videorecords of the same naturalistic mother-infant interactions. The 15 individual infant behaviors are organized into five infant behavior domains—physical, social, exploration, nondistress vocalization, and distress communication. These five domains account for most or all of young infants' principal adaptive competencies. That is, infants are growing, discovering, communicating, relating … and complaining beings … who exercise effectance however they can given the constraints of babyhood (5). We did not expect any factorial organization among the five infant domains because previous work has shown that infant behavioral domains share minimal amounts of their common variance (6).

Mother-Infant interactions and three aims

Infancy is the phase of the life cycle when adult parenting is thought to exert extremely salient influences: Not only is the sheer amount of interaction between parent and offspring greatest in infancy, but young human infants are totally dependent on parents and especially susceptible and responsive to their experiences (7). Indeed, opportunities for enhanced parental influences and prolonged childhood learning are thought to constitute evolutionary reasons for the extended duration of human infancy (8). In the two studies presented here, activities of primiparous mothers and their 5½-month infants were analyzed from naturalistic interactions at home. The principal mother-infant interaction issue investigated concerns the degree to which maternal parenting practices and infant behaviors correspond (i.e., correlate) with one another. Testing this issue in the context of a single US sample and international sample advances our understanding of specificities and commonalities of everyday family life.

The two studies had three main aims. One aim was to explore relations of the two maternal parenting practice factors and six domains to the five infant behavior domains in a U.S. sample. The U.S. sample was chosen as the target because it was the largest sample available and the originial protocol was developed in the United States. In the test of the first aim, out of 40 possible associations between mother and infant domains/factors, we hypothesized 7 paths. We expected paths from mother dyadic focus to infant physical, social, and nondistress vocalization, from mother extradyadic focus to infant physical, exploration, and nondistress vocalization, and from infant distress communication to mother-infant dyadic focus. These associations were hypothesized because mother dyadic focus includes behaviors expected to promote infants' physical development, social interactions, and responsive vocalizations. Furthermore, mother extradyadic practices focus the infant on the surrounding environment, which likewise promotes physical and exploratory behaviors as well as nondistress vocalizations. Although associations between mother and infant activities are inherently dyadic, most hypothesized relations were from mothers to infants, recognizing the prominent role mothers play in guiding interactions with their young infants. The exception was infant distress communication. The most effective means the infant commands to communicate is crying, which elicits powerful and universal responses in mothers (9), and justifies hypothesizing the direction of effect from infant to mother.

To date, the vast majority of the extant literature in developmental science, and consequently our understanding of human parenting and infancy, derives from studies conducted in so-called WEIRD (Western, educated, industrialized, rich, and democratic) nations (10). Where there are exceptions, precious little standardization has been brought to bear on comparative examinations of even the most basic parenting and developmental constructs, structures, functions, or processes (11, 12). The second aim of the present studies was to explore whether the model derived from the U.S. sample applied to a diverse international sample.

The sex of an infant is often a principal interest in developmental science (13). The third aim of the present studies was to assess whether the model of mother-infant interaction was moderated by the sex of their infants.

Biology and experience: commonality and specificity in parenting and infancy

Some signal characteristics of parenting appear to be "wired" into the biological makeup of the human species (14), and adults already know (or think they know) some about parenting by the time they first become parents. For example, parents routinely speak to their infants even though they know that babies cannot understand language, and they even speak to babies in a special speech register ("infant-directed speech") that modifies adult-directed speech in prosodic, simplicity, redundancy, lexical, and content features (15, 16). Infant-directed speech is intuitive, nonconscious, and cross-culturally common (17, 18); even deaf mothers modify their sign language to babies in much the same ways (19). Likewise, the same brain regions in mothers of different cultures are excited by infant cries, and mothers in different cultures respond in behaviorally similar ways to infant cries (20, 21). At the same time, human beings acquire parenting cognitions and practices through specific experiences: Generational, social, and media images of parenting, children, and family life play equally significant roles in helping people form their parenting cognitions and guide their parenting practices (22, 23). For example, parents from different cultures differ in the ages they expect children to reach different milestones or acquire various competencies, and they differ in their opinions about the significance of specific competencies for their children's success in social adjustment (24). The origins of variation in maternal cognitions and practices are multivariate and complex and include biological processes and psychological attributes of parents, actual or perceived characteristics of infants, and contextual influences, including social situations, socioeconomic status, and ethnicity and culture (3).

These studies

The two studies presented here aimed to uncover more about mother-infant interaction in the period of the dyad's initial

mutual accommodation in the middle of the first year of the infant's life by analyzing multiple activity domains of mothers and infants in different national samples. As key and possibly long-lasting characteristics of individuals arise in early life, mother-infant interaction is thought to be at least one important source of human development. The overall strategy was initially to use U.S. parent-infant data [capitalizing on its large *N* and which in (4) revealed a 2 factor/6 domain structure to parenting] to determine the best-fitting model of the structure of mother-infant relationships and then to evaluate whether the best-fitting structure also fit a larger international sample.

Two studies: general methods, procedures, and analytic plan

The nature and structure of mother-infant interactions were assessed to address three aims in two companion studies: one single-nation and one international. Are maternal parenting practice domains and factors related to infant behavior domains in identifiably patterned ways in a U.S. sample? Is the pattern of maternal parenting-infant behavior relationships similar for an international sample? Are mother-infant relationships moderated by infant sex in a U.S. and an international sample? Approaches to these aims were based on extensive and detailed standardized observations and systematic analyses of naturalistic parenting practices of new primiparous mothers and the behaviors of their young infants.

Participants in studies 1 and 2

A total of 923 primiparous mothers and their healthy 5½-month-old infants from Argentina, Belgium, Brazil, France, Israel, Italy, Japan, Kenya, and the United States participated in the two studies. Details about the samples appear in descriptions of Study 1 and Study 2 participants below. Justification for the focus on mothers appears in the **Supplementary Material**. Mothers were recruited from hospital or published birth notifications, patient lists of medical groups, newspaper advertisements, and targeted mailings. Mothers who expressed a willingness to participate in home-based naturalistic observations with their infants and who, with their infants, satisfied the following developmental and sociodemographic criteria were included in Studies 1 and 2 on first-come-first-recruited bases. Mothers were at least 16 years of age at their child's birth and were living in intact families; infants were firstborn only children, born at term, weighed more than 1,500 g at birth, healthy, and 5½ months of age on average at the time of the observation. Approximately equal numbers of female and male infants were enrolled into each country sample. In addition to the mother-infant dyads that met these inclusion criteria and participated, 5 dyads were excluded from Study 2: 2 dyads from France and 2 from Japan were excluded because the durations of their videorecords that could be coded totaled less than 42 min (of an expected hour), and 1 infant from Argentina was excluded because the baby slept more than 5 min during the first 50 min of recording.

Infants were studied in the middle of the first year because of the intentionality and flexibility in behavioral organization which most normally developing infants demonstrate at this time. No longer *fetus ex utero*, by the middle of the first year the infant's scope of perception has broadened to the dyad and beyond, infants actively participate in turn-taking exchanges, and they show readiness and ability to explore the world outside the dyad, looking, touching, and mouthing objects with increasingly extensive and efficient exploration. For their part, caregivers encourage infants of this age to attend to properties, objects, and events in the environment, and they provision the infant's environment with toys, books, and other objects that vary in quality and quantity and fill the infant's environment with sounds of different kinds, notably their own language.

General procedures applicable to studies 1 and 2

Procedures

Approximately 1 h of naturalistic interaction of mothers with their infants was videorecorded, microcoded, and analyzed for each dyad. Meta-analyses have indicated that maternal practices are most stable for observations lasting 30 min to 1 h compared to shorter or longer observations (25, 26); briefer observations can be unstable, and lengthier observations are likely to include highly varied activities and contexts (27). In these studies, attempts were made to remain faithful to the principle of ecological validity by focusing on naturalistic interactions between mothers and infants in their own home setting; that is, the goal was to observe spontaneous activities of the two under the most natural and unobtrusive conditions possible. Studying dyads at home presumably maximized their comfort and increased the validity of the observations. All observations were also conducted in a standardized way to render the data comparable across diverse samples. Briefly, mothers were asked to behave in their usual manner; videographers were always young women native to the country; mothers were instructed to disregard the videographer's presence insofar as possible; beside the videographer, only mother and infant were present in the home; and observations took place at times of the day when infants were awake and alert. Recording commenced only after a conventional period of acclimation to the presence of the videographer and the camera [as recommended in (28, 29)].

Maternal parenting practice and infant behavior codes

The development of censuses of maternal parenting practices and infant behaviors involved extensive observations, collaborative discussions, and intensive analyses. First, narrative observational accounts of maternal parenting practices and infant behaviors were made in the field. Field testing and refinement were then conducted. In this way, initial, unstructured descriptive data were shaped into structured observations and, ultimately,

quantitative data. Subsequently, formal operational definitions of maternal parenting practices and infant behaviors were developed to facilitate coder accuracy and consistency (see **Supplementary Tables S1, S2**). These definitions represent discrimination rules for coding target activities, and they met three main criteria: (1) the definitions were objective and referred to directly observable practices and behaviors; (2) the definitions were clear, unambiguous, and easily understood so that trained coders could accurately use them; and (3) the definitions required little or no inference. Going forward, the phrases "maternal parenting practices" and "infant behaviors" are used; however, the abbreviated generic term "activity" is used to capture the two as appropriate.

Maternal parenting practices

Eighteen individual parenting practices and two context indicators constitute primary parenting tasks and performance competencies of mothers of young infants. Together, they aggregate into the six parenting practice domains listed in **Supplementary Table S1** Column 1. Each practice and context constituent indicator is operationally defined in **Supplementary Table S1** Column 2.

Infant behaviors

Fifteen individual infant behaviors constitute key developmental and performance competencies that are critical to ontogenetic adaptation in young infants. Together, they aggregate into five infant behavior domains listed in **Supplementary Table S2** Column 1. Each behavior constituent indicator is operationally defined in **Supplementary Table S2** Column 2.

Coding

The 18 maternal parenting practices and two context indicators and the 15 infant behaviors were coded from the videorecords *via* computer entry. Coding of sets of practices and behaviors took place on multiple individual passes through the videorecords and, depending on the practice or behavior, was continuous and comprehensive or time-sampled or consisted of counts and ratings. Continuous and comprehensive coding was implemented for single or mutually exclusive and exhaustive sets of conceptually related activities. In mutually exclusive coding, only one activity can be coded for each unit of observation; in exhaustive coding, one activity must be coded for each unit of observation. Only activity initiations needed be recorded because in the software used the onset (start) of a new activity automatically signaled the offset of the preceding activity (30). A set of objective parameters was programmed into the software such that the minimum duration of an activity was set to .30 s, and an interruption of an activity for less than 1 s did not constitute a new instance of the activity. Continuous and comprehensive coding is rigorous and powerful, yielding unbiased estimates of the frequency and duration of activities on the basis of their occurrence in the uninterrupted, natural time flow (31). Mutually exclusive and exhaustive coding enjoys numerous conceptual and statistical advantages [see (30–33)]. In time sampling, whether or not an activity occurred during a fixed time interval was recorded (34, 35). Finally, some activities were counted or rated. With coded videorecords in hand, detailed analyses of maternal parenting practices and infant behaviors were undertaken.

Narrowly defined and specific activities are generally easier for coders to learn and to apply, require less interpretation and inference, and can later be aggregated for summary data analyses (as done here in the conversion of activities into domains). Concrete and basic mother and infant activities were studied, and they have been observed previously in samples from each nation [albeit at varying levels (20, 21)]. Microcoding categorizes overt activities at high temporal resolution and captures detailed information from observational data. Microcoding and microanalysis are traditional in parenting and infancy research (36–40).

Coders

A small group of trained coders was employed, and coders addressed and resolved issues that arose on account of different national samples and coder bias. First, as data from different national samples were to be coded, the needs for multiple trained reliable coders with multiple ethnic heritages and checks on measurement techniques arose. To address these problems, coding focused on recording the onsets (and so the frequency and duration) of activities rather than global ratings. Moreover, all coders were required to become reliable with a set of standardized reference codings. Second, coders may miss information—the human visual and auditory senses can be insensitive or unreliable in detecting certain activities—and coders can suffer from information overload. When a large number of target activities must be coded in a short period of time, a coder may have difficulty detecting or recording all of them. Sometimes coders harbor or develop (correct or incorrect) hypotheses about the nature and purpose of an investigation, how participants should behave, or what constitute "appropriate" data. Thus, coders may make systematic errors and hold biases based on their information-processing limitations and expectations.

To address issues of coder bias and to maintain the accuracy of quantitative measures, coders and coding adhered to standardized procedures (41): (1) Only trained and experienced but naïve coders were recruited, and stringent training criteria were employed. Only coders who possessed the ability to sustain attention, who had a propensity for detail and precision and a commitment to scientific detachment, and who were analytically minded were recruited and trained. (2) Prior to actual coding, coders were trained to criterion performance accuracy and consistency on a series of standard videorecords which had varied and representative samples of the target mother and infant activities. Coders learned to code accurately, and the pressure of time was eliminated. (3) Videorecords were randomly assigned to coders. (4) Coders were cautioned about the potential negative effects of bias, and they remained naïve to the specific scientific aims of these studies. (5) To the degree possible, precise low-inference operational definitions of activities were used. Coders learned the operational definitions and scoring procedures of the observation system as presented in a formal training manual. (6) Coding drift was corrected by means

of regular reliability checks with experienced coders and the standardized codings. Coders knew that their codings would be routinely checked for reliability but did not know which specific codings would be used. If "drift" away from coding accuracy occurred, re-training sessions were conducted (42–44).

Coding reliability

Different statistical metrics of coder reliability were employed. For all continuously coded activities, *Kappa* (κ) (45, 46) was used. *Kappa* is observed agreement beyond that expected by chance as a proportion of possible agreement beyond that expected by chance. *Kappa* was based on agreement in each 5-s interval for parenting practices and infant behaviors. *Kappa*s were always evaluated relative to the prevalence index, the bias index, and the maximum attainable κ (47, 48). For time-sampled activities, the *Intraclass Correlation* (*ICC*) (49–51) in two-way random effects models was used. After coders achieved initial reliability, at least every tenth videorecord that they coded was independently coded by second coders. Between 11% and 37% of each national sample (depending on the nation and domain) was coded independently by pairs of coders to monitor intercoder reliabilities. **Supplementary Table S3A** gives intercoder reliabilities of mothers' parenting practice domains by country; averages for the 6 maternal parenting practice domains across the 9 countries were: Nurture $\kappa = .89$, Physical $ICC = .72$, Social $\kappa = .67$, Didactic $\kappa = .73$, Material $ICC = .85$, and Language $\kappa = .70$. **Supplementary Table S3B** gives intercoder reliabilities of infant behavior domains by country; averages for the 5 infant behavior domains across the 9 countries were: Physical $ICC = .92$, Social $\kappa = .59$, Exploration $\kappa = .70$, ICC = .88, Nondistress vocalization $\kappa = .68$, and Distress communication $\kappa = .69$.

Data

Coding maternal parenting practices and infant behaviors generated multiple measures which are termed interim variables of frequency and duration, proportion, and variety, density, and consistency (**Supplementary Tables S1, S2** Column 3). Continuously coded activities generated both frequency and duration interim variables. Frequency is the number of discrete times a mother or infant engaged in an activity or, more precisely, the number of times the activity was initiated during the observation. Duration is the total time that a mother or infant engaged in the activity. Practices in the nurture domain yielded only duration interim variables. Time-sampled activities yielded a single interim variable, the proportion of observation units in which the activity occurred. Context indicators of quantity and quality of objects yielded counts and ratings of three interim variables: variety, density, and consistency.

Supplementary Tables S1, S2 Column 4 specify how interim variables were aggregated into final indicator variables for each activity domain. Indicator variables for continuously coded domains are mean standard scores (*z*-scores where $M = 0$, $SD = 1$) of the frequencies and durations of the interim variables over the first 50 min of the observation. Indicator variables which were derived from time-sampled practices are also mean standard scores. Except for mother nurture, domain scores were computed as the simple mean of the indicator variables for the domain, the indicator variables being equally scaled interim variables (mean standard scores, proportions). Because the indicator variables for mother nurture are duration scores of unequal means and standard deviations, the domain score was computed as the mean of the standard scores of the indicator variables. **Supplementary Tables S1, S2** Column 5 specify how indicator variables were aggregated to form mean standard scores of final domain variables.

Videorecords were first microcoded at level of the indicators (31, 52). To eliminate unnecessary complexity and realize clearer pictures of mother-infant interaction, dependent indicator variables were aggregated at domain levels, and analyses reported here are restricted to domains. Restricting analyses to domains takes full advantage of the multiple benefits of dimension reduction (53). **Supplementary Tables S1, S2** Column 1 list the maternal parenting practice and infant behavior domain names. Column 2 lists individual activities that were coded and their operational definitions. Column 3 lists the interim variables derived from coding those activities. Column 4 lists the final indicator variables derived from the interim variables. Column 5 lists the mean standard scores of final variables that constitute a domain and on which analyses were conducted.

The concept of an activity domain is akin to an index and distinct from the concepts of a factor or latent variable. The latter refer to unobserved constructs that manifest in, and are inferred from, several theoretically and empirically related indicator variables. The domains as used here consist of conceptually related practices or behaviors that may, or may not, be empirically or statistically related (54, 55). Justification for inclusion in a domain is conceptual coherence (*qua* an index) and not necessarily empirical relatedness (*qua* a scale). Preliminary analyses and the analytic plan appear in the **Supplementary Material**.

Study 1: mother-infant interactions in a United States sample

Study 1: the U.S. Sample

The U.S. sample consisted of 360 European American primiparous mothers and their 5½-month-old infants, 162 mother-daughter and 198 mother-son dyads. Participants were recruited from the greater Washington, DC metropolitan area, including suburbs of Maryland, Virginia, and rural West Virginia. Sociodemographic information for participating U.S. mothers and infants appears in **Table 1**. Mothers averaged 29.4 years of age ($SD = 6.2$, range = 16.3–43.1). Mothers' average educational level as measured on the Hollingshead Index with (56) 7-point education scale was 5.6 ($SD = 1.3$). Families were middle-class on average [SES; (56), Four Factor Index of Social Status: $M = 50.1$, $SD = 12.9$; see also (57)]. Infants averaged 163.4 days of age ($SD = 6.1$, range = 141 to 195) when observed. An ethnically homogenous European American community sample was recruited, first because a majority of the population of the

TABLE 1 Demographic characteristics of the U.S. sample.

	Total U.S. Sample ($N = 360$)
Mothers' age (years)	29.4 (6.2)
Mothers' education[a]	5.6 (1.3)
Infants' age (days)	163.4 (6.1)
Infants' gender (% females)	45%
Infants' birth weight (grams)	3,493.3 (508.1)
Family SES[b]	50.1 (12.9)

M(SD). Reproduced in part from Bornstein et al. (4).
[a]Hollingshead (56) 7-point scale.
[b]Hollingshead (56).

United States identifies as European American (58), and second as an initial step toward understanding the nature and structure of mother-infant interactions in advance of embarking on the more complex follow-up Study 2 and analysis with nationally diverse samples (59, 60).

Study 1: U.S. sample results

Descriptive statistics

Supplementary Tables S4A,B present the means and standard deviations for each maternal parenting practice and infant behavior domain score for the U.S. sample.

Mother-Infant interaction model

Figure 1 presents the standardized solution to the structural portion of the final, sequentially constructed model, S-B $\chi^2(38) = 79.31$, $p < .001$, Robust CFI = .93, RMSEA = .06, 90% CI = [.04, .07]. Modifications of the hypothesized model included (1) dropping associations of maternal dyadic and extradyadic focus with infant nondistress vocalization; (2) replacing the path between maternal dyadic focus and infant physical development with a path from mother encouragement of physical behavior to infant physical development; (3) adding a path from mother encouragement of physical behavior to infant exploration; (4) replacing the path between infant distress communication and maternal dyadic focus with a path from infant distress communication and mother nurture; and (5) adding a (negative) path from infant nondistress vocalization to maternal nurture. In addition, two pairs of variances/unique variances for infant behaviors were allowed to covary: social and nondistress vocalization, and exploration and distress communication (negative). Infant social and nondistress vocalization were allowed to correlate because babies may babble while engaging in face-to-face interaction with their mothers. Exploration and distress communication were allowed to correlate negatively because distressed babies are unlikely to engage with objects in their environment. The model reproduced observed correlations with an average absolute standardized error of .03. All parameters estimated in the model were significant at the .05 level or stronger. **Supplementary Table S5** presents the correlation matrix, variances, and standardized residuals for the final model.

The maternal dyadic factor related positively to the infant social domain: Mothers who engaged in more dyadic focus had infants who engaged in more social exchanges with their mothers. The maternal extradyadic factor and unique variance of the mother physical domain related positively to the infant physical and exploration domains: Mothers who encouraged their infants' physical development more and mothers who engaged in more extradyadic interactions had infants who exhibited higher levels of motor development and explored their environments more. Two infant behaviors contributed to the time mothers spent in nurturing them: Mothers whose infants vocalized nondistress less and communicated distress more nurtured their infants more.

Infant sex

To test whether the final model fit equally well for mother-daughter and mother-son dyads, a series of nested multisample models that sequentially introduced constraints on the measurement model path coefficients and covariances was constructed (61). All factor loadings, factor variances, and unique variances were constrained to be equal. A preliminary test in which no parameter estimates were constrained to be equal fit the data, $\chi^2(76) = 116.49$, $p < .01$, CFI = .94, RMSEA = .06, 90% CI = (.03, .07), suggesting that more restrictive models were appropriate. In testing the series of nested multisample models, a consistent pattern emerged in which two path coefficients (infant distress communication to mother nurture and mother physical to infant exploration) and one unique variance (mother nurture) differed for mothers of female and mothers of male infants; there were no differences in any other parameter estimates tested. In the most rigorous test in which all parameters except these three coefficients were constrained to be equal, an adequate fit was achieved, $\chi^2(101) = 149.98$, $p < .01$, CFI = .92, RMSEA = .05, 90% CI = [.03, .07]. The difference in χ^2 between this model and the model that imposed no invariance constraints was not significant, $\chi^2(25) = 33.49$, $p = .12$, suggesting that, with the exceptions of the two path coefficients and one unique variance, imposing invariance across measurement model (as described above), path coefficients, and covariances had no deleterious effects on model fit. The two path coefficients which showed a sex difference were the paths from infant distress communication to mother nurture (standardized coefficient = .30, $p < .001$, for mothers of female infants and .06, $p = .34$, for mothers of male infants) and from mother physical to infant exploration (standardized coefficient = .22, $p < .001$, for mothers of female infants and .02, $p = .75$, for mothers of male infants): Distress communication of female infants was associated with their mothers' nurturing, and mothers who more often encouraged their female infants' physical development had female infants who engaged in more exploring. No parallel relations existed in mother-son dyads. The unique variances associated with mother nurture (standardized unique variances = .44 for mothers of female infants and .68 for mothers of male infants, $ps < .001$) differed statistically between mothers of female infants and mothers of male infants; however, both were significant.

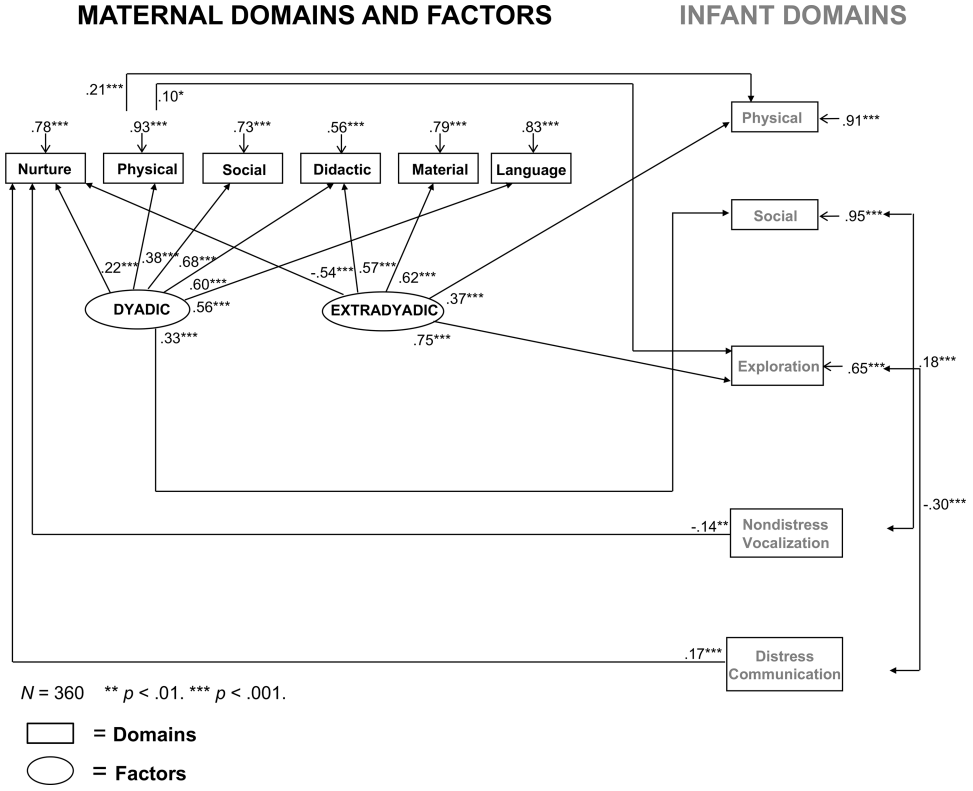

FIGURE 1
From videorecords of naturalistic mother-infant interactions at home in a U.S. sample (N = 360), 20 maternal parenting practices and 15 behaviors of their 5½-month-old infants were microcoded. The 20 maternal parenting practices aggregated into 6 domains and subsequently into 2 factors, and the 15 infant behaviors aggregated into 5 domains. The standardized solution for the final mother-infant interaction model is shown in figure. Numbers associated with single-headed arrows from maternal factors to maternal domains and from maternal domains or factors to infant domains are standardized path coefficients; numbers associated with double-headed arrows are standardized covariance estimates; and numbers associated with single-headed arrows and maternal or infant domains are error or disturbance terms, the amount of variance not accounted for by paths in the model.

Study 1: discussion

European American first-time mothers' parenting practices with their young infants have a hybrid bifactorial (dyadic and extradyadic) structure that is expressed in six parenting domains [nurture, physical, social, didactic, material, and language (4)]. Infant behaviors aggregate into five behavioral domains (physical, social, exploration, nondistress vocalization, and distress communication). In terms of their associations, European American first-time mothers who engage in more dyadic interactions have infants who engage in more social exchanges with their mothers; and mothers who engage in more extradyadic interactions and mothers who encourage their infants' physical development more have infants who exhibit higher levels of motor development and explore their environments more. Finally, mothers whose infants communicate distress more (and vocalize nondistress less) nurture their infants more. The overall structure of European American first-time mothers' parenting infants largely obtains for mothers with daughters and mothers with sons. The General Discussion sets these results in broader empirical and theoretical contexts.

Study 2: mother-infant interactions in an international sample

According to a survey of 10 international journals concerned with psychological aspects of infancy, 92% of articles published between 2002 and 2012 were based on WEIRD populations (62). In brief, too little is still known about parenting, infancy, and mother-infant interaction across a broad swath of the world's nations. In consequence, Study 2 was designed to evaluate the nature and structure of mother-infant interactions in 9 diverse national samples. To the extent that research in developmental science is dominated by WEIRD samples, it is challenging to distinguish universal processes from those specific to WEIRD societies. Some universals in parenting, infancy, and mother-infant relationships likely exist, as parenting infants in different places likely draws on the same human neural, mental, and emotional machinery, just as infants likely elicit similar responses from parents that may be requisite for their wholesome development. However, human activities are known to vary (sometimes quite dramatically) across populations in different places, and mother-infant interactions constitute one such prominent activity.

Study 2: the international sample

Altogether 653 primiparous mothers and their healthy 5½-month-old infants were recruited into the international sample from Buenos Aires and Córdoba Province, Argentina ($n = 139$), Ghent and Antwerp, Belgium ($n = 117$), Rio de Janeiro, Brazil ($n = 40$), Paris, France ($n = 59$), Haifa, Israel ($n = 31$), Padua and Ruoti, Italy ($n = 100$), Tokyo, Japan ($n = 47$), and the Kamba tribe, Kenya ($n = 30$); additionally, data from a subsample ($n = 90$) of mother-infant dyads from the United States from Study 1 were used in Study 2. That subsample, stratified by maternal age and education and selected randomly, did not differ from the U.S. Study 1 sample in the means and variances of three key sociodemographic characteristics (mothers' age and education and family SES). As the same factor structure and comparable model fit indices were obtained with and without the U.S. mothers in the total international sample, reported results are based on the total international sample (including U.S. mothers).

Table 2 presents sociodemographic information for all participants in each country. Mothers averaged 27.7 years of age ($SD = 4.6$, range = 16.2–44.0). Because differences exist between countries in the duration, quality, and content of schooling, bicultural researchers adjusted mothers' years of schooling in each nation so that all education scales were equivalent to the Hollingshead U.S. scale. Mothers' average educational level as measured relative to the Hollingshead Index (56) 7-point education scale was 4.6 ($SD = 1.3$). Families in the 9 international samples were middle-class on average as measured by the Hollingshead ($M = 43.2$, $SD = 12.6$). Infants averaged 161.1 days of age ($SD = 8.0$, range = 131–198).

Study 2: international sample results

Descriptive statistics

Supplementary Tables S6A,B present the means and standard deviations for each maternal parenting practice and infant behavior domain score for all participants and by each country separately.

Mother-Infant interaction model

Figure 2 presents the standardized solution to the final model with correlated variances/unique variances added, S-B $\chi^2(35) = 131.52$, $p < .001$, Robust CFI = .92, RMSEA = .07, 90% CI = [.05, .08]. The model reproduced observed correlations with an average absolute standardized error of .03. All parameters estimated in the model were significant at the .05 level or better. Supplementary Table S7 presents the correlation matrix, variances, and standardized residual for the final model.

Similar relations between maternal parenting practice factors and domains with infant behavior domains were found in the Study 2 international sample as in the Study 1 U.S. sample. The maternal dyadic factor related positively to the infant social domain; the maternal extradyadic factor and the unique variance of the mother physical domain related positively to the infant exploration and physical domains; and the infant communicated distress domain and nondistress vocalization (negative) domain related to the maternal nurture domain.

Infant sex

To test whether the final international sample model fit equally well for mother-daughter and mother-son dyads, a series of nested multisample models was constructed that sequentially introduced constraints on the measurement model path coefficients and covariances (61). All factor loadings, factor variances, and unique variances were constrained to be equal. A preliminary test in which no parameter estimates were constrained to be equal fit the data, $\chi^2(70) = 166.88$, $p < .001$, CFI = .92, RMSEA = .07, 90% CI = [.05, .08], suggesting that more restrictive models were appropriate. In testing the series of nested multisample models, a consistent pattern emerged in which one path coefficient (the infant nondistress vocalization domain to the mother nurture domain) differed for mothers of female infants and mothers of male infants; there were no differences in any other parameter

TABLE 2 Demographic characteristics of the international samples.

	Mothers' Age		Mothers' Education[a]		Infants' Age[b]		Infants' Sex	Infants' Birth Weight[c]		Family SES[d]	
	M	*SD*	*M*	*SD*	*M*	*SD*	% females	*M*	*SD*	*M*	*SD*
Argentina ($n = 139$)	25.3	4.9	3.9	1.4	165.1	8.3	46.8	3,343.5	462.3	34.5	14.6
Belgium ($n = 117$)	29.3	3.6	5.2	1.1	157.1	9.7	47.0	3,405.9	453.2	47.6	11.0
Brazil ($n = 40$)	25.8	5.9	3.9	1.9	156.7	5.6	52.5	3,349.7	379.2	36.4	13.9
France ($n = 59$)	30.8	4.7	5.4	1.3	166.0	10.9	44.1	3,252.5	366.5	53.4	10.7
Israel ($n = 31$)	28.0	3.5	5.4	0.7	166.3	4.7	51.6	3,346.2	433.6	50.9	6.7
Italy ($n = 100$)	27.4	4.5	3.5	1.5	154.9	5.1	50.0	3,247.5	388.4	33.4	13.6
Japan ($n = 47$)	29.0	2.9	5.6	0.9	162.0	9.1	51.1	3,039.8	364.9	52.8	11.0
Kenya ($n = 30$)	21.7	3.4	2.5	1.7	159.1	9.1	50.0	2,913.7	558.9	–	–
U.S. ($n = 90$)	29.6	6.0	5.6	1.3	164.1	6.3	43.3	3,539.9	537.3	50.3	12.9
Total ($N = 653$)	27.7	4.6	4.6	1.3	161.1	8.0	47.6	3,317.7	446.1	43.2	12.6

Reproduced in part from Bornstein et al. (4).
[a]Hollingshead (56) 7-point scale.
[b]Days.
[c]Grams.
[d]Hollingshead (56).

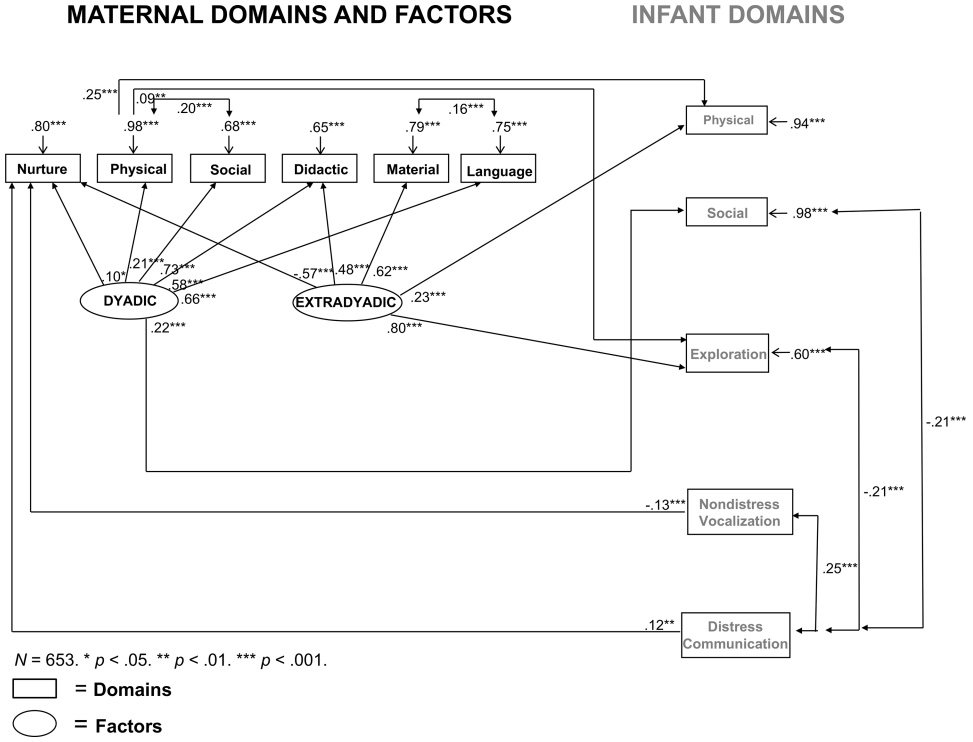

FIGURE 2
From videorecords of naturalistic mother-infant interactions at home in an international sample, aggregated from Argentina, Belgium, Brazil, France, Israel, Italy, Japan, Kenya, and the United States ($N = 653$), 20 maternal parenting practices and 15 behaviors of their 5½-month-old infants were microcoded. The 20 maternal parenting practices aggregated into 6 domains and subsequently into 2 factors, and the 15 infant behaviors aggregated into 5 domains. The standardized solution for the final mother-infant interaction model is shown in figure. Numbers associated with single-headed arrows from maternal factors to maternal domains and from maternal domains or factors to infant domains are standardized path coefficients; numbers associated with double-headed arrows are standardized covariance estimates; and numbers associated with single-headed arrows and maternal or infant domains are error or disturbance terms, the amount of variance not accounted for by paths in the model.

estimates. In the most rigorous test in which all parameters except this one path coefficient were constrained to be equal, an adequate fit was achieved, $\chi^2(100) = 191.20$, $p < .001$, CFI = .93, RMSEA = .05, 90% CI = [.04, .06]. The difference in χ^2 between this model and the model that imposed no invariance constraints was not significant, $\chi^2(30) = 24.32$, $p = .76$, suggesting that, apart from the one path coefficient, imposing invariance across the measurement model, path coefficients, and covariances had no deleterious effects on model fit. The one path coefficient which showed an infant sex difference was the path from the infant nondistress vocalization domain to the mother nurture domain (standardized coefficient = −.04, $p = .41$, for mothers of female infants and −.21, $p < .001$, for mothers of male infants): nondistress vocalizing in male infants was associated with less maternal nurturing, but no such relation existed in female infant-mother dyads.

Study 2: discussion

Mothers' parenting young infants in several samples from around the world has a higher-order bifactorial (dyadic and extradyadic) structure that is expressed in six domains [nurture, physical, social, didactic, material, and language (4)]. Infant behaviors aggregate into five domains (physical, social, exploration, nondistress vocalization, and distress communication). In terms of their interactions, mothers who engage in more dyadic focus have infants who engage in more social exchanges with their mothers; and mothers who engage in more extradyadic focus and mothers who encourage their infants' physical development more have infants who explore their environments more and who exhibit higher levels of motor development. Finally, mothers whose infants communicate distress more and vocalize nondistress less nurture their infants more. The overall structure of parenting infants in several international samples largely obtains for mothers with daughters and sons. The General Discussion sets these results in broader empirical and theoretical contexts.

Cross-national research usually compares two (or just a few) national locales. However, the number of rival explanations of a common phenomenon can be reduced when the number of samples compared is increased (63), so the larger the number of national samples studied the more compelling is the conclusion that any observed generic findings (here about the nature and structure of mother-infant interactions) may be robust and internationally common. For Study 2, mothers and infants were recruited from 9 South American, North American, European, African, Middle Eastern, and East Asian countries that also varied on dimensions of possible national comparison that included, for

example, economic, educational, ecological, and climatic factors (64). Despite this variation, a common structure of mother-infant interaction emerged.

General discussion

The central aims of these studies were to explore relations of two maternal parenting practice factors and six domains to five infant behavioral domains in U.S. and international samples and assess whether models of mother-infant interactions were moderated by infant sex. Previous work with both the U.S. and 9 international samples supported a 2 factor/6 domain model of maternal parenting practices (4). Here, the maternal parenting practice factors and domains related in systematic, specific, and similar ways to infant behavior domains in U.S. and international samples with only three of many possible associations moderated by infant sex. Developmental science benefits from examining the perspectives of parent, child, and context simultaneously. The parental perspective provides the vital social circumstances for child care; the child perspective provides an indispensable basis for assessing the impact of caregiving; and the contextual perspective provides the ideals and practices of society or nation that embeds parent and child. Here we discuss relations between the maternal factors and domains and infant domains, strengths and limitations of the U.S. and international studies, the role of infant sex in mother–infant interactions, as well as theoretical conclusions and clinical implications of this work.

Mother-Infant interaction: associations and specificities

The design of the current studies was cross-sectional, and so strictly speaking their results are fittingly interpreted in terms of associations between mothers and infants and do not untangle direction of "effects" or imply causation between mothers and infants. However, the parent-infant relationship is in many respects regarded as asymmetrical, acknowledging the predominant role mothers play in guiding interactions with their young infants (65), and we hypothesized some relations from mothers to infants. We therefore first discuss mother-infant "effects" in the data but also point to some clear reciprocal infant "effects" on mothers. Furthermore, in this discussion we identify and elaborate specificities revealed in these mother-infant interaction data. Of course, inability to specify direction of effects in no way subtracts from important conclusions about structure, association, correspondence, and specificity in mother-infant relationships. The specific concurrent correspondences begin to characterize important mutual influences that mother and infant exert on one another from an early period in the infant's life.

Mother-infant effects

Although parental genes contribute to infant proclivities and abilities in different domains, all prominent theories of development, such as relational systems, judge experience in the world as either the principal source of individual growth or as a major contributing component (2). Parents (and other caregivers) furnish and shape infants' experiences and directly influence infant development by the attitudes they hold and by the actions they exhibit. Evidence for heritability neither negates nor diminishes equally compelling empirical evidence for the direct short- and long-term influences of parent-provided experiences in infant development (3, 66).

These companion studies revealed two prominent associtions between mothers' parenting practices and their infants' behaviors. The first association was mothers' dyadic factor in relation to infant social behaviors with mother. One central task of infancy is achieving wholesome emotional and social development. Mothers help their infants to reach this goal by forging close interpersonal relationships. Thus, mothers engaging in dyadic forms of interaction is integral to parenting and infant socioemotional successes (67–69). Parental warmth and emotional support (a dyadic focus) appear to be important for infant's social exchanges and for children's future socioemotional competencies. The second set of associations that emerged were mothers' extradyadic factor and their encouragement of infant physical development in relation to infant exploration of the immediate physical environment and infant physical development. A second central task of infancy is accommodating to and coming to understand the material world outside the dyad. Mothers' extradyadic parenting practices and their promotion of infant physical development scaffold infants' exploratory behaviors and physical development. Being introduced to and beginning to negotiate the world outside the dyad are similarly significant developmental briefs for young infants.

Infant-mother effects

These analyses also revealed two prominent expected associations of infants' behaviors with their mothers' parenting practices. First, infants' distress communication was associated with maternal nurturing; that is, infants who fretted and cried had mothers who appropriately attended to them. It is less likely that mothers who nurture have infants who communicate more distress and more likely that infants who communicate distress have mothers who nurture. This infant-effects interpretation is supported by a three-culture study that examined and compared coded maternal responsiveness to infant activities during home-based naturalistic interactions in New York City, Paris, and Tokyo; it revealed that mothers do indeed respond to their infants' vocalizing distress with nurturance [(70); see also (20, 21)]. Nonetheless, confirmation of direction of effects will depend on sequential analyses, longitudinal designs, and experimental investigations. Second, infants' nondistress vocalization was negatively related to maternal nurturing; that is, mothers whose infants were vocalizing nondistress (cooing, babbling, and the like) refrained from engaging in similar nurturing activities with their infants. These infant effect findings accord with many examples that populate the developmental science literature. Notoriously, infant physiognomy attracts adults

(71), and Lorenz (72) contended that facial features of "babyishness" universally provoke adults to reflexively express solicitousness towards infants.

The dyadic-extradyadic balance that characterizes the mother-infant relationship likely has meaningful and far-reaching consequences in the life of the child as the dynamic systems perspective posits that reciprocity between mother and infant specifically facilitates higher-level forms of interaction. To the extent that mothers effectively support and promote both affiliative and exploratory goals for their infants, infants' chances to develop both socioemotional and mental adaptive competencies are improved. These two equally vital systems are present at a surprisingly early point in the development of the mother-infant relationship and across an equally surprising diversity of national contexts.

National and international studies of parenting and infancy: commonalities and specificities

These studies fall into the category of international developmental science, and the "story" of that approach to understanding human ontogeny is at base one of similarities and differences, universals and specificities (6, 12). The story that emerged from these studies is no different. Admittedly, "universal" is likely never truly universal (there being some exception somewhere, and proving a universal is impossible), and "specific" is likely never truly specific (there being some commonality somewhere, and proving a specific is likewise impossible). Nonetheless, noteworthy nomothetic and some idiographic lessons emerged in these studies.

On commonalities

Two sorts of broad commonalities emerged from these studies, one having to do with conceptually corresponding mother-infant associations and a second having to do with infant sex. Across samples in these studies, maternal parenting practices related to corresponding infant behaviors: Mothers who encouraged infants in more social activities had infants who engaged in more social activities, mothers who didactically encouraged their infants had infants who explored their environments more, mothers who fostered their infants' physical development more had infants who were physically more developed, and infants who vocalized distress more had mothers who nurtured their infants more. Such universals in parenting and infancy are supported by several arguments. First, there may be special and exacting constraints and demands in parenting infants that opportunistically apply universally. That is, certain parenting practices could recur across (even very different) contexts on account of common determinants of parenting in, say, factors endemic to evolution, to biology, to social history, or to children. Universal characteristics of parenting may be instinctual to a parenting "stage" in the human life cycle. It could be in the nature of being a human being—as much as a parent—to optimize the success of one's offspring and thereby to ensure the survival of one's genes (8, 73). Maternal hormones and the maternal nervous system may have evolved to treat and respond to human infants in some uniform ways (14, 20, 21, 74, 75). A universalist position also points to the shared environment as cause of uniformity in parenting; that is, certain economic or ecological factors are common even to different national samples on account of worldwide historically converging and homogenizing patterns of modernization, urbanization, Westernization, migration, or dissemination *via* media, and they cumulatively contribute to the deconstruction of many traditionally differentiated cultural patterns. On purely empirical grounds, moreover, the groups participating in these studies also created the possibility of identifying generalities of childrearing. The locales studied are more alike than not in terms of modernity, urbanity, economics, politics, living standards, even ecology and climate, and therefore it was possible to recruit roughly equivalent sociodemographic samples. Families were typically nuclear in organization; mothers normally the primary caregiver in the family setting; and parents shared many of the same larger and long-term goals for their children, notably physical health, social adjustment, mental achievement, and economic security. Last, by virtue of their helplessness or those "babyish" characteristics mentioned earlier, which are of course structurally universal, infants may elicit common patterns of interaction from their caregivers (71, 72, 76–78). Separately or collectively, these several evolutionary, biological, historical, and interpersonal forces likely engender some similarities in parenting and in infant development (79). Which specific force or forces these converging patterns reflect is difficult, if not impossible, to determine.

The second commonality to emerge from these studies had to do with infant sex. It is important to attend to sex similarities and differences in infancy for a variety of reasons, not the least of which are that even small differences in sexed patterns of development or treatment of infants likely cumulate over time; moreover, even if female and male infants are treated similarly the two could still experience similar environments or interpret similar experiences differently (13). Much of what is known about parenting infants and infant development with respect to sex comes from small samples and single locales in the minority world of WEIRD countries where a long-standing tradition has touted sex differences. However, the keen and consistent historical attention paid to sex in cultural, parenting, and developmental sciences has tended to substantiate surprisingly few practicable sex differences (13). Indeed, on the basis of more than 45 meta-analyses Hyde (80, 81) advocated a more general "gender similarities" hypothesis. In the current two studies, equivalent numbers of female and male infants were recruited into each sample, and in support of that similarities hypothesis analyses of associations of the six factors and two domains of maternal parenting practices with the five infant behavioral domains revealed only three moderation effects by infant sex of 80 possible mother-infant relationships (<4%). In accord with the gender similarities hypothesis, female and male infants appear to differ relatively little in their interaction experiences.

On specificities

A prevailing assumption in parenting studies is that the overall level of parenting affects children's overall level of functioning. This

position has been challenged by a more differentiated view that asserts specificity in parent-offspring interactions (82). That is, developmental relationships between parents and infants are not generalized, but are specific. As mentioned, only conceptually related mother–infant correspondences proved to be common across diverse international samples, despite considerable variation in many national traditions and situations, attitudes and actions. Domain-specific mutual correspondences in mother–infant interaction patterns appear to be widespread and similar across international samples. By contrast, there was little correspondence between maternal parenting practices and infant behaviors that were not conceptually related. In other (concrete and contrasting) words, mothers who engage in extradyadic practices more with their infants do not have infants who necessarily engage them more socially, and mothers who engage their infants more dyadically do not necessarily have infants who explore their environments more. The infants in these studies are only 5½ months of age, barely beyond *fetus ex utero*; so, specific mother–infant attunement is also fast developing.

It has been thought by some that differences among children's common home environments within the normal species range have no effect on children's outcomes [(83); see also (84)]. But parenting and infant behaviors alike vary, and patterns of associations between them suggest that variations within the normal range in particular kinds of parenting practices are associated with variations within the normal range in particular kinds of infant behaviors. Infants and mothers tend to show attunement and specificity with one another, and increasing evidence suggests that specific (rather than general) parental activities relate concurrently (and predictively) to specific (rather than general) aspects of infant performance or competence (82). These findings support the *specificity principle* which holds that specific experiences at specific times exert specific effects over specific aspects of child development in specific ways (3, 6, 20, 82). Developmental scientists and theoreticians today do not ask whether caregiving affects child development, but which parent-provided experiences affect which aspects of child development when and how, and they are interested also to learn the ways in which individual children are so affected, as well as the ways individual children affect their own development. To detect regular relations between antecedents in parenting, experience, and environment on the one hand and outcomes in infant and child characteristics on the other, we need to seek and to find precise and specific combinations of independent and dependent variables. In this light, parenting and infancy alike are each best conceptualized as multivariate, modular, and specific in nature.

Limitations of these studies

The design and analyses of these studies and the generalizability of the results are constrained by main terms of the Specificity Principle—setting, person, time, process, and outcome (3, 6, 20, 82). These two studies focused on specific activities (the maternal parenting practice and infant behavior indicators, domains, and factors) occurring in specific types of interactions (open, naturalistic) in specific settings (the familiar home) under specific conditions (infants in awake, sated, and alert states with dyads alone) in specific people (primiparous mothers and their 5½-month infants) in (nine) specific countries at a particular point in historical time. In consequence, the findings apply and might generalize specifically to similar activities, interactions, settings, persons, conditions, people, countries, and times. Investigations of other parenting practices and other infant behaviors in other situations under other conditions at other times by other categories of mothers with children of other ages could result in similar or different patterns of results. For example, mother-infant interactions could change dramatically in the context of multiple caregivers and multiple infants all present at the same time. Additionally, fathers actively engage in caregiving and are acknowledged to make independent contributions to children's development (85, 86). Furthermore, samples from 9 different countries were recruited, including two in South America, one in North America, three in Europe, one in the Middle East, one in Africa, and one in East Asia; however, no claims are made that they are representative of their nations or of the world's cultures. All these considerations naturally constrain the generalizability of the parenting practice and infant behavior domain structures as well as the patterns of practice-behavior relations reported here.

Due to the complexity of the models and the small sample sizes in some countries, we were not able to test meaisrement invariance of the model across countries. Our strategy to combine all countries in a single model answers whether the model is generalizable in a more heterogeneous multi-country sample, but it does not tell us whether the model holds in each and every country.

Etic constructs consist of accounts, descriptions, and analyses of activities that apply broadly across cultures and are expressed in terms of conceptual schemes and categories that are regarded as meaningful and appropriate by the broad community of scientific observers. By contrast, emic constructs consist of accounts, descriptions, and analyses expressed in terms of conceptual schemes and categories that are regarded as meaningful and appropriate by members of a particular community. The maternal parenting practices and infant behaviors studied here are likely etic, but their emic connotations could still differ across samples (64, 79). The everyday maternal parenting practices and infant behaviors operationalized and observed in these studies were representative of prominent and common interactions of new mothers with their young infants and were identical across the different cultural settings, so their comparability was assured. Nonetheless, understanding the relation between activity and meaning depends on context as well as the unit of analysis and the level of abstraction chosen for analysis.

Implications for theory and practice

These studies aimed to learn more about human parenting during the significant period of the mother-infant dyad's initial

mutual accommodation in the middle of the first year of the infant's life by recording, coding, analyzing, and comparing specific observable parenting practices of mothers and behaviors of infants across diverse samples. Empirical and clinical implications of this work would be twofold. First, empirically, studies of parenting, infancy, and mother-infant interactions have been undertaken at microanalytic and macroanalytic levels. Here, individual maternal parenting practices and infant behaviors were coded microanalytically, and domains and factors of mother-infant interactions were examined. By assessing these foundational in-the-moment building blocks of mother-infant interaction and how they are structured and manifest across international samples, these studies provide insights for future students of parenting, infancy, and family theory as well as international developmental science. Among many open questions would be to evaluate predictive associations of these parenting factors and domains for later child development.

Second, this close analysis of everyday behaviors also has relevance for the intersection of cognitive and clinical science, as such naturalistic tasks as basic caregiving require the coordination of multiple cognitive faculties whose deconstruction could reveal which specific processes underlie which specific caregiving shortcomings (87, 88). How mother-infant interactions vary in atypical populations may have important implications for therapeutic diagnosis and treatment.

Conclusions

These studies suggest that maternal parenting practices and infant behaviors are structured and that mother-infant interactions are characterized by conceptual correspondences consistent with notions of commonality, specificity, and modularity (6, 89). Parenting and infancy are common and modular in the senses that the two factors and six domains in mothers relate to separate developmental domains in infants, and they are specific in the sense that maternal dyadic activities relate to infant social activities and maternal extradyadic activities relate to infant exploration and physical development.

Certain enduring psychological characteristics might arise early in life, and the nature of parent-infant interaction is thought to contribute to individual development and cultural variation. As a result, studies of parenting, infancy, and mother-infant relationships have often been undertaken in attempts to address questions about caregiving, the origins and early development of individuals, and the influences of culture. Moreover, assumptions about the specificity and commonality of parenting, infants, and relationships between parents and infants may be advantageously tested within the context of international developmental research.

Mothers across different national samples showed some striking similarities in interacting with their infants. These converging patterns might reflect inherent attributes of caregiving (at least in industrialized and developed societies) or the historical convergence of parenting styles or the increasing prevalence of homogeneous childrearing patterns. They may also be instigated by infants themselves. In the end, different people (presumably) wish to promote similar general competencies in their offspring, and they do so in some manifestly similar and specialized ways.

Data availability statement

All data and materials for these studies may be accessed, upon reasonable request and for legitimate scientific purposes, by contacting the corresponding author.

Ethics statement

The present studies were conducted according to guidelines established by the Declaration of Helsinki, with written informed consents obtained from a parent for each infant before any data collection by trained research staff. All procedures involving human subjects in this study were approved by the Institutional Review Board at the Eunice Kennedy Shriver National Institute of Child Health and Human Development (88-CH-02) and by ethics committees in each country.

Author contributions

All authors contributed to the article and approved the submitted version.

Funding

MB, DP, and the research were supported by the Intramural Research Program of the NIH/NICHD, USA; MB by an International Research Fellowship at the Institute for Fiscal Studies, London, UK, funded by the European Research Council under the Horizon 2020 Research and Innovation Programme (grant agreement No. 695300-HKADeC-ERC-2015-AdG); RMP was supported by the European Research Council (ERC) under the European 25 Union's Horizon 2020 research and innovation programme (Grant agreement No. 758813; MHINT).

Acknowledgments

We thank H. Azuma, S. Bali, L. Cote, A. De Houwer, C. Galperin, C.-S. Hahn, O.M. Haynes, M. Kabiru, S. Maital, M.-L. Moura de Seidl, M. Ogino, M.-G. Pêcheux, J.T.D. Suwalsky, P. Venuti, and A. Vyt. Our collaborators in each country are senior professionals and scholars who took active parts in the recruitment and conduct of this work. The ideas and opinions expressed herein are those of the authors alone, and endorsement by the authors' institutions is not intended and should not be inferred. This ms. extends a prior publication (4) and so for accuracy and completeness some text in this paper repeats text from that publication.

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/frcha.2023.1124037/full#supplementary-material.

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frontiers | Frontiers in Child and Adolescent Psychiatry

TYPE Original Research
PUBLISHED 19 June 2023
DOI 10.3389/frcha.2023.1122371

OPEN ACCESS

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RECEIVED 12 December 2022
ACCEPTED 20 April 2023
PUBLISHED 19 June 2023

CITATION
Campbell A, Lewis G, Costantini I, Cordero M, Skinner A, Dermott E, Miller T, Kennedy M-R and Culpin I (2023) Maternal and paternal depressive symptoms and parental vocalisation behaviours in infancy: findings from UK-based birth cohort.
Front. Child Adolesc. Psychiatry 2:1122371.
doi: 10.3389/frcha.2023.1122371

Maternal and paternal depressive symptoms and parental vocalisation behaviours in infancy: findings from UK-based birth cohort

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Background: Both maternal and paternal postnatal depression (PND) are associated with increased risk of less optimal offspring developmental outcomes. Early exposure to differences in maternal and paternal vocalisation behaviours associated with maternal and paternal PND may be important in this relationship. However, little research has captured vocalisation patterns at home without researchers present.
Objectives: This study sought to examine the associations between maternal and paternal PND and various aspects of parental vocalisation behaviours.
Methods: Mothers ($n = 104$) and fathers ($n = 34$) of six-months old infants from the Avon Longitudinal Study of Parents and Children Generation-2 (ALSPAC-G2) provided video footage of mother- and father-infant interactions filmed at home using the head-worn video cameras (headcams) without the need for researchers to be present. Twenty-five mother-infant and father-infant interactions were coded on multiple aspects of parental and infant vocalisation behaviours using the micro-behavioural observational coding system. Parental (PND) was measured using the Edinburgh Postnatal Depression Scale (EPDS; total score).
Results: Frequencies and duration of vocalisation behaviours were similar in mothers and fathers. However, there was an indication that fathers demonstrated higher frequency and duration of commands, exclamations and ironic/sarcastic tone, and criticisms compared to mothers, while mothers engaged in more teaching compared to fathers. Linear regression models indicated that maternal and paternal PND were not associated with the majority of vocalisation behaviours. However, there were some specific patterns observed, mostly related to the emotional tone of the vocalisations. Higher levels of maternal PND were associated with lower frequency of speech in a neutral tone, frequency and duration of use of humour, and increased duration of speech in a positive tone. Higher levels of paternal PND were associated with higher mean duration of speech, infant-directed speech, higher frequency and duration of laughing, and increased duration of speech using questions and encouragement.
Conclusion: These findings extend existing research by investigating the associations between maternal and paternal PND and a wide range of vocalisation behaviours captured and coded using innovative methods and in a more ecologically valid way than previous studies.

KEYWORDS

Avon Longitudinal Study of Parents and Children (ALSPAC), paternal postnatal depression, maternal postnatal depression, parental vocalisation, infant vocalisation, parent-infant interactions, behavioural micro-coding, birth-cohort study

Introduction

A large body of research has now documented the high prevalence of maternal postnatal depression [PND; (1)], its link to potentially negative offspring development (2), and associated health and societal consequences (3). Despite mounting evidence to support increased risk of postnatal depression in men [PND; (1)], and associated adverse offspring outcomes (4), the epidemiology of paternal PND and its impact on the child has received less attention in research. The overall prevalence of maternal postnatal depression has been estimated at 23.8%, while in men this estimate approximates 10.4% (1) with several studies reporting strong associations between maternal and paternal mood during this period (1, 5, 6).

Many studies have shown that parenting behaviour is less sensitive and attuned in the context of maternal PND (7–9), which is on the of the potential pathways for mental health risk transmission in families (10). In comparison, pathways from paternal PND to offspring outcomes are less well understood, but paternal parenting behaviours are also emerging as a potential pathway of transmission (11). A meta-analysis of 28 observational studies concluded that paternal PND has small but statistically significant effects on parenting. Fathers who experienced depression demonstrated small, but meaningful, decreases in positive parenting behaviours ($r = -0.19$; e.g., less warmth, sensitivity, and appropriate discipline) and small, but meaningful, increases in negative parenting behaviours ($r = 0.16$; e.g., more hostility, intrusiveness, and inappropriate discipline). These effect sizes were comparable to the associations found between PND and maternal positive ($r = -0.20$) and negative parenting ($r = 0.22$) (11).

Traditionally, broad positive and negative domains of maternal (9) and paternal (11) parenting in the context of parental depression have been investigated. However, more insights into the specific manifestations of these broad constructs are needed to improve the identification of potential intervention targets (12, 13). Specifically, maternal vocalisations are one of the possible manifestations of impaired responsiveness that characterise mother-infant interactions in the context of depression (14), which have also been linked to adverse offspring outcomes (15). Similarly, one of the key pathways through which paternal PND may influence offspring development is through its effects on father-child interactions, including paternal vocalisation behaviours (11).

Both maternal and paternal vocalisation behaviours are important for a range of offspring outcomes, including language (16, 17), socio-emotional and cognitive development (16, 18, 19). For instance, frequency of maternal vocalisation has been found to be positively associated with cognitive development and educational attainment (20, 21) and negatively associated with childhood psychopathology (22). Furthermore, the quality of maternal vocal interaction with her infant has been shown to be more important for child language outcomes than global maternal sensitivity [defined as maternal ability to perceive and to interpret the signals of her child, and promptly and appropriately respond to them; (7, 23)]. There is also evidence that mothers who experience depression vocalise less when interacting with their infants (24), are less likely to increase the mean length of their utterances as their children develop (25), and use fewer words overall when interacting with their infants (26). Mothers with depression are also less likely to use specific types of vocalisations associated with better child outcomes. It has been shown, albeit inconsistently (27), that the frequency of infant-directed speech [characterised by a sing-song pitch, generally carried by exaggerated prosody compared to the more monotone style used to communicate with adults; (28)] decreases as maternal PND increases (29). Although mothers with depression tend to speak at an overall higher mean pitch when addressing their infants (25), the infant-directed speech becomes flatter, and more restricted (30, 31), which may be interpreted by infants as less positive (32) and have a negative impact on infant associative learning (33, 34). A recent systematic review found evidence for a reduction in the amount, but not the complexity, of infant-directed speech as maternal depressive symptoms increased (35). It is important to note that these studies may not capture culture-specific variations in depressed mothers' speech (36). Mind-minded speech (defined as caregiver's ability to comment appropriately on infant's putative internal states during interactions) is an important part of the parental vocalization repertoire (37), which reflects parental ability to accurately recognise infant's mental state (38). Maternal PND has been found to be associated with lower frequency of mind-minded speech in a clinical sample (39), with maternal ability to recognise their infant's agency also being impaired (20). In addition, mothers with depression have been found to use more self-focused speech (40), which is more likely to contain words with negative valence, criticism, and/or hostility (20, 41).

Unlike research on maternal PND and vocalisation behaviours, there remains a paucity of studies that examine the impact of paternal PND on different aspects of paternal vocalisations (19, 42). The few previous studies on vocalisation in fathers with depression have focused on specific aspects, such as parental speech registers with pre-verbal infants (43) and cognitive and mentalising features (19), rather than a comprehensive range of vocalisation behaviours. Compared to fathers without PND, fathers with PND use speech that is more focused on paternal rather than infants' experiences, comprising more negative and critical utterances (19), as well as being lower in modulation (43).

It should be noted that important differences between mothers and fathers have been noted in the literature on wider aspects of parent-infant interactions, including the more physically arousing nature of paternal compared to maternal play (44). However, a more recent comparison of studies between maternal and paternal vocalisation behaviours suggests that the similarities seem to outweigh the differences during infancy, with both mothers and fathers modifying their speech when interacting with their infants (45). It has also been suggested that depression has a comparable effect on parenting and parent-child interactions, with both mothers and fathers who experience PND displaying increases in hostility, instrusiveness, and disengagement, and decreases in sensitivity, warmth and responsiveness (11). Limited existing research precludes any conclusions as to whether any such similarities or differences

map onto depressed mothers' and fathers' vocalisation behaviours with their infants.

The validity and reliability of measures to assess parenting is a key issue in developmental research (46, 47). Both self-reported and independently observed measures of parenting are subject to limitations, including reporting (48–50) and social desirability biases (51). Despite the limitations, observational measures are better predictors of offspring cognitive and emotional outcomes (51) and are particularly sensitive to detect changes in parental and infant behaviours following interventions (46) compared to self-reported measures. Social desirability bias may be addressed by using more ecologically valid first-person cameras [hereafter referred to as headcams; see (52) for detailed description], which reduce demand characteristics whilst capturing a higher frequency of less socially desirable maternal behaviours compared to "gold standard" observational methods [i.e., researcher observing or filming the interaction in a clinical, research or home setting; (52)].

The aims of the current study were to examine the associations between both maternal and paternal PND and a comprehensive range of infant-directed maternal and paternal vocalisation behaviours. Vocalisation behaviours were recorded in the home without the presence of a researcher using the headcams, maximising the possibility of capturing naturalistic interactions and reducing demand characteristics (52). Four vocalisation behaviours of interest were identified *a priori*—parental speech, infant-directed and mind-minded speech, and emotional tone of speech. As existing research on the associations between paternal PND and vocalisations is limited, these behaviours were selected, and hypotheses were made, based on studies of maternal vocalisations. Specifically, we hypothesised that maternal and paternal PND would be associated with (1) lower frequency and duration of all speech, infant-directed and mind-minded speech, as well as positive emotional tone; and (2) higher frequency and duration of negative and neutral emotional tone. We examined the associations between maternal and paternal depression and all other vocalisation behaviours in a hypothesis-free manner.

Methods

Study cohort

The sample comprised participants from the ALSPAC cohort (**Figure 1**). During Phase I enrolment, 14,541 pregnant mothers residing in the former Avon Health Authority in the south-west of England with expected dates of delivery between 1 April 1991 and 31 December 1992 were recruited. The total sample size is 15,454 pregnancies, of which 14,901 were alive at 1 year of age. ALSPAC Generation 2 (ALSPAC-G2) was set up to provide a unique multigenerational cohort and builds on the existing ALSPAC resource of originally recruited women and their partners (Generation 0; ALSPAC-G0) and their offspring (ALSPAC-G1) followed up for 26 years. Recruitment of the next generation ALSPAC-G2—the grandchildren of ALSPAC-G0 and children of ALSPAC-G1—began on 6th June 2012. Up to 30th June 2018, 810 ALSPAC-G2 participants from 548 families had been recruited. Over 70% of those invited to early- and late-pregnancy, second week of life, 6-, 12- and 24-month assessments attended, with attendance >60% for subsequent visits up to 7 years. Further details on the cohort profile, representativeness and phases of recruitment, including ALSPAC-G2, are described in four cohort-profile papers (53–56). ALSPAC study website www.bristol.ac.uk/alspac/ contains details of all the data that is available through a fully searchable data dictionary and variable search tool (http://www.bris.ac.uk/alspac/researchers/our-data/).

Ethical approval

Informed consent for the use of data collected via questionnaires and clinics was obtained from participants following the recommendations of the ALSPAC Ethics and Law Committee at the time. Study data were collected and managed

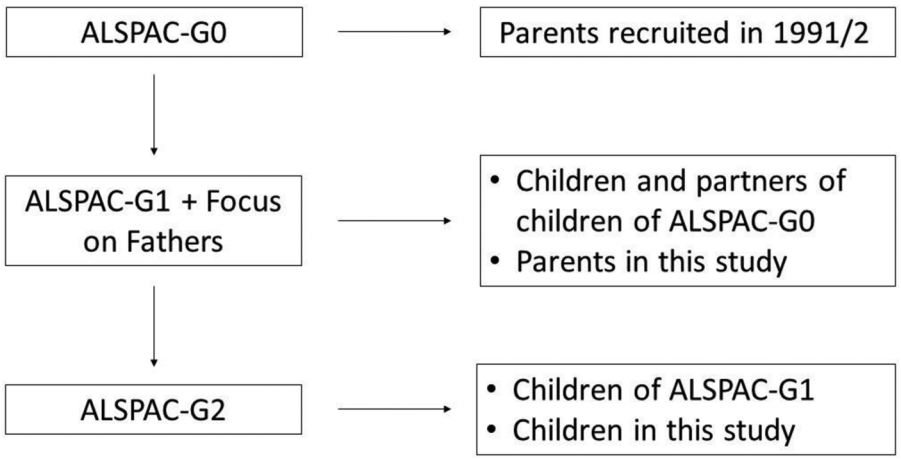

FIGURE 1
Flow chart of ALSPAC structure in relation to this study.

using Research Electronic Data Capture (REDCap), a secure web-based electronic data capture tools hosted at the University of Bristol (57).

Recruitment into the headcams study

A wide range of social, lifestyle, clinical and biological data have been collected on all family members repeatedly, including videos of parent-child interactions recorded using the headcams. Recruitment of mothers into the headcams study began on 7th July 2016, with 422 (90%) of mothers and their infants attending a 6-months assessment at the research clinic. 266 (63%) of mothers who attended the clinic were invited to record interactions with their infant using the headcams at home. 141 (53%) of these mothers consented to participate and 104 (74%) mothers provided video footage of mother-infant interactions. Initially, biological fathers and mothers' partners were invited to participate in the headcams study indirectly through an invitation to the mother when their child joined ALSPAC-G2. On 22nd July 2019, through additional funding from Wellcome Trust, a separate research clinic for fathers was set up (Focus on Fathers) inviting fathers directly to attend a range of assessments, including the headcams, when their G2 child was six months old. Overall, 194 fathers were invited to attend, with 83 (43%) fathers consenting to participate and 34 (18%) fathers providing video footage of father-infant interactions. For the purposes of this study, 25 mother-infant and 25 father-infant dyads were fully coded on various aspects of parental and infant vocalisations using the micro-behavioural observation coding system (58).

Videorecording procedures using the headcams

We captured video and audio footage of mother- and father-infant interactions using the headcams previously used for recording infant's eye view of their environment (59). The headcams are worn on headbands by both the parent (mother and father) and the infant, capturing two separate videos from the parent and infant perspective for each interaction. Headcams have previously been shown to be reliable for capturing mother and infant behaviours (52) and have been extensively used with fathers in the ALSPAC cohort. A questionnaire enquiring about fathers' experiences of using the headcams suggested that fathers perceive them to be user-friendly with no bearing on how they or their infant engage in the interaction. Separate headcam footage from both the parent and infant cameras were synchronised by the researchers for coding purposes. Headcam protocols were identical for both mothers and fathers. Parents were given fully-charged headcams and asked to use them at home during mealtime and play interactions. For the mothers, interactions analysed in this study were classed as "mealtime" (infant engages in eating = 24) and "stacking task" (mother and infant engage in a play task with a stacking toy; $n = 1$). For fathers, the interactions were classed as "mealtime" ($n = 15$); "stacking task" ($n = 4$), and "free play task" (father and infant engage in a play as they normally would; $n = 6$). Examples of each activity are presented in the MHINT micro-coding scheme (58). All videos were recorded at participants' home. Thus, it was possible for siblings/other caregivers/pets to be present during the interactions. Only three out of 25 children were from the same mother-father-child triad. Videos for 25 distinct mother-infant, and 25 distinct father-infant dyads (one father provided two interactions) were used in the present analyses.

Measures

Exposures: maternal and paternal postnatal depression (PND)

We refer to parental PND not as a clinical diagnosis, but as experiences of self-reported maternal and paternal depressive assessed using the Edinburgh Postnatal Depression Scale [EPDS; (60)], a 10-item self-reported questionnaire validated with women and men for use during the perinatal period (61, 62). Maternal depressive symptoms were assessed at multiple time points, including early (<20 weeks) and late pregnancy (>28 weeks), and 715 days after birth with the measure completed closest to the six-month assessment included in the analyses. Paternal depressive symptoms were extracted from birth, annual and six months postnatal questionnaires with all measures included in the analyses to maximise the sample (none of the fathers had EPDS measures available at all three time points). In order to capture the full variation in depressive symptoms, individual depression items were summed to derive a continuous score used in all analyses (score range: mothers 0–30; fathers 0–24 with higher scores indicating more severe depressive symptoms).

Outcome: parental and infant vocalisation behaviours

All interactions were coded on a continuous event-basis using the MHINT micro-coding scheme (58) and specialised software for behavioural research Noldus Observer XT 14.0 (64). In summary, within each behavioural group (e.g., caregiver vocalisation), behaviours (e.g., speech, laugh) are mutually exclusive and exhaustive, thus, at each point in time, exactly one behaviour from each behavioural group must be coded. Modifiers allow for more detailed categorisation within a behavioural group (e.g., within "vocalisation" behavioural group, modifiers allow the coder to categorise the tone of the speech as positive, negative, or neutral). If a modifier is associated with a behavioural group, both the behaviour group and the modifier group must be coded. For the purposes of this study, only parental and infant vocalisations were coded, which included any sound made by the infant and caregiver – voluntary or involuntary and meaningful (i.e. any sound which is not verbal but still has a communicative meaning; e.g., sighs) or non-meaningful (e.g., yawning) sounds. Within "caregiver vocalisation" behavioural group, there are

seven behaviours and twenty-two potential modifiers, while "infant vocalisation" behavioural group is composed of nine behaviours and five modifiers (Table 1). The full manual describing the micro-behavioural observational coding system is available online, including an exhaustive list of all overarching behavioural codes, individual behaviours and modifiers (58). For visualisation of codes underlying parental vocalisation behaviours please see Figure 2.

Videos of maternal and paternal interactions were coded by different researchers. Coding of maternal interactions was completed by three independent female researchers with at least a Master's level qualification in psychology or a related discipline, all of whom are co-authors on this paper. Coding of paternal interactions was completed by one male and three female researchers with Master's and Doctorate qualifications in Psychology. Coders were trained in using the coding scheme and blind to parental depression status. For reliability purposes, four videos of mother-infant and four videos of father-infant interactions were double coded, with inter-rater reliability assessed using Cohen's kappa separately for the overall behaviour group ($\kappa = 0.91$; 0.90–0.93). All reliability analyses were conducted using Noldus Observer XT 14.0 (64). All videos were coded for five minutes in line with previous research (65) and recent evidence suggesting that thin slice sampling (i.e., <5 min) is a suitable approach across different behavioural groups, including vocalisation (66).

Potential confounders

Maternal, paternal and infant characteristics

Analyses were adjusted for risk factors that have been previously found to be associated with maternal and paternal PND and parental vocalisation, including child sex (20), birth order [first born vs. second or later born; (67)], maternal (assessed at delivery) and paternal (assessed at six-months assessment) age in years (68) and parental highest educational attainment [compulsory secondary level up to age 16 years/GCSE vs. noncompulsory secondary level up to age 18 years/AS/A Levels and university level education/Degree and higher; (69)] assessed at birth.

Characteristics of mother- and father-infant interactions

Analyses were also adjusted for a number of characteristics pertaining to mother- and father-infant interactions. Infants are active participants in the interaction and their behaviour may elicit certain behavioural responses in mothers (e.g., greater vocalisation in infant may evoke greater vocalisation in mother); thus, we adjusted for the frequency/duration of infant vocalisation. In addition, parent-child interactions were recorded at home, often with other caregivers/siblings present. Therefore, we adjusted for the total duration of caregiver speech directed solely at the infant.

TABLE 1 Caregiver and infant vocalisation, corresponding behaviours and modifiers.

Behavioural group[a]	Behaviour	Modifiers[b]
Caregiver vocalisation	Speech	Language
		Type of sentence
		Tone
		Infant- and adult-directed speech
		To whom speech is directed
		Acknowledgement
		Reference to self
		Attribution of personality
		Criticism
		Praise
		Use of humour
		Attuned and non-attuned mind-mindedness (63)
		Encouragement
		Discouragement
		Verbal intrusiveness
		Verbal role reversal
		Verbal play
		Odd content
		Sociality of verbal play
		Globality and specificity
		Teaching
		Use of real name/nickname
	Musical sounds	–
	Laugh	Nervous laugh
	Vocal imitation	Tone
	Bodily sounds	Type of bodily sound
	Non-verbal sounds	Tone
	Silent	–
	NPTC caregiver vocalisation	–
Infant vocalisation	Laughing	–
	Distressed	–
	Non-distressed	Tone
	Vocal imitation	Tone
	Babbling	Tone
	First words	Tone
		First words type
		Type of sentence
		Verbal role reversal
	Screaming	Tone
	Bodily sounds	Type of bodily sounds
	Silent/none of the above	–
	NPTC infant vocalisation	–

NPTC, not possible to code.
[a]Behavioural group refers to an overarching behavioural category, comprised of mutually exclusive and exhaustive behaviours.
[b]Modifiers allow for more detailed categorisation within behavioural group.

Statistical analyses

First, we examined characteristics of our sample by parental and child characteristics (Table 2) and frequency and duration of parental and infant vocalisation behaviours (Table 3) using χ^2 and ANOVA tests. We ran Pearson correlations to examine the associations

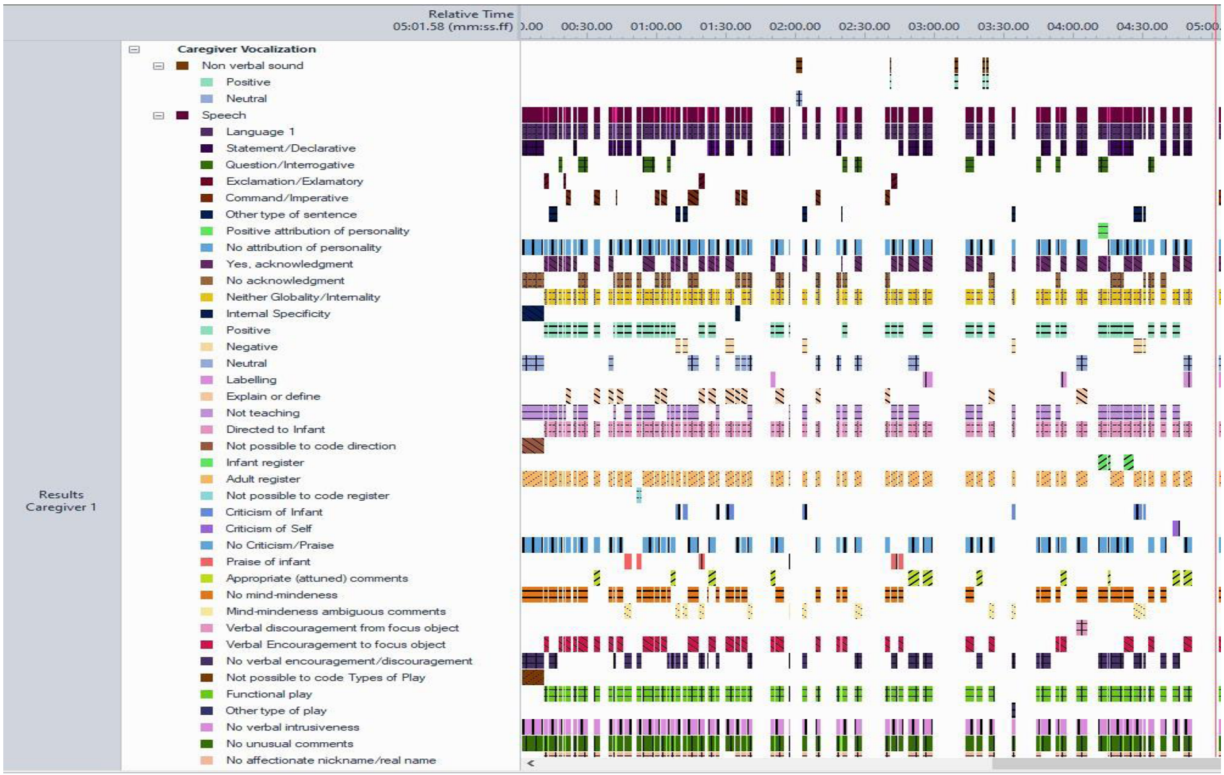

FIGURE 2
Example of paternal vocalisation behaviours visualised using behavioural software observer-XT (length of video 5 min).

between maternal and paternal PND and infant vocalisations. Second, we conducted linear regressions to examine the associations between maternal and paternal PND (continuous exposures) and the frequency (mean rate per minute) and mean duration of parental vocalisation behaviours as continuous outcomes. Parental vocalisations that violated the assumptions of linear regression or were uncommon (e.g., criticism, intrusiveness, discouragement) were either dichotomised using a median split or divided into equal quintiles to derive ordinal variables. We then conducted ordinal logistic regressions and logistic regressions to examine the odds of being in a lower quintile or a category with a lower frequency or mean duration of each vocalisation behaviour as parental PND score increased. All models were first estimated unadjusted (exposure and outcome only), following incremental adjustment for amount of speech directed to infant, frequency/mean RPM/mean duration of infant vocalisation, and parental and child characteristics. Hypotheses-led analyses included models examining associations between maternal and paternal depression and frequency and duration of parental (1) all speech; (2) infant-directed speech; (3) attuned mind-mindedness; (4) positive emotional tone; (5) negative emotional tone; and (6) neutral emotional tone. The associations between maternal and paternal PND and the frequency and duration of all other parental vocalisation behaviours were examined without specific hypotheses. All analyses were conducted in Stata v.15 (Stata Corp., Texas, USA) (70) A sensitivity power analysis conducted using G*Power 3.1 (71) indicated that with a sample size of 25, $\alpha = 0.05$, and 80% power, the minimum effect sizes this study was powered to detect were $\beta = 0.51$ and POR = 3.56. However, given that multiple tests were conducted, effect sizes at and above these thresholds could still be underpowered and findings were interpreted with caution.

TABLE 2 Characteristics of the study sample.

	Parental characteristics	
	Fathers	Mothers
Parental education, *n* (%)		
GCSE	14 (56%)	6 (24%)
AS/A level	7 (28%)	13 (52%)
Degree/higher	<5 (–)*	5 (20%)
Birth order, *n* (%)		
First-born	19 (76%)	17 (68%)
Second or later born	6 (24%)	8 (32%)
Parental age, mean (SD)	28.8 (3.58)	25.0 (1.06)
Parental PND (EPDS), mean (SD)	8.17 (5.11)	6.61 (5.37)
	Child characteristics	
	Boys	Girls
Child gender, *n* (%)	23 (46%)	27 (54%)
Child age, mean (SD)	30.9 (3.74)	30.4 (7.89)

EPDS, Edinburgh Postnatal Depression Scale; PND, postnatal depression.
*Censored to prevent disclosure because of small cell counts.

10.3389/frcha.2023.1122371

TABLE 3 Frequency and duration of parental and infant vocalisation behaviours.

Vocalisations	Infant vocalisation behaviours					
	N (%)		Mean RPM (SD)		Mean duration (SD)	
	Fathers	Mothers	Fathers	Mothers	Fathers	Mothers
Distress	15 (60%)	15 (60%)	0.80 (1.32)	0.69 (0.95)	5.40 (9.84)	2.67 (3.95)
χ^2 and ANOVA, *p*-value		0.00, 1.00		0.35, 0.724		1.29, 0.204
Non-distress	24 (96%)	23 (92%)	1.87 (1.46)	2.74 (2.40)	3.77 (3.71)	2.14 (2.11)
χ^2 and ANOVA, *p*-value		0.35, 0.552		−1.53, 0.131		1.90, 0.062
Any vocalisation[a]	25 (100%)	24 (96%)	1.02 (0.73)	1.35 (1.00)	5.42 (5.47)	5.33 (8.93)
χ^2 and ANOVA, *p*-value		1.02, 0.312		−1.35, 0.184		0.05, 0.963
	Parental vocalisation behaviours					
Laughter	17 (68%)	17 (68%)	0.46 (0.55)	0.36 (0.41)	1.42 (1.36)	1.23 (1.55)
χ^2 and ANOVA, *p*-value		0.00, 1.00		0.76, 0.449		0.45, 0.654
Vocal imitation*	<5 (–)*	5 (20%)	0.02 (0.12)	0.14 (0.40)	0.08 (0.40)	0.37 (0.91)
χ^2 and ANOVA, *p*-value		3.03, 0.082		−1.43, 0.16		−1.46, 0.150
Musical sounds*	5 (20%)	7 (28%)	0.15 (0.45)	0.20 (0.50)	0.49 (1.09)	2.33 (5.66)
χ^2 and ANOVA, *p*-value		0.44, 0.508		−0.36, 0.718		−1.60, 0.116
Speech	25 (100%)	25 (100%)	7.71 (3.01)	7.09 (3.50)	2.20 (0.62)	2.47 (2.47)
χ^2 and ANOVA, *p*-value		–		0.67, 0.503		−0.89, 0.376
Non-verbal sounds	22 (88%)	24 (96%)	1.37 (1.16)	1.45 (1.29)	1.79 (1.14)	1.49 (0.96)
χ^2 and ANOVA, *p*-value		1.42, 0.492		−0.23, 0.819		0.98, 0.327
Silence	25 (100%)	23 (92%)	6.54 (2.17)	6.89 (4.11)	7.46 (8.79)	5.50 (3.72)
χ^2 and ANOVA, *p*-value		2.08, 0.149		−0.38, 0.707		1.03, 0.309
	Modifiers of parental speech					
Command	23 (92%)	14 (56%)	0.82 (0.69)	0.45 (0.63)	1.77 (0.71)	1.34 (1.77)
χ^2 and ANOVA, *p*-value		8.42, 0.004		1.94, 0.058		1.14, 0.261
Exclamation	20 (80%)	10 (40%)	0.58 (0.54)	0.20 (0.30)	1.96 (1.21)	1.17 (3.16)
χ^2 and ANOVA, *p*-value		10.70, 0.005		3.13, 0.003		1.16, 0.253
Question	24 (96%)	24 (96%)	2.01 (1.08)	2.13 (1.50)	2.00 (0.84)	2.43 (2.15)
χ^2 and ANOVA, *p*-value		0.00, 1.00		−0.34, 0.732		−0.93, 0.355
Statement	25 (100%)	25 (100%)	2.86 (1.64)	3.08 (1.57)	2.70 (1.16)	2.74 (1.17)
χ^2 and ANOVA, *p*-value		–		−0.48, 0.629		−0.11, 0.908
Acknowledgement	25 (100%)	25 (100%)	3.16 (1.59)	4.40 (3.56)	2.14 (0.68)	2.42 (1.66)
χ^2 and ANOVA, *p*-value		–		−1.59, 0.118		−0.80, 0.425
Neutral tone	24 (96%)	25 (100%)	2.20 (1.53)	2.36 (1.28)	2.09 (0.81)	2.84 (1.52)
χ^2 and ANOVA, *p*-value		1.02, 0.312		−0.40, 0.687		−2.16, 0.036
Positive tone	25 (100%)	25 (100%)	5.29 (2.72)	4.35 (3.50)	2.21 (0.76)	2.44 (1.44)
χ^2 and ANOVA, *p*-value		–		1.06, 0.292		−0.72, 0.473
Negative tone	<5 (–)*	5 (20%)	0.13 (0.35)	0.03 (0.07)	0.58 (1.25)	0.21 (0.50)
χ^2 and ANOVA, *p*-value		0.13, 0.713		1.34, 0.186		1.37, 0.177
Ironic/Sarcastic tone	8 (32%)	<5 (–)*	0.09 (0.14)	0.06 (0.15)	0.77 (1.28)	0.58 (1.81)
χ^2 and ANOVA, *p*-value		1.75, 0.185		0.71, 0.480		0.41, 0.681
Adult-directed speech	25 (100%)	25 (100%)	5.84 (2.97)	3.60 (2.44)	2.2672	2.6632
χ^2 and ANOVA, *p*-value		–		2.92, 0.005		−1.25, 0.218
Infant-directed speech	24 (96%)	25 (100%)	1.87 (1.81)	3.22 (3.07)	2.06 (1.14)	2.49 (1.60)
χ^2 and ANOVA, *p*-value		1.02, 0.312		−1.88, 0.065		−1.09, 0.280
Attribution of personality	6 (24%)	9 (36%)	0.17 (0.45)	0.12 (0.24)	0.55 (1.18)	0.88 (1.63)
χ^2 and ANOVA, *p*-value		0.86, 0.355		0.54, 0.592		−0.82, 0.415
Praise of infant	20 (80%)	16 (64%)	1.03 (1.31)	0.53 (0.98)	1.57 (0.90)	1.86 (2.69)
χ^2 and ANOVA, *p*-value		1.59, 0.208		1.52, 0.134		−0.51, 0.609
Praise of other person	5 (20%)	<5 (–)*	0.04 (0.08)	0.04 (0.13)	0.95 (2.50)	0.25 (0.83)
χ^2 and ANOVA, *p*-value		0.59, 0.440		−0.001, 0.999		1.33, 0.190
Criticism of infant	10 (40%)	<5 (–)*	0.19 (0.35)	0.03 (0.12)	0.98 (1.30)	0.29 (1.21)
χ^2 and ANOVA, *p*-value		7.02, 0.008		2.12, 0.039		1.94, 0.057
Criticism of other person*	5 (20%)	<5 (–)*	0.10 (0.33)	0.02 (0.06)	0.67 (1.74)	0.19 (0.62)
χ^2 and ANOVA, *p*-value		0.59, 0.440		1.19, 0.239		1.31, 0.195
Use of humour	7 (28%)	12 (48%)	0.15 (0.32)	0.18 (0.26)	0.93 (1.69)	1.01 (1.31)
χ^2 and ANOVA, *p*-value		2.12, 0.145		−0.38, 0.706		−0.17, 0.866
Attuned mind-mindedness	20 (80%)	13 (52%)	0.91 (1.20)	0.21 (0.26)	1.86 (1.16)	1.21 (1.66)

(*continued*)

TABLE 3 Continued

Vocalisations	Infant vocalisation behaviours					
	N (%)		Mean RPM (SD)		Mean duration (SD)	
	Fathers	Mothers	Fathers	Mothers	Fathers	Mothers
χ^2 and ANOVA, *p*-value		4.37, 0.037		2.87, 0.006		1.62, 0.112
Encouragement	25 (100%)	23 (92%)	2.37 (2.41)	1.83 (1.75)	2.33 (1.65)	2.05 (1.32)
χ^2 and ANOVA, *p*-value		2.08, 0.149		0.90, 0.371		0.66, 0.511
Discouragement	13 (53%)	14 (56%)	0.17 (0.21)	0.35 (0.52)	1.18 (1.35)	1.43 (2.44)
χ^2 and ANOVA, *p*-value		0.08, 0.777		−1.65, 0.106		−0.44, 0.660
Intrusiveness	14 (56%)	<5 (–)*	0.68 (2.05)	0.12 (0.37)	1.71 (1.89)	0.31 (0.83)
χ^2 and ANOVA, *p*-value		8.68, 0.003		1.35, 0.183		3.39, 0.001
Role reversal*	<5 (–)*	<5 (–)*	0.01 (0.04)	0.06 (0.19)	0.08 (0.38)	0.38 (1.19)
χ^2 and ANOVA, *p*-value		1.09, 0.297		−1.38, 0.173		−1.18, 0.243
Verbal play	15 (60%)	7 (28%)	2.09 (3.17)	0.14 (0.40)	1.33 (1.28)	0.65 (1.32)
χ^2 and ANOVA, *p*-value		5.19, 0.023		3.06, 0.004		1.85, 0.070
Use of nickname	12 (48%)	8 (32%)	0.25 (0.46)	0.15 (0.30)	1.05 (1.44)	0.88 (1.54)
χ^2 and ANOVA, *p*-value		1.33, 0.248		0.83, 0.410		0.41, 0.687
Use of real name	16 (64%)	15 (60%)	1.30 (2.01)	0.43 (0.48)	1.57 (1.52)	1.69 (1.98)
χ^2 and ANOVA, *p*-value		0.08, 0.771		2.09, 0.042		−0.24, 0.813
Reference to self	18 (72%)	18 (72%)	0.56 (0.61)	0.36 (0.51)	1.96 (1.36)	1.65 (1.50)
χ^2 and ANOVA, *p*-value		–		1.22, 0.229		0.77, 0.444
Global speech*	<5 (–)*	<5 (–)*	0.01 (0.04)	0.04 (0.10)	0.12 (0.58)	0.20 (0.63)
χ^2 and ANOVA, *p*-value		2.00, 0.157		−1.50, 0.139		−0.49, 0.629
Specific speech*	<5 (–)*	9 (36%)	0.04 (0.13)	0.13 (0.23)	0.54 (1.76)	0.67 (1.28)
χ^2 and ANOVA, *p*-value		3.95, 0.047		−1.67, 0.101		−0.29, 0.770
Teaching	9 (36%)	17 (68%)	0.30 (0.55)	0.33 (0.46)	0.99 (1.50)	2.44 (2.75)
χ^2 and ANOVA, *p*-value		5.13, 0.024		−0.18, 0.854		−2.30, 0.026

EPDS, Edinburgh Postnatal Depression Scale.
*Censored to prevent disclosure because of small cell counts.
[a]Any vocalisation: any verbal sound made by the infant, including distress, non-distress, screaming, bodily sounds, babbling, first words.

Results

Characteristics of the sample

In summary, the majority of children in our sample were first-born, of similar age, with a higher proportion of girls than boys. The average age of mothers and fathers was lower than that reported nationally in the UK [30.7 and 33.6 respectively; (72)] with mothers reporting higher educational attainment compared to fathers. The mean depression score (EPDS) for mothers (Mean = 6.61, SD = 5.37) was similar to that previously reported [Mean = 6.34, SD = 4.33; (73)], while the mean depression score for fathers in our sample (Mean = 8.17, SD = 5.11) was higher in comparison with previous research [Mean = 4.35, SD = 3.72; (73)] (Table 2).

Descriptive characteristics of infant and parental vocalisation behaviours

Frequency, mean RPM, and mean duration of parental and infant vocalisation behaviours are displayed in Table 3. Overall, there were no differences in frequency and duration of infant vocalisation behaviours during father-infant, compared to mother-infant, interactions. Non-distress and any vocalisation (any verbal sound made by the infant, including distress, non-distress, screaming, bodily sounds, babbling and first words) were the most frequent behaviours displayed by the infants. Similarly, there were no differences between frequency and duration of maternal and paternal vocalisation behaviours when interacting with their infants. The most frequently demonstrated maternal and paternal vocalisations were speech, non-verbal sounds, silence and laughter, which also had the longest duration. With regard to modifiers of parental speech, the most frequent sentence structures were statements and questions, with both mothers and fathers acknowledging their infants during interactions. Fathers demonstrated higher frequency and mean RPM of commands and exclamations compared to mothers. Both mothers and fathers used positive and neutral tone, with somewhat higher mean duration of neutral tone displayed by the mothers compared to fathers. Negative and ironic/sarcastic tone was a rare feature of parental speech, although there was some indication that fathers used ironic/sarcastic tone more frequently than mothers. Both mothers and fathers engaged in adult- and infant-directed speech, although mean duration of adult-directed speech was higher, and mean duration of infant directed speech was lower, in fathers compared to mothers. Both mothers and fathers praised their infants during interactions, however, the frequency, mean RPM and duration of criticism directed toward the infant was higher in fathers than mothers. Similarly,

frequency and mean duration of intrusive vocalisation behaviours was higher in fathers compared to mothers. Despite higher frequency and duration of criticism and intrusiveness, fathers engaged in attuned mind-mindedness more often, and for longer duration, compared to mothers. High frequency of infant-directed encouragement and low frequency of infant discouragement was displayed by both mothers and fathers. Frequency and mean RPM of verbal play was higher in fathers than mothers. Both mothers and fathers addressed their infants by their real name more often than the nickname, with some indications that fathers had higher mean RPM of using infant's real name compared to mothers. Both frequency and mean duration of teaching was higher in mothers compared to fathers. There was no evidence to suggest that paternal and maternal PND were correlated with the frequency of infant vocalisation behaviours, including distress, non-distress or any infant vocalisation (Table 4).

TABLE 4 Correlations between paternal and maternal PND and infant vocalisations.

Infant vocalisation	Correlations with paternal PND (EPDS; $n = 23$)	Correlations with maternal PND (EPDS; $n = 23$)
Frequency of infant distress	$r = 0.08$ (−0.45, 0.62), $p = 0.752$	$r = -0.14$ (−0.51, 0.21), $p = 0.49$
Frequency of infant non-distress	$r = 0.31$ (−0.07, 0.70), $p = 0.111$	$r = -0.33$ (−0.64, 0.08), $p = 0.10$
Frequency of any infant vocalisation[a]	$r = 0.06$ (−0.38, 0.51), $p = 0.773$	$r = -0.09$ (−0.47, 0.32), $p = 0.66$

EPDS, Edinburgh Postnatal Depression Scale; PND, postnatal depression.
[a]Any infant vocalisation: any verbal sound made by the infant, including distress, non-distress, screaming, bodily sounds, babbling, first words.

Associations between parental PND and vocalisation behaviours

There was no evidence for associations between maternal PND and the majority of vocalisations in hypothesis-led analyses. There was evidence for a reduction in the frequency of maternal neutral tone as maternal PND increased in the unadjusted and adjusted models (β: −0.11, 95% CI: −0.20, −0.02, $p = 0.016$; Tables 5, 6). There was also evidence that increases in maternal PND were associated with increased odds of being in a quantile with higher duration of positive tone in models adjusting for amount of speech directed to the infant and duration of infant vocalisation (POR: 1.20, 95% CI: 1.02, 1.40, $p = 0.026$), and fully adjusted models (POR: 1.28, 95% CI: 1.04, 1.56, $p = 0.017$). There were fewer than five mothers displaying negative tone, precluding from examining associations with PND using inferential statistics.

Within hypothesis-free analyses of maternal vocalisations, there was only evidence for an association between maternal PND and duration of maternal encouragement. After adjusting for amount of speech directed to the infant, there was evidence that increased maternal PND was associated with increased odds of being in a quantile that encouraged their children for longer periods of time (POR: 0.08, 95% CI: 0.01, 0.15, $p = 0.036$). There was also weak evidence for this association when adjusting for amount of speech directed at the infant and mean duration of infant vocalisation (POR: 0.07, 95% CI: −0.003, 0.15, $p = 0.06$).

Similarly to mothers, there was no evidence of associations between paternal PND and the majority of paternal vocalisation behaviours in hypotheses-led analyses (Tables 5, 6). However, there was some evidence that paternal PND was associated with higher odds of being in a quantile with higher frequency of

TABLE 5 Linear regressions of hypothesis-led analysis of associations between maternal and paternal PND and parental vocalisation behaviours.

Parental vocalisation behaviours	Paternal PND (EPDS; $n = 23$)			
	Unadjusted[a]	Adjusted for amount of speech directed to infant[b]	Further adjusted for frequency or mean of infant vocalisation[c]	Further adjusted for maternal, paternal and child characteristics[d]
	B [95% CI], *p*-value	B [95% CI], *p*-value	B [95% CI], *p*-value	B [95% CI], *p*-value
Frequency of paternal speech	−0.01 [−0.28, 0.27], $p = 0.966$	−0.02 [−0.22, 0.17], $p = 0.800$	−0.02 [−0.22, 0.18], $p = 0.839$	0.02 [−0.27, 0.32], $p = 0.878$
Frequency of paternal neutral tone	0.01 [−0.03, 0.04], $p = 0.773$	0.01 [−0.03, 0.04], $p = 0.781$	0.01 [−0.03, 0.04], $p = 0.795$	−0.01 [−0.06, 0.04], $p = 0.567$
Duration of paternal neutral tone	0.03 [−0.03, 0.09], $p = 0.320$	0.03 [−0.03, 0.09], $p = 0.323$	0.02 [−0.03, 0.08], $p = 0.363$	0.03 [−0.06, 0.11], $p = 0.520$
	Maternal PND (EPDS; $n = 23$)			
Frequency of maternal speech	−0.13 [−0.49, 0.13], $p = 0.309$	−0.11 [−0.34, 0.12], $p = 0.335$	−0.10 [−0.33, 0.13], $p = 0.380$	−0.09 [−0.36, 0.17], $p = 0.471$
Frequency of maternal neutral tone	−0.11 [−0.20, −0.02], $p = 0.016$	−0.11 [−0.20, −0.03], $p = 0.010$	−0.12 [−0.20, −0.03], $p = 0.011$	−0.10 [−0.19, −0.002], $p = 0.045$

EPDS, Edinburgh Postnatal Depression Scale; PND, postnatal depression.
[a]Unadjusted model containing exposure and outcome only.
[b]Adjusted for amount of caregiver speech directed to infant.
[c]Further adjusted for frequency or mean duration of infant vocalisation.
[d]Further adjusted for maternal and paternal (age at birth and education) and child (sex) characteristics.

TABLE 6 Ordered logistic regression of hypothesis-led analysis of associations between maternal and paternal depressive symptoms and caregiver vocalisations.

Caregiver vocalisation	Paternal PND (EPDS; $n = 23$)			
	Unadjusted[a]	Adjusted for amount of speech directed to infant[b]	Further adjusted for frequency or mean of infant vocalisation[c]	Further adjusted for maternal, paternal and child characteristics[d]
	POR [95% CI], p-value	POR [95% CI], p-value	POR [95% CI], p-value	POR [95% CI], p-value
Duration of paternal speech	1.07 [0.93, 1.23], $p = 0.362$	1.06 [0.92, 1.23], $p = 0.380$	1.07 [0.93, 1.23], $p = 0.369$	1.28 [1.01, 1.63], $p = 0.045$
Frequency of paternal infant register	1.01 [0.88, 1.16], $p = 0.881$	1.01 [0.88, 1.16], $p = 0.867$	1.02 [0.88, 1.18], $p = 0.816$	1.01 [0.80, 1.27], $p = 0.923$
Duration of paternal infant register	1.12 [0.97, 1.29], $p = 0.131$	1.12 [0.97, 1.29], $p = 0.120$	1.13 [0.97, 1.30], $p = 0.104$	1.27 [1.00, 1.61], $p = 0.046$
Frequency of paternal mind-mindedness	1.07 [0.94, 1.25], $p = 0.353$	1.08 [0.92, 1.25], $p = 0.349$	1.07 [0.92, 1.25], $p = 0.395$	0.93 [0.74, 1.17], $p = 0.556$
Duration of paternal mind-mindedness	0.99 [0.86, 1.14], $p = 0.872$	0.98 [0.85, 1.13], $p = 0.793$	0.98 [0.84, 1.13], $p = 0.764$	0.86 [0.68, 1.08], $p = 0.202$
Frequency of paternal positive tone	1.20 [1.02, 1.41], $p = 0.032$	1.20 [1.02, 1.42], $p = 0.031$	1.24 [1.04, 1.47], $p = 0.014$	1.28 [1.02, 1.61], $p = 0.037$
Duration of paternal positive tone	1.09 [0.94, 1.27], $p = 0.230$	1.14 [0.97, 1.33], $p = 0.108$	1.17 [0.98, 1.38], $p = 0.069$	1.21 [0.94, 1.55], $p = 0.129$
	Maternal PND (EPDS; $n = 23$)			
Duration of maternal speech	1.01 [0.88, −0.8], $p = 0.934$	1.01 [0.88, 1.15], $p = 0.933$	1.03 [0.90, 1.19], $p = 0.639$	1.10 [0.93, 1.30], $p = 0.246$
Frequency of maternal infant register	0.93 [0.82, 1.06], $p = 0.290$	0.90 [0.78, 1.04], $p = 0.170$	0.90 [0.77, 1.04], $p = 0.138$	0.90 [0.77, 1.05], $p = 0.173$
Duration of maternal infant register	1.01 [0.89, 1.15], $p = 0.873$	1.01 [0.89, 1.16], $p = 0.839$	1.03 [0.89, 1.18], $p = 0.718$	1.04 [0.89, 1.21], $p = 0.647$
Frequency of maternal mind-mindedness	1.10 [0.97, 1.26], $p = 1.141$	1.10 [0.97, 1.25], $p = 0.147$	1.09 [0.96, 1.25], $p = 0.187$	1.08 [0.95, 1.24], $p = 0.243$
Duration of maternal mind-mindedness	1.10 [0.96, 1.26], $p = 0.158$	1.10 [0.96, 1.26], $p = 0.160$	1.14 [0.98, 1.32], $p = 0.083$	1.12 [0.96, 1.31], $p = 0.155$
Frequency of maternal positive tone	0.92 [0.81, −0.57], $p = 0.237$	0.93 [0.81, 1.07], $p = 0.294$	0.93 [0.81, 1.07], $p = 0.295$	0.94 [0.80, 1.09], $p = 0.361$
Duration of maternal positive tone	1.13 [0.98, 1.29], $p = 0.092$	1.14 [0.98, 1.31], $p = 0.082$	1.20 [1.02, 1.40], $p = 0.026$	1.28 [1.04, 1.56], $p = 0.017$
Duration of maternal neutral tone	1.01 [0.88, 1.16], $p = 0.845$	1.04 [0.90, 1.21], $p = 0.590$	1.08 [0.92, 1.26], $p = 0.328$	1.10 [0.91, 1.32], $p = 0.313$

POR, proportional odds ratio; EPDS, Edinburgh Postnatal Depression Scale; PND, postnatal depression.
[a]Unadjusted model containing exposure and outcome only.
[b]Adjusted for amount of caregiver speech directed to infant.
[c]Further adjusted for frequency or mean duration of infant vocalisation.
[d]Further adjusted for maternal and paternal (age at birth and education) and child (sex) characteristics.

paternal positive tone in the unadjusted and fully adjusted ordered logistic regression models [Proportional Odds Ratio (POR): 1.28, 95% CI: 1.02, 1.61, $p = 0.037$; Table 6], although confidence intervals were wide. Paternal PND was also associated with higher odds of being in a quantile with higher mean duration of paternal speech (POR: 1.28, 95% CI: 1.01, 1.63, $p = 0.045$; Table 6) and infant-directed speech (POR: 1.27, 95% CI: 1.00, 1.61, $p = 0.046$; Table 6), however this was only apparent in fully adjusted ordered logistic regressions models accounting for maternal, paternal and child characteristics.

Hypotheses-free analyses of modifiers of paternal speech revealed no evidence for associations between paternal PND and the majority of paternal speech modifiers (Table 7). However, paternal PND was associated with higher odds of being in a quantile with higher frequency (POR: 1.52, 95% CI: 1.13, 2.05, $p = 0.005$; Table 7) and mean duration (POR: 1.63, 95% CI: 1.18, 2.25, $p = 0.003$; Table 7) of paternal laugh in the unadjusted and fully adjusted ordered logistic regression models. Paternal PND was also associated with higher odds of being in a quantile with higher mean duration of paternal question (POR: 1.79, 95% CI: 1.19, 2.70, $p = 0.005$; Table 7) and encouragement (POR: 1.25, 95% CI: 0.98, 1.60, $p = 0.073$; Table 7), however, this was only evident in fully adjusted ordered logistic regression models accounting for maternal, paternal and child characteristics.

There was no evidence to suggest that paternal PND was associated with any of the rare modifiers of paternal speech, including paternal discouragement and criticism of the infant, negative and ironic/sarcastic tone, intrusiveness, use of humour and teaching the infant (Table 8).

10.3389/frcha.2023.1122371

TABLE 7 Ordered logistic regressions hypothesis-free analyses of modifiers* of paternal and maternal speech.

Modifiers of caregiver speech	Paternal PND (EPDS; $n = 23$)			
	Unadjusted[a]	Adjusted for amount of speech directed to infant[b]	Further adjusted for frequency or mean of infant vocalisation[c]	Further adjusted for maternal, paternal and child characteristics[d]
	POR [95% CI], *p*-value	POR [95% CI], *p*-value	POR [95% CI], *p*-value	POR [95% CI], *p*-value
Frequency of paternal laugh	1.17 [1.00, 1.37], $p = 0.058$	1.17 [1.00, 1.36], $p = 0.050$	1.21 [1.02, 1.44], $p = 0.027$	1.52 [1.13, 2.05], $p = 0.005$
Duration of paternal laugh	1.20 [1.03, 1.41], $p = 0.022$	1.20 [1.03, 1.41], $p = 0.021$	1.21 [1.03, 1.42], $p = 0.021$	1.63 [1.18, 2.25], $p = 0.003$
Frequency of paternal command	0.99 [0.86, 1.14], $p = 0.883$	0.97 [0.83, 1.12], $p = 0.661$	0.97 [0.83, 1.12], $p = 0.670$	0.96 [0.75, 1.23], $p = 0.775$
Duration of paternal command	1.06 [0.91, 1.23], $p = 0.447$	1.06 [0.91, 1.23], $p = 0.446$	1.06 [0.91, 1.23], $p = 0.435$	1.23 [0.95, 1.59], $p = 0.112$
Frequency of paternal question	0.96 [0.84, 1.10], $p = 0.603$	0.96 [0.84, 1.11], $p = 0.613$	0.96 [0.84, 1.11], $p = 0.614$	0.91 [0.74, 1.13], $p = 0.398$
Duration of paternal question	1.12 [0.96, 1.29], $p = 0.139$	1.12 [0.96, 1.30], $p = 0.132$	1.12 [0.96, 1.30], $p = 0.146$	1.79 [1.19, 2.70], $p = 0.005$
Frequency of paternal exclamation	1.03 [0.89, 1.19], $p = 0.670$	1.03 [0.89, 1.19], $p = 0.666$	1.03 [0.89, 1.19], $p = 0.654$	1.17 [0.93, 1.48], $p = 0.182$
Duration of paternal exclamation	1.00 [0.86, 1.13], $p = 0.866$	1.00 [0.86, 1.13], $p = 0.844$	1.00 [0.86, 1.13], $p = 0.890$	1.21 [0.95, 1.54], $p = 0.124$
Frequency of paternal statement	0.97 [0.84, 1.12], $p = 0.705$	0.95 [0.82, 1.11], $p = 0.556$	0.95 [0.81, 1.11], $p = 0.539$	0.96 [0.77, 1.19], $p = 0.684$
Duration of paternal statement	1.03 [0.88, 1.22], $p = 0.666$	1.04 [0.88, 1.22], $p = 0.671$	1.02 [0.87, 1.21], $p = 0.761$	1.15 [0.90, 1.46], $p = 0.276$
Frequency of paternal praise of infant	1.11 [0.95, 1.30], $p = 0.194$	1.09 [0.93, 1.28], $p = 0.279$	1.10 [0.93, 1.29], $p = 0.254$	1.12 [0.88, 1.42], $p = 0.370$
Duration of paternal praise of infant	1.20 [1.03, 1.41], $p = 0.020$	1.20 [1.03, 1.40], $p = 0.023$	1.20 [1.03, 1.41], $p = 0.022$	1.23 [0.98, 1.55], $p = 0.076$
Frequency of paternal encouragement	0.95 [0.83, 1.10], $p = 0.519$	0.93 [0.80, 1.08], $p = 0.356$	0.93 [0.80, 1.08], $p = 0.348$	0.82 [0.65, 1.05], $p = 0.113$
Duration of paternal encouragement	1.10 [0.95, 1.28], $p = 0.196$	1.10 [0.95, 1.28], $p = 0.209$	1.11 [0.95, 1.30], $p = 0.174$	1.25 [0.98, 1.60], $p = 0.073$
	Maternal PND (EPDS; $n = 23$)			
Frequency of maternal laugh	0.98 [0.86, 1.12], $p = 0.747$	1.10 [0.87, 1.14], $p = 0.993$	1.10 [0.87, 1.14], $p = 0.955$	1.00 [0.86, 1.18], $p = 0.954$
Duration of maternal laugh	1.02 [0.89, 1.16], $p = 0.816$	1.02 [0.89, 1.18], $p = 0.727$	1.05 [0.91, 1.21], $p = 0.483$	1.07 [0.91, 1.26], $p = 0.425$
Frequency of maternal command	0.88 [0.76, 1.02], $p = 0.092$	0.84 [0.71, 1.00], $p = 0.057$	0.84 [0.71, 1.00], $p = 0.057$	0.86 [0.70, 1.05], $p = 0.131$
Duration of maternal command	0.91 [0.79, 1.05], $p = 0.198$	0.91 [0.78, 1.05], $p = 0.187$	0.89 [0.77, 1.04], $p = 0.159$	0.90 [0.76, 1.06], $p = 0.198$
Duration of maternal question	1.06 [0.91, 1.22], $p = 0.454$	1.06 [0.91, 1.22], $p = 0.453$	1.05 [0.91, 1.21], $p = 0.512$	1.14 [0.96, 1.36], $p = 0.122$
Frequency of maternal exclamation	0.94 [0.81, 1.10], $p = 0.458$	0.95 [0.81, 1.12], $p = 0.567$	0.95 [0.80, 1.13], $p = 0.562$	1.05 [0.86, 1.28], $p = 0.606$
Duration of maternal exclamation	0.93 [0.80, 1.08], $p = 0.351$	0.90 [0.76, 1.07], $p = 0.226$	0.90 [0.76, 1.08], $p = 0.269$	0.99 [0.80, 1.22], $p = 0.916$
Duration of maternal statement	1.05 [0.92, 1.20], $p = 0.497$	1.05 [0.92, 1.21], $p = 0.447$	1.09 [0.94, 1.26], $p = 0.266$	1.26 [1.02, 1.56], $p = 0.032$
Frequency of maternal praise of infant	0.96 [0.84, 1.10], $p = 0.589$	1.06 [0.88, 1.28], $p = 0.550$	1.08 [0.88, 1.32], $p = 0.454$	0.97 [0.75, 1.26], $p = 0.823$
Duration of maternal praise of infant	1.00 [0.88, 1.13], $p = 0.959$	1.02 [0.89, 1.18], $p = 0.737$	1.02 [0.89, 1.18], $p = 0.747$	0.93 [0.77, 1.12], $p = 0.428$
Frequency of maternal encouragement	0.93 [0.81, 1.07], $p = 0.310$	0.93 [0.81, 1.08], $p = 0.356$	0.94 [0.81, 1.09], $p = 0.403$	0.94 [0.80, 1.10], $p = 0.428$

POR, proportional odds ratio; EPDS, Edinburgh Postnatal Depression Scale; PND, postnatal depression.
[a]Unadjusted model containing exposure and outcome only.
[b]Adjusted for amount of caregiver speech directed to infant.
[c]Further adjusted for frequency or mean duration of infant vocalisation.
[d]Further adjusted for maternal and paternal (age at birth and education) and child (sex) characteristics.
*Modifiers allow for more detailed categorisation within behavioural group, in this instance maternal and paternal speech.

TABLE 8 Logistic regressions analyses of rare modifiers* of paternal speech (dichotomised; behaviour did vs. did not occur).

Modifiers of caregiver speech	Paternal PND (EPDS; $n = 23$)			
	Unadjusted[a]	Adjusted for amount of speech directed to infant[b]	Further adjusted for frequency or mean of infant vocalisation[c]	Further adjusted for maternal, paternal and child characteristics[d]
	OR [95% CI], *p*-value	OR [95% CI], *p*-value	OR [95% CI], *p*-value	OR [95% CI], *p*-value
Paternal infant discouragement	0.96 [0.81, 1.13], $p = 0.613$	0.95 [0.80, 1.13], $p = 0.572$	0.95 [0.80, 1.13], $p = 0.589$	0.84 [0.62, 1.14], $p = 0.265$
Paternal criticism of infant	1.03 [0.87, 1.21], $p = 0.721$	1.03 [0.87, 1.22], $p = 0.742$	1.03 [0.87, 1.22], $p = 0.730$	0.92 [0.71, 1.20], $p = 0.554$
Paternal negative tone	1.03 [0.85, 1.25], $p = 0.752$	1.03 [0.85, 1.25], $p = 0.742$	1.05 [0.85, 1.29], $p = 0.650$	1.07 [0.75, 1.52], $p = 0.706$
Paternal intrusiveness	1.01 [0.85, 1.19], $p = 0.973$	1.00 [0.85, 1.19], $p = 0.973$	1.00 [0.84, 1.19], $p = 0.985$	1.01 [0.70, 1.45], $p = 0.966$
Paternal sarcasm	1.00 [0.82, 1.17], $p = 0.834$	1.00 [0.83, 1.17], $p = 0.869$	1.00 [0.83, 1.18], $p = 0.917$	1.01 [0.77, 1.33], $p = 0.926$
Paternal use of humour	1.03 [0.86, 1.23], $p = 0.711$	1.04 [0.85, 1.27], $p = 0.714$	1.10 [0.82, 1.48], $p = 0.521$	0.90 [0.59, 1.36], $p = 0.620$
Paternal teaching	1.19 [1.00, 1.48], $p = 0.109$	1.19 [1.00, 1.48], $p = 0.115$	1.19 [1.00, 1.49], $p = 0.114$	1.10 [0.76, 1.60], $p = 0.600$

OR, odds ratio; EPDS, Edinburgh Postnatal Depression Scale; PND, postnatal depression.
[a]Unadjusted model containing exposure and outcome only.
[b]Adjusted for amount of caregiver speech directed to infant.
[c]Further adjusted for frequency or mean duration of infant vocalisation.
[d]Further adjusted for maternal and paternal (age at birth and education) and child (sex) characteristics.
*Modifiers allow for more detailed categorisation within behavioural group, in this instance maternal and paternal speech.

Discussion

Main findings

In line with previous research, we found that there were more similarities than differences between maternal and paternal vocalisation behaviours (45). Fathers and mothers both engage in equal frequency and duration of vocalisation behaviours when interacting with their infants, with speech, non-verbal sounds, silence and laughter being the most frequent vocalisations. There were also similarities in sentence structure, such as use of statements and questions, with both mothers and fathers acknowledging their infant during interactions. Both mothers and fathers used positive and neutral tone, although the mean duration of maternal neutral tone was higher than that for fathers. High frequency of encouragement of infant behaviours and low frequency of infant discouragement was observed in both mothers and fathers, with both addressing their infants by their real name more frequently than a nickname.

There were also some notable differences between maternal and paternal vocalisation behaviours. For instance, fathers demonstrated higher frequency and mean duration of commands and exclamation compared to mothers, while mothers engaged in more teaching compared to fathers. Existing research on content and function of maternal and paternal speech has documented a similar pattern, with fathers producing more direct (74) and prohibition commands than mothers (75). In line with previous research, fathers in our study engaged in more verbal play (both frequency and mean duration) compared to mothers (76). Adult- and infant-directed speech was a feature of both maternal and paternal vocalisation behaviours, though the mean duration of adult-directed speech was higher and that of infant-directed speech was lower in fathers compared to mothers. Existing research on paternal infant-directed speech to preverbal infants is rare. There is some evidence to suggest that, similarly to mothers, fathers make some prosodic modifications, but to a lesser extent. This is possibly due to men's lower average pitch compared to women's (45, 77).

Even though negative and ironic/sarcastic tone was a rare feature of parental speech, there was some evidence that this was more frequently displayed by fathers than mothers. This finding is consistent with earlier studies suggesting that fathers are more likely to tease their children compared to mothers (78). Similarly, frequency and duration of both criticism of the child and verbal intrusiveness was higher in fathers compared to mothers. Given the exploratory nature of our study, these findings should be interpreted with caution. However, these findings are in line with existing research suggesting that fathers may be less sensitive, more intrusive, directive and parent-centred than mothers during parent-infant interactions (79). It is possible that fathers engage in a more direct, stimulating, and challenging style of father-child interactions, so called "activation" parenting (80), which may seem more intrusive, but is important for promoting social and cognitive competencies in children (117). It has been previously argued that moderate levels of intrusiveness combined with positive and challenging stimulation in a supportive context that characterise fathers' interactional style allows children to explore new horizons while feeling safe and protected (82–84). It has also been argued that maternal and paternal sensitivity may be expressed differently through emotional warmth (mothers)

and physical stimulation and playful interactions [fathers; (85)]. It has been argued that these two types of experiences chart the "rhythm of safety" vs. the "rhythm of exploration", both of which are essential for healthy infant development (86). Future research that examines sequences of parental and child behaviours will enable us to examine behavioural manifestations of paternal intrusiveness in combination with other interaction behaviours (e.g., positive and/or negative affect) and, subsequently, their potentially differential effect on child development (87). This may lead to a reframing in how intrusive behaviour is defined and applied in the context of father-child interactions, and what it means for child development.

Despite higher frequency and duration of criticism and intrusiveness, fathers in our study engaged in mind-mindedness more often and for longer duration than mothers. Existing research on mind-minded speech in mothers and fathers is somewhat inconsistent, with some studies reporting no differences in the overall frequency of mind-minded comments between mothers and fathers (88), while other earlier studies noting more attentive utterances produced by fathers compared to mothers (89).

Based on existing literature, we hypothesised that the frequency and duration of maternal and paternal speech, as well as infant-directed and mind-minded speech and positive emotional tone will decrease, while the frequency and duration of negative and neutral emotional tone will increase in the context of parental depression. Our findings did not fully support these hypotheses. As hypothesised, there was evidence that as maternal PND increased, the frequency of maternal neutral tone decreased. We found no evidence for an association between paternal PND and use of a neutral tone. However, contrary to our original hypotheses, higher levels of maternal and paternal PND were associated with increased duration of parental positive tone, encouragement and laughter, all of which may be vocal proxies for more positive and sensitive interactions. Similarly, we found evidence to suggest that higher levels of paternal PND were also associated with increased duration of paternal speech, as well as infant-directed speech and questions, which may be suggestive of more infant-centred interactions.

Several explanations may be put forward to contextualise our findings. Existing research suggests that fathers with clinical levels of depression may engage in less positive parenting practices, and other enriching language activities with the child such as reading, singing songs and telling stories (90). However, effects of paternal PND on parenting, including vocalisation behaviours, may be more subtle in community samples with relatively mild levels of depression (91), and may not necessarily present themselves as overtly negative vocalisations (overall rare in our sample). Both neutral and positive tone were a predominant feature of maternal and paternal speech, whilst negative tone was rare with only 4% of fathers and 5% of mothers using a negative tone. It may be that there was more variability in neutral and positive tone vocalisations to detect effects associated with parental PND, with the opposite true for the negative parental tone. It is also possible that those parents who experience mild levels of PND have more emotional insight and empathy, and, thus, engage in more sensitive parenting, including vocalisation behaviours. It is possible that parents with increased PND try to compensate for their low mood by speaking in a positive tone, and their tone may not reflect genuine positive emotion. It is possible that more global qualitative coding such as the Emotional Availability Scales which capture an overall emotional tone would find differential results and this would be an interesting future direction to test this hypothesis. In addition, the focus of our analyses was the associations between parental PND and the frequency and duration of parental vocalisation behaviours, but sequences and patterns of behaviours may better capture patterns of expressed depressed mood.

Another contextual framework to explain our findings may be the changing nature of beliefs and attitudes surrounding contemporary parenting practices. Sociological literature has meticulously documented changes in parenting that occurred in the last forty years (92). The phenomenon of intensive or hyper-parenting (93), a highly demanding and child-centred approach to parenting, which includes heightened parental awareness of the adverse consequences of "bad parenting" ranging from poor educational to developmental outcomes (93, 94). Consequently, the process of raising a child through "concerted cultivation" (95) and attentive parenting may offer a way of mitigating the risks (94), including those associated with adverse parental mental health [for the critique and contested nature of such parenting practices see (96–99)]. Although the term "parenting" may be gender-neutral, the lens of intensive parenting has been predominantly focused on mothers as the primary agents responsible for shaping child outcomes (98, 100). However, the expectation that fathers should also be involved in parenting and childcare has also become prevailing in contemporary society (101, 102), with the demands of intensive parenting, albeit not to the same degree as mothers (101, 103), also extending to men. Intensive parenting is embedded in middle-class values (104), with "concerted cultivation" made possible through higher levels of financial and educational resources, with higher parental socio-economic status being consistently associated with more positive and consistent parenting styles and practices (105). Based on this evidence, it may be possible that both mothers and fathers in our study modified their vocalisation behaviours in line with their knowledge of the effects of mental health on parenting and the child, or there were more likely to engage in attentive and child-centred parenting in line with contemporary assumptions on what it means to be a "good" parent. Future longitudinal research with larger samples is needed to corroborate our findings regarding parental depression and vocalisation behaviours, particularly in the context of beliefs and expectations surrounding contemporary parenting practices.

Strengths and limitations

One of the strengths of the study is the assessment of both maternal and paternal PND and vocalisation behaviours in early infancy. Most of the research to date has focused on maternal PND and its impact on parenting (2), with only a few studies

addressing the impact of paternal PND on vocalisation behaviours during father-infant interactions. This approach continues to perpetuate a potentially problematic stance in developmental psychology, placing the mother-infant relationship at the cornerstone of human development. Similarly to mothers, features of father-infant vocalisation interactions may also constitute a transmission pathway by which paternal PND impacts the child. This argument is in line with the recently articulated stance to consider both maternal and paternal mental health from a family system perspective for both research and intervention purposes (106). Our comparisons of maternal and paternal vocalisation behaviours suggest that there are more similarities than differences between maternal and paternal vocal interactions with the infant, with comparative effects of parental PND on some aspects of vocalisation behaviours.

The use of observational rather than parent-reported measures to assess parental vocalisation behaviours is another strength of this study. The association between parental PND and the reporting of parenting has been consistently supported (107). In addition, there is some evidence to suggest that the headcams may be better at capturing vocalisation behaviours compared to "gold standard" observational methods due to the build-in microphones positioned closer to the participants' face (52). Importantly, the use of headcams is more likely to reduce participant reactivity and demand characteristics, enabling us to capture less socially desirable behaviours, including parental vocalisations (52). Although the advantage of reducing demand characteristics is not specific to the headcams, recording interactions in the familiar setting of a home context without a researcher present may facilitate capturing more variability in parental behaviours, compared to traditional observational methods. The use of the headcams may also reduce parental social anxiety and feelings of being judged, particularly in those parents who experience depression, compared to "gold standard" observational methods with a researcher filming the interactions, facilitating more natural positive responses to the child.

We captured a wide range of parental vocalisation behaviours, including a more detailed categorisation of each vocalisation withing a wider behavioural group using event-based micro-coding scheme (58). Arguably, the micro-coding systems may be better at highlighting complex patterns of dyadic interactions, capturing behaviours from both parents and infants as active participants in the interaction (108). It has also been argued that in comparison to global ratings, the systematic nature of micro-behavioural coding allows for the capture of more precise information on the nature of the observed behaviours (109). Indeed, our micro-coding behavioural scheme enabled us to capture multiple dimensions of parental and infant vocalisation with unprecedented degree of granularity regarding parental vocalisation behaviours (110, 111). Given the lack of evidence regarding the impact of maternal and, particularly, paternal depression on their vocalisation behaviours, such a degree of detail is particularly important.

The detailed nature of the micro-coding scheme has also enabled us to build a comprehensive comparison of maternal and paternal vocalisation behaviours across a range of dimensions, including their variation in intensity and frequency. Arguably, the use of headcams during mealtime and play interactions as they naturally take place at home, combined a multidimensional and versatile micro-coding behavioural scheme may be a better methodological paradigm to capture and assess the dynamic and transactional nature of parent-child interactions.

It should be noted, however, that our study is explorative in nature and findings should be interpreted with caution due to the fact that the study was not adequately powered to detect the observed effect sizes – the relatively small sample size and multiple testing with parental vocalisations as outcomes increased the possibility of committing a type 1 error. In addition, vocalisation behaviours made by fewer than five mothers and fathers had to be removed from the analyses, thus, associations between maternal and paternal PND and such behaviours could not be investigated. Further replication studies with a larger sample are needed to substantiate our preliminary findings, as well as provide more insights into the effects of parental PND on more rare aspects of parental vocalisations (e.g., maternal criticism of infant and intrusiveness). In addition, there were some discrepancies between the nature of the tasks completed between mothers and fathers, with mothers predominantly engaging in mealtime and stacking tasks, whilst a proportion of fathers have also engaged in a free play task. This could potentially elicit different type of parental vocalisation behaviours, with more goal-oriented interactions (e.g., mealtime and stacking task) eliciting vocalisations that are not necessarily generalisable across all parent-child interactions. Fathers engaging in free play task may also elicit parental vocalisations that are not directly comparable to less physically arousing and task-oriented interactions that mothers and infants accomplished. However, recent comparisons of studies between maternal and paternal vocalisation behaviours suggest that, despite some differences, both mothers and fathers modify their speech depending on the nature of the interaction (45).

Another limitation of the study relates to potential selection bias. The ALSPAC cohort is now a three-generational study, comprising "G0": the cohort of original pregnant women, the biological father and other carers/partners, "G1": the cohort of index children, and "G2": the cohort of offspring of the index children, from which our study sample was drawn. The G0 mothers are overall from somewhat higher socio-economic background compared to the general population, whilst G1 participants who enrolled their children in G2 are more engaged with the ALSPAC study and more educated compared to those who did not participate in the study (55). By design, G1 participants fall within a restricted age range, with maternal age being further restricted by missing very young mothers who were not recruited, and the average age of mothers and fathers in this sample was lower than that reported nationally in the UK [30.7 and 33.6 respectively; (72)]. Both maternal age and education have been previously found to be important confounders in the association between parental depression, offspring outcomes and parenting (68, 63). It may be possible that infants of older and more educated parents are less likely to be exposed to specific manifestations of reduced parental insensitivity, including more negative vocalisation behaviours, associated with parental

depression (112, 113). Fathers in our sample had higher mean depression scores than those previously reported, with men scoring on average 2 points above women. Anecdotally, it may be possible that fathers who experienced mental health difficulties were more likely to engage with the headcams study because of the insights it may bring into their parenting and potential impact on the child.

Associations among parental mental health, parenting and offspring development are complex and bidirectional (114). In line with transactional developmental models (115), children with more difficult temperament may influence maternal and paternal PND, as well as parental behavioural responses (116). We attempted to account for possible evocative effects by adjusting our analyses for the frequency and duration of infant vocalisation. However, addressing the possible bidirectionality (117) was outside the scope of the present study.

Conclusions, implications, and future research

Pathways between maternal and paternal PND, parenting behaviours and offspring outcomes are complex and not fully elucidated. Our findings relate to one aspect of these complex relationships, notably the impact of parental PND on specific manifestations of vocalisation behaviours. Descriptively, we found more similarities than differences between maternal and paternal vocal interactions with their infants, with comparative effects of parental PND on some aspects of vocalisation behaviours, notably positive speech tone, encouragement and laughter. Our findings that higher levels of maternal and paternal PND were associated with increased duration of these behavioural proxies for more positive and sensitive interactions are tentative and implications of the findings are limited. Future replication efforts should focus on larger population-based samples that capture more variability in parental vocalisation behaviours, as well as contemporary beliefs and attitudes that define "good" parenting practices. These findings may indicate that the existing associations between PND and reductions in parental sensitivity require further detailed research.

Future research avenues should also focus on examining associations between specific aspects of parental vocalisation behaviours and more global measures of parental sensitivity to provide further insights into behavioural manifestations of warm and responsive parenting, particularly in the context of parental PND. Better understanding of specific behavioural manifestations of parenting and the overall quality of parent-child relationship and interactions may provide insights into the nature of difficulties that characterise early parent-child interactions, as well as key differences in maternal and paternal behaviours that may indicate depressed mood (61). In addition, the evidence-base regarding the effects of specific parental vocalisation behaviours, as well as patterns and sequences of such vocalisations, on offspring outcomes is lacking and should be strengthened through further investigations.

The coding scheme (58) applied in this study captures an unprecedented range of parental and infant behaviours (e.g., facial expressions, proximity) which should also be addressed in future investigations as potential markers of parental sensitivity which may be affected by parental depression. Traditionally, the main focus in parenting studies has been on mothers, with assessment of paternal parenting based on assessment of maternal parenting and mother-child relationships. Although such strategies may be useful to capture broader aspects of parenting, such as sensitivity and responsiveness, increasingly evidence suggests that the maternal template as a dominant methodology does not capture behaviours that may be unique to fathers, modelling parental sensitivity almost exclusively on maternal behaviours (80). The detailed nature of our coding scheme enables us to build a comprehensive picture of both maternal and paternal behaviours and to capture both differences and similarities in such behaviours across a range of parent-child interactions. It should be noted that even though families may be viewed as organized systems, each individual, including the infant, is an active, contributing member and part of the process that creates and maintains behavioural patterns (117, 118). Thus, the impact of infant temperament and behaviour on parental vocalization behaviours across a range of developmental stages and task scenarios in the context of parental mental health should also be studied.

Data availability statement

The datasets presented in this article are not readily available because ALSPAC data are available through a system of managed open access. The study website contains details of all the data that is available through a fully searchable data dictionary and variable search tool data dictionary. The application steps for ALSPAC data access are highlighted below. (1) Please read the ALSPAC access policy, which describes the process of accessing the data in detail, and outlines the costs associated with doing so. (2) You may also find it useful to browse the fully searchable research proposals database, which lists all research projects that have been approved since April 2011. (3) Please submit your research proposal for consideration by the ALSPAC Executive Committee. You will receive a response within 10 working days to advise you whether your proposal has been approved. If you have any questions about accessing data, please email alspac-data@bristol.ac.uk.

Ethics statement

The studies involving human participants were reviewed and approved by Informed consent for the use of data collected via questionnaires and clinics was obtained from participants following the recommendations of the ALSPAC Ethics and Law Committee at the time. The patients/participants provided their written informed consent to participate in this study.

Author contributions

AC, IC, RP contributed to the conception and design of the study. AC, IC performed data analyses and wrote the first draft of the manuscript. IC, MC, MK coded and analysed the data. ED, TM contributed to the interpretation of the data. AS contributed to the acquisition of data. All authors contributed to the article and approved the submitted version.

Funding

The UK Medical Research Council and Wellcome (217065/Z/19/Z) and the University of Bristol provide core support for ALSPAC. A comprehensive list of grants funding is available on the ALSPAC website (http://www.bristol.ac.uk/alspac/external/documents/grant-acknowledgements.pdf). This work is part of a project that has received funding from the European Research Council (ERC) under the European Union's Horizon 2020 Research and Innovation Programme (grant agreement no. 758813; MHINT), including RP, IC, and MC's time was funded by this grant as well as development of the headcam technology and data collection in mothers and children. IC was funded by the Wellcome Trust Research Fellowship in Humanities and Social Science (212664/Z/18/Z), which has also funded MK's time to code parent-child interactions. MK and AK are supported by Cancer Research UK [C18281/A19169 and C18281/A29019] and the MRC Integrative Epidemiology Unit at the University of Bristol [MC_UU_00011/6 and MC_UU_00011/3]. This study was also supported by the NIHR Biomedical Research Centre at the University Hospitals Bristol NHS Foundation Trust and the University of Bristol. The views expressed in this publication are those of the author(s) and not necessarily those of the NHS, the National Institute for Health Research. This publication is the work of the authors and AC and IC will serve as guarantors for the contents of this paper.

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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frontiers | Frontiers in Child and Adolescent Psychiatry

TYPE Methods
PUBLISHED 23 June 2023
DOI 10.3389/frcha.2023.1111299

OPEN ACCESS

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RECEIVED 29 November 2022
ACCEPTED 18 April 2023
PUBLISHED 23 June 2023

CITATION
Skinner A, Costantini I, Stone C, Darios J, Gray M, Culpin I and Pearson RM (2023) Identifying stakeholder priorities in use of wearable cameras for researching parent-child interactions.
Front. Child Adolesc. Psychiatry 2:1111299.
doi: 10.3389/frcha.2023.1111299

Identifying stakeholder priorities in use of wearable cameras for researching parent-child interactions

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Wearable Cameras (WCs) enable researchers to capture objective descriptions of what participants see and experience as they go about their normal lives. When studying interactions between individuals (e.g. between a parent and child), using multiple WCs can provide highly detailed descriptions of interactions with levels of ecological validity not possible with other methods. However, the use of WCs brings challenges too, and understanding these is key to developing and optimising these methods. We captured the challenges experienced by a variety of stakeholders, namely parents and a range of different researcher roles (academics, field-workers and data processors) involved in a large UK study exploring parent-child interactions using low-cost, off-the-shelf WCs. High among the challenges identified were difficulties caused when subjects are temporarily not in view in the video footage captured. This and other factors identified were used as criteria to select a new, improved WC. The new WCs reduced the time faces were not in view by 75%. We report this and the other challenges identified, and suggest how these can be used to guide and help optimise future studies of this kind.

KEYWORDS

wearable camera, priorities, parent, child, interactions

Introduction

The last two decades have seen the adoption of wearable cameras (WCs) in a variety of research domains, from the objective measurement of lifestyle behaviours (1), to developing methods for ethnography (2), to tools for enhancing self-management of chronic diseases (3). There are a number of benefits in using WCs devices. The cameras capture what the wearer sees and interacts with as they move through their environment, providing passive, objective measures of environment and behaviours in free-living conditions. The devices also remove the need for a researcher to be present, which is particularly important in maintaining the ecological validity of studies focused on natural interactions between people (see **Supplementary Materials** for further detail).

One further advantage of WCs is that they capture the scene from the perspective of the individual. This is particularly beneficial when studying children as their height, and the limited mobility of infants, mean they have a very different perspective on the world to adults. This has led researchers to use WCs to explore a number of factors in children, including the frequency and variation in facial expressions and identities infants encounter

(4), the broad nature of children's visual environments (5), and children's daily exposure to food marketing (6). This team has adapted features from many of these studies to use WCs to explore links between parent-child interactions and parental depression (7, 8). A unique feature of these studies is that they combine WCs in both parent and child to explore their joint experiences by capturing different perspectives. For example, synchronised footage captured from the parent WC shows the child and the child WC the parent, but also if the parent or child leaves the room the footage captures where they go. A further application of WCs could be as a tool to enhance video feedback used to improve parent-child interactions therapeutically (9).

However, in addition to these benefits, the use of WCs brings a variety of technical, practical and analytical challenges too. In their review of the experiences of adults using WCs to record a variety of health-related behaviours, Wilson and colleagues (10) found participants were initially concerned about cameras being intrusive, but for most participants this was not felt to be the case in practice, while some participants reported that design issues with the camera's user interface had limited their interactions with the cameras. Madison et al.'s scoping review (3) of the use of WCs in disease self-management identified a number of technical challenges, most significantly the difficulty and effort required in identifying specific behaviours in the footage captured.

In terms of the challenges around using WCs with children, Smith and colleagues' review of the use of WCs to study children's environments (5) listed a number of practical challenges, including the need for the camera to have a wide field of view (given the tendency for infants and children to shift focus and turn their heads more frequently), and have methods of fixing that are both secure and well tolerated by the child. Signal et al. (6) identified that coding the images captured from child worn WCs is resource intensive. While coding footage from adult WCs can also take considerable effort, this appears to be exacerbated in footage from young children, again possibly because reduced attention span leads to an increase in head movements which makes the coding of facial attributes more difficult.

Turning to the issues specific to the use of WCs to explore interactions between children and parents, our initial pilot work in parents and children from a UK cohort study (7) again highlighted the importance of secure and correct placement of the WCs, and the intensive nature of coding the footage captured. Further suggestions for improvements to WCs included better controls, and increased battery life and storage capacity. As with many of these studies, these issues were identified primarily by researchers through a variety of interactions with the parents and children. In a follow-up study in Soweto in South Africa (8), feedback was sought directly from mothers. This included new insights that children's behaviour appeared unaffected by the presence of the WCs in the various situations in which they were used, that there was generally a high level of acceptance of the use of WCs in families, and that having clear visible indication of when WCs were recording was important to parents.

The findings from these studies illustrate the importance of directly seeking feedback from a range of stakeholders involved in this kind of research. In the current study, for the first time, we drew on the experiences of both parents, and the different types of researchers (academics, fieldworkers, video coders) contributing to our research using WCs to explore parent-child interactions. We collaborated with an industry partner specialising in health-related product design to identify and prioritise the challenges and issues faced by each of those groups of stakeholders. In addition to helping us understand the challenges themselves, this allowed us to build a set of requirements that; (i) enabled the identification of an alternative WC device already on the market that had the potential for immediate improvements (e.g., increased speed and accuracy of coding footage from WCs) and, (ii) will be of broad use to other researchers interested in using WCs to capture footage of interactions in free-living conditions.

Methods

Overview

We worked with Kinneir Dufort (KD), a user-centred digital product design consultancy based in Bristol, UK. We began by conducting an exercise capturing challenges around the use of WCs for researching parent-child interactions from a range of stakeholders. Participants were primarily from the research team and participants in the Avon Longitudinal Study of Parents and Children (ALSPAC) at the University of Bristol, UK, but also included input from research teams from SAMRC/Wits Developmental Pathways for Health Research Unit study at University of the Witwatersrand, South Africa. The outputs of this exercise were prioritised lists of challenges for each stakeholder group. The top priority challenges across the stakeholder groups were then used as criteria to select a new, improved WCs device. We identified one issue that had been particularly problematic in our experience with WCs, coding interactions when the faces of parents or children were not in view, and compared performance in this for the old and new WCs.

Participants

Four types of stakeholders were identified, and participants of mixed age, sex, and backgrounds were invited to take part in sessions identifying challenges (numbers in parentheses are numbers that attended):

Parents ($n = 3$)

Researchers ($n = 9$):

- Academics, conceptualising and designing the study ($n = 5$)*
- Fieldworkers, working with participants to implement the study ($n = 3$)
- Data processors, downloading, processing and coding the captured footage ($n = 4$)*

**Note: Three of the four Data processors were Academics who had extensive experience coding videos so also responded as Data processors.*

In line with local ethical guidance, the small numbers in each group meant demographic data was not recorded to ensure anonymity.

Video footage study cohort

All video footage used in the comparison of WCs in this study was recorded from participants from the ALSPAC cohort, and information on this cohort is presented below.

During Phase I enrolment, 14,541 pregnant mothers residing in the former Avon Health Authority in the south-west of England with expected dates of delivery between 1 April 1991 and 31 December 1992 were recruited. Of these initial pregnancies, there was a total of 14,676 foetuses, resulting in 14,062 live births and 13,988 children who were alive at 1 year of age. A further 913 pregnancies were recruited during Phases II, III and IV respectively, resulting in an additional 913 children being enrolled. The total sample size is 15,454 pregnancies, of which 14,901 were alive at 1 year of age. The Children-generation 2 (ALSPAC-G2) was set up to provide a unique multigenerational cohort and builds on the existing ALSPAC resource of originally recruited women and their partners (Generation 0; ALSPAC-G0) and their offspring (ALSPAC-G1) followed up for 26 years. Recruitment of the next generation ALSPAC-G2—the grandchildren of ALSPAC-G0 and children of ALSPAC-G1—began on 6th June 2012. Up to 30th June 2018, 810 ALSPAC-G2 participants from 548 families had been recruited. Over 70% of those invited to early- and late-pregnancy, second week of life, 6-, 12- and 24-month assessments attended, with attendance >60% for subsequent visits up to 7 years. Further details on the cohort profile, representativeness and phases of recruitment, including ALSPAC-G2, are described in four cohort-profile papers (11–14).

The ALSPAC study website www.bristol.ac.uk/alspac/ contains details of all the data that is available through a fully searchable data dictionary and variable search tool (http://www.bris.ac.uk/alspac/researchers/our-data/). Informed consent for the use of data collected via questionnaires and clinics was obtained from participants following the recommendations of the ALSPAC Ethics and Law Committee at the time.

Study data were collected and managed using REDCap electronic data capture tools hosted at the University of Bristol. REDCap (Research Electronic Data Capture) is a secure, web-based software platform designed to support data capture for research studies (15).

Recruitment into the WCs study

Ethical approval for the study was obtained from the ALSPAC Ethics and Law Committee and the Local Research Ethics Committees. Recruitment of mothers into the headcams study began on 7th July 2016, with 422 (90%) of mothers and their infants attending a 6-months assessment at the research clinic. 266 (63%) of mothers who attended the clinic were invited to record interactions with their infant using the headcams at home. 141 (53%) of these mothers consented to participate and 104 (74%) mothers provided video footage of mother-infant interactions. Initially, biological fathers and mothers' partners were invited to participate in the headcams study indirectly through an invitation to the mother when their child joined ALSPAC-G2. On 22nd July 2019, through additional funding from Wellcome Trust, a separate research clinic for fathers was set-up (Focus on Fathers) inviting fathers directly to attend a range of assessments, including the head cams, when their G2 child was six months old. Overall, 283 fathers were invited to attend, with 154 (54%) fathers consenting to participate and 86 (30%) fathers providing video footage of father-infant interactions.

Videorecording procedures using the WCs

We captured video and audio footage of mother-infant and father-infant interactions using the type of WC previously used to record infant's eye views of their environment (4). The WC was available in a variety of different specifications from many different manufacturers. We used devices from Boddban, which had a resolution of 720×480 pixels at 30 frames/s, and a field of view of approximately 60 degrees (referred to here as the "old" WCs device and shown in **Figure 1**). The WCs were worn on headbands by both the parent (mother or father) and the infant, capturing two separate videos from the parent and infant perspective for each interaction. WCs protocols were identical for both mothers and fathers. Parents were given fully-charged WCs and asked to use them at home during mealtime and play interactions. The separate WCs footage from the parent and infant cameras were subsequently synchronised by the researchers and interactions between the parent and infant were then coded using a micro-behavioural observation coding system developed by the project team (16).

Procedures

Capturing stakeholder challenges

Two sessions were conducted in 2020. The sessions were physically based in a meeting room at the University of Bristol, and a virtual equivalent of the setup developed using the Mural Visual Collaboration software tool was presented to the research team in University of the Witwatersrand, and to colleagues previously involved with the studies but now living in Chile. For the in-person sessions in Bristol the stages in the study pipeline were presented as columns on a whiteboard. Each attendee was assigned to one of the stakeholder types, and each stakeholder type had a different colour card, so that while the challenges raised would remain anonymous, they could be grouped by stakeholder type (note that three academics also had extensive experience coding videos so also contributed as data processors). An illustration of the layout used is in shown in **Figure 2**. Attendees in the

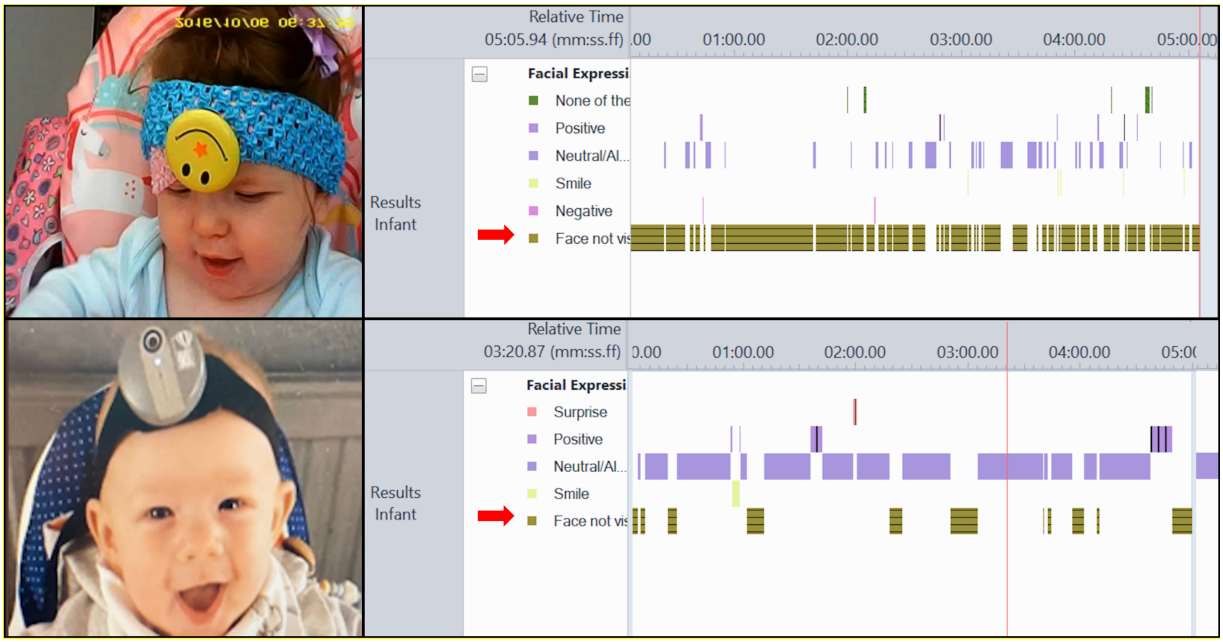

FIGURE 1
Old WCs (top left), and new WCs (bottom left). Micro-coding showing amount of time the observed face is not in view (highlighted with red arrows) for old WCs (top right) and new WCs (bottom right). Note micro-codings are examples for those devices and not for the infants shown.

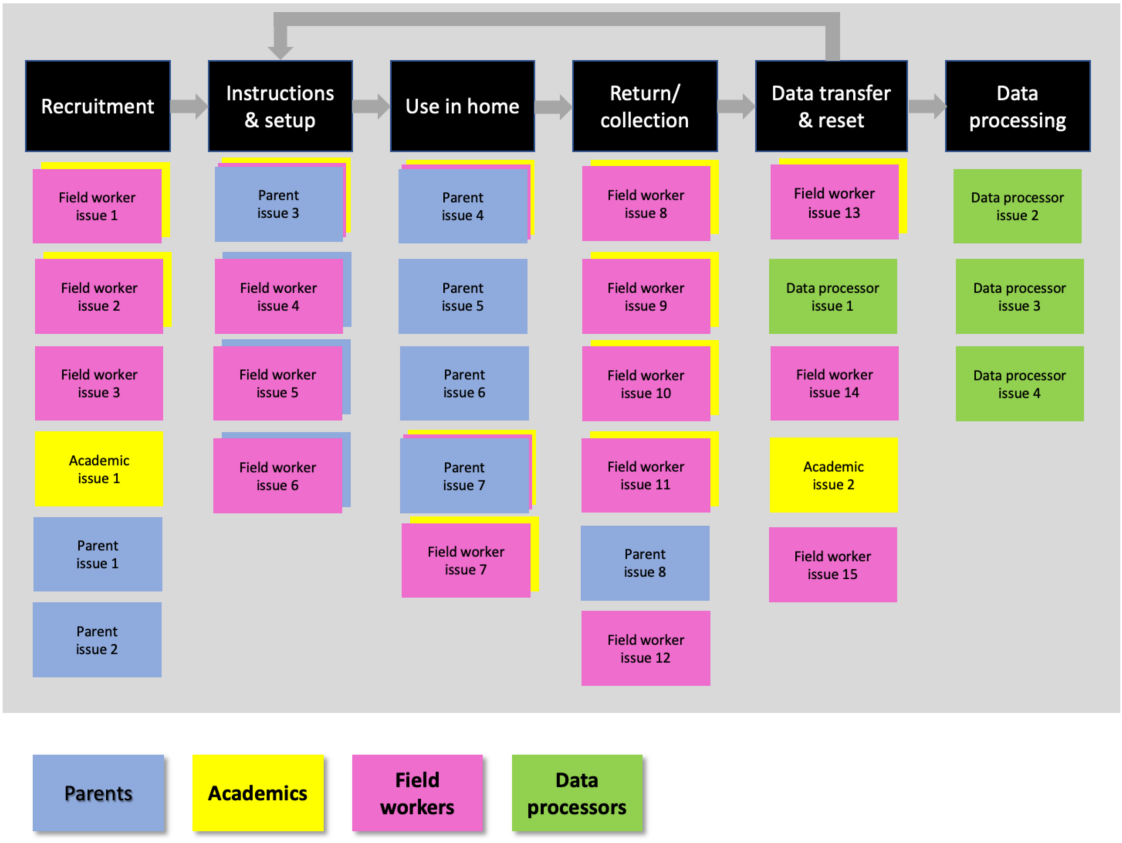

FIGURE 2
Illustration of method in which different stakeholders added challenges against study pipeline stages.

remote version of this sessions followed the same procedure with the same layout in Mural. Cards from each stakeholder group were combined, thematically similar challenges were grouped, and those raised most frequently were ranked as highest priority. Given the novelty and potentially intrusive nature of these new WCs methods, the attitudes and opinions of parents were of particular interest, so for this group we report additional detail on the challenges they identified.

Comparing old and new WCs devices

When reflecting on the various stages in our WCs studies, the most resource intensive step has been the coding of parent-child interactions in the WCs footage (7), and this echoed the findings of other recent reviews of WCs methods (6, 10) The main difficulty identified by the researchers was coding parent-child interactions when their faces were not in view. Having faces visible is particularly important when coding interactions so that facial expressions, and then emotional states can be coded accurately. Given this, we selected time "face not visible" as a measure to use to compare the performance of the old and new WCs. To quantify how the old and new WCs influenced this, whenever the face of a child or parent went out of frame we coded it as "face not visible" using the coding scheme developed by the team (16), and recorded the duration it was not visible (see Figure 1). We did this for all videos from the ALSPAC study that had 5 min of headcam footage from both a parent (mothers only) and child. 75 videos were processed in total (49 using the old WCs and 26 using the new WCs).

Results

Prioritised stakeholder challenges

The prioritised lists of challenges from each stakeholder group are shown in Figure 3.

Key challenges and implications

Considering the top three priorities across the four stakeholder groups, there were five distinct challenges. These key challenges, with a summary of their implications (also captured from the cards in the two stakeholder sessions), are summarised in Table 1.

TABLE 1 Key challenges and implications.

Key Challenges	Implications
Simplicity and ease of use	Barriers to participant recruitment Higher attrition during study Excessive fieldworker time needed
Comfort and stability of fitting	Higher attrition during study Excessive fieldworker time needed Difficulties and delays coding interactions (faces and bodies of participants not in frame if WCs moves from optimal position)
Professional and stylish appearance	Barriers to participant recruitment
Camera field of view and video quality	Difficulties and delays coding interactions (faces and bodies of participants not in frame if WCs moves from optimal position)
Video footage format for synchronisation	Additional steps required processing footage before coding of interaction (e.g. if video stored in segments which need assembling into single sequence)

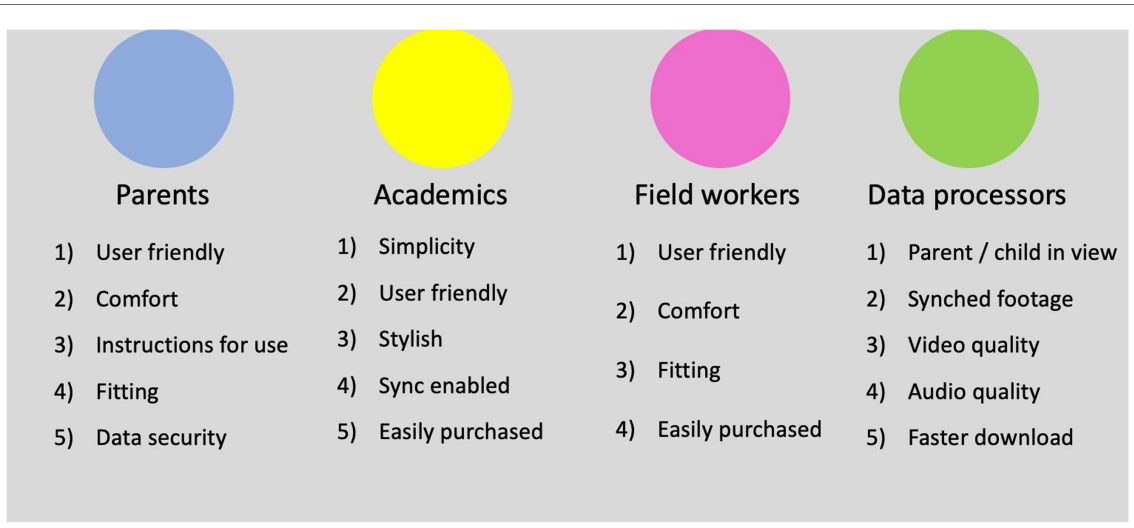

FIGURE 3
Prioritised lists of WCs challenges by stakeholder group.

Additional details from parents

To provide further detail on parents' issues and perspectives, for each of the priority challenges identified by the parents we have included a number of the most informative direct quotes from the parents in Table 2.

TABLE 2 Direct quotes from parents.

Priority Challenges	Quotes from parents
User friendly	"What does the light mean!? Wore all the time as a consequence." "Having a box to keep it safe when not in use would be good." "I found the orientation of the camera (using it upside down) confusing."
Comfort	"Could camera be attached to a hat or cap instead?" "Of the potential new headbands I prefer the design without a securing band over the top of the head." "It's reassuring to know the camera has been cleaned before I get it."
Instructions for use	"Having a user guide to refer to would be useful." "Would be helpful to know how long a charge lasts for." "Had no idea how long it would take to charge."
Fitting	"Adjustable headband to accommodate different size heads would be useful." "Children try to remove cameras from themselves and parents."
Data Security	"I want reassurance about exactly what the data will be used for." "If the footage capture will be linked to mental health data in any way this needs to be clear in the information provided." "What happens if the person coding the video knows me?"

Candidate new WCs devices and performance against selection criteria

The five devices identified as candidate new WCs (at the time of the work in 2020) and their performance against the selection criteria are shown in Figure 4. The device selected as the new WC to be trialled was the WearCam manufactured by Ucam 247 (see device in use in Figure 1). This had a resolution of 1280 × 720 30 frames/s and a field of view of 85 degrees.

Comparisons of old and new WCs devices in key data processing stages

The data illustrating the median duration in seconds that the face was coded as "face not visible" are shown in Table 3. These statistics were derived using The Observer XT (v16) software package from Noldus (https://www.noldus.com/observer-xt) for coding behaviours in video footage, which uses an event-based, time stamped coding system to record the onset and offset of behaviours, which includes

TABLE 3 Face not visible duration per coded video.

WCs device	Median (sec)	Inter-quartile range (sec)	Upper quartile (sec)	Lower quartile (sec)
Old (19 parents, 30 infants)	16.3	25.9	33.9	8.1
New (12 parents, 14 infants)	4.7	3.1	5.7	2.7

FIGURE 4
Candidate devices and performance against selection criteria.

faces going out of view. The onset and offset times were used by The Observer XT package to compute the total number of "face not visible" occurrences and the duration of each occurrence, which were then combined to provide total durations per video (16).

Discussions

Principle findings

A set of five key challenges were identified across the different groups of stakeholders involved in research using WCs for measuring parent-child interactions in the UK cohort study ALSPAC, and SAMRC/Wits Developmental Pathways for Health Research Unit study at University of the Witwatersrand in South Africa:

- Simplicity and ease of use
- Comfort and stability of fitting
- Professional and stylish appearance
- Camera field of view and video quality
- Video footage format for synchronisation

Using these issues as selection criteria, it was possible to review a range of candidate WCs and select a new device potentially better suited to the specific needs of recording parent-child interactions.

To compare the performance of the old and newly selected WCs, we identified time "face not visible" per video as a key downstream metric, because having the faces of the parent and child visible is vital in the coding of emotional state and reactions needed to assess parent-child interactions. The median "face not visible" time per video for the new WC was reduced to approximately a quarter that of the old device. This improvement in keeping faces of parents and children in view, most likely the result of a combination of increased field of view, video quality (e.g., adaptation to varying light levels), ease of use, and secure fitting, will considerably reduce the likelihood of missing a reaction or a change in facial expression, making coding easier and faster.

Key recommendations for future research

From the challenges identified across the stakeholder groups in this study, we make the following suggestions for future research using WCs.

When selecting a WC, ensure:

- The device has simple to use controls, ideally a single button for starting and stopping recording.
- The device has a clear visual indicator showing when it is recording.
- The device has age-appropriate fixing mechanisms that enable the device to be located stably in an optimal position, and that are comfortable for the participant (particularly important if the participant is a young child).
- The device has a professional appearance.
- The field of view of the device is wide enough to capture the events of interest, taking into account younger children are likely to have higher levels of head movement.
- The device is sufficiently sensitive to work in (reasonably) low light conditions inside homes.
- The device stores video footage in a format that simplifies video synchronisation across multiple cameras (e.g. make sure footage is not stored as multiple segments).

Once the device is selected, simple to follow instructions are developed and tested with parents.

Strengths and weaknesses

To the best of our knowledge, this is the first study to have directly sought feedback from both parents and researchers in a range of different roles (academic, fieldworker, and data processors) about the use of WCs to study parent-child interactions. The varied stakeholders contributing to this study were drawn from what is potentially the largest study to date using WCs to assess parent-child interactions. The fieldworkers, researchers and data processors in particular have considerable experience recruiting and engaging families in research, working with parent and child dyads, processing WCs footage, and coding parent-child interactions.

The novel and potentially intrusive nature of these new WCs methods means the opinions of parents were of particular interest, and we have included additional information from parents in the form of direct quotes. Future studies of this topic would benefit from more extensive qualitative research with parents. While the nature of the cohort studies in which this work was conducted meant the parents were well matched for age, variations in other factors, including social-economic position, may have influenced the use of the WCs and the comparison of device performance reported here.

The candidate new WC devices considered and the device selected will have been specific to the time the study was conducted (2020), and will likely have been superseded by the time of publication. However, the challenges identified in the use of WCs for measuring parent-child interactions, and the approach for using these to consider and select new WCs will remain relevant over time.

Conclusions

Working with a range of stakeholders involved in projects utilising WCs to assess parent-child interactions, and an industry partner specialising in digital product design, we identified a number of priority challenges relating to use of WCs in this field of research. These issues were then used as selection criteria to identify a new WC device optimally suited to capturing footage of parent-child interactions. This new device dramatically improved one of the key factors enabling quality coding of interactions—the extent to which the faces of all of the individuals interacting are in view in the footage captured. The challenges identified will be important in guiding future research using WCs to assess interaction between parents and children, and more broadly in the use of WCs in advancing methods for objective assessments in a range of health research domains (17).

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/s.

Ethics statement

The studies involving human participants were reviewed and approved by ALSPAC Ethics and Law Committee and the Local Research Ethics Committee at University of Bristol. 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 minor(s)' legal guardian/next of kin for the publication of any potentially identifiable images or data included in this article.

Author contributions

AS and RP: conceptualised the work. All authors contributed to designing and running the workshops. JD and MG: were responsible for identifying and comparing devices. IC, IC and RP: were responsible for coding of video footage. All authors contributed to the article and approved the submitted version.

Funding

Prof Pearson, Ms Costantini and the development of the headcam technology and data collection in mothers and children were supported by the European Research Council (ERC) under the European Union's Horizon 2020 Research and Innovation Programme (Grant agreement No. 758813; MHINT). Dr Skinner and Mr Stone were supported by Cancer Research UK (C18281/A19169, C18281/A29019) and the MRC Integrative Epidemiology Unit at the University of Bristol (MC_UU_00011/6). Dr Culpin was also funded by the Wellcome Trust Research Fellowship in Humanities and Social Science (212664/Z/18/Z). The UK Medical Research Council and Wellcome (Grant ref: 217065/Z/19/Z) and the University of Bristol provide core support for ALSPAC. This publication is the work of the authors and Prof Pearson will serve as guarantor for the contents of this paper.

Acknowledgments

Other Kinneir Dufort departments with input to the project: Insight & Innovation—Kelly Dawson, Holly Empson. Industrial Design—Christopher Althorpe, Niall McRiner, Oliver Needham, Charlotte Davis. Prototyping—Andrew Phillips, David Brown. Software & Electronics—James Holmes, Alex Waldron. We are extremely grateful to all the families who took part in this study, the midwives for their help in recruiting them, and the whole ALSPAC team, which includes interviewers, computer and laboratory technicians, clerical workers, research scientists, volunteers, managers, receptionists and nurses.

Conflict of interest

JD and MG were employed by Kinneir Dufort. The remaining 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/frcha.2023.1111299/full#supplementary-material.

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frontiers | Frontiers in Public Health

TYPE Original Research
PUBLISHED 27 June 2023
DOI 10.3389/fpubh.2023.1100923

OPEN ACCESS

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RECEIVED 17 November 2022
ACCEPTED 30 May 2023
PUBLISHED 27 June 2023

CITATION
Kasamatsu H, Tsuchida A, Matsumura K, Hamazaki K, Inoue M, Inadera H and the Japan Environment and Children's Study Group (2023) Impact of longer working hours on fathers' parenting behavior when their infants are 6 months old: The Japan Environment and Children's Study.
Front. Public Health 11:1100923.
doi: 10.3389/fpubh.2023.1100923

Impact of longer working hours on fathers' parenting behavior when their infants are 6 months old: The Japan Environment and Children's Study

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Objective: Long working hours have been suggested to affect fathers' parenting behavior, but previously reported findings have been inconsistent. This study examined the association between the working hours and parenting behavior of fathers while accounting for other factors related to their parenting behavior, using data from the Japan Environment and Children Study (JECS), a large cohort study in Japan.

Methods: Data from 43,159 father–mother pairs were analyzed. The mother assessed the father's frequency of seven parenting behaviors at 6months after delivery. Then, each behavior was classified into a high-engagement group (always and sometimes) or a low-engagement group (rarely and never). The father's weekly working hours was obtained from his responses and was classified into six levels.

Results: Logistic regression analysis showed that after adjustment for covariates, fathers' weekly working hours was inversely associated with the frequency of all parenting behaviors examined in this study (p for trend <0.0001). Compared with fathers working ≥0 to ≤40h per week, those working >65h per week showed the following adjusted odds ratios (95% confidence intervals) for low engagement in parenting behaviors: playing at home, 2.38 (2.08–2.72); changing diapers, 2.04 (1.89–2.20); and bathing the child, 2.01 (1.84–2.18).

Conclusion: This study suggests that the greater time constraints imposed by longer working hours constitute a major factor that discourages fathers from engaging in childrearing behavior. Intervention targeting long working hours could contribute to measures aimed at promoting high-engagement parenting behaviors among fathers.

KEYWORDS

birth cohort, childrearing and child care, long working hours, play, work-style reform

1. Introduction

Previous studies have reported many benefits of fathers' early involvement with their children in the postpartum period, including children's accelerated neurodevelopment (1) and positive behavioral outcomes at school age (9 and 11 years) (2), as well as reduced risk of mothers' psychological distress at 1 year after delivery (3). In recent years in the United States and Europe, the traditional image of fathers as the breadwinner has evolved into that of "involved fathers," "new fathers," and "new men" to also include their role in caring for their children and in family life more generally (4–6). Time-use surveys conducted in 20 countries between 1965 and 2003 (7) have shown that men's unpaid work time, including child care, has increased over time.

In relation to this trend, studies have investigated factors associated with fathers' childrearing behavior, mostly since the 1990s. From a sociological perspective, Shelton et al. reported five factors determining fathers' engagement in housework and childrearing: time availability, household demands, relative resources, ideology, and alternative resources (8). Empirical studies have examined the relationship of fathers' childrearing behavior with various factors, including working hours and employment status (9–11), mothers' educational background (12), age of the youngest child and number of children (13), mothers' income as a proportion of total family income (13, 14), essentialist perceptions of men and women as parents (15), and ethnicity and country context (12, 16).

Among these factors, fathers' working hours has been studied in the United States and Europe, Korea, Singapore, Australia, Israel, and Japan as an indicator that can be objectively measured in any country in order to consider individual fathers' time availability. Although many studies have found an inverse association between fathers' work hours and frequency of parenting behaviors (13, 15, 17, 18), others have reported a limited association (12, 14), an association weakened by other factors (9), or no association (5, 19, 20), so the strength of association is inconsistent among previous studies. In addition, research on fathers' parenting behavior and its determinants does not have as long a history as such research on mothers (4). Most studies to date have involved hundreds to thousands of participants, and only a few studies have involved tens of thousands of participants.

Among the countries where previous studies on fathers' working hours have been conducted, in Japan, men tend to work longer hours compared with men in other Organisation for Economic Co-operation and Development (OECD) countries, at an average of 451.8 min per day compared with 317.8 min per day. Meanwhile, the average time spent by Japanese men on unpaid work at home, including housework and childcare, is 40.8 min per day, which is less than one-third of the 136.5 min per day for men in other OECD countries. Japanese women, in comparison, spend an average of 224.3 min per day engaged in unpaid work at home, highlighting the still large burden of housework and childcare that falls on mothers (21). One possible explanation for the inconsistency in the association between fathers' working hours and the frequency of childrearing behaviors in previous studies is that the range of fathers' working hours was narrower in the countries where these studies were conducted and so did not clearly show differences between fathers with normal working hours and those with long working hours. The clear trend toward longer working hours in Japan offers a good opportunity to reexamine the impact of time constraints on fathers' parenting behavior for a wider range of fathers' working hours.

Against this backdrop, the purpose of this study was to address working hours as a major determinant of fathers' parenting behavior and to examine its association with the frequency of parenting behaviors, using a dataset of about 43,000 father–mother pairs obtained from the Japan Environment and Children's Study (JECS), a large cohort study in Japan.

2. Materials and methods

2.1. Study design

The JECS is a government-funded, nationwide birth cohort study that aims to evaluate the impact of environmental factors on children's health and development. In total, 103,057 pregnancies were registered from 15 Regional Centres across Japan between January 2011 and March 2014, and detailed descriptions of the JECS can be found elsewhere (22). Mothers were recruited during pregnancy. The children's fathers were recruited only after the mothers (or their children after birth) had started participation in the study. About half as many fathers as mothers were registered (23). Recruitment involved a face-to-face explanation of the survey, and written informed consent was obtained from all participants. The authors assert that all procedures contributing to the present work comply with the Helsinki Declaration of 1975, as revised in 2008. All procedures involving human subjects in the JECS protocol were reviewed and approved by the Ministry of the Environment's Institutional Review Board on Epidemiological Studies (100910001) and the Ethics Committees of all participating institutions. The protocol of the present study was approved by the Institutional Review Board of the University of Toyama (R2020171).

2.2. Study data

This study used the jecs-qa-20210401 (jecs-ta-20190930) dataset, which was first released in October 2019 and completed in February 2022. The dataset contained entries for 49,657 unique father–mother pairs. We excluded data without participation of the father (51,161) and with multiple participation of the father–mother pair (2,239). We also excluded pairs from the analysis for the following reasons: there was missing data on the father's weekly working hours (2,984); the father's daily working hours were >24 h or weekly working days were >7 days (77); the father did not live with the mother and child or the father's coresidence status with family members was not known (3,268); the respondent reporting the father's engagement in childcare behaviors was not the mother (168); and the infant's sex was not known and thus could not be included in the multivariable analysis (1). Finally, data from 43,159 father–mother pairs were analyzed (Figure 1). In this study, we assumed that the father in each pair was the biological father of the child.

2.3. Measurements

A self-administered questionnaire was used to collect information on demographics, medical and obstetric history, physical and mental health status, lifestyle factors, occupation, and socioeconomic status.

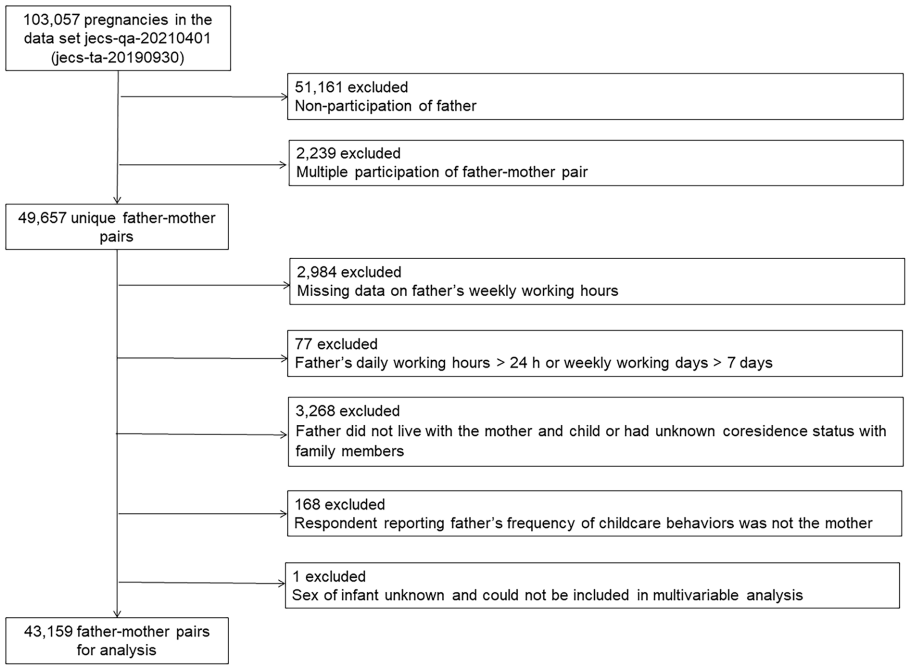

FIGURE 1
Participant flow diagram.

The questionnaire was distributed three times to mothers (during early and mid/late pregnancy and at 6 months after delivery) and once to fathers (between the mother's pregnancy and when their infant reached 1 month of age). Data from the medical records were transcribed by physicians, midwives/nurses, and/or research co-ordinators.

2.4. Independent variables

The father's weekly working hours was calculated from the "number of working days per week" and "number of working hours per day (including overtime)" obtained from the father's survey responses. We then grouped working hours into six categories according to the classification of Tanaka et al. (24): ≥0 to ≤40 h; >40 to ≤45 h; >45 to ≤50 h; > 50 to ≤55 h; >55 to ≤65 h; and >65 h per week.

2.5. Dependent variables

Based on the mother's survey responses at 6 months after delivery, the following seven parenting behaviors of the father were assessed: (a) playing at home, (b) playing outdoors, (c) helping with feeding, (d) changing diapers, (e) dressing, (f) bathing, and (g) putting the child to bed. Responses were provided on a 4-point scale (always, sometimes, rarely, and not at all). These seven items were selected for assessing the fathers' parenting behaviors because similar items were assessed in previous studies in Japan, Western countries, and other Asian countries (25–28). Then, each of the fathers' parenting behaviors was classified into a high-engagement group (always and sometimes) or a low-engagement group (rarely and never).

2.6. Covariates

The following covariates were considered: father's age during the mother's pregnancy (≤24 years; 25–29 years; 30–34 years; or ≥35 years); father's highest educational level (junior high school or high school; technical junior college, technical/vocational college, or associate degree; or bachelor's degree or graduate degree [master's/doctorate]); father's alcohol intake during the mother's pregnancy (never-drinker; ex-drinker; current drinker); father's smoking status during the mother's pregnancy (never; previously did, but quit before learning of the mother's pregnancy; previously did, but quit after learning of the mother's pregnancy; currently smoking); annual household income (<4 million Japanese Yen [JPY]; 4 to <6 million JPY; or ≥6 million JPY); coresident family members of the father–mother pair during the pregnancy [twin or more of the surveyed infant(s); older sibling(s) of the surveyed infant(s); mother's parent(s); or mother's parent(s)-in-law]; the year the mother became pregnant (≤ 2011; 2012; ≥ 2013); and infant's sex (male or female). In this study, the short form of the Autism-Spectrum Quotient Japanese version [AQ-J-10; (29)] was included to evaluate whether the father exhibited autistic traits during the mother's pregnancy. The AQ-J-10 is a short form of the AQ (30) used to screen adolescents and adults with high-functioning pervasive developmental disorders and is a reliable and validated instrument. In this study, a score of ≥7 used as a cut-off (29) to categorize the results. Mother's postpartum depression at 1 month after delivery was assessed using the Edinburgh Postnatal Depression Scale (EPDS), with a score of ≥9 used as the cut-off (31, 32) to categorize results. Cronbach's alpha for the EPDS was 0.82, as shown in our previous study (33).

10.3389/fpubh.2023.1100923

2.7. Statistical analysis

To estimate the risk of low engagement in fathers' childcare behavior according to their weekly working hours category, we performed multivariable logistic regression analysis to calculate odds ratios (ORs) and 95% confidence intervals (CIs). Two-sided *p*-values less than 0.05 were considered to indicate statistical significance. Missing data of covariates were included as categorical variables in the adjusted model. In tests for trend, fathers' weekly working hours was evaluated as a continuous variable. For the sensitivity analysis, we compared the adjusted ORs and 95% CIs obtained from categorizing fathers' engagement in parenting behavior as "high" or "low" in the multivariable logistic regression analysis with those obtained from categorizing fathers' engagement in parenting behavior according to four frequencies (always, sometimes, rarely, and never) in the multinomial logistic regression analysis. Data were analyzed using SAS version 9.4 software (SAS Institute Inc., Cary, NC).

3. Results

Table 1 shows the participants' characteristics. In terms of hours worked, about 60% of fathers reported working ≤50 h per week, followed by 9.6% reporting working 50 h to ≤55 h, 16.2% reporting 55 h to ≤65 h, and 15.2% reporting >65 h. About 70% of the fathers were in their 30s or older. The most frequent highest educational level of the fathers was junior high school or high school (40.8%). Just under 70% of the respondents had household incomes of <6 million yen. In terms of family coresidence during the mother's pregnancy, 51.7% of the father–mother pairs lived with the infant's older sibling, 9.5% with the mother's parent(s), and 12.4% with the mother's parent(s)-in-law. Male sex of the infant was slightly more common (51.0%). The proportion of families raising multiple birth infants was 0.9%. During the mother's pregnancy, 75.1% of fathers continued to drink and 41.0% continued to smoke. Autistic traits were reported in 6.6% of the fathers. The percentages of years in which mothers were pregnant was 35.0% before 2011, 33.3% in 2012, and 31.6% after 2013, almost the same percentage. Meanwhile, 14.3% of mothers showed symptoms of postpartum depression.

Table 2 shows ORs and 95% CIs for the association between fathers' weekly working hours and their engagement in parenting behavior when their child was 6 months old. After adjustment for covariates, fathers' weekly working hours was still inversely associated with the frequency of all seven parenting behaviors examined in this study (*p* for trend <0.0001). Compared with fathers who worked ≥0 to ≤40 h per week, fathers with weekly working hours of >40 to ≤45 h had significantly higher adjusted ORs for low engagement in helping with feeding and bathing. Moreover, among fathers in the four remaining categories with weekly working hours of >45 h, the ORs for low engagement were significantly higher for all seven of the parenting behaviors. Among fathers who worked >45 to ≤50 h, adjusted ORs (95% CI) ranged from 1.10 (1.04–1.16; putting the child to bed) to 1.38 (1.21–1.57; playing at home). These ranged from 1.15 (1.06–1.26; dressing) to 1.38 (1.16–1.63; playing at home) among fathers who worked >50 to ≤55 h, and from 1.29 (1.21–1.37; putting the child to bed) to 1.65 (1.43–1.89, playing at home) among those who worked >55 to ≤65 h. Among fathers who worked >65 h per week, the ORs for low engagement in "playing at home" tended to be higher than for

TABLE 1 Participant characteristics (*N*=43,159).

Characteristics	*n* (%)
Fathers' weekly working hours category	
≥0 to ≤40 h	9,328 (21.6)
>40 to ≤45 h	5,744 (13.3)
>45 to ≤50 h	10,414 (24.1)
>50 to ≤55 h	4,155 (9.6)
>55 to ≤65 h	6,979 (16.2)
>65 h	6,539 (15.2)
Father's age (years)	
≤24	2,644 (6.1)
25–29	10,105 (23.4)
30–34	14,355 (33.3)
≥35	15,963(37.0)
Missing	92 (0.2)
Father's highest educational level	
Junior high school or high school	17,599 (40.8)
Technical junior college, technical/vocational college, or associate degree	10,214 (23.7)
Bachelor's degree, graduate degree (master's/doctorate)	14,952 (34.6)
Missing	394 (0.9)
Father's alcohol intake during mother's pregnancy	
Never drank	9,095 (21.1)
Ex-drinker	1,511 (3.5)
Current drinker	32,425 (75.1)
Missing	128 (0.3)
Father's smoking status at mother's pregnancy	
Never	12,561 (29.1)
Previously did, but quit before learning of mother's pregnancy	10,176 (23.6)
Previously did, but quit after learning of mother's pregnancy	2,053 (4.8)
Currently smoking	17,696 (41.0)
Missing	673 (1.6)
Father's AQ-J-10 score during mother's pregnancy	
0–6	40,182 (93.1)
≥7	2,839 (6.6)
Missing	138 (0.3)
Annual household income (JPY)	
<4 million	15,375 (35.6)
4 to <6 million	13,856 (32.1)
≥6 million	11,270 (26.1)
Missing	2,658 (6.2)
Coresident family members of the father–mother pair	
Twin or more of the surveyed infant(s), yes	395 (0.9)
Older sibling(s) of the surveyed infant(s), yes	22,305 (51.7)
Mother's parent(s), yes	4,096 (9.5)

(Continued)

TABLE 1 (Continued)

Characteristics	*n* (%)
Mother's parent(s)-in-law, yes	5,358 (12.4)
Year the mother became pregnant	
≤2011	15,109 (35.0)
2012	14,351 (33.3)
≥2013	13,625 (31.6)
Missing	74 (0.2)
Mother's postpartum depression at 1 month after delivery[a]	
Yes	6,163 (14.3)
Missing	713 (1.7)
Infant's sex	
Male	22,015 (51.0)
Female	21,144 (49.0)

AQ-J-10, Short form of the Autism-Spectrum Quotient Japanese version; JPY, Japanese Yen.
[a]Postpartum depression: total Edinburgh Postnatal Depression Scale score of ≥9.

other parenting behaviors when compared with fathers who worked ≥0 to ≤40 h per week (adjusted OR [95%CI]: 2.38 [2.08–2.72]).

Supplementary Table S1 shows adjusted ORs for each covariate in relation to the frequency of the fathers' parenting behaviors. The OR for fathers with low engagement in all seven parenting behaviors was significantly higher when an older sibling(s) was present than when not present and when the mother showed symptoms of postpartum depression than when they did not. Furthermore, the ORs for fathers' low engagement tended to be significantly higher in the following groups compared with the reference group: fathers aged ≥35 (reference group: ≤ 24), fathers who continued to smoke even after learning of the pregnancy (reference group: never), fathers with AQ-J-10 scores of ≥7 during the pregnancy (reference group: 0–6), fathers living with the mother's parents (reference group: living elsewhere), and, interestingly, fathers with a female infant(s) (reference group: male).

Supplementary Table S2 shows the adjusted ORs and 95% confidence intervals obtained from categorizing fathers' engagement in parenting behavior according to four frequencies (always, sometimes, rarely, and never) in the multinomial logistic regression analysis. The results were consistent with those obtained from categorizing fathers' engagement in parenting behavior as "high" or "low" in the multivariable logistic regression analysis.

4. Discussion

This analysis of data from a large cohort study in Japan revealed a significant inverse association between fathers' working hours and the frequency of their engagement in parenting behaviors. Fathers with the highest weekly working hours (> 65 h) showed a stronger tendency to have low engagement in the parenting behaviors of "playing at home," "changing diapers," and "bathing" compared with those who worked ≥0 to ≤40 h per week. In addition, this study classified fathers' working hours per week into six groups to examine the association with the frequency of their parenting behaviors, thus allowing examination of the lower limit of weekly working hours associated with low-engagement parenting behaviors. Among the covariates considered, the following were associated with the fathers' low engagement in parenting behavior: the infant(s) having an older sibling(s), the mother showing symptoms of postpartum depression, father's age ≥ 35 years, father continuing to smoke even after learning of the pregnancy, father showing autistic traits, living with the mother's parent(s), and female sex of the infant(s). These results suggest that the impact of fathers' working hours on the frequency of their parenting behavior is large compared with the other variables included as covariates.

Many previous studies conducted outside Japan examining the association between fathers' working hours and the frequency of parenting behaviors have found inverse associations similar to those found in this study, but findings on the strength of the association have been inconsistent. As indicated earlier in the introduction, it is possible that working hours considered long in previous studies outside of Japan were shorter than those in Japan; for example, Coles et al. (12) defined long working hours as ≥45 h per week and McGill (9) as ≥51 h per week. It is also possible that the distribution of working hours was not as wide and uniformly distributed as in Japan. Because of this, this study could examine the relationship between the frequency of fathers' engagement in parenting behaviors and their working hours over a wider range of working hours compared with previous studies outside Japan. Previous studies conducted in Japan have generally reported inverse associations, but the number of subjects was several hundred to several thousand participants (17, 18). Therefore, to our knowledge, this is the first study to examine the relationship between these two factors among tens of thousands of participants in Japan. In addition, the study was able to consider a large number of covariates. With the strengths listed above, this study provides new findings supporting the inverse association found between parenting behaviors and fathers' working hours.

The status of fathers' parenting behaviors in each working hours category was determined in detail. First, fathers working >40 h to ≤45 h tended to be less engaged in helping with feeding and bathing compared with those working ≥0 to ≤40 h. The tendency to have low engagement in helping with feeding and bathing seems to be due to the fact that fathers with longer working hours come home late and so are not present when their children need to be fed or bathed. Fathers working >45 to ≤50 h were found to have lower engagement in all seven parenting behaviors evaluated in this study compared with those working ≥0 to ≤40 h. In Japan, a maximum amount of overtime work is set by law (which came into effect in April 2019 for large enterprises and April 2020 for small and medium-sized enterprises), which in principle may not exceed 45 h per month (34). A father working >45 to ≤50 h per week (i.e., > 5 h to ≤10 h of overtime per week) would fall below this monthly limit of 45 h per month. Among fathers in this study who worked longer (> 50 h per week), all the parenting behaviors examined showed low engagement, suggesting that weekly working hours of >45 to ≤50 h could be a guide for encouraging fathers' participation in childcare.

Working >65 h per week corresponds to about 5 h of overtime per day. About one in six fathers in our data worked this much. Fathers in this group showed a stronger tendency to have low engagement in all parenting behaviors compared with fathers working ≥0 to ≤40 h per week. This suggests that time constraints due to long working hours are a major obstacle to fathers' engagement in parenting behaviors. The data used in this study were obtained in the early 2010s. A survey conducted by the Ministry of Internal Affairs and Communications

10.3389/fpubh.2023.1100923

TABLE 2 Odds ratios (95% confidence intervals) for fathers' low engagement in parenting behaviors when their infant(s) was 6 months old according to fathers' weekly working hours category.

Engagement in paternal parenting behaviors	Fathers' weekly working hours category						
	Group 0 ≥ 0 to ≤40h	Group 1 > 40 to ≤45h	Group 2 45 to ≤50h	Group 3 > 50 to ≤55h	Group 4 > 55 to ≤65h	Group 5 >65h	*p*-Value For trend
Play							
At home ($n = 43,009$)							
High	8,912 (95.8)	5,460 (95.4)	9,786 (94.4)	3,908 (94.4)	6,490 (93.3)	5,906 (90.7)	
Low	388 (4.2)	265 (4.6)	586 (5.7)	234 (5.7)	466 (6.7)	608 (9.3)	
Crude OR	1.00	1.12 (0.95–1.31)	**1.38 (1.21–1.57)**	**1.38 (1.16–1.63)**	**1.65 (1.44–1.89)**	**2.37 (2.07–2.70)**	**<0.0001**
Adjusted OR[a]	1.00	1.16 (0.99–1.37)	**1.38 (1.21–1.57)**	**1.38 (1.16–1.63)**	**1.65 (1.43–1.89)**	**2.38 (2.08–2.72)**	**<0.0001**
Outdoors ($n = 42,995$)							
High	7,107 (76.5)	4,340 (75.8)	7,658 (73.9)	3,036 (73.3)	4,990 (71.8)	4,457 (68.4)	
Low	2,183 (23.5)	1,386 (24.2)	2,711 (26.2)	1,106 (26.7)	1,962 (28.2)	2,059 (31.6)	
Crude OR	1.00	1.04 (0.96–1.12)	**1.15 (1.08–1.23)**	**1.19 (1.09–1.29)**	**1.28 (1.19–1.37)**	**1.50 (1.40–1.62)**	**<0.0001**
Adjusted OR[a]	1.00	1.05 (0.97–1.13)	**1.14 (1.07–1.22)**	**1.18 (1.08–1.28)**	**1.26 (1.17–1.35)**	**1.49 (1.39–1.60)**	**<0.0001**
Caregiving							
Helping with feeding ($n = 42,838$)							
High	6,624 (71.6)	3,918 (68.7)	6,915 (66.9)	2,710 (65.6)	4,336 (62.6)	3,810 (58.7)	
Low	2,630 (28.4)	1,785 (31.3)	3,417 (33.1)	1,420 (34.4)	2,595 (37.4)	2,678 (41.3)	
Crude OR	1.00	**1.15 (1.07–1.23)**	**1.25 (1.17–1.32)**	**1.32 (1.22–1.43)**	**1.51 (1.41–1.61)**	**1.77 (1.66–1.89)**	**<0.0001**
Adjusted OR[a]	1.00	**1.13 (1.05–1.21)**	**1.23 (1.15–1.30)**	**1.31 (1.21–1.42)**	**1.47 (1.37–1.57)**	**1.73 (1.62–1.86)**	**<0.0001**
Changing diapers ($n = 43,021$)							
High	7,658 (82.3)	4,722 (82.4)	8,171 (78.8)	3,221 (77.8)	5,254 (75.5)	4,531 (69.5)	
Low	1,643 (17.7)	1,006 (17.6)	2,202 (21.2)	920 (22.2)	1,702 (24.5)	1,991 (30.5)	
Crude OR	1.00	0.99 (0.91–1.08)	**1.26 (1.17–1.35)**	**1.33 (1.22–1.46)**	**1.51 (1.40–1.63)**	**2.05 (1.90–2.21)**	**<0.0001**
Adjusted OR[a]	1.00	1.04 (0.95–1.13)	**1.24 (1.16–1.34)**	**1.33 (1.21–1.45)**	**1.49 (1.38–1.61)**	**2.04 (1.89–2.20)**	**<0.0001**
Dressing ($n = 43,027$)							
High	7,147 (76.9)	4,392 (76.7)	7,660 (73.8)	3,071 (74.1)	4,839 (69.6)	4,237 (65.0)	
Low	2,153 (23.2)	1,336 (23.3)	2,718 (26.2)	1,074 (25.9)	2,116 (30.4)	2,284 (35.0)	
Crude OR	1.00	1.01 (0.93–1.09)	**1.18 (1.10–1.26)**	**1.16 (1.07–1.26)**	**1.45 (1.35–1.56)**	**1.79 (1.67–1.92)**	**<0.0001**
Adjusted OR[a]	1.00	1.03 (0.95–1.11)	**1.17 (1.09–1.25)**	**1.15 (1.06–1.26)**	**1.44 (1.34–1.54)**	**1.78 (1.66–1.91)**	**<0.0001**
Bathing ($n = 43,015$)							
High	8,109 (87.2)	4,912 (85.8)	8,734 (84.2)	3,436 (83.0)	5,693 (81.8)	5,023 (77.1)	
Low	1,194 (12.8)	812 (14.2)	1,636 (15.8)	706 (17.0)	1,265 (18.2)	1,495 (22.9)	
Crude OR	1.00	**1.12 (1.02–1.24)**	**1.27 (1.17–1.38)**	**1.40 (1.26–1.54)**	**1.51 (1.39–1.65)**	**2.02 (1.86–2.20)**	**<0.0001**
Adjusted OR[a]	1.00	**1.12 (1.02–1.23)**	**1.27 (1.17–1.37)**	**1.38 (1.25–1.53)**	**1.49 (1.36–1.62)**	**2.01 (1.84–2.18)**	**<0.0001**
Putting the child to bed ($n = 43,002$)							
High	4,900 (52.7)	2,942 (51.4)	5,174 (49.9)	2,000 (48.3)	3,176 (45.7)	2,780 (42.7)	
Low	4,400 (47.3)	2,784 (48.6)	5,191 (50.1)	2,143 (51.7)	3,780 (54.3)	3,732 (57.3)	
Crude OR	1.00	1.05 (0.99–1.13)	**1.12 (1.06–1.18)**	**1.19 (1.11–1.28)**	**1.33 (1.25–1.41)**	**1.50 (1.40–1.59)**	**<0.0001**
Adjusted OR[a]	1.00	1.04 (0.97–1.11)	**1.10 (1.04–1.16)**	**1.18 (1.10–1.27)**	**1.29 (1.21–1.37)**	**1.46 (1.37–1.56)**	**<0.0001**

[a]Covariates were adjusted for father's age, father's educational background, father's alcohol intake at mother's pregnancy, father's smoking status at mother's pregnancy, father's autistic traits at mother's pregnancy, annual household income, coresident family members of the mother–father pair [twin or more of the surveyed infant(s); older sibling(s) of the surveyed infant(s); mother's parent(s); or mother's parent(s)-in-law], year the mother became pregnant, mother's postpartum depression at 1 month after delivery, infant's sex. Bold indicates statistical significance ($p < 0.05$). OR, odds ratio.

during the same period reported that 13.7% of men worked ≥60 h per week (35). Although the rate that we report here is slightly higher, it is presumably because the survey conducted by the Ministry included the entire working population aged ≥15, whereas the data in our study covered mainly people in their 20s–30s. Therefore, it is reasonable to assume that the data obtained in this study generally reflect the trend in working hours in Japan in the early 2010s.

It is worth noting that fathers' long working hours is likely to have a strong negative effect on the time they engage in play, and the group that worked >65 h per week showed a trend toward higher ORs for low engagement, especially for "playing at home," compared with other parenting behaviors. Fathers playing with their children has been reported to have a positive impact on children's behavioral outcomes (36). The fact that working long hours was more strongly associated with low engagement in "playing at home" behavior compared with other parenting behaviors is presumably due to aspects of the business culture in Japan. From the time the data were collected to the present, most men in Japan have worked full-time with fixed starting hours (37, 38). Generally, an 8-h workday would consist of arriving at work at 9:00 a.m. and leaving at 5:00 p.m. On workdays, fathers are more likely to play with their children at home during the few leisure hours in the evening and night when the children are awake. Therefore, longer work hours would cause the father to return home later and likely have less leisure time. In this context, the more immediate aspects of childcare such as caregiving may take precedence over play at home. For example, "helping with feeding" and "dressing" might have been done before work hours, and thus might have been less affected by working hours compared with "play at home."

Previous studies have indicated that long working hours have negative effects on both physical and mental health (39, 40). Takehara et al. surveyed 3,514 families with children under 1 year of age and reported that 11.0% of fathers had self-reported moderate or severe psychological distress (41). Previous studies outside Japan have also reported that "new fathers" attempt to balance their roles as breadwinners and childcare providers by reducing their leisure time (9). The long working hours seen in the present study could themselves have a negative influence on both physical and mental health, and the additional burden of childcare could further increase the risk of ill health. Currently, fathers are forced to balance childcare while maintaining long working hours, which is presumed to place a heavy burden on them individually.

Among the covariates considered, this study also found that fathers tended to be less engaged in childrearing when the children were girls than when they were boys. In early childhood, parents are considered to play an important role in socializing children into gender roles (42). It is theorized that fathers are more involved in the child-rearing of boys than girls because of shared interests, the desire to serve as a male role model, and the aspiration to invest in boys' future educational and economic success, in line with traditional gender norms (43, 44). Therefore, even at 6 months of age, these fathers may be more involved with boys than girls because of these fathers' mentalities.

As mentioned in the previous paragraph, according to a more recent survey conducted by the Ministry of Internal Affairs and Communications in 2021, the percentage of men working ≥60 h per week was 7.9% compared with 13.7% in 2011, indicating a downward trend (35, 45). This decline in long working hours reflects the effects of the "work-style reform" that the Japanese government has been promoting as policy. This suggests the effectiveness of efforts to reduce long working hours at the community and population level. The father's employer and co-workers, who often form his closest social circle, may be able to play a role in generating time for him to engage in parenting behavior, as described below. To this end, it is necessary to change the environment that creates long working hours in the first place. Second, flexible working patterns need to be introduced. In 2021, only about 10% of men in Japan had flexible work arrangements with no fixed starting time (38), indicating that there is much room for improvement here. Third, it is important to establish a system that enables men with children to fully utilize the parental leave system. Revisions to labor laws in recent years have granted men more flexibility in terms of parental leave (46). However, there are still some barriers to realizing a work environment in which more men can take advantage of these systems. The actual effects of efforts to increase fathers' engagement in parenting behaviors will need to be examined further in newer cohorts.

This study has three main strengths. First, reliable findings were obtained using data from a large cohort study in Japan to examine the effects of the fathers' long working hours in relation to the frequency of their parenting behaviors, with adjustment for other factors. Second, we prospectively examined the relationship between their working hours and the frequency of their parenting behaviors and found a dose–response relationship. Third, the fathers' parenting status was data obtained when their infant was 6 months old, so it was possible to examine data that was well controlled with respect to the infant's age and the mother's employment status (most mothers were presumed to be on childcare leave as provided in law).

This study also has some limitations. The first was the objectivity of the data on the frequency of the fathers' parenting behaviors, which were assessed subjectively by the mothers. Previous studies have reported that wives tend to underestimate the frequency of their husbands' parenting behavior (47). In addition, mother's marital satisfaction may have influenced the subjective assessment of the father's parenting behavior (48); however, this study did not obtain such data and so this potential factor could not be examined. Therefore, it is necessary to take into account the influence of bias due to the mothers' subjective evaluation. The second limitation was the recruitment method. This study included only fathers whose partner had begun participation in the JECS and had consented to recruitment of the fathers. Fathers were recruited through a face-to-face method, but only about half as many fathers registered compared with mothers. This could have caused selection bias in which fathers who work in a way that prevented them from being present at the time of face-to-face recruitment were not included in the study. In addition, we cannot exclude the possibility that the father registered during the mother's pregnancy was not the same father who was the subject of the evaluation of the frequency of parenting behaviors when the child was 6 months old, though such differences were considered to be very rare. The third limitation is the generalizability of the results obtained in this study. Fathers' parenting behavior is also influenced by social frameworks such as traditional gender ideology that are deeply rooted in their society and by public childrearing support systems (15, 16). In the early 2010s when the data for this study was collected, parental leave systems for fathers were not as widespread outside of Europe and the United States (49). This could have been one reason why the relationship between fathers' working hours and parenting behavior became clearer in this

study. Further studies should be conducted in other countries and regions where men work longer hours, as in Japan, to see if a similar relationship is found between fathers' longer working hours and their frequency of parenting behaviors. In addition, in recent years, government policies have expanded childcare support in Japan, for example, the law was revised to promote men taking parental leave (46). Therefore, it will be necessary to investigate over time the impact of these changes in public social systems on the relationship between fathers' working hours and parenting behavior in Japan. The fourth limitation was that this observational study could not assess causal relationships. In Japan, as mentioned earlier, work-style reform is being promoted and long working hours are on the decline. In addition, the average time that men spent with a child under the age of 6 years on childcare increased in 2021 compared with 2011 (50, 51). This increase suggests that measures to decrease long working hours could be effective for increasing fathers' parenting time, although a causal relationship cannot be determined.

5. Conclusion

This study found a significant inverse association between fathers' working hours and the frequency of their parenting behaviors. Our results suggest that greater time constraints imposed by longer working hours are a major factor that discourages fathers from engaging in childrearing behavior. Intervention targeting long working hours could contribute to measures aimed at promoting high-engagement parenting behaviors among fathers. Since these data were obtained, measures aimed at reducing long working hours have been promoted as policy in Japan. However, the actual effects of these efforts to increase fathers' engagement in parenting behaviors will need to be examined further in newer cohorts.

Data availability statement

The data analyzed in this study is subject to the following licenses/restrictions: Data are unsuitable for public deposition due to ethical restrictions and the legal framework of Japan. Publicly depositing data containing personal information is prohibited by the Act on the Protection of Personal Information (Act No. 57 of 30 May 2003; amended 9 September 2015). The open sharing of epidemiologic data is also restricted by the Ethical Guidelines for Medical and Health Research Involving Human Subjects enforced by the Japan Ministry of Education, Culture, Sports, Science and Technology and the Ministry of Health, Labour and Welfare. All inquiries about access to data should be sent to: jecs-en@nies.go.jp. The person responsible for handling enquiries sent to this e-mail address is Dr. Shoji F. Nakayama, JECS Programme Office, National Institute for Environmental Studies. Requests to access these datasets should be directed to jecs-en@nies.go.jp.

Ethics statement

The studies involving human participants were reviewed and approved by all procedures involving human subjects in the JECS protocol were reviewed and approved by the Ministry of the Environment's Institutional Review Board on Epidemiological Studies (100910001) and the ethics committees of all participating institutions. This study protocol was approved by the Institutional Review Board of the University of Toyama. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

Author contributions

HK, AT, and HI conceived of and designed the study. HK and KM analyzed the data. HK drafted the manuscript. AT, KM, KH, MI, HI, and the JECS group critically reviewed the draft and checked the analysis. The JECS group collected the data and obtained the funding. AT, KM, and HI provided administrative, technical, and material support. All authors approved the submission of the manuscript in its current form.

Funding

The JECS was funded by the Ministry of the Environment, Japan. The funding source played no role in the study's design, collection, analysis, or interpretation of data; in the writing of the report; or in the decision to submit this paper for publication. The findings and conclusions of this article are solely the responsibility of the authors and do not represent the official views of the above government agency.

Acknowledgments

We are grateful to the participants of the JECS and to all individuals involved in the data collection process.

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/fpubh.2023.1100923/full#supplementary-material

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Appendix

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frontiers | Frontiers in Child and Adolescent Psychiatry

TYPE Original Research
PUBLISHED 14 August 2023
DOI 10.3389/frcha.2023.1124883

OPEN ACCESS

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RECEIVED 15 December 2022
ACCEPTED 03 July 2023
PUBLISHED 14 August 2023

CITATION
Bozicevic L, Hill J, Chandra PS, Omirou A, Holla C, Wright N and Sharp H (2023) Cross-cultural differences in early caregiving: levels of mind-mindedness and instruction in UK and India.
Front. Child Adolesc. Psychiatry 2:1124883.
doi: 10.3389/frcha.2023.1124883

Cross-cultural differences in early caregiving: levels of mind-mindedness and instruction in UK and India

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Introduction: Most studies on parenting and its role in child development are conducted in Western countries, but it cannot be assumed that characteristics of parental practices are similar in non-Western settings. Research characterizing cultural differences in parenting is required to inform the focus of studies designed to test differential outcomes from such practices in children over time and across cultures. The present cross-cultural study examined differences in maternal speech during mother–child interactions, and, specifically, in the use of mind-mindedness, instruction and control, and the expression of warmth (i.e., positive comments).
Methods: We observed 100 dyads (50 from the UK and 50 from India) during mother-infant play interactions at 7 months. Maternal speech was transcribed and translated prior to independent coding, and this was coded using established measures together with a newly developed measure of "Instructions".
Results: Substantially large differences between UK and Indian mothers were observed. Compared with UK mothers, Indian mothers made fewer mind-minded comments about their infants, and they issued more instructions and made more controlling and positive comments. Findings from this study might reflect cultural differences in how parental style might be expressed according to cultural priorities and values.
Conclusions: The implications of these very large differences in parenting across cultures for child development remain to be investigated and are discussed in the present paper.

KEYWORDS

parenting, cross-culture, observational method, mother–child interaction, mind–mindedness, instructions, parental control, warmth

1. Introduction

Parenting style characterized by responsiveness to infants' behaviors and likely mental states is associated with better emotional and behavioral outcomes during childhood and beyond (1, 2). This understanding of the role of early parenting is mainly based on research conducted in Western settings and the associations between these parental practices and child outcomes cannot be assumed to be universal (3–5). In fact, there may be cultural variations in norms and values that lead non-Western parents to prioritize different behaviors, such as providing guidance to their children, and these may be evident even during infancy (3, 4). In turn these culturally-valued parental behaviors may be associated with favorable outcomes in these settings. The extent and types of cultural

differences in parental practices are inconsistently explored in research; their investigation is important because it might contribute to the further understanding not only of child development in non-Western settings, but also of cultural variations in the relationship between parenting and child outcomes vs. "universal" associations which can be found across settings (5). In this study, we analyzed maternal speech during a standardized play procedure between UK and Indian mothers with their infants. Based on available evidence on differences in parenting practices we examined the hypothesis that Indian mothers, as representative of Asian culture, show more evidence of guidance (i.e., instructions), and they interpret and verbalize infant mental states less often than UK mothers, representative of Western culture.

In recent years a growing body of research has examined the construct of "mind-mindedness", the caregivers ability to interpret the mental states underpinning their infant's behaviors, which can be assessed as the number of appropriate mind-minded comments made during interactions with their children (6). There is a wealth of data supporting the idea that early parenting in which the parent seeks to follow and understand their infant's behaviors, is associated with a wide range of positive cognitive, behavioral and social outcomes. In fact, higher levels of mind-minded comments have been associated with better social-emotional understanding (7, 8) and secure attachment (9–11), and fewer behavioral problems and emotional difficulties (10, 12, 13). These findings are however mainly drawn from Western research (2, 14) with the question of whether they are cross-cultural processes yet to be answered. As theoretical formulations link mind-mindedness to the promotion of autonomy and self-expression (independent qualities) in children (15), mind-mindedness might be seen as less relevant and therefore displayed less by parents from cultural settings that value interdependent qualities (e.g., obedience, respect for elders) more than independent qualities. This has been supported in a few cross-cultural studies: three found that Chinese mothers of eighteen months-three years old children are less mind-minded than US, UK and Australian mothers during a story-telling task, when they are asked to talk about their children, and during an observed play interaction (16–18). Moreover, a study comparing Japanese and British mothers when talking about their 3–6 years old children found that Japanese women made a significantly lower proportion of mind-related comments compared to British women (19). Finally, in a comparison of 29 German and 28 Indian infants aged 3 months, Keller and colleagues (2010) reported higher levels of the broad construct "autonomy promoting" behaviors in the German families, and higher levels of "relatedness" in the Indian families (20). Autonomy promoting included scales similar to mind-mindedness, and relatedness included references to social norms. Therefore, to date, there are only a few existing cross-cultural studies assessing the construct of mind-mindedness in Asian settings, and even fewer in South Asian settings, and no previous study has compared parenting across cultural settings using blind ratings to deal with potential rating bias based on cultural expectations.

Another widely observed characteristic of parenting is guiding children to teach them appropriate behaviors, and social, cognitive and motor skills. Although this parental practice might be observed across cultures, studies conducted in non-Western settings suggest that parents from cultures which value interdependent qualities (e.g., obedience), such as Asian populations, may give particular priority to parental behaviors aimed to guide their children, such as teaching and instructing, rather than respond to their needs and verbalize their mental states (16, 21). There is, however, limited evidence regarding these parental practices in infancy. For instance, Reddy and colleagues compared parent-infant interaction during daily life between 6 and 12 months of age in nine middle-class urban families in the United Kingdom and thirteen middle-class urban families in India; they found that rates of parent directives to the infants were higher in the Indian dyads (22, 23). Directives were characterized as either positive, for example "Press this one" or "You try it" and negative, for example "No, don't go" or "Don't put it in your mouth." While these studies are notable for many reasons (e.g., early assessment of directiveness, use of observational methods, cross-cultural comparison), the sample sizes were small, and families included belonged to the urban middle class. While telling children what to do to regulate their behavior it is seen as desirable in non-Western settings as it promotes obedience and respect for elders as well as appropriate behavior, these practices might be perceived as controlling (i.e., intrusive, pressurizing, or dominating) in North American and European settings as they undermine children's sense of autonomy (24, 25). Although "positive" forms of control do exist (e.g., authoritative practices including parental guidance, monitoring, and rule setting), high levels of behavioral control, assessed through observations of Western parents interacting with their children, have predominantly been associated with poorer developmental outcomes including insecure attachment (26, 27), and externalizing and internalizing problems (28–30). A key question therefore is whether parental instructions and parental behavioral control are essentially the same (e.g., parental guidance), but valued to different degrees across cultures, and perhaps also associated with different developmental outcomes, or whether they are different constructs. In this study, we set out to examine cross-cultural use of parental "Instructions" (assessed using a newly developed scale) and we also coded parental "Control" using a European measure in order to compare the two.

Maternal warmth or positive affect (i.e., affection and acceptance expressed toward children) is considered another key parenting dimension which promotes child adjustment (e.g., secure attachment, fewer internalizing and externalizing problems, and fewer callous-unemotional traits) and optimal cognitive, and social-emotional development (5, 28, 29, 31–33). Parental positive affect appears to be associated with mind-mindedness, in Western populations (13, 32), and with control in Asian settings (34). These results might indicate that positive affect is a common factor among different cultures associated with good outcomes irrespective of other dimensions of parenting considered desirable in different cultures (5). It may also moderate the association between parental control and negative child outcomes, such as externalizing and internalizing problems (35, 36).

The main aim of the study was to compare maternal speech in a sample of UK and Indian mother-infant dyads while interacting in a

play-based task, in their levels of mind-mindedness, instructions, control and positive affect. We hypothesized that Indian mothers would use parental practices aimed to guide the children as evidenced by higher levels of instructions to a greater extent than mothers from UK, who, by contrast we hypothesized would use practices aimed to understand their infants' motives as evidenced in higher numbers of mind-minded comments. We did not make predictions for the direction of any differences in levels of control, nor of positive affect across Indian and UK families.

2. Materials and methods

2.1. Procedure and design

Participants were identified from two longitudinal studies in the UK and India with planned common measurement at parallel time points. In both studies only women aged 18 or above, who gave birth to a live singleton baby, without severe congenital abnormality were included in the samples. The UK Wirral Child Health and Development Study (WCHADS) sample has been described in previous publications (37). In brief, first time pregnant women, who could speak English, were recruited at 20 weeks from a publicly funded (NHS) maternity unit serving a defined geographical area with a broad representation of socioeconomic conditions but very few non-White inhabitants. WCHADS is representative of the population of child-bearing age women in the area from which the sample was drawn, the Wirral (UK), which is slightly more deprived than the rest of the UK. From a total of 1,233 women recruited, 316 were selected for intensive study, stratified by psychosocial risk, and of them 273 were observed with their infants at 7 months (Figure 1). In India participants were drawn from the Bangalore Child Health and Development Study (BCHADS) who were first recruited into the Prospective Assessment of Maternal Mental Health Study, PRAMMS (38) and then followed up through infancy in the BCHADS. In the PRAMMS 909 women attending the Antenatal clinic at the Government Referral Hospital (GRH) in South Bangalore (India) were recruited during the first two trimesters of pregnancy [see (36) for further information on the recruitment]. Exclusion criteria included having a major mental illness, having had major health complications during the current pregnancy, reporting harmful use of alcohol or other psychoactive substances, not speaking the language for assessment (Kannada), and not planning to reside in the same city. Women were from predominantly from low-income groups. From the original sample, 825 women had a singleton and live birth and were eligible for postnatal assessments and, of them, 407 were observed with their infants at 7 months (Figure 1). Compared to the population of the Karnataka urban areas, the BCHADS cohort is similar in terms of education, and marital and socio-economic status (39, 40).

Informed consent was obtained from parents in both studies. The UK study was approved by the Cheshire North and West Research Ethics Committee (UK) on the 27th of June 2006. The Indian study was approved by the National Institute for Mental Health and Neuroscience (NIMHANS) Ethics Committee on the 2nd July 2015 and the University of Liverpool Ethics Committee (1st March 2016).

2.2. Participants

A sample of 100 mothers (50 from UK and 50 from India) was randomly drawn from those with recordings of interactions between mothers and infants in the two studies, with minimization by infant gender. As shown in Table 1, the infants in the Indian sample were on average one month older than in the UK sample, and the Indian mothers were substantially younger than the UK mothers, and were more likely to have left full time education at age 18 or younger which can be expected due to population statistics. In contrast to the UK mothers, all of

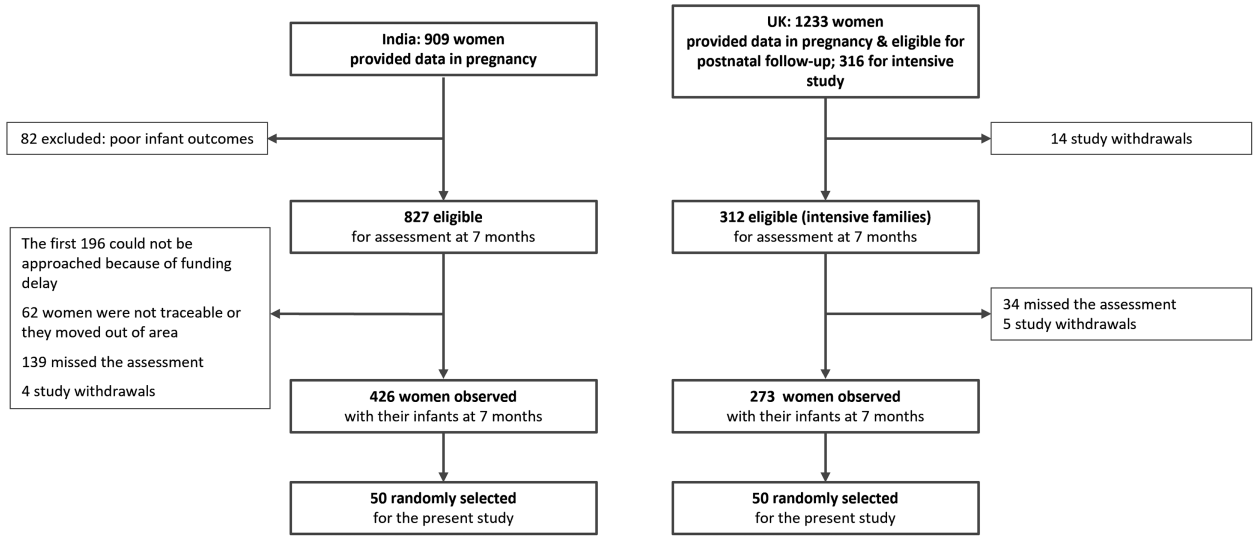

FIGURE 1
Flow chart showing the selection of the sample.

TABLE 1 Demographic characteristics of the UK and Indian families.

	UK ($N = 50$)	India ($N = 50$)	p-Value
Infant's age (months)	6.8 (sd 0.73)	7.8 (sd 1.56)	<.001
Infant's gender (male)	50 (50%)	50 (50%)	
Maternal age (years)	27.3 (sd 6.28)	22.8 (sd 2.64)	<.001
Education finished beyond 18 years	23 (46.0%)	5 (10.0%)	<.001
Parity (primiparous)	50 (100%)	25 (50%)	
Marital status (married/cohabiting)	31 (62.0%)	50 (100%)	<.001

Values of p are provided for comparisons of means using independent groups t-tests, and for comparisons of binary variables using χ^2. No formal comparison tests were conducted for infant gender and parity as they were determined by the study design.

the Indian mothers were married. The equal numbers of male and female infants, and the differences is parity were by design. It was not feasible to match the samples on income because of the large economic disparities between the countries. According to the World Bank, average annual per capita income in India in 2020 was 1,663 US dollars compared to 36,248 US dollars in the UK. However, both study samples from which the subsample was drawn reflected similar strata of the general populations. In the Indian sample 50% of the families with available data had an "upper-low" income which corresponds to a monthly income of 12,000 Rs (£121.37) (37). In the UK sample we characterized families using the Index of Multiple Deprivation (38) which uses postal codes to assign codes based on area income, employment, health, education and training, barriers to housing and services, living environment and crime. Based on this classification 54% of the UK families were living in postcodes characterized nationally as belonging in the most deprived quintile.

2.3. Measures

2.3.1. Maternal speech during mother-infant interactions

All of the mother-infant interactions in the UK were recorded at a community centre in rooms designed for filming, while in India 40% were filmed in a similar setting and 60% at home. Mothers from both samples were filmed in a 15 min dyadic free play interaction with their children following the procedure developed by the National Institute of Child Health and Human Development (41). In this procedure mothers are asked to play as they would normally do with their children for 7 min with a child's favorite toy brought from home (which could be an object as well as a toy) and for the following 8 min with a standard set of toys (which were culturally adapted to the two settings). Video-recording mothers and infant while interacting has been demonstrated to be a feasible methodology in a sample of Indian families in a urban setting (42). Moreover, the use of the play-based task with toys was piloted with local mothers prior to starting the study and it appeared to be culturally acceptable; belonging to an urban area along with the presence of local Government Anganwadi Centers which encourage use of play may have facilitated the exposure of families to playing with toys.

Transcripts were made from audio-recordings of mothers' speech over the 15 min of play with their infants. Indian transcripts were translated into English by members of the team proficient in both languages. All the transcripts were then checked by other members of the team who substituted the cues and references that might have provided evidence of their country of origin (e.g., London bus, Iggle Piggle, chapati) with neutral words which carried similar meaning and would not alter the coding of the comment (e.g., bus, doll/teddy bear, bread). Prior to coding, utterances (i.e., comments) were marked out on each transcript so as to obtain a total number of utterances for each mother; each utterance was coded for the presence of the mutually exclusive codes described below as present or absent. A total number of utterances coded as mind-mindedness, control, instructions, and positive affect was calculated for each woman, providing them of four different total scores. Finally, the percentage of codes for each category out of the total number of utterances was calculated for each mother (i.e., percentage of comments coded as mind-mindedness, percentage of comments coded as instructions, percentage of comments coded as control, and percentage of positive comments) in order to compare them despite differences among women in the length of the speech. These percentages were used in the analyses.

2.3.2. Maternal mind-mindedness

Mind-mindedness was rated on the basis of comments on child's mental states such as desires and preferences (e.g.,: "Do you want to sit?", "You like the bee, don't you?"), cognition (e.g.,: "Are you more interested in the cube?", "You know that song", "Are you ignoring mummy?"), emotions (e.g.,: "Are you getting fed up?", "You had enough", "Now you are happy to lie down and play") or intentions (e.g.,: "You are trying to stand up", "Are you trying to eat it?") (43). The use of transcripts meant that appropriateness of mind-minded utterances could not be rated as in previous observational studies of parents and children (2); therefore, only an index of the use of the mind-related comments can be drawn from our results. Percentages of comments coded as mind- mindedness have however been used in previous studies using interviews of parents in which appropriateness cannot be judged because infant behaviors are not being observed (2, 13).

2.3.3. Maternal instructions

In order to clarify whether Indian and UK mothers differ in the extent to which they tell their infants how to behave, we devised an "Instructions" measure to index parental guidance and a coding manual was created *ad hoc* for this study.

The procedure used to generate the Instructions measure and assess inter-rater reliability was as follows. After creating coding rules, ten transcripts from the UK and India, but not included in the present study, were read in order to generate a dictionary of examples and add detail to the rules. A further 10, not included in the final sample, were rated for practice using the coding system and the dictionary and discussed by the research team. Finally, a further 20 transcripts, which were included in the study, were rated by two independent coders to generate

percentage scores in relation to the total number of utterances over the assessment period (see Reliability section).

In the coding of Instructions only utterances that unambiguously gave directions regarding the infant's behavior were counted (i.e., mothers indicate an action and the object/way with which to perform the action). Examples included "Get the ball from the box and give it to me", "Don't put that in your mouth" and "Look at these toys".

2.3.4. Maternal control

Coding of maternal verbal control was based on a mother–child play coding scheme devised for coding from observations (44, 45). In the original Stein and colleagues' coding scheme 'strong control' includes commands, strong requests, inhibitions, forbids, cautioning, and correcting comments; some of these comments could be coded as both instructions as well as other controlling utterances (e.g., get the ball). However, in order to remove item overlap, the maternal verbal control measure used in this study included all the controlling utterances, but not the comments that were coded as Instructions. Examples of controlling comments included are "No", "Look", "I will take it away" "That's not right", and "You don't need that".

2.3.5. Maternal positive comments

Coding of maternal positive comments was based on a mother–child play coding scheme devised for coding from observations (44). In this coding scheme complimentary and affectionate comments on children's behavior, character or appearance, such as "What a good boy", "Well done", "Clever girl" and "My beautiful baby", are coded for positive affect.

2.4. Reliability

Two trained coders independently coded 20 transcripts and their interrater reliability for maternal speech codes was high for each parenting dimension: mind-mindedness ICC = .98, instructions ICC = .95, control ICC = .99, and positive comments ICC = .91.

2.5. Data analyses

Log transformations were applied to all skewed variables, which in each case yielded distributions appropriate for parametric analyses. Group differences in demographic characteristics were analyzed using Chi square and *t*-tests. Bivariate associations between demographic and parenting variables were examined using partial correlation coefficients controlling for membership of UK or Indian groups. Group differences in parental practices were analyzed using transformed percentage scores for each of the parenting dimensions as dependent variables and using Multivariate Analysis of Covariance (MANCOVA); the analysis was performed controlling for maternal age, whether mothers left education at 18 or under, and child age at the time of the assessment. Family income and marital status showed no variability in the Indian families, and parity showed no variability in the UK sample, by design, so these were not included in the analyses.

3. Results

From the results it emerges that, on average, Indian mothers made 269.98 (SD: 152.138; range: 31–764) comments, and UK mothers made 191.76 (SD: 72.958; range: 26–334) comments. The Indian mothers spoke more than the UK and so the groups were compared using percentages of the total. Table 2 shows the differences in percentages, which in each case reflected a difference in absolute numbers of comments (see Supplementary Table S2).

3.1. Correlations among socio-demographic variables and parenting dimensions

As shown in Table 3 older mothers had somewhat lower percentage scores for instructions and verbal control, and a higher percentage of positive comments, although all of the correlations were non-significant. Percentage mind-minded comments were positively associated with higher instructions and positive comments. Although percentage instructions and control utterances were positively correlated, the association was non-significant, suggesting that they measure different aspects of parenting (see Supplementary Table S1 for correlations between parenting dimensions within each group).

3.2. Group differences in the parenting dimensions

Mean percentage scores for mind-minded comments, positive comments, control and instructions comparing UK and India mothers are shown in Table 2. The untransformed values are shown as they are more readily interpretable than the transformed ones. Values of *F* were derived using transformed scores in MANCOVA controlling for infant age, mother age, and age left education. The model confirmed what is evident in Table 2, that UK mothers make substantially more mind-minded comments than Indian mothers ($d = .36$, $p < .001$), and that

TABLE 2 Group differences in the parenting dimensions.

	UK ($N = 50$)		INDIA ($N = 50$)		F (1, 95)	p
	M	SD	*M*	SD		
Mind-minded comments	5.94	3.092	1.99	2.477	38.222	<.001
Instructions	10.88	5.411	28.23	15.314	40.884	<.001
Control	4.94	4.615	24.32	14.382	46.587	<.001
Positive comments	2.39	2.574	13.02	9.687	98.767	<.001

Multivariate Analysis of Covariance (MANCOVA) controlling for maternal age, whether mothers left education at 18 or under, and child age at the time of the assessment.

TABLE 3 Partial correlation coefficients among socio-demographic variables and transformed parenting dimensions.

	Infant age	Maternal age	Age finish education	Mind-minded comments	Instructions	Control
Maternal age	.040					
Age finished education	−0.086	0.168				
Mind-minded comments	−0.043	0.001	0.065			
Instructions	0.051	−0.144	−0.025	0.211*		
Control	0.011	−0.145	0.060	0.056	0.143	
Positive comments	0.002	0.125	0.047	0.214*	0.164	−0.001

Partial correlations controlled for membership of UK vs. Indian groups.
*$p < .05$.

Indian mothers utter more instructions ($d = 1.51$, $p < .001$), use more verbal control ($d = 1.81$, $p < .001$), and they make more positive comments ($d = 1.50$, $p < .001$).

4. Discussion

4.1. Differences in parenting dimensions between UK and Indian mothers

In a comparison of two groups of mothers and infants randomly drawn from general population samples, our hypotheses that UK mothers would make more mind-minded comments, and issue fewer instructions than Indian mothers were confirmed. Although we made no predictions regarding positive affect or levels of verbal control, Indian mothers made considerably more positive and controlling comments than the UK mothers. In each comparison the differences were very large, with differences in transformed scores all over one standard deviation.

These findings suggest that the parenting environments for infants in the UK and in India are markedly different. As we noted earlier, few previous studies have examined these differences using content of speech drawn from observations of parenting. In those that have done so, the differences have been similarly large. The study by Reddy and colleagues (2013) compared guidance assessed as parental "directives", observed at home in UK and Indian middle-class families. Even in this small sample ($N = 22$) the difference between the groups at 6 months was highly significant, and this reflected a large difference, with UK mothers giving a mean of 12 directives per hour and the Indian mothers, 37 per hour. In the comparison of middle-class German and Indian families by Keller and colleagues (2010) which provides a comparable study of mind mindedness (named "mental states of the baby") assessed among the indicators of an "autonomy supporting conversational style", the difference in means was highly significant, with the German sample talking more frequently about children's mental states compared to the Indian sample, suggesting a large difference in a moderately small sample ($N = 57$). These results seem in line with the idea that promoting individuality and autonomy, which is an important socialization goal for parents from Western independent settings, may not have the same central role in non-Western interdependent cultures. These societies place high importance on relatedness with the social group (Keller et al., 2010), and they expect children to incorporate values of obedience, respect for the elders, and conformity to parents' directives as well as self-control (3, 46).

4.2. Potential association between parenting dimensions and child outcomes

The large differences that we found, which seem to be consistent with previous research, pose major questions for our understanding of the role of parenting in early development. If quality of parenting early in development has a crucial role in influencing social, emotional, behavioral, and educational outcomes, then either infants in one setting are receiving markedly less favorable parenting than infants in the other, or the dimensions of parenting associated with positive outcomes are different in the UK and in India. Based on available evidence regarding the prevalence of child psychiatric disorders across the two countries, which are broadly similar, the first interpretation seems unlikely (47, 48). Moreover, any differences are much smaller than would be predicted if the large differences in parenting styles that we found reflected large differences in environmental quality. In addition, data on educational outcomes in the UK, where one of the largest minority groups is Indian, shows that, in primary school, Indian children perform on average better than White British peers (49). Therefore, it is likely that all infants need sensitive and attentive parenting, but this is manifested differently across cultures and that different dimensions of parenting underpin favorable outcomes across the cultures (5). Several lines of evidence support this interpretation. For example, high parental control, consistently associated with poor outcomes in Western settings, is commonly not associated with negative outcomes in other cultural settings (24, 50–52). One explanation could be that some aspects of control, such as providing guidance through instructions, is perceived, in non-Western cultures, as a central parental responsibility and, consequently, children might experience these child-rearing practices as expressions of involvement and care as opposed to restriction of their autonomy and rejection (24, 50, 53–55). Another possibility is that, while in Western studies parental control is commonly associated with lack of warmth and other positive behaviors, in Asian settings there might be coexistence of positive affect expressed by parents and controlling behaviors, with the former buffering the relationship between high control and negative child outcomes (5, 35). Literature suggests that in Asian cultures, praise is used to encourage good behaviors and

obedience and to promote interdependence with the social group as much as other forms of parenting aimed to direct child behaviors, such as verbal control (56–58). The context of this research is different because dyads are in a play situation rather than a disciplinary one, however our findings showing how Indian mothers are both more directive and more positive than UK mothers seem to support the premise that both strategies are dominant in Asian cultures. Looking at the transcripts, it appears clear that some positive comments made by mothers are more evaluative/expressing approval for behaviors (e.g., "Good boy/girl", "Well done!"), while some others are more expression of admiration and affection ("You are so pretty", "You are my love"). Future research might explore these differences further and the possible associations with other parenting behaviors and later child outcomes. If correct, the conclusion that the large differences that we observed reflect major differences in effective and supportive parenting across cultures would have implications for the identification of differential pathways to socialization and optimal development across cultures. Future studies should explore the association between different parenting styles and a variety of child development and educational outcomes.

4.3. Strengths and limitations

The strengths of our study included that families were selected at random from larger samples recruited from the general population during pregnancy, the observation procedures were the same in the UK and in India, the use of the percentage score for the parenting dimensions allowed controlling for level of verbosity, and transcripts were rated after cues to cultural context were removed. These methodological strengths may also have introduced limitations. First, the request to mothers to play as they would normally do with their children may not have meant the same thing to UK and Indian mothers, even though the piloting of the play task and previous studies confirmed that the procedure was acceptable and feasible in a urban Indian sample of mothers and infants (42). Second, 60% of the videos in the Indian sample were recorded at home instead of the lab and we cannot assume the location did not have any influence on maternal and child behavior. Third, rating from transcripts also introduced the limitation that coding depended on content of utterances rather than tone, and did not account for mothers' non-verbal behaviors. In the case of mind-mindedness it was not possible to judge the appropriateness of the mothers' comments for their infants' behaviors; therefore, the group differences found in the use of mind-mindedness should be considered with caution, even though they seem to confirm the other few existing findings from cross-cultural studies conducted in Asia which found a lower prevalence in Asian samples compared to Wester ones (16–19). Fourth, both samples had high representations of low socio-economic families, so the findings may not generalize to more affluent contexts in either country. Finally, the two groups are not homogeneous in terms of socio-demographic characteristics (e.g., maternal age and education), which was due to differences between the UK and Indian populations (e.g., older, and better educated women in the UK sample compared to the Indian).

4.4. Future directions and clinical implications

The implications for future investigation are numerous. At the practical, clinical and policy level, we need to know more about variations in parenting practices across ethnic groups within Western settings, and how these may differ across generations, and similarly how these change with Westernization in non-Western settings. Research conducted in non-Western settings is growing, together with interest in studying cultural variations that exist within same countries due to the high presence of immigrant families and their children. Developing culturally appropriate parenting interventions based on knowledge of natural cultural variations in approach is fundamental to avoid transposing programs from one context to another which would result in delivering messages inconsistent with parents' beliefs and their cultural norms. It should also increase the acceptability and effectiveness of such interventions. In terms of developmental processes, longitudinal studies are needed to test the key question of how different parenting dimensions are associated with later social, emotional, behavioral and educational outcomes across cultures (31). In line with emerging evidence linking specific aspects of parenting to specific types of psychopathologies, these studies need to examine whether these also vary by culture. Finally, future studies might benefit from the assessment of parenting styles of other caregivers especially in Asian settings where typically other family members care for children on a daily basis along with mothers.

Data availability statement

The datasets presented in this article are not readily available because of ethical constraints. Anonymised summary data may be made available to bona fide researchers on approval of an application for access. However, we do welcome formal approved collaborations for the analysis of data. Requests to access the datasets should be directed to hmsharp@liverpool.ac.uk.

Ethics statement

The studies involving human participants were reviewed and approved by Cheshire North and West Research Ethics Committee (UK), National Institute for Mental Health and Neuroscience (NIMHANS) Ethics Committee and the University of Liverpool Ethics Committee. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

Author contributions

LB and JH wrote the first draft of the manuscript. AO, LB, and NW organized the database and performed the statistical analysis. All authors contributed to the article and approved the submitted version.

Funding

The WCHADS study was funded by UK Medical Research Council (Grant G0400577) to JH, HS. The BCHADS study was funded jointly by UK Medical Research Council and The Indian Council for Medical Research (Grants MR/N000870/1 and ICMR/MRC-UK/2/M/2015-NCD-1) to HS, PC and JH.

Acknowledgments

The authors are grateful to Wirral University Teaching Hospital NHS Foundation Trust, Wirral Community NHS Foundation Trust, Cheshire and Wirral Partnership NHS Foundation Trust who supported the recruitment into the UK study in pregnancy. The views expressed are those of the authors and not necessarily those of the funders. We are very grateful to all participating families and to the broader research staff groups in UK and India who contributed to data collection in the studies.

Conflict of interest

The authors NW, JH, LB declared that they were an editorial board member of Frontiers, at the time of submission. This had no impact on the peer review process and the final decision.

The remaining 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/frcha.2023.1124883/full#supplementary-material

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frontiers | Frontiers in Child and Adolescent Psychiatry

TYPE Methods
PUBLISHED 24 August 2023
DOI 10.3389/frcha.2023.1122841

OPEN ACCESS

EDITED BY
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RECEIVED 13 December 2022
ACCEPTED 03 August 2023
PUBLISHED 24 August 2023

CITATION
Lekhuleni F, Desai R, Coetzee B, Pearson R and Rochat TJ (2023) Testing the acceptability and feasibility of video observational methodology to measure parent-adolescent communication and interaction.
Front. Child Adolesc. Psychiatry 2:1122841.
doi: 10.3389/frcha.2023.1122841

Testing the acceptability and feasibility of video observational methodology to measure parent-adolescent communication and interaction

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Background: Existing research has shown that the parent-adolescent relationship and its associated communication and interaction styles are important for adolescent development and outcomes. Measuring parent-adolescent communication and interaction using self-report methods has substantial research limitations. Video observational methodologies offer a novel and more objective approach to measuring parent-adolescent communication and interaction from the point of view of participants. This study aims to explore the feasibility and acceptability of this methodology, and analysis using automated coding software in an urbanized context.

Methods: This study recruited parent-adolescent pairs in Soweto, South Africa which included 11–15-year-old adolescents and their biological parents. Parent-adolescent communication and interactions were measured using novel video observational portable head cameras called "Teencams". Feasibility was evaluated by testing three observational game tasks (Matching pairs card game, Jenga and Charades) to stimulate communication and interaction between 16 parent-adolescent pairs, and the Teencam's ability to record video and audio content. Acceptability was explored using one-on-one interviews with the parents ($n = 14$), on whether they found the Teencam comfortable to wear, whether the parents believed their adolescents acted naturally, and which observational game tasks were feasible during their interactions. The videos were analysed using automated coding software called FaceReader which detects and codes basic facial expressions.

Results: The Teencam methodology was found to be feasible and acceptable amongst parent-adolescent pairs in Soweto, South Africa. The Matching pairs card game stimulated excellent interaction and communication with good video and audio quality. Some feasibility limitations were identified in the operations (switching on/off and starting recording), the ability of the device to cope with the movement of the participants, and the lighting conditions of the room, all of which resulted in poor coding and analytic output from FaceReader. Refinements and adjustments were made to the methodological protocol by improving the head cameras and lighting conditions and refining the Matching pairs card game, which resulted in improved analytic output from FaceReader.

Conclusion: Based on these findings, a methodological protocol was developed to measure parent-adolescent interaction and communication in an urban setting. The unique contribution of this research lies in its potential to lead to improved methodologies for measuring parent-adolescent communication and interactions.

KEYWORDS

acceptability, feasibility, video observation, parent-adolescent, communication, interaction

1. Introduction

Parenting and the quality of the parent-child relationship are important for adolescent health and well-being. Numerous studies, including research in South Africa, have illustrated associations between the parent-child relationship and positive outcomes for adolescents, especially in the early transition into adolescence (1, 2). The parent-adolescent relationship is however often strained as a consequence of developmental shifts involved as adolescents move towards autonomy (3). Adolescents in South Africa also face a myriad of challenges: poor educational outcomes, various forms of poverty and abuse, and less-than-ideal mental and physical health, including high rates of HIV (4). In high-risk environments, it may be especially important to understand and facilitate relationship support for parents and adolescents that ensure adolescents can grow towards autonomy and independence while managing potential risks.

Positive parent-child communication influences the reduction of risky behaviours among adolescents such as substance use and abuse, delinquent behaviours, and risky sexual behaviours (5–7). The quality of the parent-adolescent relationship is reflected in parent-adolescent communication and interaction. Parent-adolescent communication is a process through which beliefs, attitudes, values, expectations and knowledge are conveyed between parents and adolescents (8). Parent-child interactions are rooted in daily activities and function as an enhancement to the parent-child relationship. During an interaction with a parent, children learn social skills such as sharing, cooperating, and respecting others' belongings (9). While patterns of parent-child communication and interactions begin to develop earlier in childhood, during adolescence, parents and adolescents face new challenges in their relationship with changing developmental needs in the adolescent, and changes in the parenting context (10, 11).

Methods for studying these relationships have traditionally used self-reported questionnaires, which have many limitations such as systematic biases (12) and may be susceptible to misinterpretation of the actual interactions between parents and adolescents. Furthermore, concordance between parent and adolescent reports of each other's emotions and behaviours tends to be low (13), all of which raises substantial questions about the validity of these self-report measures. In addition, some research has shown that when parent self-reports are compared to directly observed objective measures of parenting, most parents report their parenting to be worse than it is (14). Compared to the measurement issues involved in self-report data, ratings of observed parenting behaviours by trained researchers are considered more reliable (12, 13, 15). Yet these methods have been expensive to collect and have been very time-consuming to score and code, making them far less evident in literature from lower-income contexts.

Video observational methodologies using video observational equipment in the absence of a researcher, have been used widely for decades and have been found to have enormous benefits including objectivity, reliability, and opportunities for detailed analysis (16). However, there are challenges with video observational methods related to camera reactivity in which children get distracted by the cameras and participants, in general, change their behaviour because of camera awareness. While direct observations of relationships have the advantage of being objective, they also have several disadvantages in that they are costly to implement and time-consuming to code and make use of (17).

Currently, new technology has emerged called head cameras or spy cameras which are worn on the body or head to record video and audio of the participant's viewpoints, behaviours and environment in a more naturalistic way (18, 19). The advantages of these wearable cameras include the low cost of the equipment, the elimination of a researcher being present, reducing potential influences of the researcher on parent-adolescent behaviour, and that it enables the ability to record and sync the viewpoints of the parent and their adolescent child, so different perspectives, emotions and behaviours are captured under more naturalistic conditions. Alongside this, highly advanced coding software which substantially reduces the coding time of observations by automating the preparation of data clips for coding, now has the potential to strengthen methodological approaches. Two studies examining parent-adolescent interactions utilized a validated coding software known as FaceReader to analyze facial expressions and emotional states (20, 21). The footage for analysis was obtained from wall-mounted cameras. The use of this coding software may particularly be beneficial in resource-constrained contexts like South Africa, where it could minimise the time and resources required for coding and analysing objective data.

Most observational research that make use of wearable head cameras with parents and children has focused on the first five years of life (22). They have previously been used for recording infants' eye views of their environment and infant-mother interactions (18, 23, 24). Almost no research to date has developed developmentally standardised methodologies for observing parent-adolescent communication and interaction in Low- and middle-income countries (LMIC). Less is understood about the validity of parent-adolescent observational protocols

and the acceptability or feasibility of this approach in these settings. Little is also known about how to code these data within the South African cultural and socio-economic context.

The current study (made up of two studies) piloted a method to measure parent-adolescent communication and interaction in a low-income urbanized setting characterized by a diverse ethnic and cultural, predominantly African population. The study findings will likely inform and strengthen the development of interventions to improve parent-adolescent communication and interaction.

The primary aims of each study was as follows:

Study 1:

1. To pilot test the feasibility of three observational game tasks that elicit prosocial behavior, competitiveness, problem-solving, conflict resolution, and communication skills between the parent-adolescent pairs while wearing head cameras, which records audio and video footage.
2. To explore the acceptability of the video observational methodology based on parent feedback from individual interviews.

Study 2:

3. To explore the ability of automated coding software to capture and analyse facial expressions and emotional cues to inform the development of a methodological protocol.

2. Methods

2.1. Research setting

The research took place at the MRC Developmental Pathways to Health Research Unit (DPHRU) research site in Soweto, a low-income urban setting in South Africa. Soweto is the most populous urban residential area in South Africa, with 1.2 million residents living in 200 square kilometres (6,357 per km^2) an estimated 300,000 of whom are adolescents aged 11–18 years. Soweto faces challenges common to highly urban metropolitan areas in LMIC including poor housing, overcrowding, high unemployment and poor infrastructure. This research was embedded in an existing study called the BEACON study. The BEACON study is a large-scale cohort study of parents and young adolescents which aims to test the role of executive function on adolescent risk behaviours. Within the BEACON study, there exists a subgroup known as the BEACON Advisory Group (BAG), consisting of parent and adolescent pairs. The primary purpose of this group is to pilot test the methodologies and measures that will later be implemented with the larger BEACON cohort.

2.2. Inclusion and exclusion criteria

The inclusion criteria across study 1 and 2 were that adolescents be aged between 11 and 15 years, that a biological parent who is also a primary caregiver take part, a parent's willingness to participate and an adolescent's willingness to assent, the absence of mental and physical disabilities which may hinder participation, and residency in the study area as well as the intention to remain in the study area for 3 years.

2.3. Ethical considerations

Ethical approval (protocol number: M190801) was granted by the University of the Witwatersrand Ethics Committee in the Health Sciences Faculty for both studies and associated phases. Parental consent and adolescent assent were obtained for participation in the study. Participants were informed about the voluntary nature of their involvement and their right to withdraw from any activities at any time without consequence. To ensure confidentiality, transcripts and video data were assigned Participant Identification Numbers (PIDs) and stored securely on a password-protected computer.

3. Study 1: feasibility of the three observational game tasks (Phase 1)

Study 1 addresses objective 1 and 2 of this study and consisted of two phases. The first phase explored the feasibility of the three observational game tasks. The second phase explored the acceptability of the Teencam methodology.

3.1. Research participants

The participants for this phase of the study consisted of a BEACON advisory group (BAG). BAG participants were recruited from two sources: key informant referrals and enumeration lists. Trained research assistants were responsible for identifying and approaching up to five potential parent-adolescent participants through door-to-door recruitment. These initial participants were also requested to refer others they may know who could be interested in joining the study. Additionally, enumeration lists consisting of participant contact details were obtained from other cohort studies conducted in the unit. These lists contained individuals who had previously given consent to be contacted for participation in other studies and were purposefully selected and invited to take part in the BAG study. Pairs were consecutively approached and 16 parent-adolescent pairs were recruited and had given consent and assent to be BAG members.

3.2. Materials

3.2.1. Teencams

The head cameras called Teencams used to test the feasibility of the observational task were novelty spy cameras in the form of lapel badges and were yellow with a black smiley face. They were head-worn by attaching them onto an elastic headband (see **Figure 1**). The Teencams can record audio and video and store the footage

FIGURE 1
Parent and adolescent view of the Teencam footage.

on a built-in SD card. These Teencams were used to record observational tasks conducted with the BAG participants.

3.2.2. Stimuli material

The stimuli materials included three different games; the Matching pairs card game, Jenga and Charades. The selection of game tasks was driven by the goal of fostering prosocial behaviour, competitiveness, problem-solving abilities, conflict resolution, and effective communication skills among participants. Game tasks were selected as a strength-based approach due to their alignment with promoting family support and the joy derived from parent-child play (25). The Matching pairs card game consisted of 52 standard card packs, of which 10 Matching card pairs were selected and used for the game. The Jenga game consists of 54 rectangular blocks, of which 27 blocks were used, stacked three per layer. The "Charades game—Soweto version", was developed by the researchers by sourcing images and words that were relatable to the Soweto population and printing them in a card format. The images and words included landmarks in Soweto such as malls, hospitals, stadiums, the Soweto towers etc., and other common foods and day-to-day activities that people in Soweto are exposed to.

3.3. Procedure

Observational tasks were conducted over three different workshops with parent-adolescent pairs which spanned over three different days. Details of the procedure in each workshop are presented in Table 1. The Teencam activity took place during the refreshment break of the BEACON cohort study, wherein the parent-adolescent pairs both wore the Teencams while sitting around a table facing each other to record their communication and interaction, and to ensure that facial expressions and emotional cues were captured. The Teencam task lasted approximately 15 min each. The parent-adolescent pairs were expected to participate in all three workshops.

Across all three workshops, before the Teencam activity started, the adolescents (in a separate room from the parents) were taught the game and then asked to teach the game to their parents. During workshop 1, the responsibility of switching on the Teencams was assigned to the parents themselves. However, this approach resulted in several cameras not being activated accurately. To prevent a recurrence of this issue in workshops 2 and 3, the researchers took on the responsibility of managing the activation and deactivation of the cameras.

3.4. Participant exclusions and final sample

As seen in Figure 2, 31 BAG members were recruited. There were 16 adolescents and 15 parents, and one parent enrolled two adolescents. In workshop 1, all parent-adolescent pairs participated but due to technical errors (cameras not recording full observations, or one/both perspectives), three pairs were therefore excluded from the study and 13 parent-adolescent pairs were included in the final sample for workshop 1. During workshop 2 and 3, an equal number of nine parent-adolescent pairs were included in the final sample. The other pairs were excluded due to absenteeism, not meeting eligibility criteria of having a biological parent or technical errors.

3.4.1. Participant characteristics

In total, there were 16 parent-adolescent pairs in this pilot study as presented in Table 2. Unfortunately, one parent passed away before socio-demographic data were collected for the BAG participants via a questionaire as part of Study 2, therefore participant characteristics are only reported for 15 adolescents and 14 parents. The adolescents were predominantly female (n = 9, 60%) and only biological mothers were enrolled in the pilot study. The average age of the adolescents was 12.2 years (SD = 1.37) and the average age of the parents was 37.21 years (SD = 7.11). All the pairs identified themselves as African. Most of the parents were unemployed (n = 12, 85.71%) and over half of the parents reported having completed primary school education only.

3.5. Data analysis

Videos from each workshop were manually observed and coded by the author FL, who coded each video using a yes (criteria was met)/no (criteria was not met) classification based on specified dimensions and her observational fieldnotes taken at the time of the recordings. Each of these dimensions specified below had specific criteria that were coded and counted. The

TABLE 1 Teencam activities per workshop and activity instructions.

Workshop number	Activity	Activity Instruction
1	Matching pairs card game	• The parents themselves were instructed to switch the Teencams on and start the recording for themselves and their adolescents. • A pack of cards (Old Maid & Go Fish: designed for 11–12-year-olds, Hearts and Crazy: designed for 13–15-year-olds), was given to each pair, which included 10 Matching pair cards with different images and words on them such as animals and people demonstrating different careers and activities. • All cards were placed facing down on the table. • Each participant took a turn to turn over two cards, if they were a matching pair, they took the pair off the table into their pack. If the cards didn't match, they were turned back over to face down again. • As the turns proceeded the players had to remember where they had seen the card before that was matching. • The participant with the most matching card pairs won the game.
2	Jenga game	• The researcher switched the Teencams on to start the recording, provided instructions for participants to not touch the Teencams and then exited the room. • Each pair was given the Jenga blocks to build a tower. • The players took turns removing a block from the tower and balancing it on top, creating a taller and increasingly unstable structure as the game progressed. • The game ended when the tower fell—either completely or if any block fell from the tower (other than the block a player moves on a turn). • The player who collapses the tower loses the game. • For this study, each pair was given 27 blocks because the entire 54 blocks would not work since they had to play the game sitting down with limited movement.
3	Charades game	• The researcher switched the Teencams on to start the recording, provided instructions for participants to not touch the Teencams and then exited the room. • The charades game started with placing word and image printouts on the table facing down, the adolescent had to start the game by pulling one card and facing it to the parent and having the parent act out clues about the image or word on the card and the adolescent had to guess what they thought the clues refer to. • The player guessing the game had three chances to guess what was on the card, if not successful the player giving clues had to give them the correct answer. • Players had to alternate to give clues and guess the words or images as shown to them by the opponent. • The player who guessed the most correct answers won the game.

coding of these dimensions was cross-checked by authors TR, BC and RD to ensure accuracy and consistency.

3.5.1. Technical reliability

The Teencam's ability to successfully record interactions. The number of audio and video recordings obtained and those with technical problems were counted.

3.5.2. Usability

The ability for the Teencam to be switched on and off, start and stop recording, which were obtained from researcher fieldnotes.

3.5.3. Audio quality

The extent to which the researcher could hear the vocalizations articulated by the participants from the video footage and be able to transcribe them verbatim, measured using a yes/no classification system and researcher fieldnotes.

3.5.4. Video quality

The ability for the researcher to detect facial expressions, eye gaze, and general facial and body movements and responses which were obtained from researcher fieldnotes.

3.5.5. Feasibility of the observational task

This was determined by the participant's ability to understand and carry out the rules of the game, and for the game to elicit communication and interaction obtained from researcher fieldnotes.

3.5.6. Quality of the interaction

The extent to which the game elicited conversation and engagement between the parent-adolescent pairs obtained from researcher fieldnotes.

4. Results

4.1. Technical reliability

Technical reliability was assessed in each workshop for all participating pairs, irrespective of eligibility. The number of audio and video recordings and those with technical problems were counted. In Workshop 1, out of 16 parent-adolescent pairs, only one pair experienced recording issues, resulting in missing audio and video data. Additionally, one parent viewpoint did not record video, but audio was obtained from the other viewpoint. Thus, audio recordings were available for 15 pairs (94%), and 13 pairs had complete video and audio recordings from both parent and adolescent viewpoints (81%). In Workshop 2, no technical errors were detected among the 12 participating pairs. Workshop 3 involved 15 pairs, but two pairs had missing video and audio data. Similarly, one adolescent viewpoint lacked video recording, but

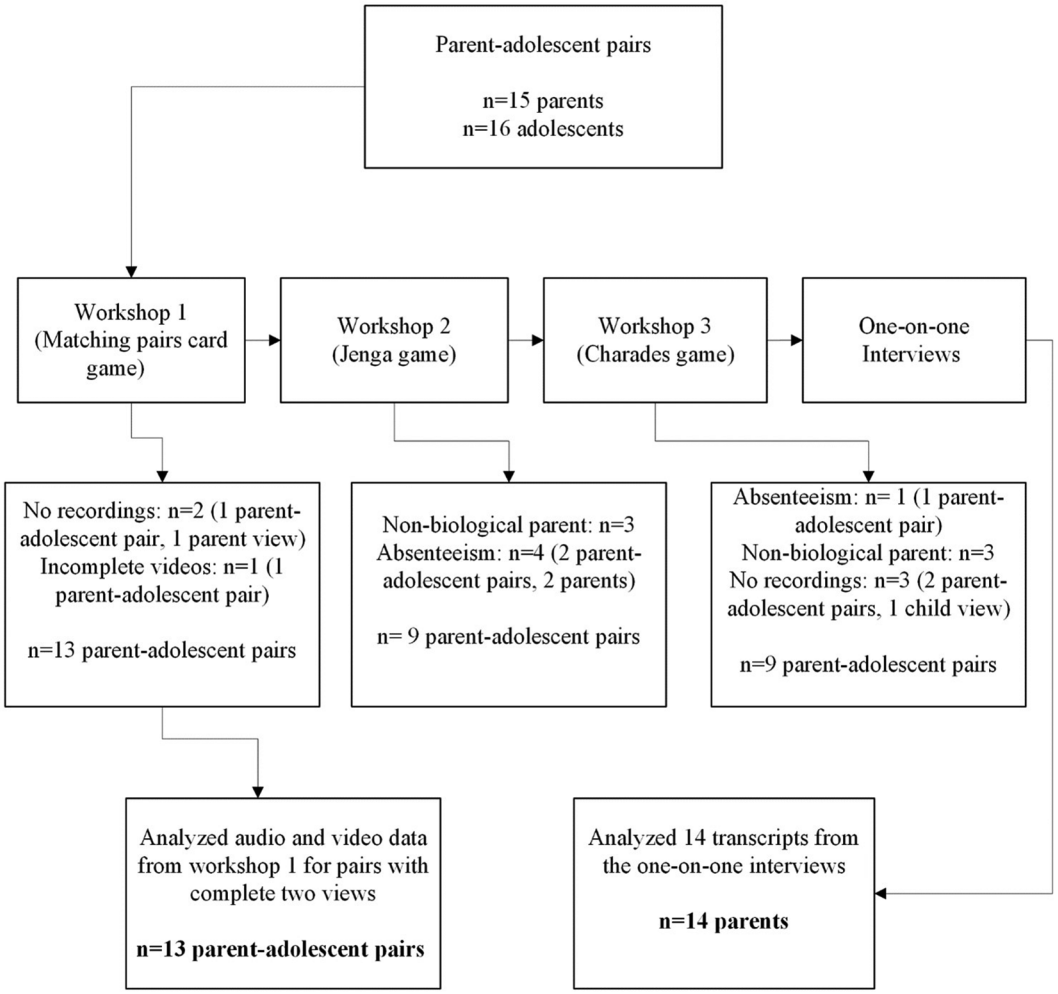

FIGURE 2
Consort diagram for study 1 of BAG participants per workshop.

audio was obtained from the other viewpoint. Consequently, Workshop 3 had audio recordings for 14 pairs (94%), and 12 pairs had complete video and audio recordings from both parent and adolescent viewpoints (80%). Overall, Teencam demonstrated excellent technical reliability, recording the different games with an overall reliability exceeding 80%.

TABLE 2 Participant characteristics of the BAG participants.

	Adolescent		Parent	
	n	%/mean (SD)	*n*	%/mean (SD)
Age	15	12.2 (1.37)	14	37.21 (7.11)
Gender				
Male	6	40		
Female	9	60	14	100
Race				
African			14	100
Employed			2	14.28
Highest education level				
Primary school			8	57.14
Matric (senior school certificate)			5	35.71
Post-matric			1	7.14

4.2. Usability of the Teencam

The device had several features that impeded user functionality for the researchers. Researcher fieldnotes indicated that the Teencam devices lacked clear indicators of recording status and did not have easily identifiable start and stop buttons. Consequently, researchers had to rely on a trial-and-error approach, pressing various combinations of buttons to turn the device on or off and initiate or terminate recording. This erratic button pressing led to technical glitches, including missed session recordings. Identifying these missed recordings was only possible during video footage screening after a session when the Teencam was connected to a laptop.

4.3. Audio quality

The Teencam device demonstrated good speech recording capabilities. The presence of background noise generated

by other participants in the same room while playing the game would sometimes hinder the clarity of the recorded conversations, posing some challenges for accurate transcription. Specifically, during the Charades game, there was a higher incidence of participants talking over each other and shouting, in contrast to the Matching pairs card game and Jenga. This discrepancy can be attributed to the forced turn-taking structure of the latter games, which facilitated smoother communication by ensuring participants did not speak over one another.

4.4. Video quality

As seen in Figure 1, video clips of parent-adolescent interactions capture the participants faces and shoulders from either the adolescent or parent's perspective. The estimated 60-degree field of view occasionally resulted in participants being cut out of view, especially during movement. Tilted heads and focus on the Jenga tower caused participants faces to be out of view. The Charades game videos had relatively poor quality due to participant movement but faces remained visible as the game required eye contact. The Matching pairs card game showed less movement and better video quality due to participants being fixed on the cards on the table. The room lighting conditions for all game tasks were average, resulting in slightly dark videos and light reflections on faces. Due to the file size of a long continuous recording, the Teencams automated functionality was to split the video into multiple shorter 10-min videos for each viewpoint, which was time-consuming when saving and labelling the videos.

4.5. Understanding of the game

According to the researcher fieldnotes and the yes/no classification, differences were observed in the way the pairs understood the game. During the Matching pairs card game, parents understood the game the first time it was explained to them by the adolescent. Only one adolescent had to repeat the instructions of the game to their parent. For the Jenga game, it was observed that two adolescents did not understand the rules of the Jenga game from the researcher and therefore communicated the incorrect instructions to the parent. For those adolescents who correctly explained the instructions, it still took two teachings for three different parents to understand the instruction. Moreover, at some points, three parents needed the adolescents to repeat or remind them of the instruction. During the Charades games, all the adolescents could explain the instructions of the game properly and the parents understood the instruction at the first teaching. It was found that one parent participant took at least two teachings to understand the game across all workshops that were attended.

4.6. Quality of the interaction

The researchers observed variations in interaction quality among the pairs during the different games played across the three workshops. The Charades and Matching pairs card games fostered active engagement and stimulated game-related conversations, even leading to occasional accusations of cheating and increased competition between pairs. In contrast, the Jenga game elicited minimal to no interaction, with most pairs remaining quiet and focused to prevent the tower from collapsing.

4.7. Evaluation of the games for further analysis

The researchers evaluated all games collectively on the understanding of the game, audio, video, interaction quality and attendance. The Matching pairs card game was well understood by all participants and the instructions of the game were correctly followed. The Matching pairs card game also had the best audio quality due to the turn-taking of the game and the least amount of background noise from the other participants in the room. The video quality was also good for the Matching pairs card game as there was minimal movement and participants were hardly cut out of view. The interaction was also good as the game elicited competitiveness and topics of conversation that related to the game. Given that the game took place during the first workshop, attendance and participation were excellent. Therefore, the protocol for the BEACON cohort included the Matching pairs card game which was selected to be implemented in study 2 to inform research question 3.

5. Study 1: acceptability of the Teencam methodology (Phase 2)

5.1. Materials

5.1.1. Interview schedule

The interview schedule focused on the acceptability of the Teencams and the feasibility of their use, from the perspectives of parents who took part in Phase 1. Parents were asked to report on any realized or foreseeable barriers to using the Teencams and any concerns they had. They were also asked to reflect on how they felt about being recorded, the comfort of the Teencams, whether they and their adolescent acted naturally during the observations and the game they enjoyed the most.

5.1.2. Procedure

All parents who took part in Phase 1, were invited to return to the research site and take part in individual in-depth interviews. The individual interviews were facilitated by qualified research assistants who were proficient in English and also proficient in the local languages of the community (i.e., isiZulu). Interviews were audio recorded and ranged in length between 11 and 23 min. The audio recordings were transcribed verbatim and translated into English by the same qualified research assistants.

5.1.3. Data analysis

To analyse the individual interviews with parents, ATLAS.ti version 8 was used to code and analyse the data using categorical

content analysis (26). Analysis of the interview transcripts began with a period of reflection and internalisation of the data by the author FL. Preliminary codes were developed and defined based on the objectives of this Phase and emerging patterns from the transcripts. Codes were further refined after discussions with the remaining authors. These final codes were used to develop overarching themes. Illustrative quotes for each theme were extracted and presented in this manuscript (27).

6. Results

Of the 15 parents that were invited to participate in the one-on-one interviews, one parent passed away leaving 14 one-on-one interviews with parents. Interviews with parents on the acceptability of the Teencam methodology yielded the following themes: naturalistic behaviour, observational activity, and Teencam methodology for future research.

6.1. Naturalistic behaviour

During the first workshop, some parents ($n = 9$) reported feeling nervous, and self-conscious about being video recorded and claimed that this initially impacted their and their adolescent's ability to behave naturally. However, by the third workshop, participants were familiar with the methodology, began to feel more comfortable being recorded and behaved more naturally. Some participants felt that they acted naturally throughout all the workshops, but others stated that they were always aware of being recorded and held back negative behaviour. Some parents ($n = 4$) felt that the placement of the head camera was uncomfortable causing irritation, limiting their movement and leading them to always be aware of the camera recording.

> *"At first I felt like I should be careful of whatever that I do or say but as time went by I was free." (BAG 13, 46 year old parent)*

> *"I'm always myself, if I want to reprimand my child I will do so while wearing the cameras. I won't lie about who I am to impress you guys." (BAG 11, 33 year old parent)*

> *"…she kept on saying that mum don't say some things because they can hear everything that we are saying." (BAG 9, 56 year old parent)*

> *It's not comfortable, it's disturbing, you can't open your eyes. You must focus on it, basically, it must always be in the right space and not move." (BAG 7, 34 year old parent)*

6.2. Observational activities

The most enjoyable observational task was the Matching pairs card game and Jenga. In particular, parents stated that they were familiar with the Matching pairs card game and often play it with their children at home. Parents reported Charades being the least enjoyable game as it allowed more opportunities for cheating and the game relied on the ability of the opponent to demonstrate well.

> *"It's the same cards that we usually play in the house. It's quite easy to understand, It's not complex." (BAG 2, 29 years old parent)*

Almost all parents ($n = 11$) preferred that the adolescent instruct and teach the parents the game as it was a valuable educational exercise for their adolescent. One parent felt that adolescents had an unfair advantage because they were already familiar with the game. Others suggested a rotation among parents and adolescents in teaching and instructing each other.

> *"It's a good idea because it shows that she learnt what she was doing with you. If she can teach me, it shows that she was listening." (BAG 15, 37 year old parent)*

> *"I also wanted to win, It's not fair. The adolescents were winning because they were taught the game before." (BAG 11, 33 year old parent)*

> *"Maybe you can alternate, have the parents teach the kids this week and the kids teach the parents the following week" (BAG 2, 29 year old parent)*

6.3. Teencam methodology for future research

When parents were asked about their overall impressions of the Teencam methodology, almost all participants had positive views. Parents highlighted that it allowed them to communicate with their children and one parent was willing to take the head cameras home for further observation. On the other hand, one participant was concerned about confidentiality and the way the videos were going to be used. Another participant felt that the Teencam was too intrusive and preferred to talk to researchers rather than be video recorded.

> *"Teencam has given me the chance to communicate with my child, I wish we could take it home" (BAG 3, 41 year old parent)*

> *"I don't have a problem with Teencam, I was only concerned about who is going to watch the footage." (BAG 6 & 16, 37 year old parent).*

> *"I don't like Teencam, I feel like if you guys want to know us you can… I think you can know us better through communication instead of putting cameras on our foreheads." (BAG 11, 33 year old parent)*

Most parents ($n = 10$) also stated that future participants would be willing to participate in the Teencam methodology, provided that the researchers orientate and reassure participants on the purpose, privacy and use of the video footage.

> *"I think they will be willing as long as it is explained from the onset that it is not played for the other people." (BAG 2, 29 year old parent)*

7. Study 2: codability of automated software

Study 2 addressed objective 3 and consists of one phase that explored the codability of the videos using automated coding software.

7.1. Research participants

Phase 2 consisted of a Respondent Driven Sampling (RDS) approach (28) to recruit participants into the BEACON cohort. RDS used in previous surveys in South Africa (29–31) uses a chain referral system that begins with a purposefully selected convenience sample or "seed". The seeds in this study came from the following sources: (1) BAG parents and (2) community recruiters who were responsible for recruiting eligible participants but did not participate in the study. Each seed was required to identify and refer eligible participants to the study and these individuals in turn referred potential participants to the study, and so on. This procedure creates an expanding system of chain referrals characterized by "waves" of recruitment. Unlike snowball sampling, RDS produces more reliable data estimates by using a "link-tracing design" that estimates participant network sizes and calculates selection probabilities between recruiters and their recruits (32). Through a sufficient number of waves of participant recruitment, a bias that the non-random choice of seeds may have introduced is overcome, which stabilises the composition of the sample, thereby becoming independent of the seeds from which recruitment began (33).

Survey administrators made use of an electronic system to help track the RDS recruitment chain. Recruits interested in participating in the study had the option of (1) Submitting their contact numbers through an electronic link sent to them via text message, which allowed an online screening eligibility survey to be sent to them at no data cost. (2) Submitting their contact numbers via WhatsApp and having a survey administrator call the participant to complete the screening eligibility survey over the phone. (3) Have their recruiters forward them a screening link which they completed and submitted with their recruiter. For every successful recruit, the recruiter received a monetary incentive (ZAR 10) (USD 0.54).

7.2. Procedure

This study involved testing the methodological protocol developed in study 1 on additional parent-adolescent pairs who were enrolled in the BEACON cohort. The purpose was to assess the effectiveness of automated coding software, FaceReader, in analyzing the video clips. FaceReader is a fully automated facial recognition software capable of coding six basic emotions: happiness, sadness, surprise, fear, disgust, and anger (www.noldus.com/facereader).Videos for analysis were chosen consecutively and had to include recordings from both the parent and the adolescent. The protocol underwent enhancements and refinements to improve FaceReader's ability to detect and code facial expressions. Following each enhancement, the output from FaceReader was recorded to identify any improvements in the automated coding of emotions through facial expressions. Following several enhancements, a final methodological protocol was developed. **Figure 3** illustrates a timeline of the refinements made.

Video clips before the refinements had the following protocol (initial protocol): As in phase 1, videos were recorded using the Teencams with a yellow lapel badge and parent-adolescent pairs

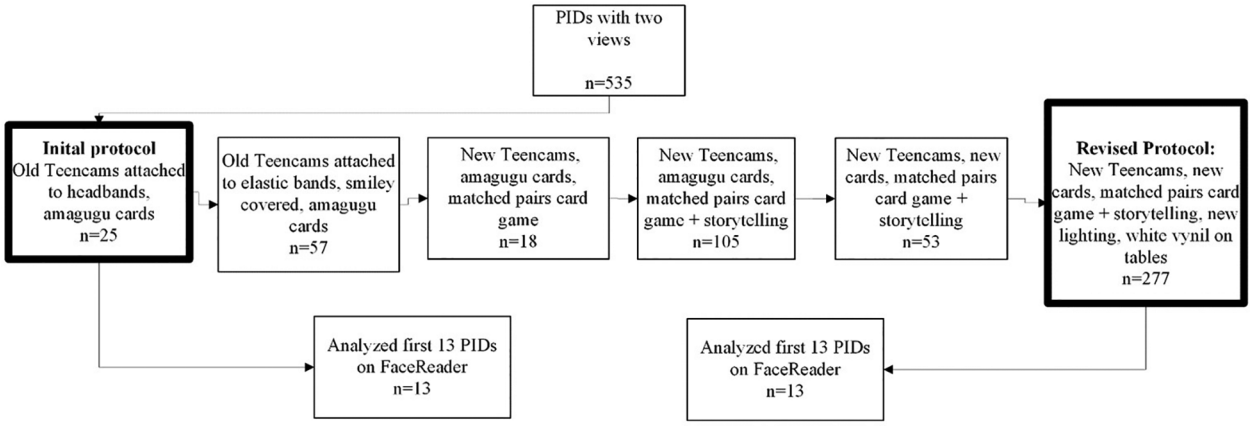

FIGURE 3
Timeline of improvements to improve video quality and FaceReader output.

played the Matching pairs card game using the Amagugu cards (n = 25). The Teencams would automatically split the video footage of the observation into 10-min video clips resulting in two video clips for each viewpoint. The lighting conditions of the assessment room contained a single fluorescent light in the middle of the room and windows on a single side that allowed for natural light to enter the room.

Refinements leading to the final revised protocol: It was found that the smiley faces on the Teencam were being coded, rather than the participant's face and the headband that the camera was attached to was obstructing the eyebrows, preventing FaceReader from detecting facial expressions. The cameras were then attached to a thin elastic band and the smiley faces on the Teencams were covered (n = 57) but this resulted in only marginal improvements. The limitations of movements and narrow-angle views would still cut out the participant's face.

Findings from the feasibility and acceptability phase of the study, as well as the codability of the videos, called for refinements and adjustments to the head cameras. New head cameras were used and had the following improvements: Head cameras were lightweight and attached to a thin and adjustable headband that did not obstruct the participants' eyebrows, allowing the detection of facial expressions. A blue light was visible to indicate when cameras were switched on and recording. Cameras included improved video resolution with a wide-angle view which is necessary for FaceReader to capture the facial expressions and muscles needed to code (180 degrees). One video clip for the entire observation from each viewpoint was also recorded. The cameras were grey and did not contain any facial features (n = 18) (see Figure 4).

To increase interaction and communication between the parent-adolescent pairs, the Matching pairs card game was further refined to make the cards more relatable and was called Teentalk. Teentalk consists of Matching card pairs designed by the researchers that consisted of eight cards with images displaying positive behaviours (peers playing and learning, positive parent-adolescent interactions and adolescents using technology) and seven cards with images displaying negative behaviours (adolescents using alcohol and tobacco, harsh parenting, bullying, adolescents looking depressed, teenage pregnancy). The Teentalk card game followed the same instructions as the Matching pairs card game. At the end of the game, participants were instructed to shuffle and distribute the cards equally amongst each other and then hold up a card from that pile and tell a story.

FIGURE 4
Parent view of improved video quality.

The lighting conditions were further improved by including more fluorescent lighting from the ceiling, white tables and open curtains to allow for natural light from the side of the room. These adjustments in the lighting illuminated the participant's face from nearly all angles and eliminated shadows as seen in Figure 4. Although individual booths were considered to minimize the background noise from other participants, there were spacing and lighting issues that also came up.

7.3. Participant exclusions and final sample

The primary aim of the BEACON cohort study is to investigate the relationship between conduct disorder and executive function (EF). A final analytic sample of n = 640 will provide >80% power (alpha 0.05) to detect a 6% difference (which is considered clinically relevant) in conduct disorders across equal size grouped binary or continuous EF composite scores, with power to detect correlations of 0.7 (medium effect size delta 0.05).

715 parent-adolescent pairs were enrolled in the BEACON study through RDS approaches. However, 129 pairs did not record videos due to technical difficulties and time constraints, 2 pairs recorded their videos in a different room due to construction sounds in the designated room. 40 pairs did not have the complete questionnaire data required by the BEACON study and 9 parent-adolescent pairs had recordings with either only the adolescent's view or the parent's view. The final sample of 535 parent-adolescent videos was achieved. The first 13 parent-adolescent pairs were selected from the group using the initial protocol and their FaceReader output was compared to the group employing the revised protocol (n = 13) as seen in Figure 3.

7.3.1. Participant characteristics

In total, there were 535 parent-adolescent pairs in this study as presented in Table 3. There was almost an equal gender distribution of adolescents but more mothers (93.46%) were enrolled compared to fathers. The average age of the adolescents was 11.88 years (SD = 0.59) and the average age of parents was 38.67 years (SD = 7.39). Most pairs identified themselves as African (98.69%). Only a quarter of parents were employed (24.67%) and half the parents reported to have obtained matric (senior school certificate) qualification.

7.4. Data analysis

This study used FaceReader version 9, issued by Noldus (www.noldus.com/facereader), to automatically analyse the video data of the observations. FaceReader automatically analyses the video every 0.033 s and produces an analysis on (1) whether the face was

TABLE 3 Participant characteristics of the BEACON participants.

	Adolescent		Parent	
	n	%/mean (SD)	*n*	%/mean (SD)
Age	535	11.88 (0.59)	535	38.67 (7.39)
Gender				
Male	257	48.04	35	6.54
Female	278	51.96	500	93.46
Race				
African			528	98.69
Coloured			7	1.31
Employed			132	24.67
Highest education level				
None			17	3.18
Primary school			124	23.22
Matric			265	49.63
Post-matric			59	11.05
Other			69	12.92

detected and analysed on any of the seven basic facial expressions (happy, sad, surprise, disgust, angry, fear, neutral) (2) the face was detected but could not be analysed or (3) no face was detected. The intensity of a facial expression detected was recorded on a scale between 0 (no intensity) to 1 (high intensity). FaceReader output was analysed by investigating the proportion of time that FaceReader could detect and code a face and the number of times FaceReader was able to code facial expressions. An independent samples *t*-test was used to detect significant differences in the software's ability to detect and code the faces between the initial and revised protocol group.

7.5. Results

The detection and codability significantly improved in the revised protocol (mean = 32.803; SE = 1,940) compared to the initial protocol (mean = 11.885; SE = 859), as indicated by a substantial increase. This difference was found to be highly significant: $t\,(24) = -9.86, p < 0.001$). Furthermore, the revised protocol demonstrated a significantly longer average duration of detection (mean = 18.22; SE = 1.1) compared to the initial protocol (mean = 6.6; SE = 0.48), with a similar level of statistical significance: $t\,(24) = -9.86, p < 0.001$.

8. Discussion

This study aimed to explore the acceptability and feasibility of using a video observational methodology to observe parent-adolescent communication and interaction using wearable headcams in an urban setting in South Africa. To our knowledge, no protocols have been developed for objectively measuring parent-adolescent interactions in urban South African settings. Little is known about how to code these data within the South African cultural and socio-economic context and how acceptable these observational methods may be for the parent or adolescent participants in this context.

This study found that the use of head cameras to capture parent-adolescent interactions was an acceptable and feasible method. This finding is in line with another study that recorded infant-mother interactions in the same context (22). The head cameras were able to successfully capture parent-adolescent communication and interaction, although there were some challenges with the technical operations of the head cameras. Studies using similar head cameras to capture mother-infant views also had challenges in turning the camera on and off and headcam placement (22, 23). While this study made improvements on the camera, the placement was still a challenge as indicated by the feedback received from parents. As found in a South African study recording infant-mother interactions, the placement and presence of the headcam still made some participants conscious of their behaviour, promoting socially desirable behaviours and suppressing inappropriate behaviours (22). However, in line with other studies using the headcam, the majority of the participants reported not being aware of the camera recording which increased their likelihood of natural behaviour (18, 22, 23). These findings show that although camera awareness was not eliminated, this method of capturing behaviour is still an improvement from having a researcher present in observing the interaction.

Literature on parent-child interaction has been examined in the context of mealtime (34–37), play-interactions (38), and parent-child conflict discussions (39). This study builds on existing literature by testing the feasibility of measuring parent-adolescent communication and interactions using game interactions. The feasibility of three different popular games (Matching pairs card game, Jenga, Charades) were tested while wearing head cameras to record video and audio of participant viewpoints while completing the game. This study found that the Matching pairs card game was able to elicit prosocial behaviour, competitiveness, problem solving, conflict resolution and communication skills while recording participant viewpoints. Similar to the literature that looks at parent-child interactions in the context of mealtime, the Matching pairs card game gave researchers an insight into the quality of the parent-child relationship that was stimulated over a game interaction. Therefore, studying dyadic game interactions offers an event to better understand parent-adolescent communication and interaction.

This study also further refined the Matching pairs card game to include custom-designed playing cards called "Teentalk". The "Teentalk" cards displayed images of risk (pregnancy, smoking, alcohol use, bullying, depression, harsh parenting), protective (friendship, green spaces, positive parenting) and digital (adolescents on electronic devices in different locations) behaviours. Parent-adolescent pairs used the "Teentalk" cards in a storytelling game, which gave insight into the way parents and adolescents talk about risk and protective behaviours while capturing video footage of their moods and emotion. According to the literature, there is a strong indication that open parent-child communication influences the reduction of risky behaviours among adolescents, such as substance use and abuse, delinquent behaviours and risky sexual behaviours (40, 41). Research conducted in South Africa is limited and has only focused on parent-adolescent communication in the context of its association with sexual risky behaviours and reproductive health (42) sexuality and HIV/AIDS (5, 43). This study offers in-depth rich contextual data on barriers and

protective factors in parent-child communication from the perspectives of both parents and adolescents. This could lead to a better understanding of how parent-adolescent relationships can be supported through effective communication and interaction to minimise adolescent risk and enhance resilience.

Finally, this study revealed that the utilization of an advanced coding software called FaceReader (https://www.noldus.com/facereader) was able to automate the coding process of facial expressions. The coding software however requires very specific conditions: participants' faces need to be in view with eyebrows visible, no faces in the background only the participant should be visible, movement should be limited and the environment should be well-lit. While this coding software was able to successfully detect facial expressions of both parents and adolescents there were instances where faces could not be detected due to adolescents looking away during conversation or hand gestures blocking the view of the face. These behaviours that could not be detected by FaceReader may still be important, especially with adolescents. The looking away may be an indication of respect, especially from the adolescents since in the African culture or tradition, maintaining eye contact for too long with adults may be seen as disrespectful (44), and the hand gestures may signify boredom. Here it may be still valuable for researchers to manually code these instances possibly using micro-coding tools as presented in these studies (18, 23). Nonetheless, this coding software has the potential to still strengthen methodological approaches in contexts like South Africa, with fewer resources and less time needed to collect and score objective data.

A limitation of the study includes observations taking place in a "controlled" environment with a researcher facilitating the process, although the researcher left the room for interactions to occur and only came back at the end of the recording time to switch off the cameras. It is recommended that future researchers consider having their pairs take the Teencams home to record their interactions in the home environment and to measure parent-adolescent communication and interaction in a natural setting. Our objective was to gather feedback on the acceptability of the Teencam methodology by conducting interviews with both adolescents and parents during workshop three. However, due to time constraints and the adolescents' fatigue from completing other assessments as part of the BEACON study, the researcher made the decision to interview only the parent participants. Future studies should consider gaining adolescent perspectives as well.

9. Conclusion

This study showed that using Teencam video observational methodology to measure parent-adolescent communication and interactions is acceptable and feasible in Soweto, South Africa. The unique contribution of this research lies in its potential to lead to improved methodologies for measuring parent-adolescent communication and interactions. In time, this pilot study could lead to innovations in our understanding of how to support parenting practices and adolescent development in high-risk contexts. Particular observational protocols however do need to be adapted for the software to successfully detect the faces and code the facial expressions and emotional cues. These include room and lighting conditions, eye contact, movement and the quality of the device. Important gestures that could not be detected by the software could be micro-coded by the researcher using available software.

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 humans were approved by Ethics Committee in the Health Sciences Faculty at the University of the Witwatersrand (protocol number: M190801). The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation in this study was provided by the participants' biological parents who were also their primary caregivers.

Author contributions

All authors contributed to the article and approved the submitted version.

Funding

This project is funded by a Wellcome Trust Intermediate Fellowship in Public Health and Tropical Medicine (award number 211374/Z/18/Z) and the Centre of Excellence in Human Development in contributing towards the setup of the Mzansi Teen lab, which was an adolescent friendly observational space used in this study.

Acknowledgments

We thank the participants, data collectors, and translators for their participation and assistance in the project.

Conflict of interest

The reviewer LM declared a past collaboration and past co-authorship with the author RD to the handling editor. The author TR declared that they were an editorial board member of Frontiers at the time of submission. This had no impact on the peer review process and the final decision.

The remaining 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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frontiers | Frontiers in Child and Adolescent Psychiatry

TYPE Original Research
PUBLISHED 07 September 2023
DOI 10.3389/frcha.2023.1176560

OPEN ACCESS

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RECEIVED 28 February 2023
ACCEPTED 21 August 2023
PUBLISHED 07 September 2023

CITATION
Krijnen LJG, Verhoeven M and van Baar AL (2023) Observing mother-child interaction in a free-play vs. a structured task context and its relationship with preterm and term born toddlers' psychosocial outcomes.
Front. Child Adolesc. Psychiatry 2:1176560.
doi: 10.3389/frcha.2023.1176560

Observing mother-child interaction in a free-play vs. a structured task context and its relationship with preterm and term born toddlers' psychosocial outcomes

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Introduction: High quality of mother-child interaction is associated with better psychosocial outcomes in children. However, this association might depend on the context in which mother-child interaction is observed as well as specific child characteristics. In this study, we examine differences in the assessment of mother-child interaction in a free-play and a structured task context. In addition, it will be investigated whether the behaviors per context are differently associated with preterm vs. term born toddlers' psychosocial outcomes.
Methods: A total of 201 Dutch mother-child dyads participated in the study, of whom 108 children were moderate to late preterm (MLP) and 93 were born at term. Mother-child interaction was observed in a free-play and a structured task context when the child was 18 months of (corrected) age. Six subscales of mother-child interaction were assessed using the Coding Interactive Behavior scheme: maternal stimulation, maternal warmth, child's negative affect, active mother and child engagement, dyadic synchrony and tense interaction. Psychosocial outcomes were assessed at 24 months of (corrected) age using the Ages and Stages Questionnaire – Social Emotional and the Child Behavior Checklist.
Results: Mother-child interaction was reliably assessed ($\alpha > .60$) in each context, except for tense interaction during free-play ($\alpha = .41$) and child's negative affect when averaged across contexts ($\alpha = 0.55$). Compared to the free-play context, during the structured task, more child's negative affect, tense interaction and active mother and child engagement was observed in MLP and term born children, and less dyadic synchrony in MLP children (p's $< .01$). Only during a structured task and for term born children, active mother and child engagement was related to less social-emotional difficulties, internalizing and externalizing behaviors. Only during free-play and for MLP children, active mother and child engagement was related to less externalizing behaviors. Dyadic synchrony during a structured task was associated with less social-emotional difficulties in MLP and term born children, and dyadic synchrony during free-play was only associated with less social-emotional difficulties in term born children (all p's $< .05$).

Discussion: Most mother-child interactive behaviors can be reliably assessed in both contexts. The structured task context elicited more varied behaviors than the free-play context. With the observations in the structured task context, more associations with children's psychosocial outcomes were found than with the observations in the free-play context. Mother-child interactions characterized by active, engaged and synchronous behaviors were associated with better psychosocial outcomes in toddlers, with some differences observed for MLP vs. term born children and for the free-play vs. the structured task context. Suggestions for future research as well as clinical practice are provided.

KEYWORDS

observational context, mother-child interaction, psychosocial outcomes, structured task, free-play, moderate to late preterm, social-emotional, internalizing and externalizing behaviors

1. Introduction

According to the ecological system theory of Bronfenbrenner, child development is partially shaped by its environment (1). The interaction between mother and child is one of the core aspects of a child's direct environment, in particular during the first years of life. A high quality of mother-child interaction – characterized by fluent, warm and reciprocal interactions – has found to be associated with positive psychosocial outcomes, such as better social-emotional skills, and less internalizing and externalizing problems in the children (2–5). Mother-child interaction is usually assessed in a free-play and/or a structured task context, which may affect the behaviors mothers and children show during the observation (6, 7). Moreover, associations between interactive behaviors and children's psychosocial outcomes may depend on the context (8, 9) and on whether the child is at risk for psychosocial problems, like preterm born children (2, 10).

Some studies use both contexts to observe mother-child interaction (e.g. 8, 11), whereas other studies choose one or the other context (e.g. 2, 12). In a free-play context, mother and child can play together in their own preferred way, often freely choosing out of a selection of toys, whereas in a structured task context, mother and child are instructed to work on a specific task together (e.g., making a puzzle). The context in which mother-child interaction is observed can lead to different conclusions about the quality of the interaction and its association with children's psychosocial outcomes due to the different types of behaviors that may be elicited. It is therefore important to gain more knowledge regarding the role of context in observing mother-child interactions and its relationship with children's psychosocial outcomes.

Several studies on mothers and their 0–5 years old children have compared behaviors between the two contexts. The most consistent finding is that mothers were more intrusive in structured task contexts than in free-play contexts (6, 7, 13, 14). Another relatively consistent finding is more positive behaviors, e.g., engagement, positive affect, sensitivity and responsiveness, during free-play compared to structured task contexts in parents (6, 11, 13, 14) and children (6, 7, 14). However, findings of a study by Volling et al. (2002) slightly differ from this: like previous studies, they found that children (12 months) showed more positive behavior during the free-play context, but the mothers of these children in contrast showed more positive behavior during the structured task. For older children (5–12 years old), Dittrich et al. (2017) found higher levels of positive behaviors in children and their mothers during a structured task and speculate that more supportive and responsive behaviors of mothers and children is elicited by setting a mutual goal – in this case making a puzzle – which may induce "positive stress" and thereby increases functional behaviors. However, their finding might be an age-specific result considering the older age range in the study of Dittrich et al. (2017) and the contradiction with other studies in younger children. Even though findings of previous studies slightly differ, there seems to be consensus that the behaviors observed are dependent on the observational context.

The observational context seems to affect the associations between mother-child interaction and children's outcomes. Focusing on maternal behaviors only, Nordahl et al. (2020) found that parenting quality during the semi-structured task context – i.e., shape sorting blocks and making a puzzle – was more predictive for children's outcomes than parenting quality during the free-play context. Even though parenting quality was not compared between both contexts, the results indicate that the semi-structured task context elicits more meaningful maternal behaviors in predicting children's outcomes. Potentially, certain behaviors are more elicited under certain circumstances, e.g., structured task, and are therefore found to be related to children's outcomes. Dittrich et al. (2017) did compare mother-child interactive behaviors between the contexts and found that children's responsiveness was higher in a structured task context, and more importantly, only within this structured context more child responsiveness was associated with less parent-reported externalizing problems. However, Dittrich et al. (2017) also found evidence that it is not necessarily the extent to which behaviors are shown that matter. Rather, the circumstances in which the behavior is shown are important. To illustrate, maternal emotional availability was higher during the structured task, but the relationship between maternal emotional availability and children's problem behavior was significantly stronger for the free-play context than the structured task context. This indicates that the seemingly same behavior, e.g., maternal

emotional availability, may be more important to be present under certain circumstances, e.g., free-play, than in other circumstances, e.g., structured task. However, it is unclear why this is the case and more research is needed to confirm these findings and identify reasons for this effect (8).

Not only the context but also child characteristics, such as preterm birth, may play an important role in the association between mother-child interaction and children's psychosocial outcomes. Krijnen et al. (2022) – who used the same sample as the current study – found that certain mother-child interactive behaviors – i.e., mother-led interaction, reciprocal engagement – were positively related with children's psychosocial outcomes when children were born at term, but not when children were born moderately to late preterm [MLP, 32–37 weeks gestational age (GA)]. So, it seems that only for term born children, but not for MLP children, certain interactive behaviors were related to better psychosocial outcomes. Krijnen et al. (2022) used a structured task context but there is evidence that results are different for a free-play context in a sample of very preterm born children (<33 weeks of GA). Gueron-Sela et al. (2015) observed both parents with their 6 month old infant in a free-play context and reported different results: When the quality of parent-child interaction was high and parental stress was low, preterm children outperformed their term born peers with respect to their social competences at 12 months of age. If the circumstances were reversed, i.e., high stress and low quality of interaction, preterm children had worse social competences than their term born counterparts (10). Landry and colleagues (15) found similar results: If parents were responsive to their child in the first year of life – as observed during free-play and daily activities, e.g., bathing – preterm children showed more growth in terms of their social and emotional competences than term born children. Based on these studies, it seems that the association between mother-child interaction and children's psychosocial outcomes may differ for children born preterm vs. at term, and that inconsistencies in findings might result from observations in different contexts.

The existing body of literature indicates that the relationship between mother-child interaction behaviors and psychosocial outcomes depend on 1) the observational context in which interactions are observed, and 2) the birth status of the child. However, no direct comparisons between a free-play and a structured task context in relation to MLP and term born toddlers' psychosocial outcomes have been made yet. The current study explores which interactive behaviors within a free-play and within a structured task context are associated with psychosocial outcomes in MLP and term born toddlers. To capture a broad picture of the child's psychosocial outcomes, three psychosocial outcome measures will be assessed: social-emotional difficulties, internalizing behaviors and externalizing behaviors. Three objectives will be addressed, with the first one being the basic evaluation of whether both observational contexts are suited to reliably assess mother-child interaction. Subsequently, interactive behaviors will be compared between observational contexts and between MLP and term born children. It is hypothesized that during the free-play context more positive behaviors – e.g., positive affect, engaged behaviors – are shown compared to the structured task context. Third, for each context will be explored whether mother-child interaction behaviors at 18 months (corrected) age are associated with psychosocial outcomes at 24 months (corrected) age and if these relationships are significantly different for MLP and term born children. No hypothesis was formulated due to the limited research on examining the role of observational context in predicting psychosocial outcomes for MLP vs. term born children and the current research is therefore of exploratory nature. With the current study, more knowledge will be obtained regarding the role of the observational context in assessing mother-child interaction and its relationship with children's psychosocial outcomes. Hence, recommendations can be provided for both researchers and clinicians about the preferred context for observing mother-child interaction, based on their specific goals (e.g., elicit certain behaviors, predict psychosocial outcomes in term born or preterm born children). Furthermore, insight will be gained in which interactive behaviors in which context are associated with better psychosocial outcomes in preterm vs. term born children.

2. Methods

2.1. Participants

The current study forms part of a larger Dutch project called Study on Attention of Preterm children (STAP) in which MLP and term born children were longitudinally assessed. Children were recruited by midwives and pediatricians from nine hospitals around Utrecht, the Netherlands, at 10 months of age, between March 2010 and April 2011. Exclusion criteria were admission to a tertiary Neonatal Intensive Care Unit (NICU), severe congenital malformations, multiple births, dysmaturity – i.e., a birthweight below the 10th percentile of the weight expected for infants' gestational age using Dutch reference curves (16) - , maternal antenatal substance abuse or chronic antenatal use of psychiatric drugs. Both parents, or one parent in the case of single parent families, had to sign an informed consent in order to participate in the study.

Initially, the sample consisted of 226 participants. Participants were included for the current study if 1) mother-child interaction was observed at 18 months of (corrected) age, and 2) at least one of the three psychosocial outcomes measures was completed at 24 months of (corrected) age. This led to a final sample of 201 participants, of whom 108 MLP and 93 term born children. See **Table 1** for the characteristics of the participants.

2.2. Procedure

The STAP study has been approved by the Utrecht Medical Center Ethics Committee (identification code NL34143.041.10). Mother and child were invited for a lab visit at Utrecht University when the child was 18 months of (corrected) age. Appointments were scheduled in such a way that the child's

TABLE 1 Participant characteristics per group of birth status.

	MLP ($n = 108$)	Term ($n = 93$)
Gender		
Male (n, %)	63 (58.33%)*	41 (44.09%)
Female (n, %)	45 (41.67%)*	52 (55.91%)
Corrected age in months, wave 1		
Mean (SD)	17.22 (0.44)	17.31 (0.47)
Range	17–19	17–18
Corrected age in months, wave 2		
Mean (SD)	23.32 (0.54)	23.59 (0.63)
Range	23–25	23–26
Ethnicity		
Dutch (n, %)	104 (96.30%)	89 (96.30%)
Gestational age		
Mean (SD)	34.69 (1.34)***	39.47 (0.98)
Range	32–36	37–41
Birth weight in grams,		
Mean (SD)	2,584.77 (502.21)***	3,576.39 (460.71)
Range	1,420–3,850	2,795–5,330
Education level mother[a]		
Low, n (%)	7 (6.48%)	2 (2.15%)
Medium, n (%)	36 (33.33%)***	10 (10.75%)
High, n (%)	65 (60.19%)***	81 (87.10%)

MLP, Moderate to late prematurely born children; SD, Standard Deviation. To test for group differences, independent samples t-tests and Fisher's exact tests were used.
[a]Low = no education, elementary school, special education, lower general secondary education; Medium = secondary or vocational education; High = college, university or higher.
*$p < .05$.
**$p < .01$.
***$p < .001$.

sleeping routine was not disrupted. First, the procedure was explained and then the children's attention capacities were assessed using the Utrecht Tasks of Attention in Toddlers using Eye tracking [UTATE; see (17) for more information] (18 min), which was not used for the current study. After this, mother-child interaction was observed (15 min). Mother-child interaction was observed in two contexts: free-play (5 min) and structured tasks (2×5 min). Observations were done in a standardized room, with on one side a play mat with toys, and on the other side a chair and table with a book and a puzzle. Mother-child observations were piloted prior to the data collection to ensure feasibility of the assessment. Free-play was chosen to observe first as this context is a relatively stress-free condition allowing mother and child to adjust to the setting. In the free-play context, the mother was instructed to play with her child as she would normally do at home. Mother and child were sitting on the play mat on the floor, surrounded by a selection of age-appropriate toys (i.e., shape sorter, building blocks, and a pop-up toy). After five minutes, the mother was asked to read a 100-pictures book to her child. Five minutes later, the mother was asked to make a wooden insert puzzle consisting of 11 animal pieces with her child. Both the book and puzzle were selected based on the zone of proximal development for 18 months old children, to ensure the tasks were challenging but not to such an extent that it would cause frustration for the child. After the observation, children received a small present and travel costs were refunded.

All observations were videotaped and coded afterwards for each context separately, resulting in two scores for each rated behavior: one for free-play and one for the structured task context. Two different raters scored the behaviors of the mother-child dyad: one rater scored maternal behaviors and another rater scored child and dyadic behaviors. Raters consisted of students that were trained by our prime trainer, who was qualified as a certified trainer by the developers of the coding scheme that was used (Coding Interactive Behavior scheme; CIB; Feldman, 1998). Following the same procedure as the certified training of Feldman, students had to code practice videos and one final, "golden-standard", video to assess their reliability. If their scoring was not yet reliable, additional training sessions were provided. When their scoring was reliable, the students started with coding the videos of the current study. As students were instructed to first watch the complete video of a mother-child dyad, and then score a maximum of five behaviors, they had to watch the video multiple times in order to rate all the behaviors. The inter-rater reliability was good, based on 21% double coded videos (ICC = 0.76).

At 24 months of (corrected) age, mothers filled out paper and pencil questionnaires regarding the psychosocial functioning of the child.

2.3. Materials

2.3.1. Mother-child interaction – 18 months

Mother-child interaction was scored using the Coding Interactive Behavior scheme (CIB; 18). The CIB assesses mother-child interaction of children aged 2–36 months by scoring behaviors of the parent (21 items; e.g., supportive presence), the child (16 items; e.g., positive affect), and their dyadic interaction (5 items; e.g., fluency of their interaction). Each behavior can be scored on a 5-point Likert scale, ranging from 1 (minimal level of the specific behavior) to 5 (maximal level). The CIB is a globally used tool, that has been well-validated and shows good psychometric properties (18).

The CIB does not have predetermined subscales and, as according to Feldman (19), it depends on the children's age and the cultural background which behaviors fit best in which subscales. Studies therefore created subscales for their own sample. Previous studies used factor analyses to form subscales for the CIB (2, 12, 19), whereas other studies did not describe the method used to form subscales (20–23). For the current study, we carried out an exploratory factor analysis to create subscales that best represented the mother-child interaction behaviors observed in the current sample. To find a factor structure that fitted both contexts and both groups of birth status, the factor analysis was run across contexts and for the total sample. Therefore, before the factor analysis was run, the interactive behaviors were averaged over the contexts and across the groups. Prior to the factor analysis, as a first step, correlations among the behaviors were calculated as Field and

TABLE 2 The definition of the subscales of mother-child interaction and the factor loadings on the subscale.

Subscale	Behaviors (factor loadings)
1. Maternal stimulation	Maternal on-task persistence (.91), maternal resourcefulness (.82), maternal limit setting (.72), maternal elaboration (.70)
2. Maternal warmth	Maternal supportive presence (.84), maternal positive affect (.85), maternal acknowledgement (.69), maternal appropriate variation in affect (.51), maternal negative affect (reversed) (-.48), maternal vocal clarity (.38)
3. Child's negative affect	Child's negative emotionality (.97), child's positive affect (reversed) (-.73), child's labile affect (.69)
4. Dyadic synchrony	Dyadic reciprocity (.78), dyadic adaptation-regulation (.76), dyadic fluency (.38)
5. Active mother and child engagement	Child's reliance on parent for help (.82), child's affection to parent (.80), child's joint attention (.55), child's initiation (.46), mother-led interaction (.35), maternal intrusiveness (.32)
6. Tense interaction	Dyadic tension (.67), dyadic constriction (.53), child's avoidance of parent (.47)

colleagues (24) recommend to remove variables showing correlations that are too high (>.80) or too low (<.30). As a second step, KMO and Bartlett's test were calculated to check whether the data and the correlations among the variables were suited for performing an exploratory factor analysis, which was the case (KMO; overall MSA = 0.76, Bartlett's test $p < .001$). Hence, the number of factors was explored based on eigenvalues, scree test and parallel analysis, indicating that a 5 or 6 factor solution suited the data in our study best. Exploratory factor analyses were carried out for the 5 and 6 factor solution, using an oblique rotation method (i.e., oblimin), allowing factors to correlate. Fit indices of both models, i.e., the 5 and 6 factor models, were compared. In addition, the content of the factors was evaluated to determine whether the factors made theoretical sense. Based on these criteria, i.e., the fit indices and the content of the factors, the 6 factor solution was selected (Fit based upon diagonal values = 0.96, RMSEA = 0.07, TLI = 0.81, RMSR = 0.04, SRMR = 0.06). The behaviors included in each factor and the factor loadings can be found in **Table 2**. All correlations between the factors were small (i.e., between .01 and .29), except for one correlation – between tense interaction and child's negative affect – that was of moderate strength, i.e., .44. This indicates that the factors represent separate aspects of mother-child interaction.

Instead of factor scores, mean scores were used for the analyses. Therefore, we use the term "subscales" instead of "factors" to refer to the types of mother-child interaction. Mean scores were used instead of factor scores for two reasons: 1) factor scores were based on the interactive behaviors across contexts whereas we needed scores per context, 2) using mean scores allows other researchers that have a comparable sample to replicate our results whereas factor scores are dependent on the sample. Mean scores for the subscales were calculated per context of free-play and structured task, by summing the scores of the behaviors and dividing these by the number of scored behaviors. Mean scores could range between 1 and 5, with higher scores showing the behaviors of the subscale more clearly.

2.3.2. Social-emotional difficulties – 24 months

The Ages and Stages Questionnaire – Social Emotional (ASQ-SE; 25) was used to assess social-emotional difficulties at 24 months of (corrected) age. The ASQ-SE measures social-emotional competencies as well as difficulties, by assessing the following dimensions: interaction with people, self-regulation, social-communication, autonomy, adaptive functioning, affect, and compliance. The 24 months age version of the ASQ-SE was used for the current study, which consists of 26 scored items (e.g., "Does your child cry, scream or have tantrums for longer periods of time?" or "Does your child like to be hugged or cuddled?"). Mothers answered whether the child showed the described behavior "most of the time" (0 points), "sometimes" (5 points), and "rarely/never" (10 points). In addition to these 3 answer options, parents could express concerns about the child's behavior for every item, leading to an additional 5 points. Sum scores were calculated, with a higher score reflecting more social-emotional difficulties. Internal consistency of the 24 months version has shown to be good, $\alpha = .80$ (26). The Dutch version of the ASQ-SE shows adequate specificity (27, 28) and acceptable (28) to slightly insufficient sensitivity (27).

2.3.3. Internalizing and externalizing behavior – 24 months

The Child Behavior Checklist 1½-5 (CBCL; 29) was used to assess internalizing and externalizing behavior. The CBCL is a parent-report questionnaire aiming to assess the child's problem behavior over the past 2 months. The two broadband scales of internalizing and externalizing behavior were used for the current study. The internalizing domain consists of 36 items measuring emotionally reactive behavior ("shows panic for no good reason"), anxious/depressed moods ("too fearful or anxious"), somatic complaints ("nausea, feels sick without medical cause"), and withdrawn behavior ("seems unresponsive to affection"). The externalizing domain consists of 24 items measuring attention problems ("can"t sit still, restless, or hyperactive"), and aggressive behavior ("hits others"). Answer options were "0 = not true", "1 = somewhat or sometimes true" and "2 = very true of often true". Sum scores were calculated by adding the answers of the items and standardized T scores were used. Higher scores indicated more internalizing and externalizing behaviors. Validity and reliability of the CBCL 1.5–5 have proven to be good (29). Internal consistency was good for both the internalizing scale ($\alpha = .89$) and the externalizing scale ($\alpha = .92$) (30).

2.4. Statistical analyses

R version 4.0.3 and SPSS Statistics version 28.0.1.1 were used to analyze the data. First, analyses were executed to investigate the internal consistency of the mother-child interaction subscales

that resulted from the exploratory factor analysis. Cronbach's alpha was calculated for each subscale per context and across contexts and values of α above .60 were considered to be sufficient (31). Secondly, mother-child interaction subscales were compared between the free-play and the structured task context per MLP and term born group, and each context was compared between the MLP and term born group, with a repeated measures MANOVA using SPSS. Context was added as a within-subject factor, with two levels (1 = free-play and 2 = structured task). Each mother-child interaction subscale was added as a within-subjects variable per context, resulting in 6 within-subject variables with 2 levels each. Group (0 = term, 1 = MLP) was added as a between-subjects factor. Child's gender (0 = male, 1 = female) and maternal educational level (three dummy variables – i.e., high, medium, low – with low education as the reference category) were added as covariates. Low educational level referred to no education, elementary school, special education, lower general secondary education. Medium educational level referred to secondary or vocational education, and high educational level referred to college, university or higher. Bonferroni correction for multiple testing was applied. Third, multiple regression analyses were run in R to investigate whether mother-child interaction predicted children's psychosocial outcomes – i.e., social-emotional difficulties, internalizing and externalizing behavior. Regression analyses were run separately for the free-play and the structured task context, per outcome measure of psychosocial outcomes, resulting in 2*3 = 6 models. All six mother-child interaction subscales were added as independent variables and were centered prior to the analyses. Group (0 = term born, 1 = MLP born) was added as a dichotomous moderator to investigate whether the relationship between mother-child interaction and children's psychosocial outcomes differed for MLP and term born children. Child's gender and maternal educational level were added as covariates using the same coding as for the repeated measures MANOVA.

3. Results

3.1. Reliability of the mother-child interaction subscales

Reliability analyses were performed to calculate the Cronbach's alpha for every subscale of mother-child interaction per context and across contexts (See Table 3). All reliability coefficients were acceptable to good (α > .60), except for tense interaction during free-play (α = .41) and child's negative affect across contexts (α = .55).

3.2. Mother-child interaction and psychosocial outcome measures

In Table 4, scores on the mother-child interaction subscales are shown per context (i.e., free-play and structured task), per group (i.e., MLP and term). Psychosocial outcome measures are shown per group.

TABLE 3 Internal consistency of the mother-child interaction subscales.

Subscale	Cronbach's alpha		
	Across contexts	Free-play	Structured task
1. Maternal stimulation	.87	.83	.81
2. Maternal warmth	.75	.75	.75
3. Child's negative affect	.55	.76	.88
4. Dyadic synchrony	.75	.62	.81
5. Active mother & child engagement	.71	.65	.64
6. Tense interaction	.76	.41	.82

Results of the repeated measures MANOVA revealed differences in mother-child interaction subscales between the free-play and structured task context (see Table 4): Three out of the six mother-child interaction subscales were observed significantly more during the structured tasks than during free-play within both the MLP and the term born group: child's negative affect, active mother and child engagement and tense interaction. In the MLP group, dyadic synchrony was lower during the structured task than during free-play. During free-play, scores on child's negative affect and tense interaction were low, i.e., close to 1, and these variables showed the lowest standard deviation of all the subscales (SD ranging from 0.17 to 0.27), indicating little variation in the scores.

When comparing the MLP and term born group on the mother-child interaction subscales per context, no differences between groups were found.

The current sample scored on average 16.88 ($SD = 12.25$) on social-emotional problems at the ASQ-SE, with scores ranging from 0 to 65. On average, children scored 43.08 ($SD = 8.69$) on internalizing behaviors and 47.87 ($SD = 8.39$) on externalizing behaviors of the CBCL with scores ranging from 28 to 71. The MLP group showed significantly more internalizing behaviors than the term born group [$t(194.9) = -3.03$, $p = .003$]. See Table 4 for scores on the psychosocial outcomes per MLP and term born group.

3.3. Regression results of mother-child interaction subscales on psychosocial outcomes

Results of the regression analyses are presented per observational context of free-play and structured task. Per observational context, three separate regression analyses were run per psychosocial outcome measure, i.e., social-emotional difficulties, internalizing and externalizing behaviors. Tables 5, 6 display the results of the three regression analyses for the free-play context and the three regression analyses for the structured task context respectively.

3.3.1. Free-play context

The total model of the free-play context explained 12% of the variance in social-emotional difficulties [$R^2 = .12$, $F(16, 183) = 1.57$, $p = .08$], 9% of the variance in internalizing behaviors [$R^2 = 0.09$, $F(16, 181) = 1.09$, $p = .37$] and 9% of the variance in externalizing

TABLE 4 Scores on the mother-child interaction subscales per observational context and per MLP and term born group, and the psychosocial outcome scores.

	MLP ($n = 108$)		Term ($n = 93$)	
	Free-play	Structured task	Free-play	Structured task
Mother-child interaction				
Maternal stimulation				
M(SD)	3.72 (0.89)	3.71 (0.84)	3.86 (0.83)	3.88 (0.79)
Range	1.75–5.00	1.50–5.00	2.00–5.00	2.00–5.00
Maternal warmth				
M(SD)	4.77 (0.35)	4.79 (0.35)	4.80 (0.38)	4.83 (0.36)
Range	3.50–5.00	3.17–5.00	3.33–5.00	3.33–5.00
Childs' negative affect	***		***	
M(SD)	1.10 (0.27)	1.34 (0.58)	1.06 (0.25)	1.35 (0.63)
Range	1.00–2.33	1.00–3. 67	1.00–2.33	1.00–4.33
Dyadic synchrony	***			
M(SD)	4.24 (0.68)	3.99 (0.84)	4.23 (0.67)	4.19 (0.74)
Range	2.33–5.00	2.00–5.00	2.66–5.00	1.67–5.00
Active mother and child engagement	***		***	
M(SD)	2.28 (0.63)	2.67 (0.64)	2.31 (0.54)	2.83 (0.63)
Range	1.00–3.67	1.17–4.33	1.17–3.33	1.50–4.25
Tense interaction	***		***	
M(SD)	1.07 (0.22)	1.28 (0.58)	1.05 (0.17)	1.22 (0.45)
Range	1.00–2.33	1.00–3.67	1.00–2.00	1.00–3.33
Psychosocial outcomes				
Social-emotional difficulties[a], M(SD)	18.17 (11.99)		15.39 (12.45)	
Internalizing behavior[b], M(SD)	44.76 (8.85)		41.10 (8.11)**	
Externalizing behavior[b], M(SD)	48.87 (7.96)		46.69 (8.76)	

MLP, Moderate to late preterm; M, mean score; SD, Standard Deviation.
[a]Data of one MLP child was missing.
[b]Data of one MLP and two term born children were missing.
*$p < .05$.
**$p < .01$.
***$p < .001$.

behaviors [$R^2 = 0.09$, $F(16, 181) = 1.15$, $p = .31$]. Even though the models did not significantly explain variance in the psychosocial outcome measures, significant relationships within the models were found.

Regarding the covariates, a high educational level vs. a low educational level, significantly predicted less social-emotional difficulties [$b = -10.35$, $t(183) = -2.39$, $p = .02$]. MLP children showed significantly more internalizing behaviors than term born children, [$b = 3.19$, $t(181) = 2.41$, $p = .02$].

Regarding the mother-child interaction subscales: Higher levels of dyadic synchrony during free-play significantly predicted less social-emotional difficulties in term born children [$b = -4.55$, $t(183) = -2.24$, $p = .03$], but not in MLP children [$b = 1.85$, $t(183) = 0.97$, $p = .34$]. These relationships were significantly different from one another, as shown by the significant moderation effect of group [$b = 6.40$, $t(183) = 2.30$, $p = .03$]. See Figure 1 for a visual representation of the interaction effect. Furthermore, active mother and child engagement during free-play was related to less externalizing behaviors in the MLP group [$b = -2,97$, $t(181) = -2.21$, $p = .03$], but not in the term born group [$b = -2,65$, $t(181) = -1.57$, $p = .12$]. Nevertheless, birth status did not moderate the association between active mother and child engagement and externalizing behaviors, indicating that the relationships found within the groups were not significantly different between the groups.

3.3.2. Structured task context

The total model of the structured task context explained 19% of the variance for social-emotional difficulties [$R^2 = .19$, $F(16, 183) = 2.67$, $p < .001$], 12% for internalizing behaviors [$R^2 = 0.12$, $F(16, 181) = 1.51$, $p = .10$] and 9% for externalizing behaviors [$R^2 = 0.09$, $F(16, 181) = 1.16$, $p = .30$]. The total model of social-emotional difficulties was significant, but the models for internalizing and externalizing behaviors were not. However, significant relationships within all the models were found.

Regarding the covariates, maternal higher educational level compared to a low educational level, significantly predicted less social-emotional problems, [$b = -10.44$, $t(183) = -2.50$, $p = .01$]. MLP children had significantly more internalizing behaviors [$b = 3.00$, $t(181) = 2.28$, $p = .02$].

TABLE 5 Results of the regression analyses of mother-child behavior observed in the free-play context, per psychosocial outcome measure.

Free-play context	Social emotional difficulties[a]		Internalizing behavior[b]		Externalizing behavior[b]	
	b(*SE*)	*t*	*b*(*SE*)	*t*	*b*(*SE*)	*t*
Intercept	25.84 (4.64)***	5.58	39.16 (3.36)***	11.67	48.97 (3.23)-	15.16
Covariates						
Child's gender	−1.65 (1.79)	−0.92	0.48 (1.30)	0.37	0.75 (1.25)	0.60
Education medium	−4.32 (4.52)	−0.96	3.84 (3.28)	1.17	−0.22 (3.16)	−0.07
Education High	**−10.35 (4.33)***	−2.39	1.48 (3.13)	0.47	−2.85 (3.01)	−0.95
Group	0.59 (1.82)	0.31	**3.19 (1.33)***	2.41	1.29 (1.28)	1.01
Mother-child-interaction						
Maternal warmth	2.12 (3.49)	0.61	−0.98 (2.54)	−0.39	1.41 (2.45)	0.58
Maternal stimulation	−0.70 (1.57)	−0.45	0.22 (1.15)	0.19	−0.54 (1.10)	−0.49
Child's negative affect	5.42 (5.42)	1.00	1.16 (3.92)	0.30	3.61 (3.78)	0.96
Dyadic synchrony	**−4.55 (2.03)***	−2.24	−0.33 (1.49)	−0.22	−0.56 (1.43)	−0.39
Active mother and child engagement	0.16 (2.42)	0.07	−1.77 (1.75)	−1.01	−2.65 (1.68)	−1.57
Tense interaction	−2.82 (8.01)	−0.35	−3.12 (5.80)	−0.54	3.03 (5.58)	0.54
Moderation effects						
Maternal warmth*Group	−0.46 (4.87)	−0.09	−1.20 (3.53)	−0.34	−0.89 (3.40)	−0.26
Maternal stimulation*Group	−1.11 (2.08)	−0.54	−0.11 (1.51)	−0.07	−0.18 (1.46)	−0.12
Child's negative affect*Group	−4.72 (7.15)	−0.66	0.38 (5.17)	0.07	−2.49 (4.98)	−0.50
Dyadic synchrony*Group	**6.40 (2.79)***	2.30	1.76 (2.03)	0.87	2.07 (1.95)	1.06
Active mother and child engagement*Group	−0.98 (3.08)	−0.32	1.31 (2.23)	0.59	−0.33 (2.14)	−0.15
Tense interaction*Group	−3.07 (9.88)	−0.31	−1.46 (7.14)	−0.20	−7.71 (6.88)	−1.12
R2	0.12		0.09		0.09	
F	1.57		1.09		1.15	
Conditional effect of Maternal warmth						
Term	2.12 (3.49)	0.61	−0.98 (2.54)	−0.39	1.41 (2.45)	0.58
MLP	1.67 (3.39)	0.49	−2.19 (2.45)	−0.89	0.52 (2.36)	0.22
Conditional effect of Maternal stimulation						
Term	−0.70 (1.57)	−0.45	0.22 (1.15)	0.19	−0.54 (1.10)	−0.49
MLP	−1.81 (1.37)	−1.32	0.10 (0.99)	0.11	−0.72 (0.96)	−0.75
Conditional effect of Child's negative affect						
Term	5.42 (5.42)	1.00	1.16 (3.92)	0.30	3.61 (3.78)	0.96
MLP	0.70 (4.60)	0.15	1.54 (3.32)	0.46	1.12 (3.20)	0.35
Conditional effect of Dyadic synchrony						
Term	**−4.55 (2.03)***	−2.24	−0.33 (1.49)	−0.22	−0.56 (1.43)	−0.39
MLP	1.85 (1.92)	0.97	1.43 (1.39)	1.03	1.51 (1.34)	1.13
Conditional effect of Active mother and child engagement						
Term	0.16 (2.42)	0.07	−1.77 (1.75)	−1.01	−2.65 (1.68)	−1.57
MLP	−0.82 (1.95)	−0.42	−0.46 (1.40)	−0.32	**−2.97 (1.35)***	−2.21
Conditional effect of Tense Interaction						
Term	−2.82 (8.01)	−0.35	−3.12 (5.80)	−0.54	3.03 (5.58)	0.54
MLP	−5.89 (5.74)	−1.02	−4.58 (4.15)	−1.10	−4.68 (4.00)	−1.17

Unstandardized coefficients are presented. Results of three regression analyses are shown, as analyses were performed per outcome measure. Child's gender; 0 = boy, 1 = girl; Group; 0 = term, 1 = Moderate to Late Preterm; MLP = Moderate to Late Preterm.

[a]Data of one MLP was missing.

[b]Data of one MLP and two term born children were missing.

*$p < .05$.

**$p < .01$.

***$p < .001$.

Regarding the mother-child interaction subscales, higher levels of dyadic synchrony significantly predicted less social-emotional difficulties in term born children [$b = -5.15$, $t(183) = -2.40$, $p = .02$], as well as in MLP children [$b = -4.38$, $t(183) = -2.48$, $p = .02$]. Additionally, higher levels of active mother and child engagement during the structured task predicted lower levels of social-emotional difficulties [$b = -4.31$, $t(183) = -2.12$, $p = .04$], less internalizing behavior [$b = -3.52$, $t(181) = -2.30$, $p = .02$], and less externalizing behavior [$b = -3.32$, $t(181) = -2.21$, $p = .03$] for children born at term. These relationships were not found for the MLP group (social-emotional difficulties: $b = -2.31$, $t(183) = -1.21$, $p = .23$; internalizing behavior: $b = -0.07$, $t(181) = -0.05$,

TABLE 6 Results of the regression analyses of mother-child behavior observed in the structured task context, per psychosocial outcome measure.

Structured task context	Social emotional difficulties[a]		Internalizing behavior[b]		Externalizing behavior[b]	
	b(*SE*)	*t*	*b*(*SE*)	*t*	*b*(*SE*)	*t*
Intercept	26.88 (4.49)***	5.98	37.86 (3.33)***	11.36	48.21 (3.26)***	14.77
Covariates						
Child's gender	−2.01 (1.72)	−1.17	0.40 (1.28)	0.31	0.43 (1.25)	0.35
Education medium	−6.50 (4.38)	−1.48	5.10 (3.26)	1.57	0.58 (3.19)	0.18
Education High	**−10.44 (4.17)***	−2.50	3.29 (3.09)	1.07	−1.65 (3.02)	−0.55
Group	0.15 (1.76)	0.08	**3.01 (1.31)***	2.28	1.28 (1.29)	1.00
Mother-child interaction						
Maternal warmth	−0.22 (3.67)	−0.06	−0.99 (2.74)	−0.36	−0.50 (2.68)	−0.19
Maternal stimulation	0.90 (1.65)	0.55	1.79 (1.25)	1.43	1.20 (1.22)	0.98
Child's negative affect	3.39 (2.77)	1.22	1.12 (2.10)	0.53	0.55 (2.05)	0.27
Dyadic synchrony	**−5.15 (2.15)***	−2.40	−1.75 (1.68)	−1.04	−0.72 (1.64)	−0.44
Active mother and child engagement	**−4.31 (2.03)***	−2.12	**−3.52 (1.53)***	−2.30	**−3.32 (1.50)***	−2.21
Tense interaction	−7.10 (4.01)	−1.77	−0.97 (3.03)	−0.32	1.33 (2.97)	0.45
Moderation effects						
Maternal warmth*Group	4.65 (5.00)	0.93	−1.16 (3.72)	−0.31	2.23 (3.64)	0.61
Maternal stimulation*Group	−1.06 (2.25)	−0.47	−2.25 (1.69)	−1.33	0.03 (1.66)	0.02
Child's negative affect*Group	−2.56 (3.97)	−0.65	−0.31 (2.98)	−0.11	−0.99 (2.91)	−0.34
Dyadic synchrony*Group	0.78 (2.77)	0.28	1.91 (2.12)	0.90	0.01 (2.08)	<0.01
Active mother and child engagement*Group	2.00 (2.79)	0.72	3.45 (2.09)	1.66	3.25 (2.04)	1.60
Tense interaction*Group	3.54 (5.07)	0.70	<0.01 (3.81)	<.01	0.24 (3.73)	0.07
R2	**0.19*****		0.12		0.09	
F	2.67		1.51		1.16	
Conditional effect of Maternal warmth						
Term	−0.22 (3.67)	−0.06	−0.99 (2.74)	−0.36	−0.50 (2.68)	−0.19
MLP	4.24 (3.42)	1.29	−2.16 (2.53)	−0.85	1.73 (2.48)	0.70
Conditional effect of Maternal stimulation						
Term	0.90 (1.65)	0.55	1.79 (1.25)	1.43	1.20 (1.22)	0.98
MLP	−0.16 (1.53)	−0.11	−0.45 (1.14)	−0.40	1.23 (1.12)	1.10
Conditional effect of Child's negative affect						
Term	3.39 (2.77)	1.22	1.12 (2.10)	0.53	0.55 (2.05)	0.27
MLP	0.83 (2.82)	0.29	0.81 (2.09)	0.39	−0.44 (2.04)	−0.22
Conditional effect of Dyadic synchrony						
Term	**−5.15 (2.15)***	−2.40	−1.75 (1.68)	−1.04	−0.72 (1.64)	−0.44
MLP	**−4.38 (1.77)***	−2.48	0.15 (1.31)	0.12	−0.72 (1.28)	−0.56
Conditional effect of Active mother and child engagement						
Term	**−4.31 (2.03)***	−2.12	**−3.52 (1.53)***	−2.30	**−3.32 (1.50)***	−2.21
MLP	−2.31 (1.92)	−1.21	−0.07 (1.42)	−0.05	−0.07 (1.39)	−0.05
Conditional effect of Tense interaction						
Term	−7.10 (4.01)	−1.77	−0.97 (3.03)	−0.32	1.33 (2.97)	0.45
MLP	−3.56 (3.10)	−1.15	−0.97 (2.29)	−0.42	1.58 (2.24)	0.70

Unstandardized coefficients are presented. Results of three regression analyses are shown, as analyses were performed per outcome measure. Child's gender; 0 = boy, 1 = girl; Group; 0 = term, 1 = Moderate to Late Preterm; MLP = Moderate to Late Preterm.

[a]Data of one MLP child was missing.

[b]Data of one MLP and two term born children were missing.

*$p < .05$.

**$p < .01$.

***$p < .001$.

$p = .96$; externalizing behavior: $b = -0.07$, $t(181) = -0.05$, $p = .96$). Nevertheless, birth status was not a statistically significant moderator between active mother and child engagement and the outcome measures. This indicates that these relationships within each group were not significantly different between the MLP and term born group.

4. Discussion

The current study explored differences in the assessment of mother-child interaction in a free-play and a structured task context as well as the associations of these interactive behaviors in each context with psychosocial outcomes in MLP vs. term

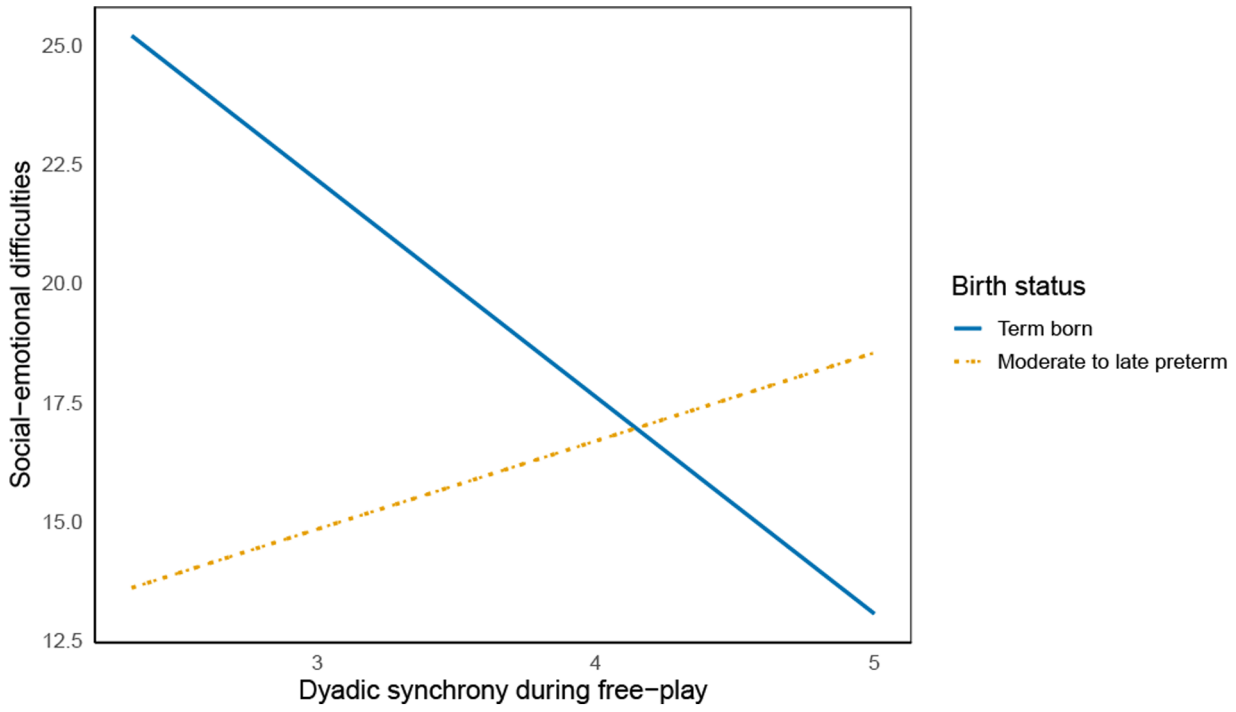

FIGURE 1
Moderation effect of birth status on the relationship between dyadic synchrony during free-play and children's social-emotional difficulties.

born toddlers. Our results showed that most mother-child interactive behaviors can be reliably assessed in both observational contexts. Furthermore, differences in mother-child interactive behaviors are observed per context, with the structured task context eliciting a greater variation in behaviors than the free-play context, including more negative and tense interactions as well as more active and engaged behaviors. Lastly, our results showed that the relationship between mother-child interaction and psychosocial outcomes depends on the observational context and the gestational age of the children, reflected in being born MLP vs. term. Associations between mother-child interaction at 18 months of (corrected) age and psychosocial outcomes at 24 months of (corrected) age were mainly found for the structured task context and for dyads with term born children. Active, engaged and synchronous interactive behaviors were associated with better psychosocial outcomes in toddlers, with some differences observed for MLP vs. term born children and for the free-play vs. the structured task context.

First, we analyzed whether mother-child interaction could be reliably assessed in each observational context. The factor analysis that we used to create subscales of mother-child interaction distinguished six factors that made theoretical sense. However, the subscale of active mother and child engagement combined somewhat unexpected behaviors: Next to positive behaviors, such as child's initiation and child's affection, maternal intrusiveness and mother-led behaviors – behaviors that are typically regarded as negative parenting practices (32) – also loaded positively, though weakly, on this subscale. It should be noted that an important part of the description of maternal intrusiveness and mother-led behaviors concerns re-directing the child's attention (18). These behaviors may therefore – in the current study – be conceptually closer to stimulating and guiding behaviors. Under certain circumstances, these stimulating and guiding behaviors may be needed, e.g., in a context in which the child is presented with a challenging task, and may then be viewed as positive behaviors. More research is needed to test this assumption. Analyses regarding the internal consistency showed satisfactory to good results for the mother-child interaction subscales, indicating that the subscales were measured reliably within and across the free-play and structured task context. Two exceptions were found: tense interaction during free-play and child's negative affect across contexts. Tense interactive behaviors were barely observed during the free-play context which may explain the low internal consistency. Therefore, we advise researchers and practitioners to use a structured task context when their goal is to observe tense interactions. The subscale of the child's negative affect showed good internal consistency in each context separately, but was lower across contexts. This lower internal consistency suggests that the same behaviors used to measure child's negative affect may not represent the same underlying construct in the free-play context vs. the structured task context. In other words, child's negative affect may represent a different construct in each context. However, as child's negative affect was almost non-existent in the free-play context, our data does not allow us to further investigate how the concepts may differ between the contexts. Future studies are needed to draw stronger conclusions regarding the interpretation of child's negative affect in each context. Nevertheless, based on our

results, we advise researchers and practitioners not to sum or average child's negative affect across contexts as a combined score may not represent a unidimensional construct. Overall, apart from the lower internal consistency of the tense interaction subscale during free-play, the mother-child interaction subscales were reliably measured in both contexts, justifying further analyses.

Secondly, we compared mother-child interaction between 1) observational contexts, and 2) the MLP and term born group. Our comparison between the two contexts indicated that the structured task context elicits a greater variety of interactive behaviors in both MLP and term born mother-child dyads. More negative behaviors, i.e., child's negative affect and tense interactions, were found which is in line with previous research (6, 13, 14). Additionally, more active and engaged behaviors were found in the structured task context, which is in line with findings of Dittrich and colleagues (2017) in 5–12 year old children. Dittrich and colleagues (2017) explained this finding by suggesting that sharing a mutual goal elicits more functional behaviors, such as responsiveness and emotional availability – a reasoning that may also apply to our findings of more active mother and child engagement during the structured task context. Furthermore, in the MLP group but not in the term born group, dyadic synchrony was lower during the structured task than during the free-play context. This may be explained by the somewhat lower attentional capacities of MLP children (33), which can make it more difficult for the child to focus on the task. In turn, the mother may have to try harder to accomplish the task. The combination of the lower attention span of the child and the mother's attempt to accomplish the task may result in less fluent interactions and less adaptation to each other's levels of involvement on the task, i.e., less dyadic synchronous behaviors. Furthermore, subscales consisting of only maternal behaviors, i.e., maternal warmth and maternal stimulation, were equally observed in both contexts. This is in line with a study of Miller et al., (2002) concluding that mothers show more consistent behaviors across situations, whereas children seem to be more affected by a challenging context, e.g., a structured task context. In the current study, materials for the structured task context were chosen based on the zone of proximal development of 18 months old children, i.e., challenging for the child, explaining why children seemed to be more affected than mothers by the structured tasks. To conclude, the structured task context seems to be a more challenging context for children rather than for mothers, and seems to elicit a greater variety of behaviors including more child's negative affect and tense interactions along with more active and engaged behaviors of both mothers and children. For MLP children, the structured task context may especially be more challenging than the free-play context as dyadic synchrony was lower.

No differences on the mother-child interaction subscales were found between the MLP group and the term born group for both contexts. This is in line with a meta-analysis reporting no differences on maternal sensitivity and responsiveness between preterm, including MLP, and term born mother-child dyads (34). In another meta-analysis, however, was concluded that preterm children, including MLP children, were less alert and more passive and mothers of preterm children more controlling, active and directive (35). A recent study with a similar design as our study – i.e., observing mother-toddlers dyads in a free-play context using the same observation coding scheme as the current study – reported differences in mother-child interaction between preterm (24–34 weeks of GA) and term born mother-child dyads (12). Less maternal sensitivity, child involvement and dyadic reciprocity were found in preterm mother-child dyads compared to the term born group, whereas maternal intrusiveness was higher in the preterm group. However, the differences in mother-child interaction between the two groups depended on the level of prematurity: the differences were larger for very preterm vs. term born children than for moderate preterm vs. term born children (12). In the current study, moderate and also late preterm children were included in the preterm group which may have led to more subtle, non-significant differences between the MLP and term born group. In conclusion, our results indicate that the quality of mother-child interaction is comparable between the MLP and term born mother-child dyads. This can be seen as a positive finding, as all mothers and children show more or less the same interactive behaviors. However, MLP children, as compared to term born children, may need higher levels of specific parental behaviors in order to reach their full potential. Indeed, studies have reported that a higher quality of parent-child interaction, e.g., maternal responsiveness, was more beneficial for social and emotional competences of preterm than term born children in the first year of life (10, 15). However, these studies did not specifically focus on MLP children, nor on the stability of the effects throughout toddlerhood, which may be objectives for future research.

The results of our main research question, i.e., the role of observational context in finding associations with children's psychosocial outcomes, showed that during a structured task as compared to free-play, more associations between mother-child interaction and toddlers' psychosocial outcomes were found. This is in line with the study of Nordahl et al. (2020). The structured task context seems to elicit more meaningful behaviors for finding associations with children's psychosocial outcomes. One of the reasons that could explain this finding is that a structured task forms a more challenging context, which can pressure the interaction between mother and child – as shown by more negative emotions but also more active and engaged behaviors. As such, the structured task may unmask more (dys)functional patterns which are more likely to be related to children's psychosocial outcomes. To illustrate, the stress induced by trying to perform a task together can elicit more negative interaction patterns between mother and child, such as more tense interactions and more negative affect, which are dysfunctional behaviors in view of a stimulating and fun interaction. On the other hand, performing a task together can increase active and engaged behaviors of both parties, i.e., functional behaviors. Therefore, structured tasks especially, may unmask a clear picture of the dynamics between mother and child, revealing more meaningful behaviors in relation to children's psychosocial outcomes.

Furthermore, we investigated whether relationships between mother-child interaction and children's outcomes differed for MLP and term born children. Term born children's outcomes were more often associated with mother-child interaction than MLP children's outcomes. For term born children during a structured task only, active mother and child engagement was related to less social-emotional difficulties, internalizing and externalizing behaviors. For MLP children during a free-play context only, active mother and child engagement was related to less externalizing behaviors. However, the relationships between active mother and child engagement and psychosocial outcomes within both contexts were not moderated by birth status, meaning that the relationships found within the MLP and term born groups were not significantly different from each other. Therefore, it cannot be concluded that different patterns were found between groups for the relationship between active mother and child engagement and psychosocial outcomes. For both MLP and term born children, dyadic synchrony in the structured task was related to less social-emotional problems. Interestingly, in the free-play context, more dyadic synchrony was related to less social-emotional difficulties in the term born group but not in the MLP group. Birth status significantly moderated this relationship, indicating that the relationship between dyadic synchrony during free-play and social-emotional difficulties was significantly different between the groups. It is unclear why more dyadic synchrony during free-play was associated with less-social-emotional difficulties in term born children, but not in MLP children. In addition, it is noteworthy that only within the MLP group – and not in the term born group – lower levels of dyadic synchrony were found for the structured task context than for the free-play context. These two findings are indications that dyadic synchrony may behave differently depending on the population under study (i.e., MLP vs. term born children) as well as the context in which it is observed (i.e., free-play vs. structured task). More research is needed to confirm these results and find reasons for this effect.

Our general finding that mother-child interaction is related to psychosocial outcomes in term born children, but to a lesser extent in MLP children, cannot be explained by differences in mother-child interaction between the groups as all subscales had comparable scores in the MLP and term born group. Nonetheless, when looking into the scores of the subscales, MLP mother-child dyads have consistently, though non-significantly, lower scores on most of the positive mother-child interactions and higher scores on tense interactions. Possibly, there are subtle differences in interactive behaviors between MLP and term born mother-child dyads that explain why MLP children's psychosocial outcomes are to a lesser extent related to mother-child interaction than term born children's psychosocial outcomes. Previous research on the current sample showed that MLP children have less developed receptive communication skills than term born children at 24 months of (corrected) age (36). MLP children may therefore learn less from mother-child interaction. MLP children may need more active, engaged and synchronous mother-child interaction during structured task contexts – the context which seemed to elicit most meaningful interactions in finding associations with psychosocial outcomes in term born children – than term born children in order to reach their full potential. More research is needed to investigate whether increasing active, engaged and synchronous behaviors is beneficial for MLP children and whether this only applies to a structured task context.

For the interpretation of our results, two factors should be considered. First, due to the correlational design of the current study, no causal conclusions can be drawn. Secondly, the effect sizes of the statistical models were rather small. However, as the current study was of exploratory nature, the aim was to identify which mother-child interactive behaviors are important to observe in which context in order to find associations with children's outcomes. Our findings give clear indications of which mother-child interactive behaviors are relevant to observe and in which context. This allows us to provide recommendations for clinical practice as well as researchers.

For both practitioners and researchers, we advise to observe in a structured task when the goal is to elicit a variety of behaviors, including negative and tense interactions as well as more active and engaged behaviors. If the aim is to observe mainly positive emotions, the free-play context is most suitable. Either context can be chosen to observe maternal stimulation and maternal warmth, as these behaviors were equally observed across contexts. For researchers who aim to predict psychosocial outcomes in toddlers based on mother-child interaction, it is advised to study interactive behaviors characterized by active, engaged and synchronous behaviors. For term born toddlers, observing in the structured task context may suffice, whereas for MLP children both contexts seem to be equally relevant. For clinical practitioners who aim to stimulate children's psychosocial development, our findings may suggest targeting interventions to increase mother and child's active and engaged behaviors, as well as dyadic synchronous behaviors. More specifically, for MLP children, the findings suggest targeting interventions to increase dyadic synchronous behaviors during structured task contexts, as well as active and engaged behaviors during free-play. For term born children, the findings suggest targeting interventions to enhance dyadic synchrony in both free-play and structured task contexts, as well as active and engaged behaviors in structured task contexts.

The current study contains strengths as well as limitations. The strengths are that a multi-method is used, i.e., observational measures and parent-report, which gives better insight in the actual behaviors compared to using only parent-report or observations. Second, the current study includes MLP and term born children whereas many studies focus on only extreme to very preterm children or the total range of preterm born children. Since MLP children form 85% of the children born preterm (37), this is an important group to study more in-depth. Limitations may have risen from the design of the current study. The structured task context included two tasks (i.e., puzzle and book) and it would therefore be preferred if the free-play context also consisted of two parts to optimally elicit mother-child interaction. Future research can take a second free-play setting into account, for example with a different selection of toys, or no

toys to simply observe how mother and child play with one another. Another limitation to acknowledge is that the mother-child interaction subscales were generated based on a factor analysis, which means that these subscales are dependent on the current sample – which partly consists of an at-risk sample, i.e., MLP children. Moreover, in our study, maternal intrusiveness and mother-led interaction unexpectedly loaded on a positive scale – i.e., active mother and child engagement – that was related to less psychosocial difficulties in children. More research in other samples is needed to investigate whether these subscales can be replicated. It would also be interesting for future research to replicate the current study using a different mother-child interaction coding scheme. Potentially, another coding scheme – such as a micro-coding scheme – would be informative, as this may reveal more information regarding which aspects of – what is generally called – maternal intrusive and leading behaviors can be beneficial for children's psychosocial outcomes and under which circumstances, e.g., in the presence of certain other observed behaviors of the dyad and/or in a specific observational context. Furthermore, a micro-coding scheme may pick up different mother-child interactive behaviors that are relevant for finding associations with children's psychosocial outcomes. Results may confirm our findings, and/or add to our study by providing more insight into the dynamics between mothers and their (pre)term born children in each context in relation to children's psychosocial outcomes.

In conclusion, the structured task context seems to elicit more meaningful interactions for finding associations with term-born children's psychosocial outcomes than the free-play context. Mother-child interactions characterized by active, engaged and synchronous behaviors were associated with better psychosocial outcomes in toddlers, with some differences observed for MLP vs. term born children and for the free-play vs. the structured task context.

Data availability statement

The data analyzed in this study is subject to the following licenses/restrictions: The data analyzed in this study can be shared upon reasonable request. Requests to access these datasets should be directed to Lisa Krijnen; l.j.g.krijnen@uu.nl.

Ethics statement

The studies involving humans were approved by Utrecht Medical Center Ethics Committee (identification code NL34143.041.10). The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation in this study was provided by the participants' legal guardians/next of kin.

Author contributions

LK: Conceptualization, Methodology, Formal analysis, Writing – original draft. MV: Conceptualization, Methodology, Writing – review & editing, Supervision. AB: Conceptualization, Methodology, Writing – review & editing, Supervision. All authors contributed to the article and approved the submitted version.

Acknowledgments

We want to thank the parents and children for their participation.

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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frontiers | Frontiers in Child and Adolescent Psychiatry

TYPE Methods
PUBLISHED 20 October 2023
DOI 10.3389/frcha.2023.1206922

OPEN ACCESS

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RECEIVED 16 April 2023
ACCEPTED 28 September 2023
PUBLISHED 20 October 2023

CITATION
Szekely E, Laplante DP, Tiemeier H, Evans J, Pearson RM, Bekkhus M, Bakermans-Kranenburg M, van IJzendoorn MH and Wazana A (2023) The DREAM BIG project as a model for harmonizing early measures of parental care and parent-child interactions across epidemiological cohorts. Front. Child Adolesc. Psychiatry 2:1206922. doi: 10.3389/frcha.2023.1206922

The DREAM BIG project as a model for harmonizing early measures of parental care and parent-child interactions across epidemiological cohorts

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Parenting is a key contributor to child development. The effects of parenting, however, also depend on child characteristics, including genetic factors. A more complete appraisal of the role of parenting thus requires a comprehensive developmental model which explores questions about parenting behavior, child susceptibility to parenting, and child psychopathology. Moving forward, we need to not only be concerned about sample sizes that limit testing of comprehensive models but also the need to replicate findings across multiple settings and samples. A consortium which harmonises key measures offers the opportunity to examine these questions. The Developmental Research in Environmental Adversity, Mental health, BIological susceptibility and Gender (DREAM BIG) consortium includes six international longitudinal prospective birth cohorts to explore the early life origins of major psychiatric disorders in childhood. Here, we will provide a brief overview of parental care research, methodological limitations, and two exciting recent attempts (i.e., the DREAM BIG consortium and the CATS-project), that address key methodological challenges.

KEYWORDS

maternal sensitivity, mother-child interactions, replication, developmental model, prenatal, genetic risk, data harmonization

The context: the importance of parental care

Humans are among the most helpless of species at birth and they remain dependent on their parents for a long time before being able to navigate the world independently. Parental care has thus direct consequences for children's survival, growth, and psychosocial development (1). The early caregiving environment supplies young children with the

necessary experiences and support for achieving their developmental milestones (2), and it plays a key role in shaping children's social-emotional and cognitive development (3). Established models of parenting postulate that the quality of the parent–child relationship is the integrated product of three broad factors: parental characteristics, infant characteristics, and context which may influence parenting in a supportive or stressful way (4, 5). Parent-infant interactions encompass a diverse range of dyadic processes, among which the most heavily investigated construct is *maternal sensitivity*, or the mother's ability to accurately perceive and interpret their infants' signals and respond to them in a prompt and appropriate manner (6–8). Decades of research on maternal sensitivity have provided evidence on its link with numerous domains of child development, including social adjustment (9), executive functioning (10), cognitive and language outcomes (11, 12), and, not the least, children's attachment relationships (13, 14).

Environmental sensitivity

Children respond differentially to parenting though with genetic and prenatal environmental factors contributing to an increased sensitivity to the environment called postnatal plasticity (15). While Belsky documented that this plasticity (measured as temperament) emerges from genetic factors (differential susceptibility) (16, 17), and Boyce and Ellis posited that this susceptibility would be rather environmentally induced, (16), both show that plasticity factors influence how individuals interact with the environment. Three patterns of environmental sensitivity have been described in the literature: diathesis-stress, differential susceptibility, and vantage sensitivity (17, 18). In diathesis-stress, a biological marker represents a disadvantage in unfavourable environments in that outcomes for carriers of that marker can only be approaching the outcome levels of noncarriers if the individual is exposed to average or advantageous environments. In vantage sensitivity, the opposite is true: the biological marker represents an advantage over noncarriers, such that in unfavorable environments carriers and noncarriers develop similarly, while carriers show increasingly better outcomes as the environment becomes more advantageous. Finally, in differential susceptibility, highly susceptible children are more responsive to both adverse and supportive environments than non-susceptible children for better or worse (15).

Gene-environment interplay

Surprisingly, few studies have examined the associations between genetic risk, prenatal adversity, and maternal care in predicting child psychological functioning, even though the quality of early parental care can be a crucial mitigating factor of the effect of prenatal environmental or genetic risk (19). In a three-way interaction model, we found that maternal looking away behaviour (negatively correlated with maternal sensitivity) moderates the risk associated with prenatal depression and the 5-HTTLPR genotype to predict depressive symptoms at 18 months, but not at 24 months (20). Similarly, we have reported that maternal looking away behaviour moderates the developmental risk from low birthweight and *DRD4* to predict disorganized attachment (21). These findings suggest that, in children with genetic and prenatal risk, the risk for psychopathology was attenuated when the mother looked away less frequently. These findings are in line with previous studies reporting that the frequency of self-reported maternal stroking during early infancy moderated the effect of pregnancy anxiety on internalizing problems when the children were 3.5 years of age (22). For mothers who experienced high levels of pregnancy-specific anxiety, high levels of postnatal stroking were related to lower internalizing scores in their children. Similar results of a moderating role of maternal stroking on child internalizing problems have also been reported for prenatal maternal depression (23) and general anxiety (24). Finally, in our recent study in the Maternal Adversity, Vulnerability and Neurodevelopment (MAVAN) sample, we found evidence for the presence of two-way interaction effects on toddler attention function, namely that positive maternal behaviors observed during mother-child interactions at 6 months postpartum mitigated the effects of both prenatal adversity and dopaminergic polygenic risk on toddler attention function (25). However, our sample was limited to find a significant three-way interaction between prenatal adversity, dopaminergic risk, and parenting behavior, and the above two-way interaction effects need to be replicated in independent samples.

Epigenetic processes

Fresh perspectives in understanding the complexities of the parent-child dynamics are also offered by behavioral epigenetic studies, which posit that the quality of maternal care sets epigenetic processes (e.g., DNA methylation) in motion that may ultimately affect offspring psychological development through modifying expression of genes involved in behavioral and stress regulation (e.g., *NR3C1, BDNF, OXTR*) (26). For example, harsh parenting contributes to similar epigenetic modifications in the child as early adversity, potentially affecting cognitive and socioemotional development in childhood (27, 28) and attachment style in adulthood (29). Importantly, epigenetic modifications are also affected by positive parent-child interactions (30, 31), translating into "positive" epigenetic mechanisms, which may act as a protective mechanism in the face of adversity-related increased DNA methylation of genes involved in behavioral and stress regulation (32, 33).

The problem: limitations of current parenting research

The replication problem

The replication crisis in science (34) is exemplified in psychological research, where the replication rate of key experiments is just above 10% (35). One reason for the lack of replication is that cohorts do not always assess the same

developmental constructs, and, even when they do, they often use different measures to assess them. In addition, without the initial registration of research hypotheses and analytic plans (e.g., in the Open Science Framework) of observational studies, akin to that found with randomized controlled trials (e.g., www.clinicaltrials.gov), it is not often clear which findings (*a priori* vs. *post hoc*) are most likely to be replicated. For clinical trials, there are broadly endorsed initiatives of prospective harmonization of outcome measures, such as the COMET initiative (https://www.comet-initiative.org/) and the CROWN initiative (http://www.crown-initiative.org/). For already existing observational studies, the retrospective harmonization of relevant predictor and outcome variables across cohorts with similar measures may prove essential in producing replicable and generalizable research findings. As well, pre-registering planned correlational analyses in intentional initiatives to replicate findings will make for more convincing results.

Measurement error

Gathering detailed observational data on parent-child interaction in large epidemiological cohorts is costly and unfeasible. However, complex developmental models that account for the interplay of genetic and pre- and postnatal environmental influences are incomplete without including precise measures on the quality of parental care. Measurement error can reduce statistical power for detecting true interaction effects in complex developmental models, as it inflates the variance of the estimate of the interaction term, similarly to multi-collinearity and non-normal distribution of the interaction terms (36–38). Observational measures of mother-child interactions are thus strongly preferred to self-report measures of parenting in studying complex developmental models in longitudinal cohorts. Observational measures, due to their complexity and cost, restrict potential sizes of epidemiological developmental cohorts. Thus, the need for larger sample sizes and valid cross-study comparisons, has led to increased interest in co-analyzing already existing data across studies. However, heterogeneity in study design and measures collected limit our capacity to easily compare or integrate data across studies (maelstrom-research.org) (39).

Small sample sizes

To be truly informative, birth cohorts, particularly those with genetic data, require large samples to test complex computational models of developmental trajectories (40, 41). While harmonization of key predictor and outcome variables across multiple birth cohort studies will greatly assist in overcoming the replication problem, *a priori* or *post-hoc* harmonization of parenting measures will also help overcome the problem of small sample sizes, that are typical of focus cohorts of large epidemiological samples, where observational measures of parenting are available (42). Combining focus cohorts from multiple large birth cohorts with harmonized parenting data can increase sample size to levels sufficient to conduct tests of complex models.

Aim of the present paper

The present paper discusses the relevance of a key methodological concept (i.e., retrospective data harmonization), which can help mitigate some of the challenges inherent in replicating study findings involving observational parent-child interaction measures. More specifically, this paper offers two valuable approaches to researchers who are interested in retrospective harmonization and integration of parent-child interaction data across independent samples.

The first approach comes from our ongoing initiative, the DREAM BIG consortium, which performs cross-cohort retrospective data harmonization of key constructs relevant to probe complex models of child development (e.g., the prenatal environment, genetic susceptibility, child psychopathology, and early parental care). The second strategy, as used in the CATS-project, focuses on the initial stages of retrospective data harmonization of observed maternal sensitivity. This method first evaluates the theoretical constructs underlying the measures and then the measures themselves prior to the recoding of original values. The DREAM BIG and CATS approaches offer helpful analytical solutions for restructuring parent-child interaction data collected with different instruments across multiple studies to indicate a comparable construct.

A proposed innovative solution: the DREAM BIG consortium as a model of cross-cohort data harmonization of child developmental constructs

The Developmental Research in Environmental Adversity, Mental health, BIological vulnerability, and Gender (DREAM BIG) research consortium was established in 2016 to examine, in a multi-site design, the developmental origins of major mental disorders (www.dreambigresearch.com). DREAM BIG includes six prospective prenatal cohorts: Avon Longitudinal Study of Parents and Children (ALSPAC, UK) (43); Generation R Study (GEN-R, Netherlands) (44); Maternal Adversity, Vulnerability and Neurodevelopment (MAVAN) project (Canada) (45); Mother, Father and Child Cohort (MoBa, Norway) (46); Prediction and prevention of preeclampsia and intrauterine growth restriction (PREDO) study (Finland) (47); and Growing Up in Singapore Towards Healthy Outcomes (GUSTO) cohort (Singapore) (48). These cohorts have comparable measures on prenatal adversity—including prenatal maternal psychopathology and prenatal environmental adversity—genetic data, observed and self-reported early parental care and parent-child interactions, and child psychopathology. Our work thus far supports the hypothesis that prenatal maternal psychopathology, social-environmental adversity, and child genetic susceptibility

for multiple psychiatric disorders and psychological traits predict emerging general and internalizing (e.g., depression and anxiety) psychopathology in 4-to-8-year-olds (49, 50).

Harmonization of major constructs within DREAM BIG

To date, DREAM BIG has harmonized measures of prenatal adversity and genetic susceptibility, and created cross-diagnostic and hierarchical harmonized measures of child psychopathology by integrating information across multiple informants at multiple time points (**Figure 1**). A brief description of these measures are provided below and a summary of the main findings to date are presented in the **Supplementary Material Table S1**.

Prenatal social-environmental adversity

This is a harmonized prenatal cumulative risk index derived from four major areas: stressful life events (i.e., death in family, accident, illness), contextual risks (i.e., poor housing conditions, financial problems), parental risks (i.e., alcohol and substance abuse, criminal involvement), and interpersonal risks (i.e., family conflict, domestic violence) (51, 52) using confirmatory factor analysis with a second-order hierarchical model.

Prenatal maternal affective symptoms

This is a set of harmonized prenatal maternal psychological symptoms constructed using confirmatory factor analyses that identified a general prenatal affective symptoms factor and three specific factors: anxiety/depression; somatic symptoms; and pregnancy-specific anxieties across cohorts (50). These prenatal maternal affective symptoms factors predicted offspring psychopathology at age 4–8 years in a meta-analysis of three cohorts (50).

Both measures of adversity (i.e., prenatal social- environmental and maternal affective) build on previous successful harmonization initiatives between ALSPAC and Generation R (51, 52). DREAM BIG innovated by separating these two measures.

Childhood psychopathology

This includes a harmonized, age-adjusted, general psychopathology factor (P-factor), and specific uncorrelated internalizing and externalizing factors consistent with the Hierarchical Taxonomy of Psychopathology (HiTOP) model (53), constructed using psychopathology measures rated by different informants (parent, child, teacher) at multiple time points between the ages of 4 and 8 years (54). A HiTOP approach to harmonizing psychopathology addresses important methodological concerns about diagnostic co-morbidity, homotypic and heterotypic discontinuities, and rater differences (53, 55).

Genetic susceptibility

Polygenic scores (PGS) for internalizing (anxiety, depression), neurodevelopmental (ADHD, ASD), psychotic (schizophrenia, bipolar), and compulsive problems (anorexia

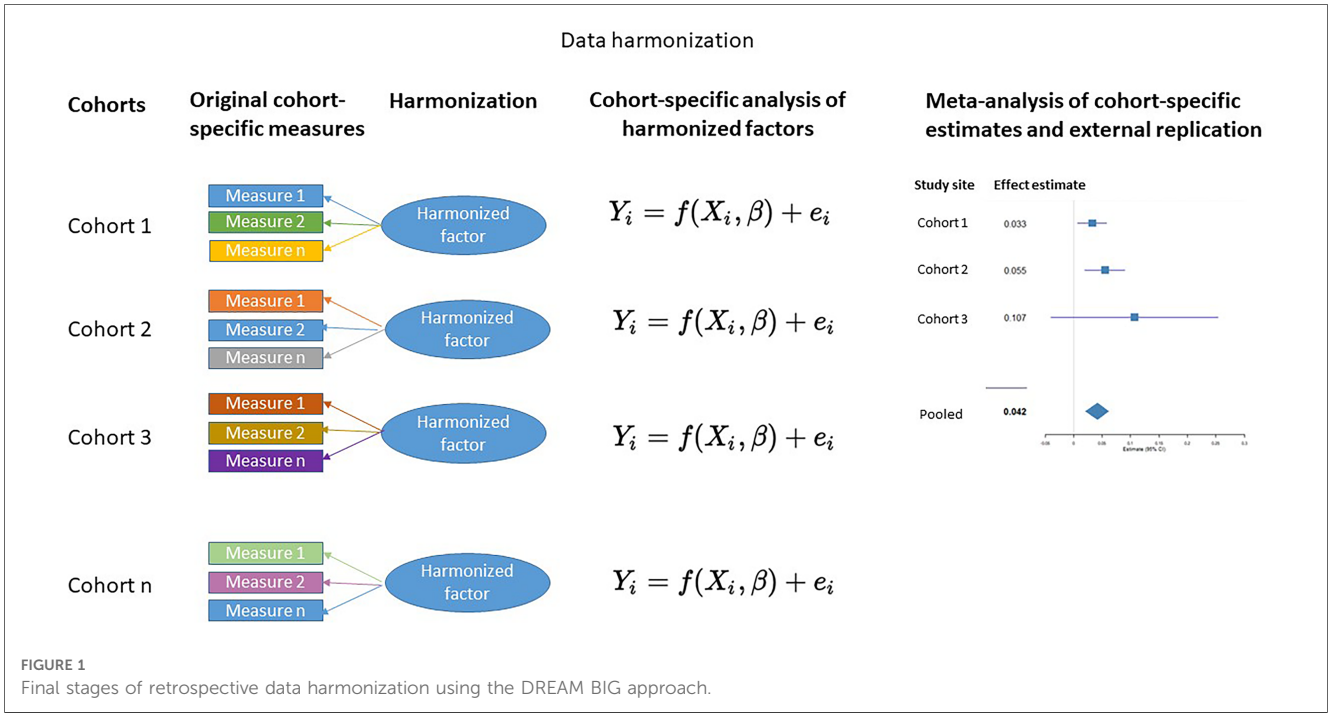

FIGURE 1
Final stages of retrospective data harmonization using the DREAM BIG approach.

nervosa, obsessive-compulsive, Tourette syndrome) will be computed in each cohort based on results of a Genomic Structural Equation Model (GenomicSEM) of 11 common psychiatric disorders using publicly available GWAS summary statistics (56). This approach models the structure of psychopathology at the genomic level and exploits genetic correlations between multiple psychiatric disorders modeled simultaneously. Further details about the GenomicSEM approach are available elsewhere (56).

Maternal care

Four of the six DREAM BIG cohorts have observational measures available on maternal sensitivity and parent-child interactions. In MAVAN, maternal care and mother-child interactions were observed during free play using the Parent-Child Early Relational Assessment (PCERA) (57) at 6, 18, 36 and 60 months, the Ainsworth Maternal Sensitivity Scales (6) at 6 and 18 months, and the Behavioral Evaluation Strategies and Taxonomies (BEST) (Educational Consulting, Inc. Florida, US; S & K NorPark Computer Design, Toronto) at 6 months. In Generation R, maternal sensitivity was observed during free play using two subscales of the Ainsworth Maternal Sensitivity Scales at 14 months (sensitivity and cooperation), and during two structured mother-child interaction tasks using the revised Erickson 7-point rating scales for supportive presence and intrusiveness (58) at 36 and 48 months in a subsample (n = 1,079). In GUSTO, maternal sensitivity was observed during free play using the Revised Mini-A short form of the Maternal Behavioral Q-Sort-V (Mini-MBQS-V) (59) at 6 months, and during a structured mother-child interaction using the Erickson 7-point rating scale at 54 months. Finally, in a subsample (N = 1,240) of the ALSPAC cohort, the Mellow Parenting Observational System (60) was used to code mother-child interactions during the Thorpe Interaction Measure (61) at 12 months.

Our current work in DREAM BIG will also harmonize the measures of observed maternal sensitivity across cohorts to test for the presence of replicable two-way and three-way interactions between prenatal adversity, child genetic susceptibility, and early maternal sensitivity on the development of child mental health problems. Integrating both harmonized parenting and child measures allows for the inclusion of complex questions assessing a wide range of well-defined observable parental care measures.

The CATS-project as a solution for the initial stages of retrospective harmonization of observed maternal sensitivity

Assessing the nature of dyadic dynamic processes, such as maternal sensitivity, is challenging, and brings critical attention to the core issue of assessment (26, 62, 63). The Collaboration on Attachment Synthesis CATS-project is a multi-site meta-analytic study focusing on synthesizing the literature regarding the association between parental cognitive representation of attachment and the child-parent attachment relationship (64). The strategy pertains to the early stages of data harmonization and can be applied to observational measures of maternal sensitivity. This three-step method includes a top-down approach to evaluating the theoretical constructs underlying the measures and a bottom-up approach to evaluating the measures prior to recoding the values (**Figure 2**) (64).

The first step represents a top-down strategy of defining a unitary construct by reviewing the existing literature screening for one or more dominant developmental framework(s). The second step is a bottom-up strategy whereby each instrument is evaluated against the theoretical frameworks identified in the first step. Here the researchers assess which theoretical subdimensions are measured by which subscale or item(s) and decide which (sub)scales or items to retain. The final step entails the recoding of scores to an identical metric based on the existing literature. So, in the case of parental sensitivity, the authors' search of the literature (step 1) indicated that the construct of parental sensitivity is derived from the attachment theory framework. The individual studies in the CATS database included eight different measures of parental sensitivity in total, which then needed to be evaluated (step 2) against the construct of maternal sensitivity derived in step 1. Finally, the authors recalculated the scores (step 3) of all the instruments to match the reference scale of one of the available instruments, the Ainsworth sensitivity scale, which is considered "gold standard" for measuring parental sensitivity (64). The authors recommend their method to be used in conjunction with the existing literature on the restructuring of measurements from different instruments into the same format (i.e., the later stages of the harmonization process) before analysis.

This exciting new strategy is filling a gap in the literature on data harmonization by providing researchers with a tool for pooling, amongst others, observational data on parental behaviors. However, this approach, which could be expanded to other predictor and/or outcome measures, is facilitated greatly by the development of new large scale epidemiological cohort studies in which predictor and outcome measures are harmonized before study onsets.

Limitations

As inherent in all retrospective data harmonization techniques, the two approaches presented here are also subject to limitations including the complexity and necessity of expert domain knowledge to pool data, and the possibility that, despite best efforts, some data may not be comparable across cohorts due to, for instance, gross heterogeneity in measures. When the available data are not comparable, there is risk of data loss (66). Moreover, and also inherent to data harmonization, details with regard to the observational context can get lost. For example, parental sensitivity can be observed during free play, unstructured home observations, or stress-inducing tasks in a

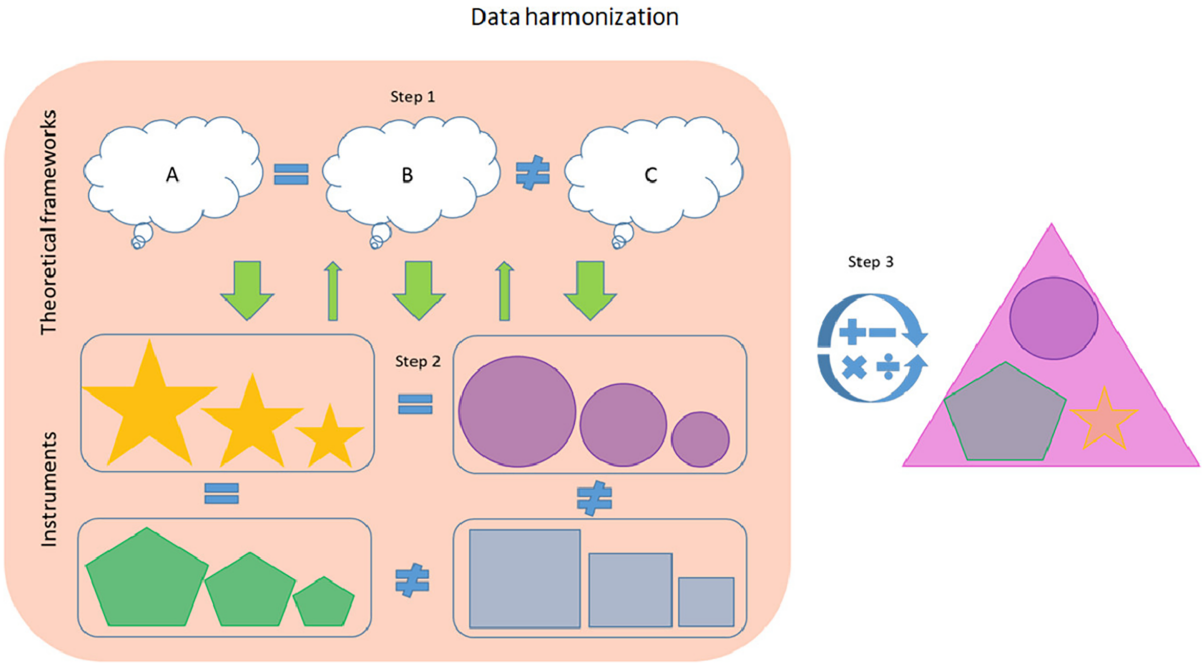

FIGURE 2
Initial stages of retrospective data harmonization using the CATS-project. Source: Graphical abstract from Verhage et al. (65).

laboratory. Such observational contextual information can be included in analyses as potential moderating factors, but type of context and measure may be confounded when specific measures are only used in specific contexts.

Implications

Harmonization and replication of complex models improve our ability to detect and understand methodologically robust and key nodes of environmental influences in children's social-emotional development. Given the rich primary and secondary intervention literature aimed at the modification of early parental care and parent-child interactions, more precise identification of susceptibility to and effects of these interactions, will additionally inform public health and primary care practices. For example, harmonized indicators of observed parent-child interaction may be used in the assessment, selection of target behaviors, intervention, and monitoring the effect of the intervention in the treatment of families with mental health problems (67).

Conclusions

The CATS approach contributes to an important avenue of the initial stages of retrospective harmonization, while the DREAM BIG approach focuses on the later stages of retrospective data harmonization of developmental and parenting research to overcome the replication problem. Both approaches can be applied, in a complementary manner, to the cross-cohort harmonization of observed mother-child interaction data. In conclusion, the above strategies offer helpful analytical solutions for restructuring data collected with different instruments across multiple studies to the same format. Further, the DREAM BIG model of harmonization and replication permits the following questions about the impact of parenting on development across the lifespan to be addressed: (i) What aspects of parental care are most important?; (ii) During what phase of development?; (iii) Which children are at highest risk?; and (iv) For what kind of outcomes?

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 has been granted by each respective DREAM BIG cohort institution for the studies conducted within the DREAM BIG consortium. For this publication, no direct access to research data was required.

Author contributions

ES, DL, HT, JE, RP, MB, MB-K, MI and AW: have made substantial contributions to the conception or design of the work, in the creation of the consortium, acquisition of data and harmonization of constructs, have drafted the work or revised it

critically for important intellectual content, provided approval for publication of the content, agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. All authors contributed to the article and approved the submitted version.

Funding

This research was made possible by the Canadian Institutes of Health Research (CIHR; grants MWG 146 330, MOP 111251, PJT-148721, UIP-179221, WI2-179938, PJT-185872, EDC-186603), the Fonds de la recherche en sante du Quebec (FRSQ; grant 22418 and 331904), and the March of Dimes Foundation (grant 12- FY12-198).

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 authors RP, HT and ES declared that they were an editorial board member of Frontiers, at the time of submission. This had no impact on the peer review process and the final decision.

Publisher's note

Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/frcha.2023.1206922/full#supplementary-material

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frontiers | Frontiers in Child and Adolescent Psychiatry

TYPE Original Research
PUBLISHED 11 January 2024
DOI 10.3389/frcha.2023.1204865

OPEN ACCESS

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RECEIVED 12 April 2023
ACCEPTED 18 December 2023
PUBLISHED 11 January 2024

CITATION
Culpin I, Lamont-Robinson C, Billington M, James M, Prewett J, Ward G, Bes Garcia M and Biglino G (2024) Piloting creative engagement strategies to explore themes of parenthood with fathers.
Front. Child Adolesc. Psychiatry 2:1204865.
doi: 10.3389/frcha.2023.1204865

Piloting creative engagement strategies to explore themes of parenthood with fathers

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Introduction: The role of the arts in health is increasingly recognised, with participatory arts-based approaches facilitating public engagement. However, little is known about men's involvement in art-based participatory research. We aimed to investigate how men who are fathers may be engaged creatively to explore experiential aspects of fathering and parenthood.

Methods: Fathers collaborated with an artist, sharing individual perspectives around fatherhood by telephone and email, leading up to creative representations of fatherhood. Initial conversations were prompted by images from a 2020 exhibition catalogue entitled "Masculinities" (Barbican Centre, London) inviting participants' responses to the photographic curation. The catalogue served as an artistic reference to gauge a sense of participants' creative predispositions, as well as a foundation to facilitate spontaneous dialogue about personal meanings of fatherhood. Fathers' experiences of contemporary arts varied greatly; yet all fathers confidently shared responses ranging from photographers' representation of masculinity and fatherhood and perceptions of what was excluded or privileged within this very specific curation. These discussions further led to conversations around representations of fatherhood and highlighted particular areas of interest in terms of fathers' involvement in research and public engagement. The artist provided reflections to each participant by email with links to arts resources building on the initial conversations. Two further shorter sessions followed as fathers' key messages emerged, and the final forms of their own creative expressions crystallised.

Results: The final pieces included a musical composition around sharing vulnerability as a new father, a word cloud to represent gendered language of parenthood, an animated graphic image representing the bond between father and child, a combination of short poetic stanzas highlighting assumptions around fatherhood, an experiential photographic record of a father and a son in the early years, and a cartoon strip around emotional intelligence in parenting.

Discussion: Arts-based participatory engagement enabled to capture deep-rooted experiences of being a father in modern society, illuminating common cultural and intergenerational perspectives, while also tapping into unique individual experiences. The richness and diversity of these unique responses suggest that arts-based methodology can facilitate public engagement with men and lead to deep reflections on complex and socially constructed phenomena such as fathering and parenthood.

KEYWORDS

creative healthcare, masculinity, fatherhood, parenthood, public engagement, participatory arts-based research, ALSPAC

Introduction

The role of the arts in health is increasingly recognised and evidenced, with participatory and creative approaches offering new ways to generate and disseminate knowledge in health and social research (1, 2). Arts-based methods have the potential to elucidate subjective health and social dimensions of human experience, in ways that complement and augment existing qualitative methodologies (3, 4). It has been argued that arts-based approaches expand on qualitative research methodologies through additional representational possibilities emerging in the creative process and sensory engagement required from participants and audiences (1, 5). Arts-based research also helps to highlight those aspects of lived experiences that are often overlooked in interviews and focus groups due to the increased participant-led nature of such methods in producing arts-based work (6, 7).

One area in which it is valuable to explore the potential of creative approaches to complement other research methods is the examination of the role that fathers play in child development, including those families where mothers experience postnatal depression. This is the subject of a research programme that combines sociological, epidemiological and developmental methods (led by IC, funded by the Wellcome Trust) to disentangle complex processes that underly transmission of mental health risks in families. The sociological aspects of the study focused on elucidating the nature of fathering and social processes that shape father involvement, while epidemiological and psychological approaches examined the effects of maternal postnatal depression on the child and the role of fathers' parenting and involvement in this context using longitudinal and behavioural-observational data on parenting and father-child interactions. The intergenerational transmission of mental health risks from parents to children is complex and multi-factorial, calling for integration of interdisciplinary approaches. In particular, the role of fathering in families affected by depression remains largely unexplored from sociological, epidemiological and developmental perspectives. Combining inter-disciplinary methodological approaches enables the analysis of processes underpinning family functioning in the context of perinatal mental health, particularly the nature and dimensions of fathering and its impact on child development. The in-depth sociological examination of the impact of maternal postnatal depression on fathers' experiences of parenting and involvement aimed to generate insights into how fathering is "co-created" and negotiated in the context of family dynamics affected by depression. This includes the development of different forms of fathering in terms of emotional and practical involvement, as well as unique insights into the impact of maternal depression on parental relationship, fathers' own mental health and the nature and quality of their interactions with children. Substantial epidemiological and sociological literature has now emphasised the important role that fathers' involvement and parenting play in child development (8–10), while paternal mental health has increasingly been linked to various emotional, behavioural and cognitive dimensions of child development in its own right (11), as well as in the context of maternal postnatal depression (12).

Participatory arts-based research can be a powerful way to unsettle limiting hierarchies and challenge representations (13, 14), but also to share experiences, build connections, and promote social change. Ball et al. (15) in their extensive review of arts-based approaches for public engagement with research, emphasize how the design and delivery of community interventions requires acute sensitivity to the cultural, political and socio-demographic context. Multiple forms of knowing, such as sensory, kinaesthetic and imaginary (16) have long been valued within practice-based research, as articulated by Sullivan: "*Such making is not just doing, but it is a complex, informed, physical, theoretical and intellectual activity where private and public worlds meet. Art practice is the outcome of intertwined objective, subjective, rational and intuitive processes*". (17, pp. 78). By engaging fathers in participatory arts-based research, we were hoping to elicit visceral, embodied and imaginative interpretations of fatherhood and parenthood; experiences which are often obscured by societal expectations and not fully captured by traditional sociological forms of enquiry.

We thus aimed to explore how fathers may be engaged creatively to explore complex and experiential aspects of fathering and parenthood beyond verbal accounts. Importantly, arts-based methods may be most suitable for engaging those fathers who are less confident in verbal expression to explore the nuances of parenting. Fathers' voices are lacking in research, and we hoped to empower them to share their stories through creative channels of communication and engagement, capturing their individual and collective experiences of parenting in a wider context of societal perceptions of masculinity and gender. These accounts may have profound implications for our understanding

of nuanced facets of father-child relationship that may be channelled into development and delivery of prevention and intervention programmes that strengthen father-child relationship and improve child development. The larger study provided a *context* and *framework* for this explorative work, primarily focused on the arts-based engagement methodology, as well as a mechanism for participant recruitment.

Despite the growing popularity of and evidence on arts-based methods in sociological, psychological and health research, very little is known about men's involvement in arts-based participatory public engagement. Here we investigate how men who are fathers may be engaged creatively to explore experiential aspects of fathering and parenthood, elaborating on their meaning through engagement with arts and individual interviews. Arts-based research is perfectly positioned to raise awareness and provide a platform for expression and meaning making for those individuals who have been traditionally less involved in research, including fathers (18). It enables to explore multiple dimensions of human condition, including fathering and parenthood, from the emotional, social, cultural and physical perspectives, reflecting myriad of ways of engaging in the world (19). By using an arts-based approach we hoped to extend methodological techniques to engage men in research while addressing social relationships, norms and expectations that shape experiences of fatherhood, exploring aspects of fathering that thus far remained inaccessible.

Methods

Participants

The sample comprised participants from the Avon Longitudinal Study of Parents and Children (ALSPAC), the Children-Generation2 (ALSPAC-G2) cohort, which was set up to provide a unique multigenerational cohort, building on the existing ALSPAC resource of originally recruited women and their partners (Generation 0; ALSPAC-G0) and their offspring (ALSPAC-G1) followed up for 26 years. Recruitment of the next generation ALSPAC-G2—the grandchildren of ALSPAC-G0 and children of ALSPAC-G1—began on 6th June 2012. Up to 30th June 2018, 810 ALSPAC-G2 participants from 548 families had been recruited. Over 70% of those invited to early- and late-pregnancy, second week of life, 6-, 12- and 24-month assessments attended, with attendance >60% for subsequent visits up to 7 years. Further details on the cohort profile, representativeness and phases of recruitment, including ALSPAC-G2, are described in four cohort-profile papers (20–23). ALSPAC study website www.bristol.ac.uk/alspac/ contains details of all the data that is available through a fully searchable data dictionary and variable search tool (http://www.bris.ac.uk/alspac/researchers/our-data/). Informed consent for the use of data collected via questionnaires and clinics was obtained from participants following the recommendations of the ALSPAC Ethics and Law Committee at the time.

On 22nd July 2019, through additional funding from Wellcome Trust, a separate research clinic for fathers was set-up (Focus on Fathers) inviting fathers directly to attend a range of assessments when their G2 child was six months old. In order to diversify the sample, fathers were also recruited through the community using a variety of mechanisms, including media advertising and study advertisements. Participants who attended ALSPAC-G2 research clinic ($n = 3$) and those fathers recruited from the community ($n = 3$) into the larger study were contacted at a later stage to participate in the arts-based participatory study. There were no specific inclusion/exclusion criteria to recruit fathers into the creative engagement study other than previous participation in the larger study (Focus on Fathers). Fathers were approached randomly using their fully anonymised Identification Number (ID).

Ethical standards

Informed consent for the use of data collected via questionnaires and clinics was obtained from participants following the recommendations of the ALSPAC Ethics and Law Committee at the time. Further ethical approval was sought to conduct arts-based participatory study from the ALSPAC Ethics and Law Committee (approved 12th October 2020). Written informed consent was obtained from the participants for the publication of any potentially identifiable images or data included in this article.

Planning and running creative sessions

Six fathers ($n = 6$, age range: 29–65) were invited and agreed to participate. All fathers were White British and in full-time employment. The majority of fathers reported university level qualifications, except one father who reported A-Level qualifications. All fathers, except one who was separated, were married to the mother of their child. In light of their prior engagement in this research, an ethical framework was already in place, however additional project considerations included the public dissemination of participants' final works (24) and the opportunities and challenges of digital platforms (25). Participants were invited to join individual artist-led sessions, conducted remotely, to elaborate creatively their recent experience of fatherhood. Participants were reassured that there was no requirement for previous arts experience, aiming to creative a safe and inclusive space and moderating participants' expectations and potential anxieties. The role of the artist facilitator in creatively supporting individual, creative explorations of fatherhood and parenthood was highlighted as central to the ethos of the project. The sessions were conducted individually, rather than in a group setting (which was also considered), to allow for nuanced individual responses to emerge. As Archibald & Blines (26) suggest: "Arts-based health research offers unique opportunities to integrate evidence of patients' lived experience with other forms of research evidence to improve understanding and knowledge translation, but transparent descriptions of this praxis are generally lacking". Throughout our mapping of the creative sessions, we

were attentive to providing an inclusive ethos designed to support diverse, unique artistic perspectives. We hoped that trust forged in earlier research involvement indicated authentic appreciation of participants' realities and knowledge systems (27) and aimed to provide opportunities for further reflection which may not surface in interview-based methods (1).

Sessions were run in November/December 2020—January/February 2021 and Covid-19 restrictions throughout the period of the public engagement project excluded face-to-face contact. We therefore drew on remote technologies and devised a framework for virtual creative 1:1 sessions led by the artist (CLR). As a prompt for conversations and an icebreaker for the creative sessions, each participant was sent a copy of "Masculinities: Liberation through photography", the catalogue of the eponymous exhibition at the Barbican Art Gallery (London, 13 July-23 August 2020), a major group show exploring how masculinity is experienced and constructed as expressed and documented through over 300 works by artists, photographers and filmmakers such as Richard Avedon, Peter Hujar, Isaac Julien, Robert Mapplethorpe and Catherine Opie (https://www.barbican.org.uk/our-story/press-room/masculinities-liberation-through-photography). The Barbican website contains a detailed description of the exhibition, including the pre- and installation images, which provide visual examples of exhibited work. The artist considered the catalogue as a shared creative launching point to facilitate the dialogue. "Fatherhood" and "masculinity" are distinct, yet related concepts that have dominated scientific and public discourse that examines their possible connections to child outcomes and to outcomes for fathers themselves (28). Our choice of catalogue was prompted by the conceptual intersection of these constructs (e.g., Fatherhood-Masculinity Model (28); to initiate and facilitate the dialogue. However, we did not intend to interrogate the distinctions and similarities of these concepts as part of the engagement process, neither did we aim to frame our engagement with fathers in any particular conceptual framework. The choice of the catalogue as a creative prompt was also driven by the practical necessity to adapt face-to-face and in-person engagement methodologies in light of the Covid-19 public health and lockdown restrictions.

Individual informal phone conversations between the artist and fathers were jointly scheduled and, increasingly, participant-led. The catalogue and imagery contained in it served as a launching point to discuss arts representation in general, effectively representing a shared visual and conversational reference. The artist requested each participant's permission to informally document dialogues, then offer reflections plus artistic resources by email following each phone-call.

Results are presented as reflections on each participant's narrative, including quotes and own writing as well as a creative output for each.

Results

The six individual narratives and corresponding imagery emerged from the creative process are presented individually. Each has been given a title (by the research team) to encapsulate the narrative.

"Wearing your heart on your sleave" (Gareth)

Gareth was intrigued by the span of the historical, stylistic and content within the catalogue archive. Images he selected to discuss included close-up explorations of facial expressions, interpersonal compositions across generations, eras and socio-cultural perspectives.

This led to reflections around being a positive role-model for his children—challenging gendered and stereotypical expectations both on the domestic and work front ("*it does frustrate me that in a time of equality fathers' rights seem unequal*") as well as assumptions around "*natural parenting*".

Gareth followed up emerging personal themes between phone calls through digital searches ["*images can appear perfect with proud, confident dads*, (…) *underneath there can be anxieties… I feel most males are likely to hide these despite it being normal*"] including sharing: "Melancholy" by Albert Gyorgy, a large-scale, seated, bronze figure with head hung low and a gaping hole in the torso—shared as a symbol of emotional vulnerability; a poignant animation represented "*fears for children's futures in this ever -changing world*"; Our Smartphone Apocalypse by Steve Cutts, which mirrored Gareth's witnessing of interpersonal disconnection between parents and children through habitual mobile-phone usage; dramatic compositions from The Cinematic Orchestra, which were exchanged to illustrate the power of music to hold contrasting emotions in balance.

Gareth chose to share an image as his creative piece (Figure 1), adding: "Fatherhood is an emotional journey and that it is okay. It doesn't make you weak. I've cried more in the first three years of my children's life than in the last 20 years". He hoped that this project would also invite mothers to "have more awareness—as I have hidden it away from my wife". He further suggested "having children brings an enhanced emotional intelligence with males, which I don't think they necessarily know how to discuss or channel… To have the best thing in the world happen to you, having this array of such strong feelings includes love, anxiety, and sadness is hard to control…" and hoped that sharing this "rollercoaster of emotion …sadness and embracing joy and dads allowing themselves to cry through both… would be helpful to other fathers".

Digital arts and multi-media provided the creative resources to extend Gareth's dialogue and reflections across this project as opposed to studio-based workshops. Gareth's choice to capture an intimate image which viscerally represented his close bonds as a father perhaps points to a more nuanced way forward regarding social media—organically incorporating technologies whilst celebrating the relational qualities of inter-personal attention.

"Different points of view" (Matthew J)

Conversations around seemingly "fixed" representations of masculinity in the Barbican catalogue inspired discussion around

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FIGURE 1
Photographic creative output from one of the participants (Gareth).

"*the impact of location and upbringing*" in identity construction and the lure of "group/gang" mentality even in the early years "*drawing boys into stereotypical behaviour patterns which limits their life experiences and abilities to connect and contribute*". Matthew J however suggested that beneath "*this veneer of washed-out individuality*", identity is still fluid. He advocated "*stepping back and cognitively processing information before emotionally responding*" to foster agency when males are feeling "*voiceless*".

Matthew J related this strategy to his current roller-coaster of experiences as a new parent and highlighted the importance of "*supporting fathers to find their own ways relating to their children—which may be complementary to those of their partners but equally valuable in models for future generations*".

As to his creative output, he created a digital animation (Figure 2) and added: "*I am very interested in pixelation as an analogy for life in that we only ever see a small part of the big picture and cannot really ever understand how it all fits together because we can't get far enough away from it. Those ideas feel very relevant to me now as well as the concept of being broken up and rebuilt which, for me, is what becoming a dad has been like. I've also included a small animation. Its small in length and size! The size is an experiment. Playing with at what point is it not readable—but I also want to convey the overwhelming scale of parenting by shrinking the individual. I wanted to represent the breaking up and rebuilding in motion as well as in still-images*".

FIGURE 2
Small animation reflecting on pixelation and idea of rebuilding, as developed by one of the participants (Matthew J).

"Permission to express emotions" (James)

James discussed an individual and group portrait from the Barbican catalogue in depth highlighting a Welsh coal-miner's eyes shining with the warmth of humanity amidst ground-in coal dust and the dissonance of banal, shared moments whilst in the full battle accessories during a Taliban group's down-time. The following conversation surfaced a desire to strip-back gendered, cultural, social and global differences, including separations between human/non-human and respect what unites us all. James later reflected on the negative impact of assumptions, prejudice, historically and culturally-rooted perspectives within parenting and suggested crafting some thought-provoking phrases or short poems to generate a wider debate. Reflecting back on the process of writing, James noted that his words seemed to have morphed into rap verses …he found himself drawing directly on his own parenting "*some parts are more angry than I expected …but I just thought I would write it all down—then edit bits out at a later date*". The following verses are the first two and final paragraphs:

Second chance

> I think about my parents and hate some of their choices
>
> Growing up to a chorus of so many raised voices
>
> Never had an opinion or ever complained
>
> Still think it affects me and keeps me restrained
>
> When I sit alone, lost in reflections
>
> Were these reasons or just deflections?
>
> Our family thrived on restraint of emotion,
>
> Hell no would we be honest and cause a commotion
>
> When I'm with my family it feels I've woke from a dream,
>
> The thought of a family this happy at one point was obscene
>
> I'd never want my daughter estranged for some time
>
> She completes our family like rhythm pairs rhyme

In conversations, James had focused on what he and his partner hoped for their family, therefore stanzas about his father such as "*Did you ever show affection without us having to ask*?" provided a stark and hard-won emotional literacy illuminating the potential to reconfigure negative experiences of fatherhood.

"Finding the right words" (Matt)

The Masculinities catalogue triggered Matt to reflect on the evolution of gender assumptions and expectations across the decades with a lack of "three-dimensional male role-models" in mind. He referenced several contemporary images which highlighted the ongoing legacy of socio-culturally prescribed behaviours such as portraits of bullfighters and fraternity rituals. Voicing the need to "*break down divisions, broaden the notion of masculinity and present healthy versions for young males in early years and adolescence*". Matt felt strongly that the visual arts could provide a powerful medium in shifting public perceptions and raising new awareness—he recalled visiting an exhibition of "*totally convincing yet completely incorrect maps*" and talked about creating images which would subvert false realities by mapping out in-the-moment, lived experience of fathers. Musing that perhaps the most pervasive influences were embedded in everyday language "*which children absorb from birth*", he considered developing two, digital word-clouds based on an analysis of parents' gendered speech around bringing up their children. Having underestimated the time and availability of relevant digital sources, Matt subsequently decided to focus on the "First Time Dads" podcast series and selected the episode "Dad guilt, Dad rage, Dad frustration, Dad envy and all the other Bad Dad feelings" for his digital analysis (https://podcasts.apple.com/gb/podcast/first-time-dads/id1297363179). As a result, he created a word-cloud (Figure 3) hoping that it might inspire debate around the impact of gendered communications and "*what it means becoming a dad*".

"Let them lead the dance" (Matthew C)

Matthew C noted the powerful visual iconography of the Barbican curation, citing "*extreme*" examples of masculinity such as body-building, and the minimal representation of family life which he felt "*undermined ordinary fatherhood—everyday Joe doing their best…*". He went on to suggest that representations of parenthood in the social media often portrayed "*idyllic*" imagery —"*an inappropriate yard stick*" leading to unhelpful comparisons. He suggested: "*…most of the time the vast majority fall somewhere in the distinctively average band of people that will make as many mistakes along the way as their children and ultimately still prove to be successful parents*".

Matthew C shared delight in "*closely observing your child's naturally emerging interests and personality*". Conversation around the stimulus of different environments brought to mind his own interest in natural structures as a young child. This led to sharing images of child-led engagements from participatory arts projects. Documentation of children's creative responses to the natural environment rekindled a desire to design "*an activity board*" for Matthew's son and triggered happy memories of handling materials and tools alongside his carpenter grandfather. " *J always seems to be happiest when he is with us and doing the same thing…he clearly learns so much from imitating … I look forward to continuing to spend time encouraging J to try new things as his interests develop*".

Ultimately Matthew C's perception of his parental role was very clear—"*supporting their journey down whatever path they chose—so that they would find their place in the world and flourish in it … an engineered childhood could be a very unhappy one*" as reflected in his choice of creative output with a photograph encapsulating a moment of everyday life (Figure 4).

"More than the sum of the parts" (Mark)

Mark was disappointed that a contemporary exhibition around masculinity featured such a minority of images around being a parent and felt the curatorial team lacked vision in representing "Masculinities". He selected a range of images to discuss—a young man objectified in the process of the photographer's aesthetic process, a tender and universally relatable series around a grandfather's peaceful death, and an uncomfortable piece raising gendered power dynamics between father-photographer and daughter-model. This level of ethical scrutiny, informed by a strong sense of justice and humanity was present in how Mark

FIGURE 3
Word cloud resulting from analysis of "First time dad" podcast episode, to encapsulate what becoming a dad means, as developed by one of the participants (Matt).

FIGURE 4
Photographic creative output from one of the participants (Matthew C).

valued fatherhood and his wish to challenge limiting, gender-specific assumptions and expectations.

Mark discussed the values of complementarity within parenting—providing a child with a balance of approaches and experiences and provided the painting below (Figure 5). "*This image was really just a quick doodle trying to allude to the value of fatherhood and what they can bring to the party. After viewing the catalogue of the photo exhibition about masculinity and our subsequent discussion. It seemed fatherhood didn't seem to have been part of the curators" agenda or hardly represented. I just feel that fatherhood should surely be one of ultimate expressions of masculinity'.*

Discussion

Creative engagement through imagery and reflection was conducive to rich and nuanced exploration of themes of fatherhood. When approaching such delicate and socially relevant topics, Gerber (16, p. 159) suggests that, in terms of social justice and impact, arts-based processes are: "well suited to dislodge, expose and address cultural, social and political structures in a transformative way that can affect how we perceive and respond to entrenched systemic issues". The arts-based participatory engagement enabled us to capture deep-rooted experiences of being a father in modern society, illuminating common cultural and intergenerational perspectives, while also tapping into unique individual experiences and meanings. In line with existing literature, fathers found arts-based methods used in this study engaging and empowering in

FIGURE 5
Watercolour realised by one of the participants to creatively encapsulate the concept of fatherhood (Mark).

accessing deeper emotions and theme surrounding fatherhood, with the process of co-creation providing an opportunity to reflect on their experiences often placing them in the context of their own upbringing and wider of socio-cultural perspectives. The richness and diversity of these unique responses suggest that arts-based methodology can facilitate public engagement with men and lead to deep reflections on complex and socially constructed phenomena such as fathering and parenthood. An arts-based approach also has the potential to inform intervention programmes, and has implications for practitioners (e.g., community support groups for men and fathers) and policies aimed to support fathers through transition to parenthood, contextualising these experiences in wider sociocultural perspectives on gender and masculinity.

From methodological standpoint, the use of an arts-based approach complemented, enriched and expanded upon the conventional qualitative methodology (i.e., in-depth qualitative interviews) employed in the main study to explore fathers' experiences of parenthood in the context of their partners' mental health (themes that emerged as part of this inquiry will be a subject of a separate publication). The opportunity for creative expression tapped into the dimensions of these experiences beyond verbal expression, providing additional dimensions and texture to the sociological enquiry by generating nuanced data and themes. Fathers' artistic expressions (through photography, drawing, writing, animation, or even creating a word cloud) served as reflections into the lived experiences of fatherhood and parenthood. The arts-based methodology was also a way of enhancing engagement in the process of knowledge creation, as well as enhancing artist–participant communication and facilitating conversations and reflections during phone interviews, generating data that was beyond the normal scope of qualitative interviews alone (29). In line with Jones (30), we argue that arts-based methodology used in our study allowed for intersubjectivity, artistic encounter (here mediated by technology), and the collective elaboration of meaning to deepen our understanding of fatherhood and parenthood in the context of wider themes pertaining to masculinity and gender. In line with previous research, we found that creative engagement illuminated aspects and dimensions of fatherhood that may be too intricate and nuanced to capture in words (31).

The richness and breadth of themes and creative outputs that emerged as a part of this participatory engagement project (e.g., emotional vulnerability of fatherhood, identity formation as a father, emotional experiences of own childhood, socially constructed language of fatherhood, gender specific assumptions surrounding fatherhood) have also highlighted fathers' awareness of their role in their children's development and their unwavering desire to be part of this journey in practical and emotional ways. The idea of "intimate fathering" that encompasses but goes beyond an emotional connection, prioritising the quality of parent-child relationship, has been strongly advocated in contemporary sociological literature (32, 33). Father involvement and quality of father-child relationship (34) have important implications for numerous aspects of child socio-emotional, behavioural and cognitive development (35, 36). Paternal mental health may disrupt the emotional quality of father-child relationship (11), which, in turn, has deleterious consequences for healthy child development (12). Thus, it is important to support fathers through family-based prevention and intervention programmes that address fathers' mental health and strengthen family cohesion, including father-child relationship.

From a practical standpoint, the thematically relevant Barbican exhibition catalogue "*Masculinities: Liberation through photography*", albeit focused on masculinity and not parenthood, provided an invaluable resource to broadly discuss arts representations and interpretations of these related yet distinct constructs. This group of participants were already confident in volunteering insights verbally, yet open to exploring and translating their perspectives around fatherhood through mixed/multi-media. The three scheduled phone-calls to each participant allowed the artist to engage in generative listening building a sense of creative pre-dispositions, motivations and unique life-experiences throughout the project. Email communications which ran in parallel with the phone-calls provided an opportunity for the participants to check in with the artist's interpretations of the dialogues. Devoid of a studio context, this reflexive strand also allowed the artist to re-calibrate the focus and selection of arts references to support (if appropriate) emerging creative enquiries. The open-ended, dynamic ethos of this process side-stepped limiting expectations of specific creative outputs.

As previously argued, this kind of participatory creative work also presents possible challenges (24). Alongside possible ethical

issues relating to privacy and risks of identification, which are mitigated by ensuring appropriate consenting, participants' wellbeing is a key aspect as the creative exploration of feelings and experiences (including potentially unexpectedly painful ones) can represent "dangerous emotional terrain" (37). The artist as a facilitator aims to ensure that appropriate signposting and support is in place during and after the engagement activities. The wellbeing of the facilitator is also an important consideration, with the whole project team providing a space for them to reflect and appropriate support if necessary. It should also be mentioned that creative expression is open to multiple interpretations and meanings. In order to address this challenge, we have invited fathers who took part in the study to reflect on meanings and interpretations of their creative engagement and expression prior to publication. The challenge of balancing artistic and scientific components as part of arts-based enquiry has also been articulated (38). In this instance, the artist (CLR) was not familiar with previous research and fathers' individual circumstances. Thus, they were able to establish a relationship as creative companions free of shared history, providing an opportunity and space for creative exchange and in-depths exploration of unique personal experiences and meanings. It has been argued that arts-based research produces a less tangible knowledge that can be tested for reliability and validity (39, 40). However, in our experience, engaging with creative arts-based co-enquiry opened up avenues for capturing rich and textured facets of fathers' emotional experiences of parenthood, embedded in personal experiences of being parented and wider societal and gender expectations.

It should be noted that our study took place during the Covid-19 pandemic, with emerging qualitative studies highlighting profound implications that public health restrictions exerted on fathers' experiences of becoming fathers (41), perceptions of their role (42) and parenting experiences (43). However, the effects of the Covid-19 pandemic on fathers' experiences of fatherhood and parenting were not the focus of the conversations between the artist and the fathers, thus, these themes and reflections did not emerge in our data. The small, and potentially selective nature, of our sample size should be highlighted as a potential limitation. The breadth and richness of the participants' experiences of fatherhood and parenting may need to be explored further using arts-based research methods in a larger and more diverse sample of fathers from various socio-economic, ethnic and cultural backgrounds. Nevertheless, despite these challenges and potential limitations, we argue that creative and arts-based participatory research methods have much to offer in generating profound insights into multi-faceted and complex phenomena such as fatherhood, parenting and mental health beyond "cognitive ways of knowing", stimulating a broader perspective while engaging fathers in research (40, 44). Furthermore, the aim of this study was to focus on exploring the appropriateness and potential of these creative approaches specifically with this demographic and indeed the richness and insightfulness of the creative outputs is a clear demonstration of the value that such approaches can offer in this context.

Data availability statement

ALSPAC data are available through a system of managed open access. The study website contains details of all the data that is available through a fully searchable data dictionary and variable search tool data dictionary. The application steps for ALSPAC data access are highlighted below.

1. Please read the ALSPAC access policy, which describes the process of accessing the data in detail, and outlines the costs associated with doing so.
2. You may also find it useful to browse the fully searchable research proposals database, which lists all research projects that have been approved since April 2011.
3. Please submit your research proposal for consideration by the ALSPAC Executive Committee. You will receive a response within 10 working days to advise you whether your proposal has been approved.

If you have any questions about accessing data, please email alspac-data@bristol.ac.uk.

Requests to access the datasets should be directed to alspac-data@bristol.ac.uk.

Ethics statement

The studies involving human participants were reviewed and approved by Avon Longitudinal Study of Parents and Children (ALSPAC) Ethics & Law Committee. The patients/participants provided their written informed consent to participate in this study. Informed consent for the use of data was obtained from participants following the recommendations of the ALSPAC Ethics and Law Committee at the time. Written informed consent was obtained from the participants for the publication of any potentially identifiable images or data included in this article.

Author contributions

IC, CL, GB and MGB: provided substantial contributions to the conception of the design of the study, acquisition, analyses and interpretation of the data. GW, MB, JP and MJ: participated in the study and provided critical insights into the design of the study. IC, CL and GB: drafted the work. IC, CLR, GB, MGB, GW, MaB, JP and MJ: critically revised the draft for important intellectual content. IC: is accountable for all aspects of the work and serves a s a guarantor of accuracy and integrity of the work. All authors contributed to the article and approved the submitted version.

Funding

The UK Medical Research Council and Wellcome (217065/Z/19/Z) and the University of Bristol provide core support for

ALSPAC. A comprehensive list of grants funding is available on the ALSPAC website (http://www.bristol.ac.uk/alspac/external/documents/grant-acknowledgements.pdf). This publication is the work of the authors and Dr Culpin will serve as guarantors for the contents of this paper. This research was funded in whole by the Dr Culpin was funded by the Wellcome Trust Fellowship in Humanities and Social Science (212664/Z/18/Z) awarded to Dr Culpin. For the purpose of Open Access, the author has applied a CC BY public copyright licence to any Author Accepted Manuscript version arising from this submission.

Acknowledgments

We are extremely grateful to all the families who took part in this study, the midwives for their help in recruiting them, and the whole ALSPAC team, which includes interviewers, computer and laboratory technicians, clerical workers, research scientists, volunteers, managers, receptionists and nurses. We would like to express our particular gratitude to Matthew Dobbs, who provided an invaluable input into the study by participating in the research and sharing his thoughts and time most generously.

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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frontiers | Frontiers in Child and Adolescent Psychiatry

TYPE Methods
PUBLISHED 04 March 2024
DOI 10.3389/frcha.2023.1214890

OPEN ACCESS

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RECEIVED 30 April 2023
ACCEPTED 09 November 2023
PUBLISHED 04 March 2024

CITATION
Wright N, Pearson RM, Crook D, Bond A and Jewell T (2024) Through each other's eyes: initial results and protocol for the co-design of an observational measure of adolescent-parent interaction using first-person perspective. Front. Child Adolesc. Psychiatry 2:1214890. doi: 10.3389/frcha.2023.1214890

Through each other's eyes: initial results and protocol for the co-design of an observational measure of adolescent-parent interaction using first-person perspective

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Background: Current observational methods to understand adolescent-parent interaction are limited in terms of ecological and content validity. We outline initial results and a protocol for future work from a programme of work to: (1) establish a new method for data capture of adolescent-parent interaction at home using wearable cameras and; (2) develop a new relevant and comprehensive observational micro-coding scheme. In Part 1, we report our completed preliminary work, comprised of an initial scoping review, and public engagement work. In Part 2, we present a protocol for the development of the new measure.

Methods: Part 1—We searched Pubmed for existing observational measures of adolescent-parent interaction for the scoping review. We also undertook public engagement work utilising a mobile research van, taken to multiple locations around Bristol, UK to engage with a variety of populations through interactive methods. Part 2—Our protocol describes plans for: (1) A systematic review of the psychometric properties of observational measures of adolescent-parent interaction; (2) Focussed public engagement workshops; (3) Harmonisation of information from existing coding schemes and literature with information from public engagement with adolescents and parents; (4) A pilot study to assess the acceptability and feasibility of the method; (5) Development of a coding scheme in consultation with expert and lay panels, and through real-life application to recorded videos from a pilot sample.

Results: Scoping review: we identified 21 adolescent-parent observational schemes, of which eight used micro-coding and 13 used globalcoding schemes. The majority of micro-coding schemes were not developed specifically for adolescents. Most studies used conflict or problem-solving tasks, which may not adequately capture positive adolescent-parent interactions. The mobile van event received views from 234 young people and/or parents. Families were positive about taking part in research using headcams. "Trust" and "understanding" were most frequently reported as important adolescent-parent relationship constructs.

Conclusions: This work represents the first attempt to truly co-design a method to assess parenting in adolescence. We hope to develop an observational measure using novel technological methods that can be used across a range of research and therapeutic settings.

KEYWORDS

parenting, measurement, family interaction, parent-adolescent, observation, adolecence, adolescent-parent

Introduction

Adolescence constitutes a crucial developmental period in which most mental health disorders typically arise (1). It also represents a period of relational transition with growing sense of identity and autonomy or independence from parents (2–4), which is accompanied by increases in adolescent-parent conflict (5) and decreases in closeness (6). Mental health disorders are rising in young people at an alarming rate (7) and child and adolescent mental health services are unable to meet the level of demand for treatment (8). Family interventions are recommended in the treatment of adolescent mental health disorders including conduct disorder, eating disorders and depression (9–11). However, understanding of adolescent-parent interaction is limited, particularly regarding micro processes underlying relationships (12). Such processes are key to relational and behavioural interventions and may be best understood from observing and analysing behavioural interactions.

There is a large body of high-quality observational evidence from studies showing that specific parenting constructs in early childhood promote later cognitive and socio-emotional development, and these findings have been successfully translated into behavioural interventions which improve relationships (13). However, such understanding is lacking in adolescence. In addition, in child, adolescent and adult romantic relationship interaction research there is a greater focus on negative and problematic interaction patterns (14, 15). Thus, there is a need for observational measures of adolescent-parent interaction that can assess relational strengths as well as difficulties, with well-established ecological and content validity. The measures are needed to allow researchers to capture real life interactions and then to make meaningful observations from them to aid better understanding of relationships during adolescence. Secondly once established to provide tools to assess and evaluate relational change in clinical settings as well as to provide feedback to families using the tools directly in interventions. It is key to achieve this so that tools are accessible to families, researchers and professionals in educational, psychology or psychiatric settings. Such measures could have several applications: firstly, to inform the development of relational interventions for clinical populations with mental health problems; secondly, to understand family processes in the general population; and thirdly, to better understand family relationships and how that links to mental health and other outcomes through use in large international prospective cohort studies. The present paper aims to set out a program of research to develop such a measure and is structured in two parts. In Part 1, we report preliminary work we have already conducted, comprised of an initial scoping review and public engagement exercise. In Part 2, we report a protocol for the next steps we will undertake to develop the measure. However, to begin with, we present an overview of the field, highlighting some of the key methodological limitations of prior research.

Overview of observational measures of adolescent-parent interaction

Firstly, we review what observational work has been conducted with parents and adolescents to date. By "observational" we mean methods where behaviour between parents and adolescents is observed and recorded to allow objective behavioural analysis. One aspect of observational analysis concerns how the interaction is ***elicited and captured*** (i.e., *where* and how it is recorded and *what* the family is doing) and the second aspect concerns how the behaviour and relationship is then ***assessed or*** "***coded***" from the observation. We explore both improvements to methods of data capture and the coding of interactions here.

We begin by scoping existing measures. Researchers have utilised observational measures of adolescent-parent interaction since at least the 1980s (16), yet to our knowledge there has never been a systematic review focused on such measures. Twenty years ago, Aspland and Gardner (17) provided a helpful narrative review of observer-rated measures of parent-child interactions, highlighting issues including differences in task (structured vs. unstructured), setting (laboratory vs. home) as well as discussing issues of validity and reliability. However, this review did not aim to identify all existing schemes, and only a few measures were discussed for purposes of illustration. Locke and Prinz (18) reviewed all measures they identified as assessing discipline and nurturance developed in the preceding two decades. Only three observational measures were identified for the adolescent period, and six identified for early adolescence. The authors highlight the need for validation studies in different cultural groups, as well as the importance of research into the ethnicity of coders as a variable which may influence coding. Jewell et al. (19) conducted a systematic review of attachment measures in middle childhood and adolescence, but only identified one scheme assessing observed adolescent-parent interaction, the goal-corrected partnership adolescent coding system (GPACS) (20), with all other observer-rated schemes assessing the child on their own, typically using attachment interviews.

Marshall et al. (21) recently conducted a systematic review of measures of adolescent-parent conflict processes and their measurement, identifying 568 measures from 467 articles, of which 54 measures utilised observer ratings. The approach to inclusion was generous, with many included studies providing scant details of the observer-rated task or measure [Marshall (2023) personal communication]. Moreover, the aim of this review was to analyse the ways in which adolescent-parent conflict has been conceptualised and measured (e.g., frequency of disagreement, duration of conflict), and the psychometric properties of measures were not assessed. Finally, there have been two systematic reviews conducted on the psychometric properties of observer-rated parent-child interaction measures for children: Cañas, Ibabe & De Paúl (22) assessed measures for 0–12-year-olds at risk of child abuse and neglect, whilst Gridley et al. (23) investigated measures for 0–5-olds used in randomized controlled trials. Both reviews highlighted a lack of strong validity evidence for such measures.

In summary, it is known that observational-measures of adolescent-parent interaction have been utilised frequently in research, yet the literature has not been reviewed, and thus the full scope of the field, as well as the psychometric properties of measures, are currently unknown. Furthermore, the extent to which previous observed measures have conducted in depth micro-analysis (where all behaviours and sequences between behaviours are explored) remains unclear because few previous studies include micro-coding systems across all behavioural domains.More in depth micro-coding is important given the potential for such micro codes to guide the development of more specific and person-centred interventions.

Limitations of existing observational measures

Whilst there are advantages to observational measures, there are challenges too, with perhaps the most widely acknowledged difficulty being the length of time needed to capture and then code recorded or live interactions. Less commonly discussed are several important threats to the validity of such measures both in terms of data capture and coding of content: firstly, a lack of ecological validity due to lab-based observation; secondly, insufficient content validity evidence due to non-involvement of parents and adolescents in the development of measures; and thirdly, a lack of evidence of content validity and measurement invariance across different cultures and changing times.

Ecological validity and methods of observation (data capture)

Home or Lab settings

In terms of ecological validity, existing observational measures of adolescent-parent interaction typically involve visits to a laboratory to take part in a structured task, such as a conflict discussion [e.g., Allen et al. (24)]. Evidence suggests that behaviour under "laboratory conditions" does not reflect behaviour at home (25, 26).

Lab assessments and researcher-administered home assessments may lead to reactivity effects, whereby people change their behaviour due to the presence of the researcher or knowledge that they are being recorded. There is limited evidence examining this: Gardner (25) reviewed the literature based on audio-recorded assessments, which suggested no evidence of reactivity effects, but this did not compare researcher-present to researcher-absent conditions. When assessments from lab and home observations are compared, lower levels of negative behaviours are shown in the lab (15) which may reflect reactivity effects in the lab setting.

In addition, even though home settings improve ecological validity as compared to lab settings, in most situations a researcher is still present and has visited at a scheduled time. We have previously provided evidence for improved ecological validity of observational assessment conducted using wearable cameras with families of infants. Lee et al. (26) found that when families with infants self-recorded interactions with wearable cameras alone, as compared to the same dyads interacting at home but recorded by a researcher, more "negative" and socially undesirable maternal behaviours were observed. Footage recorded from wearable cameras also has a major advantage in that it captures a "first-person" perspective on an interaction, in contrast to the "third-person" perspective recorded from a static camera positioned to film an interaction from a side-view. Firstly, the first-person perspective allows for superior capture of faces and eye gaze; secondly, there is the potential for the development of therapeutic uses for such footage, such as video feedback techniques in which a therapist reviews footage with a parent or adolescent, allowing them to see themselves "through the eyes" of the other person. Figure 1 provides a photograph of the wearable cameras.

Tasks to elicit interactions

Another key to ecological validity is not only where the interaction is recorded but *how* the interaction is evoked. Very early work observing parent-child interaction was conducted at home involving multiple visits from researchers who observed and coded naturally occurring family behaviour "live" (27). The time-consuming nature of this led to the use of "structured" tasks designed to elicit behaviours of interest. Dishion and Stormshak (14) conceptualise these tasks as assessing either relationship quality or behavioural management. Relationship quality tasks in infancy and childhood are free-play or separation and reunion tasks. From childhood to adolescence, planning discussion tasks (such as planning a fun family activity) are typically used to assess relationship quality. In childhood, "clean-up" tasks are used to assess behavioural management and in later childhood and adolescence problem solving or conflict discussion tasks are used. The vast majority of adolescent studies use problem solving or conflict discussion, and these tasks have been shown to elicit relevant negative interaction behaviours when they use real rather than hypothetical scenarios (14). There is conflicting evidence on whether these behaviours elicited in the

FIGURE 1
An example of the two teens wearing head-cameras completing an interaction task.

lab generalise to behaviours observed in unstructured settings at home. Behaviours observed in home settings are more strongly linked to ratings of psychopathology than behaviours observed in a lab, with the strongest associations found for unstructured tasks in the home (25). Behavioural coding across structured and unstructured tasks within the same dyads also show only modest agreement.

Although the traditional view of adolescence as a time of high conflict with parents is not supported by evidence, there is an increase in more minor conflicts in early and middle adolescence (5, 6), meaning that conflict discussions are a relevant context for assessing adolescent-parent interaction. These discussions allow observation of negative conflict processes such as criticism, hostility and coercion, and also more positive behaviours such as validation, support, and listening which may reflect adaptive conflict resolution strategies (28). However, conflict discussions are less likely to evoke other positive behaviours such as affection or shared enjoyment (14, 15). In addition, given that engaging in a conflict discussion generates negative emotion and increased physiological arousal (29–31) this context may not be best suited to assess positive adolescent-parent interaction quality. Tasks which may evoke more positive interaction qualities are needed. Such tasks may also be more acceptable and ethical in the context of parents and adolescents completing and recording tasks at home without the presence of a researcher.

Threats to the validity of existing measures that code or assess observations

Content validity refers to the extent that the *content* of an instrument adequately reflects the construct to be measured (32). For adolescent-parent interaction measures, the perspectives of parents and adolescents on content validity are strikingly absent in the development of measures. Instead, measures appear to have typically been developed in a "top-down" fashion by researchers based on theoretical constructs such as attachment [e.g., Obsuth et al. (20)] or coercive family cycles (33, 34). The lack of involvement of parents and adolescents hampers not only the content validity of measures, but also represents a missed opportunity to gain valuable suggestions on the acceptability and feasibility of tasks. Involving parents and adolescents through co-design of a measure through participatory methods would help to strengthen the content validity of a measure, in terms of both the task and the scope of the construct/s to be measured. Such work can be combined in iterative fashion during the *substantive phase* of validation (35) and feed into other key early tasks such as mapping concepts and reviewing literature.

Moreover, insufficient attention has been paid to the role of culture in developing measures, both across and within countries. For instance, content validity cannot be assumed for minoritized groups within a culture, such as ethnic minorities. Adolescent-parent relationships will be strongly influenced by cultural context, thereby complicating attempts to define norms for concepts such as communication. This points to the need for careful validation work, which can include consultation with stakeholders, qualitative interviews, as well as formal studies of measurement invariance, when seeking to validate a measure for a specific population. In addition, the culture of researchers may influence their coding: for instance, Yasui and Dishion (36) found inter-rater reliability to vary as a function of the ethnicity of coders, as well as of the concordance between the ethnicity of the coders and the families being rated.

Finally, we must consider the neglected concept of time in relation to content validity. Many measures of adolescent-parent interaction were developed several decades ago. Notwithstanding the absence of parent/adolescent involvement in their development, we can ask: do such measures retain their validity across time, or does validity evidence require continual renewal? Before answering this question, it is worth going back to first principles and considering the meaning of validity, which refers to the degree to which evidence and theory support the interpretations of test scores for proposed uses of tests (37). Thus, validity is *not a property of a measure*; rather, statements about validity should be made with regard to specific uses of a measure (37). Researchers are likely to be familiar with the notions of cross-cultural validity and measurement invariance—put simply, the need to evaluate the performance of a measure in a new context, such as a translated measure used in a new country. Returning to the question of validity across time, we suggest that adolescent-parent relationships have changed so much in Western societies that they represent a *new cultural*

context when compared to families of several decades ago. Consequently, whilst the validity evidence for all measures has the potential to degrade over time, we suggest that measures aiming to assess interactions between family members are particularly vulnerable to this due to the significant changes that have impacted adolescent-parent interaction in developed countries. Such changes include: a trend towards older age for completing transitions out of adolescence such as family formation or ending education (38); the arrival of new technology and social media, giving rise to "digital parenting" (39); and broader societal changes in parent-child relationships such as increased communication and quality-time, reduced authoritarian control and corporal punishment, and decreased parental self-efficacy (40). In summary, construct validation is an ongoing process (41) which requires evidence to justify specific uses (37); viewed in this light, existing observational measures of adolescent-parent interaction are far-from convincing in terms of content and construct validity.

Micro and global approaches to coding of observational content

Most observational coding schemes of parent-child interaction assess "global" constructs. Global ratings require the observer to form overall impressions from multiple different units of behaviour and consider frequency, intensity and duration within an entire interaction to make a numerical rating on a single scale. For example, in the global rating of maternal sensitivity, the most well-known construct in infancy, a researcher makes a numerical rating based on their global impression of how well the mother identifies, interprets and appropriately responds to her child's cues (42). This requires specific and time-consuming training to be able to assess reliably with baselines which were often developed several decades ago. Micro-coding, in contrast, focuses on individual units of behaviour and allows examination of moment-to-moment temporal sequences of behaviour (43, 44). This approach considers more subtle interactional processes and allows the identification of specific behaviours which may precede desirable or less desirable "target behaviours", thus providing unique (and flexible) information which may be readily translated into intervention to promote positive parent-child interactions (44). Micro-coding allows tracking of frequency, sequence and duration of interactive behaviour (see Figure 2). Some micro-coding approaches focus on individual units of behaviour such as facial expression [e.g., the Facial Action Coding System; FACS; (45)]. Individual units of behaviour permit automated coding, which considerably reduce the time and costs associated with observational data. Most micro-coding approaches outside of infancy reflect behavioural groupings which integrate across multiple different behaviours (e.g., facial expression, bodily movements, speech) and require consideration of the context. In the SPAFF (Specific Affect Coding System), Coan and Gottman (46) refer to these codes as "gestalt behaviour codes" and conceptualise them as unobservable latent variables which are directly observed via specific behavioural indicators. For example, "validation" is observed with the indicators of agreement/apology, summarising, and head nodding with eye contact.

Pearson and colleagues (47) developed a comprehensive micro-coding scheme for parent-infant interaction including both discrete and gestalt behaviours from a review of all existing

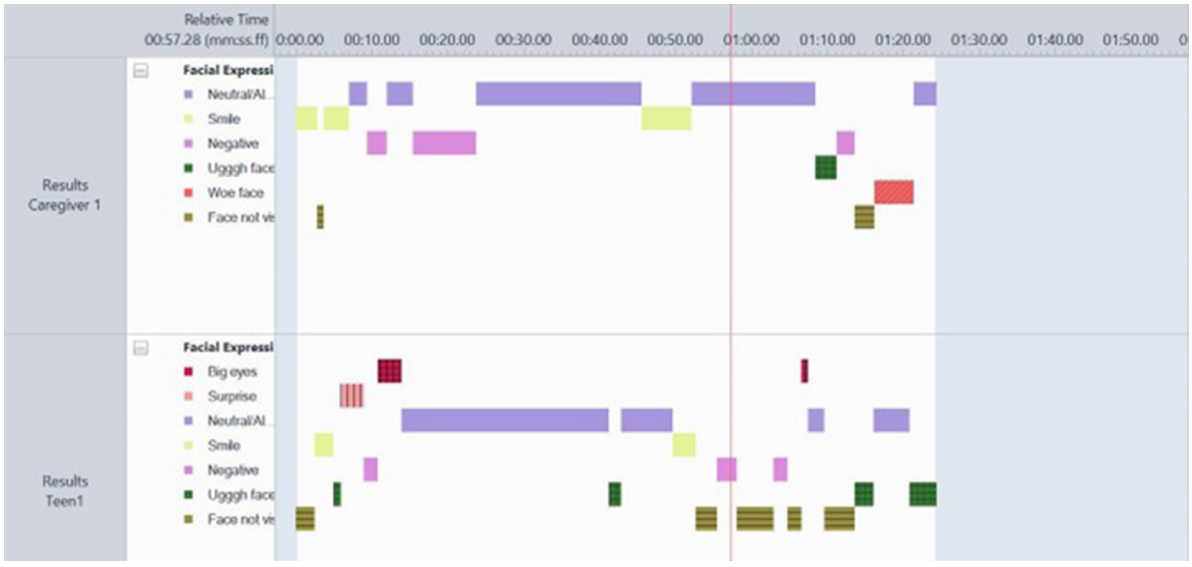


FIGURE 2
Example of micro coded data on the behavioural domain of facial expressions. The number and duration of each behaviour is visualised by the colour blocks in Observer XT.

coding schemes and have shown that reliability can be easily achieved (47, 48). The scheme is applied using the Observer XT [version 16 (49)] software which permits coding of observational data on a timeline. Figure 2 shows an example of micro coded data on the behavioural domain of facial expressions. The number and duration of each behaviour is visualised by the colour blocks using Observer XT software.

Limitations of existing micro-coding and considerations for adolescence

Micro-coding also has limitations and particular considerations regarding its suitability for adolescent behaviour. Most notably, in micro-coding in infancy the context of each specific behaviour is not usually captured. For example, consider a negative or sad face by a mother. The context of this facial expression could lead to very different meanings and thus targets for interactions. For example, it may reflect a negative emotional state in the mother and lack of warmth or may reflect emotional mirroring by the mother (which is likely to be highly sensitive). This can be lost in micro-coding even if combinations or sequences are used.

In infancy micro-coding schemes, one facial expression category that is highly predictive is a "woe" face. As first described by Beatrice Beebe (50), this is an exaggerated sad face that is specifically linked to compassion/sympathy. It does not necessarily mirror a sad face in the child but instead marks an understanding by the caregiver which signals sympathy rather than negativity. Given adolescents' vastly more sophisticated social and cognitive development relative to infants, the ability of micro-codes to capture contextual subtleties such as humour or sarcasm may be a particular challenge for coding schemes of adolescent-parent interaction.

Summary and aims

There is a need for methods to collect observational data which are acceptable, feasible and ecologically valid, and coding schemes which adequately characterise modern adolescent-parent relationships, with strong content and construct validity. Such methods can advance our understanding of parenting in adolescence and have the potential to inform the development of new interventions, based on observed interactions. This could include therapies that directly utilise observational material within the course of treatment, such as video feedback, or the adaptation of existing approaches, such as parenting groups or family therapy, utilising evidence gleaned through observational research. New methods are required due to the limitations of available measures, including substantial threats to content and construct validity.

The programme of work described here aims to develop a new observational measure of adolescent-parent interaction by: (1) conducting a scoping review of the literature to identify existing adolescent-parent observational coding schemes and extracting all interaction codes; (2) conducting public engagement work with relevant stakeholders (adolescents, parents and professionals) to identify currently relevant constructs; (3) harmonising the "top-down" information from the existing literature with the "bottom-up" information from relevant stakeholders to generate a micro-coding scheme for adolescent-parent interactions and suitable scenarios or tasks to record behaviour; (4) carrying out a feasibility study of the wearable camera methodology and initial validation of the coding-scheme in a pilot study of adolescents and parents. We believe this is the first attempt to generate a tool to measure adolescent-parent interaction which combines both the traditional "top down" approaches taken in research and clinical practice with "bottom up" information from adolescents and parents.

Overall project aims

1) Identify existing concepts important in adolescent-parent interactions from both Public Patient Involvement (PPI) and existing literature.
2) Develop an observational system to capture adolescent-parent interaction behaviour based on the existing literature and co-creation methods.
3) Explore feasibility and acceptability of wearable cams with adolescents and their parents at home.
4) Develop a protocol (including tasks) which (a) can be conducted at home (b) allows capture of relevant footage and (c) evokes / captures relevant and authentic domains of the relationship.

Initial completed work presented in this paper:

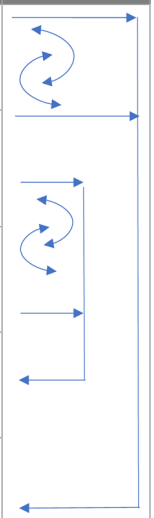
1) Scoping review of existing adolescent-parent observational measures (links to aim 1 and 2)
2) Scoping public engagement with adolescents and parents of methods and concepts (links to aim 2)

Next steps to be described as protocols in this paper:

1) Systematic review of measurement properties of existing coding schemes (links to aims 1 and 2).
2) Construct definition through focused public engagement workshops (links to aims 1, 2 and 4).
3) Harmonisation of information from existing coding schemes with information from public engagement with adolescents and parents (links to aims 1, 2 and 4).
4) Assess acceptability and feasibility of data capture by wearable camera technology (links to aims 3 and 4).
5) Development of a coding scheme in consultation with an expert panel and lay/PPI panel and through real-life application to recorded videos from a pilot sample (links to all aims).

Table 1 links the aims and objectives of the project to each piece of work outlined below, and summarises the output and current status of each.

TABLE 1 Aims, objectives and linked activities for the project.

Aim	Goal	Activity	Output	Status	Next step	
Identify known constructs and measures in parent-teen relationships	Scope existing concepts and schemes	Scoping review	21 schemes identified, very few micro- or recent.	Complete	Map to concepts identified below	
Identify new and relevant constructs in parent-teen relationships	Hear from communities what concepts are important	Mobile public engagement	Identification of most important/frequent: Trust and Understanding.	Complete	Harmonise with constructs in literature above	
Identify task/situation to elicit record behaviour	Scope what previous studies have done	Scoping review	Found most studies were in "lab" or home with a researcher present and conflict tasks.	Complete	Guide adaptions based on current needs	
Identify task/situation to elicit and record behaviour	Hear from communities what situations/tasks could work and whether wearable cameras are acceptable.	Mobile event	Protocol developed.	Complete	Integrate with existing work and design protocol	
Feasibility and acceptability of protocol	Design study procedures to test feasibility and acceptability of protocol	Full standard operating procedure and protocol developed and launched in cohort study	Protocol launched (https://www.youtube.com/watch?v = LLxWI8dplbg&t = 1s)	In progress	Data collection and analysis	
Develop micro-coding scheme	Map concepts such as trust and understanding to more specific observed behaviours	Specific targeted workshops	Specific operationally defined behavioural signatures of important constructs.	Planned		

The arrows represent the links between the different activities, with double headed circular arrows representing activities which influence each other.

Part 1—Completed ground work

Methods

Scoping review to identify existing coding schemes, relevant behaviours, and indices of relationships

To identify papers with observed adolescent-parent interaction data we conducted a search in Pubmed using the terms "parent adolescent observed interaction coding behaviour" (and all related synonyms, see Supplementary file S1 for full search terms). Abstracts were screened to identify papers which included observation of parent-child interaction with samples with a mean child age of between 10 and 19 years. The methods sections of relevant papers were then checked to identify coding schemes to be included. Coding schemes were not included if they focussed on a very specific scenario (e.g., discussions about cigarette smoking; parent-child interaction within a therapy session) or included codes only on whole-family interaction.

Public engagement/co-creation

Scoping public engagement: we conducted a PPI mobile research van event in multiple locations around Bristol, UK, in August 2022 (51) with the aim of engaging with a variety of populations including those typically considered "hard to reach". Researchers spoke to young people and their parents to find out their views on what they considered to be the characteristics of a "good" adolescent-parent relationship and key concepts were recorded using whiteboards. Parents and young people were invited to try out the wearable cameras and give their views on taking part in research using them. They were also asked what tasks or everyday scenarios would be acceptable and would best capture their relationship interactions at home. Initial conversations were used to create a voting system where subsequent families voted on their chosen task.

Results

Scoping review of coding schemes

The search terms identified 128 papers. Of those, 44 papers included adolescent-parent interaction observational coding, reflecting 9 micro- and 13 global- coding schemes. An additional 4 micro- and 2 global- schemes were identified from the reference lists of the Marshall et al. (21), Locke & Prinze (18) and Jewell et al. (19) reviews and from reviewing reference lists of relevant papers. One global scheme was added from a preliminary search ran for the systematic review of measures (described below). Given our focus on micro-coding and space constraints, we will provide a more detailed account of micro-coding schemes in this paper. These initial summaries for this paper focus on the characteristics of the schemes rather than a description or synthesis of the specific concepts assessed in the codes.

Summary of micro-coding schemes

Table 2 displays the identified micro-coding schemes. Columns summarise characteristics including: whether they were developed for adolescents; their history; what tasks they were developed for; and the type of codes contained. Micro-coding can be "event" or "timing" based. In event-based coding, once a behaviour is coded, for example when a parent smiles, they will be coded as smiling until that changes; that is, codes are updated according

to new "events". In time-based coding, the behaviour is assessed within specific time windows. For example, in a time-based coding scheme using two second intervals, at two seconds a parent could be coded as smiling; at four seconds, if the parent is still smiling, then they will again be coded as such. We use the term "behaviour groups" to describe codes that involve combinations of individual units of behaviour. For example, "fear" in the Specific Affect Coding System [SPAFF (46)] is a combination of a range of different verbal characteristics (e.g., shifts in frequency in speech, speech disturbances), body movements (e.g., gestures or fidgeting) and facial movements (e.g., gulping and biting lip).

Scheme history: Most of the identified schemes were either directly developed within or were influenced by work in the Oregon Social Learning Centre (OSLC), using social learning theory (SLT) principles, particularly Patterson's cycle of coercion (34). As described in the table, the initial Family Interaction Coding System [FICS (27)], which has not been used with adolescents so not included in the review, has been developed and extended into several other schemes which were identified (Family Process Code (FPC), RACS, Peer Process Code (PPC) (52, 68, 72)). This work is largely based on clinical samples of children and families with behavioural problems, but also some studies with general population samples with further developments of the scales. Schemes identified in this review were also influenced by schemes developed using social learning theory principles to assess conflict resolution in adult marital relationships such as the Marital Interaction Coding System [MICS (61)] and the Couples Interaction Scoring System [CISS (59)]. The Living in Familial Environments (LIFE), Codebook for Marital and Family Interaction (COMFI), Parent-Adolescent Interaction Coding System-Revised (PAICS-R) (44, 63, 70) all identified as being developed from these marital relationship schemes. The PAICS-R also draws on family systems theory. The LIFE scheme included consideration of the SLT processes involved in maintaining depression (reciprocity). Another scheme developed for children, INTERACT (57), draws on both coercion and reciprocity models from social learning theory. Another school of schemes which focus more narrowly on affect were developed from Ekman's work on coding facial expression [SPAFF & Simple Affect Coding System (SACS)] (58, 62). One identified scheme specifically focused on conversational discourse in relation to language learning (Contingency Coding System; CCS) (72). Finally, one scheme drew on psychoanalytic theory on adolescent ego development (Constraining & Enabling Coding System; CECS) (16).

Code types: Most schemes were designed to use event-based coding; the INTERACT and SPAFF are timing based; and the Relationship Process Code [RPC (55)] was described as suitable for both event and timing-based coding. All the identified schemes described "behaviour group" codes, and none focussed on coding individual units of behaviour (such as just facial expression or visual attention). Schemes from the OSLC tend to separate verbal from non-verbal in their behavioural codes, whereas other schemes combine the two modalities (e.g., the SPAFF) and some focus only on speech (PAICS-R, CCS). For example, "validation" is assessed as affect (non-verbal behaviour) in the RACS, but from speech and non-verbal combined in the SPAFF, or just speech in the CCS. Most codes reflect one person's behaviour to another (e.g., command/direct, criticism, positive physical contact), although nearly all schemes contain concepts such as "validation" which are inherently dependant on the prior behaviour of the other. Only one scheme specifically conceptualises a dyadic behaviour [discourse change; (CECS)].

Developed for adolescents: Only three schemes were described as being developed for adolescents (the RACS, PAICS-R, CECS). The CECS is described as drawing on adolescent-specific theory, the RACS is a combination of the RPC developed for children and the SPAFF developed for adults. The PAICS-R was developed from an adult scheme but describes focusing on behaviours relevant to adolescent-parent conflict. Other schemes were either developed for children and applied to adolescents, or developed to apply to all family relationships (e.g., parent-parent, parent-child, parent-adolescent).

Tasks: Most schemes were developed for problem-solving tasks, specifically conflict resolution tasks where the parent and child identify three areas of disagreement and are asked to discuss them and attempt to reach a resolution. One scheme was developed for a similar "revealed differences" task where parent and adolescent completed a moral judgement task and then discussed the answers where they differed (CECS). The OSLC schemes are described as being suitable for a variety of structured and unstructured settings (e.g., mealtimes). This includes the structured task of planning an activity. The RACS has been used with the Family Assessment Task (69) battery of discussion tasks which includes tasks designed to elicit positive discussion on: encouragement of personal growth (parent and child pick a topic of growth, such as academic achievement, to discuss) and positive recognition of family member (parent and child have a discussion about positive features of the other). No tasks were specifically designed to elicit shared enjoyment.

Summary of global coding schemes

Table 3 displays the identified global-coding schemes, with columns summarising whether they were developed for adolescents, their history, what tasks they were developed for, and the type of codes contained. A briefer and less detailed narrative summary of the characteristics of the global schemes is provided below.

Scheme history: schemes drew on a variety of theoretical backgrounds, including social learning theory, psychoanalytic work on ego development and autonomy promotion, attachment theory, family systems theory, structural family systems theory, Baumrind's (100) parenting typologies and Olson's (101) circumplex theory. Some drew on research findings on conflict resolution as well as on parenting of children with anxiety.

Code types: as all schemes are global they combine multiple different units of behaviour (e.g., speech, facial expression, body language), although some schemes rely more on speech (e.g., The autonomy and relatedness coding system (ARCS); (24)) than others which take a more balanced view of all behaviours (e.g., System for coding interactions and family functioning (SCIFF); (111)). There is some variation across schemes in how much the codes reflect an overall impression or "feeling" regarding the

TABLE 2 Summary of the characteristics of the identified adolescent-parent micro-coding schemes.

Author	Name of scheme	Summary of codes	Made for adolescents?	History/theoretical background	Developed for specific population?	Tasks developed for
Dishion et al. (52)	Family process code (FPC)	Behaviour groups represented by a 2 × 2 grid, one axis content (grouped by verbal, vocal, nonverbal, physical contact, and compliance behaviour; 9 positive, 9 negative, 7 neutral) and the other valence (Exuberant, Positive, Neutral, Negative, Unrestrained Negative, and Sad Affect). 25 codes. Event-based[a].	No—Developed for families	Developed by the Oregon Social Learning Centre group on the Family Interaction Coding System (FICS) by Reid (27). This was developed using observations of clinical families and social learning theory principles, particularly Patterson's (1982) coercive cycle (34). FICS is used with children only. This was revised into the Interaction Coding System (53) to use event-based, instead of timed interval coding, and into the Multidimensional Observations of Social Adjustment in Children (MOSAIC) (54). This was done after studying "functioning" families to better sample prosocial behaviour and behaviours shown in problem solving behaviour. MOSAIC codes were split into content, valence, activity and context. This was then reduced into the Family Process Code by reducing the behaviours and the FPC has been used with adolescents.	No	A range of tasks or unstructured settings
Dishion et al. (55)	Relationship process code (RPC)	Behavioural groups represented by a 2 × 2 grid, one axis content (grouped by verbal, nonverbal, physical) and the other valence (positive, neutral, negative). 13 codes. Event-based or time-sampling (15 s).	No—Developed for families and peer relationships	Developed from the FPC (see FPC for history) which was revised into the Interpersonal Process Code [Rusby et al. (56)] by eliminating less frequently occurring behaviours and behaviours that are difficult to code, as they require high levels of inference.	No	A range of tasks or unstructured settings
Dumas (57)	INTERACT	Five categories of codes (actor, behaviour, setting, adverb, and valence) combined according to specific syntactical rules to form discrete observation strings. Timing based.	No—Developed for families	Based on social learning theory principles of coercion and reciprocity, used to explain reinforcement of aggressive and depressive behaviour.	No	Unstructured and problem-solving tasks
Gottman & Krokoff (58), revised by Coan & Gottman (46)	The specific affect coding system (SPAFF)	Behaviour groups: Affect (based on verbal content, voice tone, context, facial expressions, gestures and body movement combined; 5 positive, 12 negative, 1 neutral). 18 codes. Timing-based (1 s with 3 s window).	No—Developed for families	Developed based on the Couples Interaction Scoring System [CISS; Gottman, 1979 (59)] and the Facial Action Coding System (FACS) (45) to include "gestalt" behavioural groups, which integrates multiple individual units of behaviour, including verbal content. Developed for adult romantic relationships and then applied to families.	No	Problem solving tasks
Hauser et al. (16)	Constraining & enabling coding system (CECS)	Verbal behavioural codes: two cognitive constructs (cognitive constrainers and cognitive enablers), two affective constructs (affective constrainers and affective enablers), and an	Yes	Developed based on theory on adolescent ego development, specifically the psychoanalytic work of Helm Stierlin (60), who was concerned with the ways in which family members inhibit adolescents who are	No	"Revealed differences" paradigm (parent and adolescent complete a moral judgement test separately then their different responses are revealed and discussed)

(*Continued*)

TABLE 2 Continued

Author	Name of scheme	Summary of codes	Made for adolescents?	History/theoretical background	Developed for specific population?	Tasks developed for
		interpersonal process construct (discourse change). Event based.		attempting to individuate from the family.		
Hops et al. (44)	Living in familial environments (LIFE)	10 behavioural codes for affective content (e.g., happy and angry) and 27 codes for verbal content (e.g., validation and affection). Event based.	No—Developed for families	Social learning theory principles, with a focus on differentiating aggressive and depressive behaviour. Reviewed literature to identify behaviours which distinguished depressed and non-depressed individuals. Also included aggressive and prosocial behaviours. Used codes from the Marital Interaction Coding System [MICS; Hops et al. (61)], the MOSAIC, and the FICS.	Families of depressed mothers.	Problem-solving tasks
Jabson et al. (62)	Simple affect coding system (SACS)	Behaviour groups: Affect (tone, facial affect, and body posture and/or orientation.no verbal content). 5 domains (Positive affect (7), validation (4), anger/disgust (12), distress (13) and neutral (2). 38 total codes. Event-based[a].	No—Developed for families	Developed by the Oregon Social Learning Center (OSLC) group based on the work of Ekman et al. (FACS) and Gottman et al. (e.g., SPAFF) on emotional display.	No	Not specified
Notarius et al. (63) adapted by Aiken et al. (64), for adolescents	Codebook for marital and family interaction (COMFI)	Behaviour groups. 6 basic categories (Problem-solving facilitation (4), problem-solving inhibition (7), emotional validation (6), emotional invalidation (9), self-disclosure (2) and depressive statements (2)). 30 total codes. Event based. Everything said in the interaction is transcribed and utterances are divided into thought units and rated.	No—Developed for families and couples.	Developed by the marriage and family studies group. Integrates features of the Couples Interaction Scoring System (CISS); Affective Style [Doane et al. (65)] the MICS which is based on social learning theory principles (61); Weiss & Summers (66) and KPI [Hahlweg et al. (67)]. Developed so that affect, content and function are integrated into single codes	No	Problem-solving tasks
Peterson et al. (68)	Relationship affect coding systems (adolescent) coding manual (RACS)	Behaviour groups: 4 categories. Verbal behaviour, which includes 3 sub-categories: conversation (3), behaviour change (3) and vocal (1). Physical behaviour (3). Affect behaviour (5). "Off codes" (4). 19 total codes. Event based.	Yes	Built by combining the RPC (see RPC section for history) and the SACS (see SACS for history). Verbal codes from RPC reduced, affect codes expanded based on SACS.	No	Problem-solving tasks and all other discussion tasks included the Family Assessment Task; FAST Dishion & Kavanagh (69): including: planning an activity, parental encouragement of growth (e.g., academic growth), positive recognition of family members.
Robin & Foster (70)	Parent-adolescent interaction coding system—revised (PAICS-R)	Six verbal behavioural groupings: Commands/Put Downs, Defends/ Complains, Problem Solution, Facilitates, Defines/Evaluates, and Talks. Event/Utterance based (but utterance defined as ongoing until the other person speaks)	Yes	Developed from the MICS, which is based on social learning theory principles and family systems theory. Specifically draws on behaviours which define the skills, communication style, and interaction patterns believed to determine resolution of parent-adolescent conflict (Robin, 1980) (71).	No	Problem solving tasks
Rodriguez et al. (72)	Contingency coding system (CCS)	Verbal behavioural groups based on utterances (8): reflection, reframe,	No—Developed for children and adolescents	Developed based on research regarding parents' conversational discourse and	Child/ adolescent cancer patients	Conversations about cancer

(*Continued*)

TABLE 2 Continued

Author	Name of scheme	Summary of codes	Made for adolescents?	History/theoretical background	Developed for specific population?	Tasks developed for
		expansion, disclosure, solicit, provision of information, imperative, and validation, plus other, un-codable and no code. Each utterance received a topic maintenance code (i.e., whether the mother "maintained" or "changed" the topic of conversation). Utterances did not receive multiple category codes (i.e., utterances could not be coded both as a reflection and solicit). Event/ utterance based.		management during their children's early language development, such as the use of repetitions, recasts, and expansions of children's speech (e.g., Fey et al. (73); Lasky & Klopp (74); Saxton (75)).		
Stubbs et al. (76)	The family and peer process code (FPPC)	Behaviour groups represented by a 2 × 2 grid, one axis content (grouped by verbal, vocal, nonverbal, physical contact, and compliance behaviour; 8 positive, 9 negative, 7 neutral) and the other valence (Happy, Caring, Neutral, Distressed, Aversive and Sad). 24 codes plus a withdrawal qualifier. Event-based[a].	No—Developed for families and peer relationships	The FPPC is a combination of the FPC, RPC and the Peer Process Code [PPC; Dishion et al. (77)] which was based on the FPC and includes additional codes relevant to peer interactions.	No	A range of tasks or unstructured settings

[a]Event based means once a behaviour is coded, for example when a parent smiles they will be coded as smiling until that changes i.e., codes are updated according to new "events". In time-based approaches the behaviour is assessed within specific time windows, so at 2 s coded as smile, at 4 s if the parent is still smiling, they will again be coded as smiling.

interaction, with some comprising specific rules about which point on the scale is assigned [e.g., ARCS; (24)] and others purely relying on global impression (e.g., Coder impressions questionnaire) (93). Some schemes describe all codes as dyadic [e.g., the Adapted Mealtime Family Interaction Coding System; MICS (91)], but most include a mix of ratings about the parent and the adolescent separately, with a smaller number of specific dyadic codes.

Developed for adolescents: Seven schemes were specifically developed for adolescents, or adolescents and their families. These often also drew on adult schemes. The remainder were developed for children and applied to adolescents or developed for both children and adolescents.

Tasks: all schemes were developed for problem solving tasks, mainly conflict discussion but also revealed differences and puzzle tasks. Many schemes were also used with planning tasks, typically planning a family activity. A broader range of discussion tasks which were designed specifically to evoke positive interactions (such as planning "the best day ever", celebrating a family member) were also used with four of the schemes (the Coder Impressions Questionnaire [COIMP, (93)], the Coding Interactive Behavior [CIB, (95)], the Family Interaction Macro-coding System [FIMS, (102)], the Iowa Family Interaction Rating Scales [IFIRS, (115)].

Overall summary

Less micro- compared to global coding schemes were identified, and many of the identified micro-schemes were further developments or extensions of existing schemes. Very few of the existing micro-coding schemes were developed specifically for adolescents and so there is less influence of adolescent specific theory on their development. The majority of micro-schemes were mostly based on social learning theory principles and were largely designed for and employed with problem solving or conflict discussion tasks. Global coding schemes were more commonly developed specifically for adolescents and drew on a wider range of theory. Whilst conflict and problem-solving tasks still predominate, these schemes have more often been employed with tasks designed to evoke positive interaction. This underscores the importance of drawing on both global and micro-schemes in the development of a new comprehensive and relevant adolescent coding scheme.

Scoping public engagement

The mobile event visited 5 unique locations in the South-West of the UK, in busy family areas during the school holidays, including a beach front, local parks in residential areas out of the city, central areas directly in the city centre (close to fairgrounds and museums) and rural "car boot" sales. The areas varied in deprivation indices and the ethnicity of the populations. The

mobile research event received active responses (*in the form of a written response on a white board and voting for proposed measures using tokens and slot boxes*) from 234 young people and/or parents. Where votes were collected, we recorded whether the vote was from an adolescent, a young adult (18–25) or a parent.

Acceptability of wearable head cameras: We asked families about the use of wearable head cameras as well as several other wearable technologies including rings, watches, actigraphy and on-body cameras (raw data in Supplementary file S2). Families had mixed views about taking part in research using wearable cameras: some were initially sceptical, but once it was explained that the proposal would be to use them for short-term interactions, not all-day surveillance, the method was deemed acceptable. Young people especially favoured seeing the footage capture from their own camera which represented the world through their eyes.

We also heard that the advent of body worn cameras used by police and in security settings has led to a sense of being watched in young people. At the heart of people's concerns was not being recorded *per se*, but the *imbalance;* in the police/security context, cameras are *only* worn by those in authority, and these cameras capture one perspective only. By contrast, in our proposed measure, both perspectives are represented. Young people were positive about collecting footage that showed the events through their eyes, not just footage watching them from another person's perspective. As shown in Figure 3, when asked about the acceptability of different wearable technologies in research, 25% of adolescents were happy to wear a wearable camera. Given that the other wearable measures were far less intrusive and mainstream (watches and rings), this demonstrates a reasonable engagement with wearable cameras. For purposes of illustration, Figure 1 shows two adolescents playing a card game wearing a wearable camera.

Task to adequately capture interactions at home: As shown in Figure 4 (raw data in Supplementary file S2), the most voted for task to adequately capture interactions at home was a discussion task to plan the day or week, with 40% of adolescents choosing this task, followed by 26% choosing meal-time, 18% playing a card or board game, 8% completing chores together and 8% reviewing their day. Parents voted for mealtimes, followed by planning their day or week and then playing a game. Many families described that playing a board or card game was not something that they would typically do, but that they would be happy to do it. We brought an example game called "Sussed" (130), a conversation-starter card game specifically developed for modern family interactions (further described below in the pilot section). Many parents and adolescents enjoyed trying out the task.

Constructs: Figure 5 presents the terms provided by parents and young people in a word cloud (raw data is presented in Supplementary file S3). "Understanding" and "trust" were described most often, followed by love, caring, communication and respect.

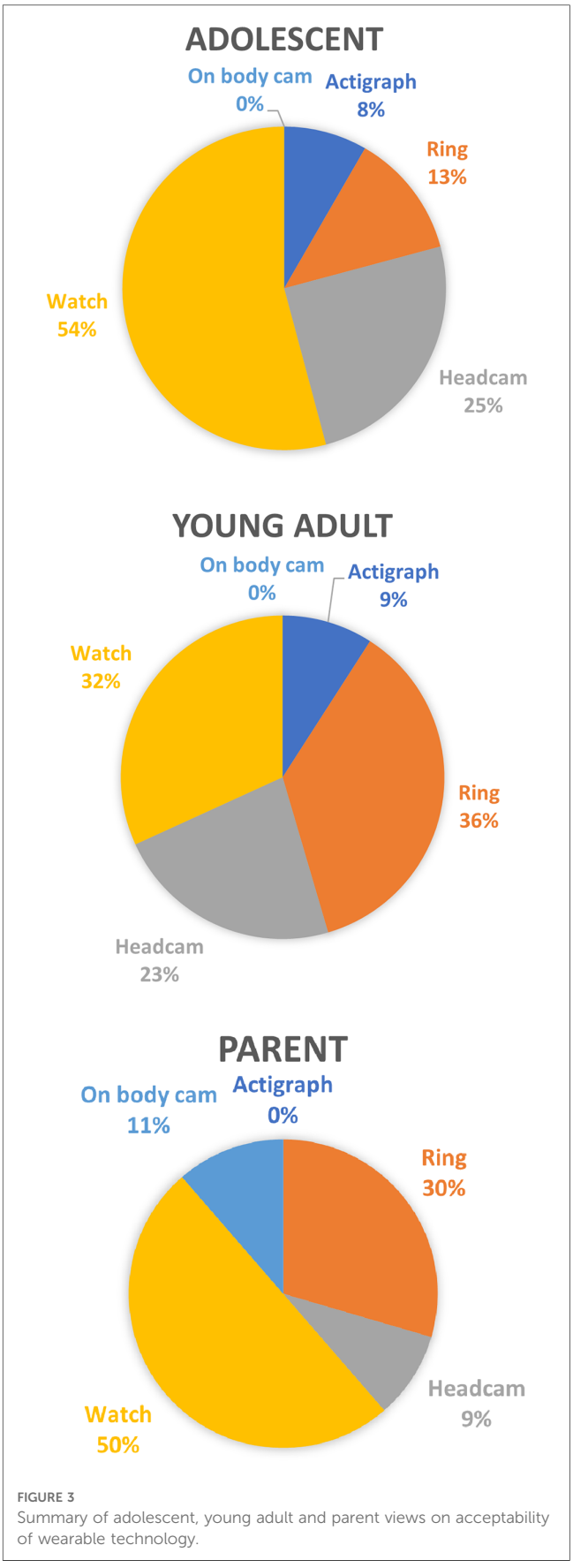


FIGURE 3
Summary of adolescent, young adult and parent views on acceptability of wearable technology.

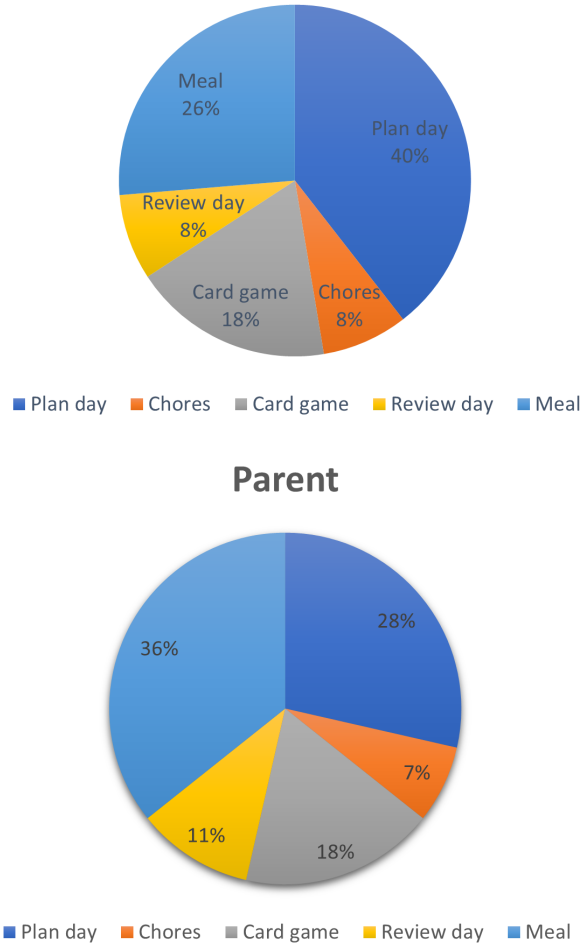


FIGURE 4
Summary of adolescent and parent report views on task to capture adolescent-parent interaction at home.

Part 2—Protocol for further work

Below we set out the next steps for the development of observational capture and coding of adolescent-parent interactions.

Systematic review of measurement properties of coding schemes

A systematic review of the measurement properties of existing observational measures of adolescent-parent measures is required, to better understand the strengths and weaknesses of existing measures, as well as to identify gaps. We have registered the review with PROSPERO (CRD42023397423) and our protocol is publicly available at [https://www.crd.york.ac.uk/prospero/display_record.php?ID = CRD42023397423]. In brief, we will conduct a new search, informed by the work presented earlier. We will search MEDLINE, EMBASE, APA PsycINFO, Web of Science (Core Collection), ProQuest Dissertations and Theses Global, Scopus and CINAHL, limited to English language, without date limits. In addition, we will search for unpublished studies on Google Scholar and PsyArXiv. The reference lists of eligible studies will be manually screened to identify other relevant studies.

We will search for studies investigating psychometric properties of observational measures of adolescent-parent interaction. We define such measures as any instrument in which a coder evaluates any aspect of adolescent-parent interaction on the basis of observed behaviour, utilising some form of a coding system, which can be micro or global. We will include: any empirical study reporting psychometric properties of an observer-rated measure of adolescent-parent interaction; the mean age of children in the sample must be between 10 and 19; by parent, we refer to biological and adoptive parents, as well as carers whose role is that of a primary caregiver to the child (e.g., foster carers); studies must be in the English language; we will include both published and unpublished studies that are available as completed full-text reports, including dissertations, book chapters or pre-print papers. We will exclude studies of interactions with grandparents or any non-primary caregiving role, as well as commentaries, letters, conference abstracts and review.

The aim of the review is to identify the best measures of adolescent-parent interactions based on their psychometric properties, using the COnsensus-based Standards for the selection of health Measurement INstruments (COSMIN) (131). We will utilise the COSMIN tools for appraising study quality, adequacy of measurement properties and overall strength of evidence, which are freely available at www.cosmin.nl. We will assess content validity, structural validity, internal consistency, cross-cultural validity, reliability, measurement error, criterion validity, and responsiveness. By identifying the existing measures with the best evidence of adequate psychometric properties, we will be able to give greater weight to such measures in terms of informing our own task and coding scheme.

Construct definition and measure development through focused public engagement workshops

We will conduct a series of workshops with adolescents, parents and health professionals, including an interactive live performance with creative arts organisation Made by Mortals (https://www.madebymortals.org/) to operationalise and "bring to life" the constructs identified in the scoping public engagement. The adolescent workshop will include some adolescents with lived experience of mental health problems and accessing mental health services as well as parents and professionals.

In contrast to traditional approaches to consultation through focus groups, we believe that the use of an arts-based approach will provide a more engaging and less abstract way to elicit views. A key strength is that the creative arts materials presented will be based on the story of a family who will represent

FIGURE 5
Word cloud presenting the relationship terms reported by adolescents and parents.

numerous lived experiences, without disclosing any one story personally. Attendees at these workshops will be invited to share ideas relating to these stories, which connect to themes arising in our earlier public engagement work.

The workshops will include the use of pre-recorded audio and video clips, as well as use of drama performance and opportunities to experience the task and wearable camera technology. We will conduct workshops at various stages in the development of the interaction measure, with the following aims:

1. To inform the development of the coding system, particularly through exploring the extent to which theoretical constructs derived from the literature align with the "experience-near" perspectives of adolescents and parents.
2. To inform the choice of task for the measure.

Harmonisation of information from existing coding schemes with information from public engagement with adolescents and parents

This will follow a stepped process:

1) Extract all codes from the identified observational parent-interaction coding schemes, including both higher-order (e.g., autonomy promotion) and lower-order (e.g., positive affect) concepts. Codes from global coding schemes will be assessed for suitability of use as micro-codes or whether they require separation into multiple concepts.
2) Research team will perform initial clustering of common and related codes and concepts to identify a taxonomy of constructs. This will involve additional broad literature searching (including fields outside psychology such as philosophy and economics) on key constructs to support operationalisation.
3) Consultation with an "expert panel" of clinicians, academics and a PPI panel of adolescents and parents to appraise the content validity of the clusters and resolve any queries or lack of consensus on concepts from the previous step.

Initial pilot of the wearable camera methodology to provide proof of concept and initial validation study

Methods of data capture through use of wearable cameras

We propose that recent techniques for measuring parent-infant interaction from a first-person perspective using wearable cameras within the family home setting (47, 26) could be adapted to investigate adolescent-parent interaction. The advantages of such an approach are:

- Increased ecological validity if used in the home setting, without the need for a researcher to be present during the interaction.
- Content Validity
  - The face-to-face view of the wearable cams captures full face view of both interactors better than mounted cameras in one

TABLE 3 Summary of the characteristics of the identified adolescent-parent global-coding schemes.

Author	Name of scheme	Summary of codes	Made for adolescents?	History/theoretical background	Developed for specific population?	Tasks developed for
Allen et al. (24)	Autonomy and relatedness coding system (ARCS)	Global codes: all rated for parent behaviour toward adolescent and adolescent behaviour toward parent: 2 promoting autonomy, 3 inhibiting autonomy, 3 promoting relatedness, 2 inhibiting relatedness. 8-point rating scale (0–4 with.5 increments) with rules based on numbers and types of statements determining rating).	Yes	Developed from Attachment theory [Bowlby (78–80)] applied to adolescents, where the attachment system is activated to provide a sense of "felt security" as opposed to safety [Allen & Land, Allen, Cummings & Davies (81–83)]. In adolescence, the exploratory attachment system is highly activated and the system whereby an individual relies and depends on their attachment figure is reduced (81). The scheme is designed to capture these processes where there is an increase in autonomous behaviour whilst still using the parent as a secure base.	No	Problem solving tasks (conflict discussion and "revealed differences" of moral dilemma task discussion)
Barrett et al. (84)	Macro-coding schedule for parent and child behaviour	Global codes: 7 individual codes (positive & negative, parent & child), 1 parent-only code (positive). 6-point scale.	No	Developed to characterise parent-child interaction in families with a child with obsessive compulsive disorder. Drew on literature suggesting parents may model caution, avoidance or fearfulness [Henin & Kendall (85)], or be strict and overinvolved [Merkel et al. (86)], lack warmth [Ehiobuche, Hoover & Insel (87, 88)], and have high expectations for their children [Hollingsworth et al. (89)].	Yes—clinically referred children	Conflict discussion and discussions around hypothetical ambiguous and therefore anxiety provoking situations the child (e.g., child sees group of children playing a game but they are laughing when child walks over)
Dickstein et al. (90), Hayden et al. (91)	The adapted mealtime family interaction coding system (MICS)	The MICS has 6 dimensions, measuring task accomplishment, communication, affect management, interpersonal involvement, behaviour control and overall family functioning. The dimensions are presented on a 7-point Likert scale ranging from 1 (very unhealthy) to 7 (very healthy).		It is adapted from the McMaster Structured Interview of Family Functioning (McSIFF) and based on the McMaster Model of Family Functioning [Epstein et al. (92)].	Children with chronic illness (but also used with general population)	Observations of family functioning in unstructured, naturalistic situations (specifically meal-time)
Dishion et al. (93)	Coder impressions questionnaire (COIMP)	79 single item description global codes: parental support (parent only, positive), behaviour management (parent only, positive and negative), conflict resolution (parent and child positive and negative) and broader interaction (parent and child, positive and negative). Some specific items assessing antisocial content. 10-point scales	Yes—adolescents and their family	Developed in the Oregan Social Learning Centre (OSLC) based on social learning theory, especially the coercion model of antisocial behaviour [Patterson, Patterson et al. (34, 94)]. Focus on assessing family management and problem solving to understand/ predict antisocial behaviour in adolescence.	General population	Designed for a range of discussion tasks [described as the FAST (69)]: planning activity, encouragement of an area of growth for the child (e.g., academic growth), positive recognition of family member, conflict discussion

(*Continued*)

TABLE 3 Continued

Author	Name of scheme	Summary of codes	Made for adolescents?	History/theoretical background	Developed for specific population?	Tasks developed for
Feldman (95)	Coding interactive behaviour (CIB)	Codes not specified (manual not openly available). 5-point rating scale.	Yes—multiple versions of the coding scheme, one for adolescents	The coding system measures elements of the theoretical model proposed by Feldman (96). The theoretical model describes how the child and the mother's behaviour influence one another. For instance, how the child and mother's biology, relationships and affective cognition influence one another which then influences overall parenting behaviour	No	Used with a range structured problem solving and discussion tasks, including conflict discussion and positive valence discussions (e.g., plan the best day ever)
Hagstrøm et al. (97)	The tangram emotion coding manual for children (TEC-M)	Global codes: 8 parent codes (positive & negative), 8 child items (positive & negative), 1 dyadic (positive). Frequency score (0–3) and intensity score (1–3) given for each code.	No—developed for children	Designed to assess profiles of emotional regulation in children in the context of parent-child-interactions. Developed based on the theoretical framework of the process model of emotional regulation [Gross (98)] with the five regulatory processes from this model constituting the skeleton of the scoring sheet.	No	Developed for a specific puzzle task designed to evoke emotion regulation behaviours
Hetherington and Clingempeel (99)	Family interaction global coding system (FIGCS)	Global codes: 14 individual codes (parent & child; negative & positive), 2 parental codes (influence and monitoring), 3 child codes (positive & negative). 5-point rating scale. Intensity and frequency rated for each item.	No—families	Scales were based on Baumrind's (1967) parenting typologies (100) and Olson's (Olson et al., 1982) circumplex theory (101).	No	Problem solving tasks
Holmbeck et al. (102)	Family interaction macro-coding system (FIMS)	Global codes: mix of dyadic and individual codes in 3 domains: 15 interactional style, 5 conflict, 8 affect (positive & negative), 3 control (positive & negative), 5 parental behaviours and collaborative problem solving (positive & negative), summary family measures (2). 5-point scale.	No—families of children and adolescents	The scheme is an adaptation of a system developed by Holmbeck et al., Johnson & Holmbeck and Smetana et al. (103–105)). Codes are also based on systems developed by Allen et al. (24, 106), Buhrmester et al. (107)—from work on parenting styles [e.g. Baumrind (100)] Julien et al. (108)—the Interactional Dimensions Coding system, developed to assess conflict and intimacy in martial communication, Levy (109)—maternal overprotection and Paikoff (110)—child scaffolding and problem solving.	No—but first used with samples of children with physical illness	Problem solving and positive event planning tasks

(*Continued*)

TABLE 3 Continued

Author	Name of scheme	Summary of codes	Made for adolescents?	History/theoretical background	Developed for specific population?	Tasks developed for
Lindahl and Malik (111)	System for coding interactions and family functioning (SCIFF)	Global codes: 4 family (negative & positive), 1 dyadic (marital communication), 5 parent (positive & negative), 4 child (positive & negative) and 2 categorical family codes. 11 total codes. 5-point scales.	No—child then applied to adolescents	Theoretical foundations for this coding system primarily are family systems [e.g., Boscolo et al. (112)], structural family theory [e.g., Minuchin (113)], and social learning theory [e.g., Patterson (34)]. These theories were used to develop codes that would capture the nature of family interaction patterns and highlight adaptive and maladaptive aspects of family relationships. Developed with children then applied to adolescents, and to triadic as well as dyadic interactions.	General population	Problem-solving tasks
Lyons-Ruth et al. (114)	Goal-corrected partnership adolescent coding system (GPACS)	Global codes: 6 parent (positive & negative), 4 child (positive & negative) and 2 dyadic (positive) codes rated on 5-point scales. 12 total codes. Categorical classification of attachment status made according to rules: 1. Secure, 2. Insecure organised and 3. Disorganised.	Yes	Developed based on Attachment theory specifically applied to adolescents and using observations of parent-adolescent interaction and Adult Attachment Interviews.	No	Reunion and conflict discussion tasks
Melby et al. (115)	Iowa family interaction rating scales (IFIRS)	Global codes: 10 individual characteristic scales (parent & child, positive & negative), 22 dyadic interaction scales (positive & negative), 2 dyadic relational (positive), 15 parenting (positive & negative), 5 individual problem solving (parent & children, positive & negative), 5 group problem solving (positive & negative), 1 group interaction scale. 60 total codes. 9-point scale. Two composites created: collaborative parenting and over-involved parenting.	Yes—adolescents from early adolescence to late adulthood, and their families	Adapted primarily from the FIGCS (Hetherington & Clingempeel, 1992, see section for history) and also draws on social interactional, behavioural (including Patterson's coercive family cycles), or social contextual theories in assessing displays of behaviours and relationship processes at the individual, dyadic, and group levels [Conger, Conger, et al., Conger & Simons, Gottman, Patterson and Patterson et al. (116–119)].	General population	Problem solving tasks and also used in positive discussion tasks
Owen et al. (120)	National institute of child health and human development study of children and youth development (NICHD-SECYD) coding scheme	Global codes: 5 parent (reflecting positive and negative), 4 child (positive and negative) and 1 dyadic (positive) codes.10 total codes. 7-point scale.	No	Developed and extended from the infancy NICHD coding which draws on attachment theory. Extended to include codes related to autonomy promotion [e.g., Ryan et al. (121)], stimulation of cognitive development, and hostility.	No	Problem solving tasks (including conflict discussion and in early adolescence planning/ problem solving tasks)
Robin and Foster (70)	Interactive behavior code (IBC)	Global codes: 31 negative communication (dyadic), and 7 positive communication (dyadic). 22/31 negative and 7/7 positive codes are rated absent or present, remainder on a 5-point scale. Modified	No—families	Behavioural and family systems theory.	No—but mainly used in clinical populations	Problem solving tasks

(*Continued*)

TABLE 3 Continued

Author	Name of scheme	Summary of codes	Made for adolescents?	History/theoretical background	Developed for specific population?	Tasks developed for
		in Pelham et al. (122) so that every item is rated on a 7-point scale				
Snyder (123)	Macro-level family interaction coding system (MFICS)	Global codes: 3 broad dyadic scales with 55 items: positive engagement (13 items, positive), withdrawal avoidance (17 items, negative), reactivity-coercion (18 items, negative). 5-point scale (1 = not true, did not occur, 5 = clearly evident, very descriptive), designed using an *a priori*, face-valid approach to assess the occurrence of behaviours reflecting positive engagement (20 items) and reactivity-coercion (17 items).	No—children and adolescents	Social learning theory.	No	Problem solving tasks, and a cooperative play activity (a block tower building task)
Vanwoerden (124)	Observational coding system for real-time parent-adolescent mentalising	Global codes: 2 parent codes (positive and negative mentalising), 2 adolescent codes (positive and negative mentalising), and one dyadic (dyadic mentalising).7-point scale.	Yes	Theory on mentalizing and hypo-mentalizing [e.g., Luyten et al., Bateman & Fonagy (125, 126)]	No	Problem-solving (conflict discussion)
Ziv et al. (127)	Conflict task coding system (CTCS)	3 parent codes and 4 adolescent codes on a 7-point Likert scale, assessing conflict tactics.	Yes	The coding system drew on attachment theory, specifically on the work of Kobak et al. (128) and Crowell et al. (129) on attachment in adults and adolescence.	No	Problem-solving (conflict discussion)

position only (see Supplementary Figure S1). This allows more subtle detections of facial expressions and vocalisations.
  - The unique perspective allowing researchers to capture interaction "through the eyes" of the young person and parent (26). Pearson and colleagues have previously established that mother-infant interaction can be reliably observed at home using this methodology (26, 132).
  - Potential use of face-reader technology to automate some aspects of coding, thereby dramatically reducing coding time.
- Therapeutic potential
  - This approach has significant potential for future development into video-feedback intervention.
  - For example, the approach is currently being used to feedback to new mums in South Africa (see Cantrell et al. in this edition). Of note a goal of parents is often whether their child looks at them/knows them, the side-by-side view of mum's perspective and child perspective allows more explicit observation of key moments that can be "re-lived", thus reinforcement of key connecting behaviours.

Pilot study aims: (1) Assess feasibility and acceptability of the wearable camera methodology in a general population sample (2) Collect footage to apply micro-coding scheme to.

Sample

The Wirral Child Health & Development study (WCHADS) is a prospective birth cohort of mothers, fathers and their first-born children based in the Wirral, UK [see Sharp et al. (133) and https://www.liverpool.ac.uk/population-health/research/groups/first-steps/ for further details]. The study has completed 13 waves of data collection since birth, including observations of parenting in the lab or at home with a researcher present at ages 6 months, 14 months, 2.5 years 3.5 years, 7 and 9 years. At age 11–12 (N = 743) and age 12–13 (N = 724) families completed postal questionnaires only. The sample are currently aged 13–15 years.

Procedure

The whole sample will be approached via email to invite a volunteer sample of 50 families to participate in the pilot. The first 50 families who express interest will be recruited. Families will be visited by a researcher to drop off the cameras and explain the procedures, and an appointment arranged for the researcher to return to collect the cameras. Primary caregivers and adolescents will complete two tasks in their own time at

home, and complete questionnaires on the acceptability of the wearable cameras and the tasks and validated questionnaires assessing relationship quality.

Measures

Observations of adolescent-parent interaction.

The head-cameras

The head-cameras (shown in Figure 1) are small circular cameras attached to a mount on an elastic adjustable headband. The camera devices are off the shelf body cameras. The headband mounts were created by an experienced user centred design company (Kinneir Dufort, KD) to ensure suitable positioning of the camera. Footage is recorded on to a micro SD card.

The tasks

Parents and adolescents will be asked to record themselves completing two tasks at home. The choice of task for this initial pilot was informed by the scoping PPI work, review of the literature, and consideration of the potential issues with using conflict discussion tasks at home and to evoke positive interaction. In the first task, parents and adolescents are asked to play the commercially available card game "Sussed" which was developed by researchers and funded by the UKRI (130). "Sussed" is a conversation starter game designed to improve social health by players answering multiple choice questions about each other, allowing players to find out how others see them, talk about how others see them and understand why people think or feel a certain way. Example question: Who do I most like to work with? (A) People who are the same as me, (B) People who are different to me, (C) I prefer to work on my own. Parents and adolescents will be provided with 10 cards which were identified from the standard yellow Sussed set (suitable for age 6+) and the green emotional health Sussed set (suitable for age 8+) by A level and first year undergraduate students. Parents and adolescents will be asked to play the game and record for 10 min. In the second task, the parent and adolescent are asked to share a drink or a snack and discuss their plans for their week, and record for 5 min.

Questionnaires

Self-developed questionnaires to assess acceptability of the methodology: Questions ask about the acceptability of using the wearable cameras, the tasks they were asked to complete, and their thoughts on collecting footage from the first-person perspective of both mother and adolescents. Parent and adolescent report.

Adolescent-parent relationship quality: the Network of Relationships (NRI) "seeks safe haven" subscale (support seeking from parent, parent and adolescent report) (134), the brief version of the Parental Feelings Questionnaire (positive and negative feelings about child, parent report and adapted for adolescent) (135) and the trust subscale of the Inventory of Parent and Peer Attachment (IPPA, adolescent report) (136).

Planned output

Feasibility indices: this will include proportion of families invited to use the wearable cameras that agree to take part, of those who agree how many provide footage, we will also record reasons for not managing to obtain recorded footage, challenges in both the initial recruitment and the recording of interactions. For example, a similar protocol was developed for parents and infants in the ALSPAC study (Using a wearable camera at home —Children of the Children of the 90s—YouTube). Such information can be used to inform protocols for use in cohort studies, time needed for researcher time and likely uptake. Potential cohorts include ALSPAC-G2 (137).

Proof of concept: recorded footage will be used to develop the adolescent-parent coding scheme by testing application of identified "behaviour groupings"/parent-child interaction codes to the videos in order to refine definitions.

1. Initial reliability and validation study: inter-rater reliability of the newly identified coding scheme will be assessed. Self-reported relationship quality will be used to provide an initial exploration of construct validity of the observed adolescent-parent relationship constructs. Given the sample size of 40 power will be too low to provide strong statistical evidence for associations between self-report and observations, which are expected to be around effect sizes of 0.3 based on previous studies linking observed and self-report of parenting (25).

Co-design of a comprehensive and relevant coding scheme in consultation with an expert panel and lay/PPI panel

Agreed behavioural domains will be operationally defined and incorporated into an Observer XT coding structure. We will apply the coding structure to the WCHADS videos and consult with experts and young people as "coders" to determine face validity regarding whether the defined behaviours can be applied to live behaviour examples. The aim is that multiple, diverse coders can use the coding scheme to accurately capture all behaviours and dyadic behaviours observed in real life interactions, and that multiple coders give the same code for the same observation (inter-rater reliability). The coding scheme will be refined during this process and may include updated codes to capture behaviours that emerge and redefinition of behaviours that do not reach inter-rater-reliability. Once finalised we will publish an open access, co-developed, fully illustrated manual of behavioural codes and observer syntax in the same way that we have for micro-coding in the early years (47).

Conclusion

The initial work presented in this paper suggests that there is a need to co-design both new methods of data capture, and new coding schemes, to assess adolescent-parent interaction. In our

scoping review, we identified that numerous observational measures have been developed over the years, but fewer coding schemes were developed specifically with adolescents in mind this was particularly the case in existing micro-coding schemes. None of the coding schemes were co-designed with adolescents. This is important since adolescence constitutes a unique period in which parent-child relationships are in transition in a variety of ways, such as becoming more symmetrical as adolescents develop more independence and autonomy (4), therefore requiring adolescent-specific theory to guide their development.

Our initial review of the evidence indicates that negative and conflictual parent-child interaction processes are well characterised, largely by the application of social learning theory principles such as Patterson's coercive cycle (34). In the programme of work described here we place emphasis on characterising the more positive aspects of adolescent-parent interaction. Positive adolescent-parent relationships are associated with greater adolescent well-being (38), and the most promising relational interventions are strengths based (138, 139). Consistent with a focus on problematic interactions, we note that a large number of data capture methods utilise problem-solving or conflict-related tasks. Whilst conflict tasks are used to code positive adolescent-parent interaction qualities, they are less likely to evoke positive interaction qualities (14, 15), and the negative affect and arousal which accompanies conflict (29–31) may mean they are not best suited to assess positive interactions. In addition, measures eliciting conflict may be less suitable for use in the home context, in the absence of researchers.

Planning activities were also quite commonly used, particularly in studies employing global scales. Planning discussions involves some problem solving and negotiation but are not conflict based. We also identified some structured discussion tasks designed to elicit positive interactions, including celebrating a family member and parent encouragement of an area of personal growth in the child or planning a fun family activity (69). In our public engagement work we asked families what the best contexts at home would be to observe their most natural adolescent-parent interaction at home. Planning their day or week was the most voted for task. Given the focus in infancy observation on tasks which elicit shared enjoyment, and our aim to observe positive adolescent-parent interaction, we also suggested a card game task which most families found acceptable. There has been very little consideration in the literature on the content and ecological validity of different observational tasks, particularly in relation to characterising positive interactions, in adolescence. This is essential for developing a method to adequately characterise adolescent-parent relationships.

In our public engagement work, we found that parents and adolescents were open to the possibility of utilising technology such as wearable cameras or heart-rate monitors and the possibility of automated technology coding behaviours. In terms of content validity, we have found that the most relevant concepts expressed in PPI work such as Trust and Understanding are not explicitly covered in existing coding or assessment tools. These higher-order concepts are likely represented by multiple individual codes contained in existing schemes. Careful conceptual and practical mapping of top down and bottom-up content will be required to ensure new coding schemes capture what is seen as most relevant.

Our work thus far has some limitations. Firstly, since the literature on observational adolescent-parent measures appears to use a wide range of terms, it is probable that our scoping review may have missed some existing measures. In addition, as most observational coding schemes are not published and can be difficult to locate, our review is likely not complete. Secondly, whilst our public engagement work will have reached individuals not usually approached by researchers and contained a diversity of class and ethnicity, it was exclusively conducted in the South-West of England. Future public engagement work should be conducted in other regions of the United Kingdom prior to developing the coding scheme or undertaking formal validation studies. Furthermore, we are currently evaluating the feasibility and acceptability of the measure in a community sample of adolescents, which will shed light on the potential use of the measure for research purposes in cohort studies. As discussed earlier in this paper, the use of the measure for different purposes and different populations requires additional evidence to support each specific use. In particular, the use of the measure in clinical samples, either for research or therapeutic purposes, will require separate evaluation in research studies. The suitability of the measure for individuals with learning disabilities or an autism spectrum condition also requires evaluation.

In summary, the work presented and planned here represents the first attempt to truly co-create a method to assess parenting in adolescence, combining bottom-up processes to harness insights from adolescents and parents, with top-down approaches to utilise and build on existing theory and research. By using creative approaches to public engagement, as well as rigorous plans for psychometric investigation, we hope to develop an observational measure that captures salient aspects of adolescent-parent interaction using novel technological methods, which can be used across a range of research and therapeutic settings.

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

An ethics checklist for the scoping public engagement van tour was submitted to the University of Bristol School of Psychologys IRB and met criteria for automatic approval (no reference number required). Ethical approval for the pilot study in the WCHADS was granted by the Cheshire North and West Research Ethics Committee on the 22 November 2022 (ref: 14/NW/1484_22_01).

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

RP, NW and TJ designed all elements of the protocol. NW, DC and AB conducted and reported the scoping review. RP, TJ and NW conducted the PPI work. NW, TJ and RP wrote the manuscript. DC and AB reviewed and revised the manuscript. All authors contributed to the article and approved the submitted version.

Funding

This work is part of a project that has received funding from the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme (Grant agreement No. 758813; MHINT). TJ was supported by a NIHR Development and Skills Enhancement Award (NIHR302102).

Acknowledgments

We would like to acknowledge the Principal Investigators of the Wirral Child Health & Development Study (WCHADS) Professor Helen Sharp, Professor Jonathan Hill, and Professor Andrew Pickles, for granting permission to conduct the initial pilot study. We are very grateful to all the families who took part. The views expressed are those of the author(s) and not necessarily those of the NHS, the NIHR or the Department of Health and Social Care.

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 authors NW and RP declared that they were editorial board members of Frontiers at the time of submission. This had no impact on the peer review process and the final decision.

Publisher's note

Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/frcha.2023.1214890/full#supplementary-material

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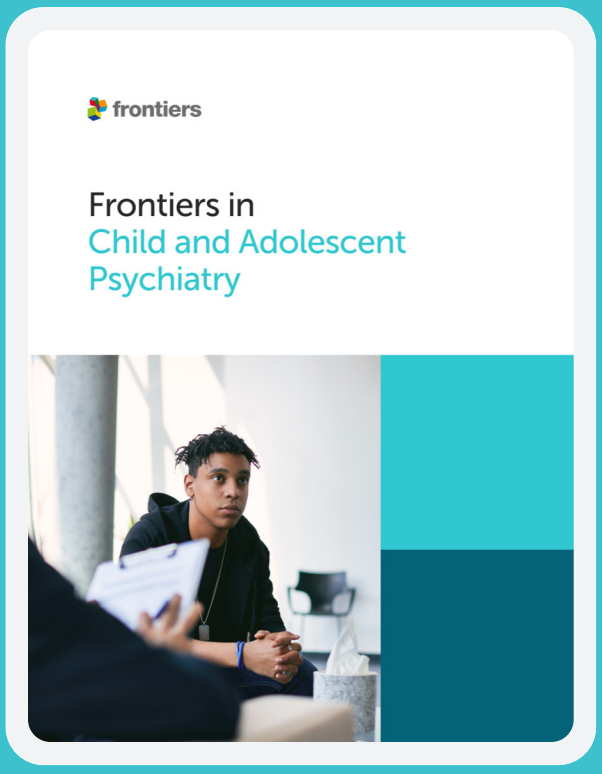

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