A systematic review on parent-child synchrony: the role of stress, resilience and psychopathology

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Abstract

Biobehavioral synchrony is defined as a reciprocal and temporal coordination that can be observed during interpersonal interactions between two or more individuals. It can encompass facial expressions, vocalization, mutual gaze as well as other physiological measures. Synchrony has commonly been measured in interactional exchanges highlighting the relational qualities and the content of the interactions between individuals. Recent literature assessed synchrony by stress-inducing tasks or while measuring stress in individuals during interactions, to index an interaction between stress and synchrony. This study provides the first systematic review to understand which role synchrony plays within families in the context of stress. A systematic search was conducted on Scopus, PubMed and PsycNET using the following keywords to identify studies: [“synchrony” and (“stress” or “resilience”) and (“family” or “parents” or “father” or “mother” or “child” or “adolescent” or “infant”)]. A total of 55 English, peer-reviewed articles assessing biobehavioral synchrony together with stress or resilience in the family context were selected. The results show that parenting stress is associated with less synchrony. However, when all members of the family were faced with the same stressor (such as a stress inducing task), there was a reduction of stress levels and increased positive affect within the family. Dyads who had high levels of emotion regulation were shown to synchronize better with one another than those who showed emotion dysregulation or negative affect. Some findings indicate that psychopathologies, notably depression, is associated with lower levels of synchrony in dyads. Stress within the family has been shown to play a role in the interaction between synchrony levels and behavioral and emotional regulations in children. The findings highlight the extent to which synchrony may be associated with family dynamics. In this sense, synchrony may help families face stress and hardships by facilitating the transmission of resilience and helping family members be more in harmony with one another.

Keywords: biobehavioral synchrony, family, parent-child relationship, stress, resilience

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Parent-child relations represent the primary bond that supports the offspring's growth, development, and the evolution of coping mechanisms for physiological and social stressors (Morris et al., 2007; Ryan, 1995; Ryan & Deci, 2000). In this perspective, Bowlby suggests that attachment behavior protects the infant by keeping the mother close in the face of stressors. Pioneers of attachment theory stipulate that a person's attachment patterns and behaviors are rooted in their parent's attachment patterns and relationship. Effective attachment behavior needs to be coupled with a reciprocal maternal behavior that efficiently responds to the infant's signals (Bowlby, 1969, 2008). This has been observed during mother-child interactions where mothers who had insecure attachment failed to respond verbally to the child's vocalization, appearing to result from intrusive and insensitive maternal behavior (Isabella & Belsky, 1991). The contingent and coordinated interaction occurring between parents and children, characterized by social reciprocity, responsivity, and temporal interactions between events form one unified process on a behavioral, biological, and affective level, which was initially defined as *parent-child synchrony* (Feldman, 2007a, 2007b).

Drawn by these theoretical foundations, the present review approaches synchrony as a multilevel, co-regulatory process that reflects and shapes the quality of parent–child interactions, particularly in contexts of stress. Attachment theory highlights the relational function of synchrony in promoting secure bonds and adaptive affective regulation, while the biobehavioral model expands this view by emphasizing physiological and neural attunement as integral components of dyadic coordination (Feldman, 2012c). These frameworks inform the present synthesis by guiding the inclusion of studies across behavioral and biological domains, and by framing synchrony as a relational mechanism through which families manage stress and promote developmental wellbeing.

Synchrony has long been viewed as a phenomenon that may occur when individuals or objects align with one another. More specifically, synchrony has been studied in human interactions, notably between couples' partners, caregivers and family members (DePasquale, 2020; Pauly et al., 2021; Ramseyer & Tschacher, 2008). This concept has facilitated a better understanding of parent-child interactions (Feldman, 2007a, 2007b; Harrist & Waugh, 2002; Leclere et al., 2014). The literature on synchrony is growing rapidly, and the concept of synchrony seems to be relevant to assessing parent-child interactions in order to better understand the family dynamic (Doba et al., 2022; Suveg et al., 2016).

Feldman's biobehavioral model proposes that humans generally tend to co-regulate their behaviors and physiological reactions to those surrounding them, which eventually helps individuals bond together and have coordinated behaviors (Feldman, 2012a, 2012c). Synchrony was previously defined as being a dyadic interaction between two individuals where reciprocal responsiveness, sensitivity and harmony can be found in the relationship (Harrist & Waugh, 2002). Maternal sensitivity, derived from the concept of reciprocal responsiveness (Ainsworth et al., 1974), can be considered as a facilitator of synchrony. In fact, it reflects the mother's set of responses, including affect, timing, flexibility, conflict negotiation, and awareness of the infant's cues (Shin et al., 2008), and follows the perception of the child's implicit behavior and distress. Reciprocal responsiveness might closely align with the "reciprocity" theory, where one may cooperate when the other person is showing the same kind of need or willingness to change, where they would both be in harmony with one another and be reciprocal in their interaction (McCoby, 1983). This willingness to change, which may derive from the maternal sensitivity mentioned above, would refer to the quality of the interactions with the children and how much the mother can be sensitive to the child's needs (Ainsworth et al., 2015; Van Huisstede et al., 2019). The dyadic reciprocity and mutuality rooted in the interaction and communication has also been referred to as positive behavioral synchrony assessed on the mutual affectivity of the dyad (Hale et al., 2023). Some other authors adopted a broader idea where synchrony may sometimes be positive and other times negative based on its nature and connotation. The in-phase synchrony would refer to a more positive interaction of mutual exchanges in the same direction, whereas the anti-phase synchrony would indicate exchanges in the opposite direction (Pauly et al., 2021).

Two of the components that seem to be common between several definitions are the interactional occurrence and the temporal alignment (Harrist & Waugh, 2002; Hoehl et al., 2021). This can be defined as a process where individuals adapt to one another including any type of behavioral, mental or physiological activities (Hoehl et al., 2021). Behavioral synchrony can be described as a temporal coordination of behaviors occurring within interactions that help shape the development in the child (Leclere et al., 2014). Moreover, several definitions agree that parent-child synchrony can be observed during interactional exchanges and, for this reason, and given the current evidence, synchrony would serve to assess relational qualities as well as the content of the interaction. And that is; by considering the reciprocal behaviors, parents and children may have with one another as well as the occurrence of the behaviors.

While synchrony has often been examined in relation to emotion regulation and normative developmental outcomes (Feldman, 2007b; Leclere et al., 2014), less attention has been given to its role in contexts of stress, risk, and resilience. This gap is particularly relevant given theoretical models suggesting that synchrony may serve as a key relational mechanism through which families buffer stress and support adaptive regulation (Feldman, 2020; Masten, 2014). Moreover, although the literature is growing, existing research remains fragmented across behavioral, physiological, and neural domains, often relying on disparate methods and conceptualizations (Davis et al., 2017; Suveg et al., 2016). These inconsistencies make it difficult to draw integrative conclusions about how synchrony functions in ecologically valid family contexts. The present review addresses this gap by synthesizing evidence across multiple levels of analysis, behavioral, physiological, and neurophysiological, and by grounding the findings within attachment and biobehavioral frameworks to clarify the role of synchrony in relational adaptation under stress.

Synchrony, child development and stress

Studies on synchrony have contributed to the field of developmental psychology by paving the way for researchers to delve into the impact of early interactions between parents and children (Feldman, 2007b). This was shown in a systematic review, where mother-child synchrony was associated with typical development and positive cognition and behavior in the child (Leclere et al., 2014). One of the earliest works on mother-child synchrony found that mother-child synchrony, specifically on an affect level such as reciprocity, predicted the child's self-control at 2 years old (Feldman et al., 1999). In a dyadic context, the inherent bidirectionality of synchrony arises and serves a specific purpose. While the parent adjusts to the child and responds to their needs positively, the child adapts to the parent, developing self-control and self-awareness. Thus, synchrony eases child self-regulation, autonomy, social and emotional wellbeing, and supports parent-child secure attachment and bond development (Feldman, 2017; Feldman et al., 2009; Harrist & Waugh, 2002; Kochanska et al., 2008; Leclere et al., 2014; Swingler et al., 2014).

Synchrony and resilience

Based on the biobehavioral model, synchrony may contribute to resilience as previously defined as the capacity a system has to adapt to disturbances that may pose a threat on the systems' development and functioning (Masten, 2014). Synchrony would play a vital role in the three tenets of human resilience which are neural and behavioral plasticity, attachment and sociality and the capacity to inspire strength in the face of trauma, as it helps children develop emotional regulation skills and helps with social bonding within the family (Feldman, 2020). In fact, mother-child synchrony not only helps with the plasticity, but also it allows children to expand their abilities to communicate and interact with their environment and to regulate their emotions facing certain situations, which indicates a better adaptation to adversities, making them more resilient (Feldman et al., 1999; Masten & Monn, 2015; Priel et al., 2019).

Previous studies examining synchrony in the context of stress and resilience have used diverse methodologies across developmental stages. For instance, behavioral synchrony has often been assessed through microanalytic coding of face-to-face interactions in free-play or structured problem-solving tasks, typically in early or middle childhood (Beebe et al., 2016; Feldman, 2007a). Physiological synchrony has been indexed during lab-based stress-inducing paradigms, such as still-face procedures, the strange situation or other mild cognitive challenges (Suveg et al., 2016;

Weisman et al., 2015). Such studies demonstrate that biobehavioral synchrony tends to be higher in dyads with lower parenting stress and greater affective availability and may buffer the effects of adversity on child outcomes. The present review synthesizes these behavioral and physiological approaches to clarify how synchrony contributes to adaptive functioning in the context of stress and resilience.

Synchrony and psychopathology

Difficulties in synchrony have been associated with both the emergence and maintenance of various forms of psychopathology in children. Disruptions in dyadic coordination, whether reflected in reduced affective reciprocity, misaligned responsiveness, or physiological asynchrony, may contribute to the development of internalizing or externalizing symptoms (Criss et al., 2002; Deater-Deckard, 2008; Feldman, 2007b). Importantly, synchrony disruption may not carry the same implications across levels of analysis. At the behavioral level, both concordant and discordant patterns can yield either adaptive or maladaptive outcomes depending on the content of the interaction. Patterson's coercion model demonstrates that parent–child interactions characterized by tightly coordinated negative affect and coercive exchanges can reinforce maladaptive cycles and heighten the risk for externalizing problems (Patterson, 1982; Patterson et al., 1992). By contrast, in the physiological and hormonal domain, disruption often refers to misalignment or atypical concordance in stress- or affiliative systems (e.g., cortisol, vagal tone, oxytocin), which may signal difficulties in biobehavioral (Feldman, 2007a; Lunkenheimer et al., 2011; Suveg et al., 2016; Woody et al., 2016). For example, dyads with a maternal history of depression exhibit significantly less behavioral synchrony and fewer positive emotional exchanges compared to non-depressed dyads (Kudinova et al., 2019; Woody et al., 2016). Similar processes have also been observed at the neuroendocrine level, where elevated maternal depressive symptoms were linked to heightened oxytocin reactivity during shared tasks, possibly reflecting altered or compensatory co-regulation dynamics (Gadassi Polack et al., 2021).

Crucially, recent findings caution against assuming that higher physiological concordance is always beneficial. Positive physiological synchrony in respiratory sinus arrhythmia (RSA) during a negative mood induction was associated with less adaptive outcomes for children when caregivers lacked the skills to effectively support their child's emotional development (Creavy et al., 2020). This aligns with emerging evidence that behavioral and physiological synchrony can move in opposite directions under stress: in studies measuring both domains simultaneously, dyads under higher parental stress or anxiety often display stronger physiological synchrony (e.g., vagal tone, cortisol) coupled with lower behavioral coordination, a pattern linked to maladaptive outcomes. More broadly, these findings suggest that synchrony may follow a non-linear pattern, with both too little and too much concordance posing risks depending on context. Indeed, research on romantic couples has identified an inverted U-shaped association between neural synchrony and relationship functioning, raising the possibility that similar curvilinear dynamics may also characterize parent–child synchrony.

Together, these findings underscore the importance of distinguishing between adaptive and maladaptive synchrony, as well as between behavioral and physiological disruptions, and recognizing that context and non-linear dynamics critically shape whether synchrony serves as a protective or risk process in development.

Measures of Parent-child synchrony

Given its inherently multilevel nature, synchrony has been investigated across behavioral, physiological, and neural domains, each capturing distinct but interrelated aspects of parent–child coordination (Feldman, 2012c; Hoehl et al., 2021). Behavioral measures provide insight into overt co-regulatory exchanges, such as shared affect and turn-taking, while physiological and neurophysiological indices allow researchers to probe deeper into the biological substrates of relational attunement. Investigating synchrony across these levels is critical, particularly in the context of stress and resilience, as physiological synchrony may reveal patterns of co-regulation not always observable at the behavioral level (Davis et al., 2018; Suveg et al., 2016), and neural synchrony may capture subtle relational processes linked to empathy, joint attention, and mentalization (. Nguyen et al., 2020; Reindl et al., 2018).

Behavioral Synchrony

At a behavioral level, synchrony is observable as a co-occurrence and coordination, in the form of behaviors, gaze, emotional expression, and vocalization patterns (Beebe et al., 2016; Mayo & Gordon, 2020; Yale et al., 2003). Behavioral synchrony has been operationalized in different ways throughout the literature. Some authors sought to assess synchrony based on some of the definitions mentioned above: responsiveness, mutual engagement, and reciprocity, observed during mother-child interactions (Hale et al., 2023; Im-Bolter et al., 2015). Other researchers have assessed behavioral synchrony through head movement or through calculated body movement using analysis algorithm to quantify synchrony (Hadley & Ward, 2021; Ramseyer & Tschacher, 2011). Synchrony has also been measured through vocal frequency or pitch and eye gazes (Imel et al., 2014; Northrup & Iverson, 2020). Synchrony has been generally measured through interactions between participants such as a free-play interaction between family members or during tasks developed to induce stress such as the Strange Situation or the Face-to-Face Still-Face Paradigm (Ham & Tronick, 2009).

Physiological Synchrony

On a physiological level, a growing body of literature points to occurring physiological synchrony involving the hypothalamic-pituitary-adrenal (HPA) axis and the central and autonomic nervous systems, where it may indicate a similar biological state between two or more individuals, notably parents or caregivers and their children (Feldman, Magori-Cohen, et al., 2011). Several markers of biological systems are usually used to measure synchrony such as: cardiovascular activity (vagal activity, interbeat interval, heart rate), electrodermal activity, salivary alpha amylase, finger pulse amplitude, skin temperature, and cortisol (Davis et al., 2018). When assessing synchrony, indices such as cortisol or vagally mediated heart rate variability[1] (vmHRV) are mainly observed following certain stressors (Gordis et al., 2010; Woody et al., 2016). Regarding cortisol, evidence from endocrinological studies suggests a strong correlation between mother's and children's cortisol responses to stress, from infancy (Bright et al., 2012) to late adolescence (Papp et al., 2009). Mother-child parasympathetic activity – the branch of the autonomic nervous system that helps the body to relax, notably by slowing the heart and relaxing the muscles (LeBouef et al., 2023) – is coupled and linked to the mother's general arousal and the child's arousal peaks tend to be further followed by higher parent-child synchrony (Wass et al., 2019). Along this line, vmHRV, a marker of parasympathetic activity, reflects how individuals may co-regulate each other's physiological reactions and is considered an intra-individual regulation index as an individual may mirror the reactions of others (Appelhans & Luecken, 2006; Helm et al., 2018).

Another physiological marker, which is oxytocin, is said to promote affiliation and social bonding, and to be associated with higher parent-child behavioral synchrony (Feldman, 2012b; Priel et al., 2019). This physiological synchrony has been observed in parent-child interactions in high-risk sample and typically developing dyads (Davis et al., 2018). An increase in mother-child cortisol synchrony has also been seen in dysfunctional families where unhealthy parenting patterns occurred such as violence, punishment, or low or negative affect (Hibel et al., 2009; Papp et al., 2009; Ruttle et al., 2011; Williams et al., 2013).

Neuro-physiological Synchrony

Synchrony can also be observed at the neural level, known as inter-brain synchrony (IBS). IBS refers to the temporal alignment of neural processes between two or more people interacting in a social context (Czeszumski et al., 2020). This concept has attracted many researchers through the

[1] Some studies refer to vagally-mediated Heart Rate Variability (vmHRV) as Respiratory Sinus Arrhythmia. Although these are not interchangeable terms, in this study, we decided to use vmHRV because it refers to the physiological process behind this cardiac measure and highlights the role of the vagus nerve.

employment of the hyperscanning technique, which involves the real-time and simultaneous acquisition of brain data from multiple individuals performing a task which allows for the study of the neural basis of social interactions (Hari et al., 2013; Holroyd, 2022). Hyperscanning studies have mostly investigated IBS using functional near-infrared spectroscopy (fNIRS), electroencephalography (EEG) or magnetoencephalography (MEG) and functional magnetic resonance imaging (fMRI) (Nguyen, Anna Bánki, et al., 2020). In the family context, IBS is suggested to reflect the quality of parent-child relationships and may play an important role in parent-child coordination (Nguyen, Anna Bánki, et al., 2020), to support children's cognitive and social development (Alonso et al., 2024). Previous studies have shown positive associations between IBS and behavioral synchrony (Liu et al., 2024; . Nguyen et al., 2020; Quiñones-Camacho et al., 2020), child emotion regulation (Reindl et al., 2018), positive parental attitude (Liu et al., 2024; Nguyen et al., 2021), and attachment representation (Nguyen et al., 2024). Furthermore, IBS has been found to be associated with parental stress (Azhari et al., 2022; Azhari et al., 2019; . Nguyen et al., 2020; Thompson et al., 2024) and family adversity (Hoyniak et al., 2021) highlighting the importance of state-like factors related to the familial environment.

Current Study

While previous reviews have examined aspects of parent–child synchrony, the current review offers a distinct contribution by integrating behavioral and physiological studies through a biobehavioral and attachment-based lens. Earlier research has largely emphasized behavioral synchrony in normative contexts, often relying on structured microanalytic coding systems without incorporating biological indices or theoretical models of stress adaptation (Leclere et al., 2014). Broader conceptualizations of interpersonal coordination have included family and romantic dyads but have not explicitly focused on developmental trajectories or adversity-related processes (DePasquale, 2020). Other reviews have explored emotional regulation and physiological synchrony, yet often without anchoring these processes in the relational dynamics that characterize caregiving interactions (Birk et al., 2022; Davis et al., 2017). By adopting theory-driven inclusion criteria and a multilevel synthesis strategy, the present review aims to clarify how parent–child synchrony across behavioral and physiological domains, interacts with stress, psychopathology, and resilience processes within attachment and biobehavioral frameworks, thereby advancing understanding of its role in developmental trajectories under conditions of adversity.

1- In this work, we aimed at conducting a systematic review focused on the role of parent–child synchrony by synthesizing findings across behavioral, physiological, and neurophysiological levels. The main purpose of this synthesis is to highlight the potential role of synchrony in shaping family interactions and relational regulation. Behavioral synchrony refers to coordinated verbal and non-verbal exchanges (e.g., gaze, affective mirroring, turn-taking), physiological synchrony of autonomic activity (e.g., vmHRV), and cortisol while neurophysiological synchrony encompasses brain-based coupling assessed through methods like EEG or fNIRS. This multilevel approach allows for a more comprehensive understanding of how synchrony functions as a core relational process.
2- This review focused on how parents and children synchronize with one another while considering the level of stress family members may have, either by engaging in a stressful situation/task or by measuring stress regulation levels during a task, which refers broadly to behavioral, physiological, or self-reported indicators of how parent–child dyads cope or respond to stress. This serves as the first systematic review that takes stress and resilience into account while assessing parent-child synchrony.
3- Moreover, this review aimed at understanding how parent-child synchrony may be associated with: (1) stress, (2) anxiety and depression (two stress-related mental disorders) and (3) resilience. The review incorporates studies reporting concurrent and cross-sectional associations during interactions, as well as longitudinal research examining synchrony as a predictor of subsequent psychological outcomes and resilience processes.

Methods

Search Strategy and Selection Criteria

This review's protocol was pre-registered in Prospero (CRD42023416101). The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines were used for the current review and the PRISMA-Protocol (PRISMA-P) was followed when preparing the manuscript (Moher et al., 2009; Moher et al., 2015; Page et al., 2021). A systematic search was conducted on March 10th, 2025 on the academic databases: *Scopus, PubMed* and *PsycINFO*, using a string consisting of the following relevant keywords: [("Synchrony") AND ("Stress" OR "Resilience") AND ("Family" OR "Parents" OR "Father" OR "Mother" OR "Child" OR "Adolescent" OR "Infant")]. In the current study, all studies that measure stress using psychometric scales or physiological measures during an interactive task, were considered as meeting the inclusion criteria. No specific age range was examined, all studies from early childhood to late adolescence were included. All retained articles were: (1) available in English; (2) published in a peer-reviewed journal and were not dissertations, qualitative research or opinion or theoretical papers; (3) measured synchrony within the family system and assessed stress or resilience.

The search strategy for this review was intentionally focused on the term synchrony to preserve conceptual precision and align with definitions rooted in attachment theory and biobehavioral models (Feldman, 2007a, 2012a). Although constructs such as attunement, coordination, co-regulation, and concordance are sometimes used in adjacent literatures, they are not always interchangeable with synchrony and may refer to broader or less temporally specific processes (Beebe & Steele, 2016). Prior reviews, have adopted broader search strings to capture a wider set of interpersonal coordination phenomena (DePasquale, 2020); however, the present review sought to restrict inclusion to studies explicitly referring to synchrony in the context of caregiver–child interactions. This decision reflects a methodological trade-off between sensitivity and precision. While this may have led to the exclusion of conceptually relevant studies labeled under different terminology, it was considered appropriate to maintain terminological coherence across behavioral, physiological, and neurophysiological domains.

This review included only empirical studies that directly measured parent–child synchrony, either behaviorally (e.g., affective matching, gaze, turn-taking), physiologically (e.g., vmHRV, cortisol), or neurophysiologically (e.g., EEG, fNIRS). To be eligible, studies had to examine synchrony in relation to either stress or resilience. Both constructs were treated as measured variables within studies, rather than population-level inclusion criteria. Specifically, studies were included if they assessed how synchrony was influenced by stress-related factors such as parenting stress, parental psychopathology, or socioeconomic adversity, or if synchrony was examined in relation to resilience indicators such as emotion regulation, secure attachment, or adaptive coping. Synchrony needed to be measured explicitly and reported as such; studies addressing related constructs without using the term synchrony were excluded. Studies had to involve parent–child dyads and include an interactive task (e.g., free play, still-face, problem-solving) that allowed synchrony to be observed or quantified. For eligibility, studies were required to investigate parent–child synchrony in the context of either stress or resilience. Stress was defined broadly to include exposure to adversity (e.g., parental psychopathology, trauma, or socioeconomic disadvantage), whereas resilience referred to adaptive functioning or coping processes despite such adversities.

The review focused on interactions within the caregiving dyad and did not include broader family dynamics beyond the parent–child relationship. Studies were excluded if they did not explicitly examine synchrony as a construct, or if they referred only to general relational processes such as attunement, co-regulation, or coordination without defining or measuring synchrony directly. In addition, studies were excluded if they focused on dyads outside the parent–child relationship (e.g., siblings, teachers, or peers), or if stress and resilience were not assessed through either psychometric, behavioral, or physiological indicators. Only peer-reviewed articles published in English were considered.

Data Analysis

The initial search (March 10th ,2025) yielded a total of 491 articles (203 on *Scopus,* 154 on *PubMed,* 134 on *PsycINFO*) that were all downloaded and put into a spreadsheet with the following information: article title, authors, year of publication, journal, doi, and keywords. Duplicated studies were automatically removed, leading to a total of 273 articles. The following steps were done by two reviewers separately who included articles according to the eligibility criteria based on the abstract and/or the title. Selection criteria were conducted in accordance with the MOOSE guidelines for meta-analyses and systematic reviews of observational studies (Stroup et al., 2000). Reasons for exclusion were coded by every reviewer (it is noteworthy to mention that when several reasons for exclusion were found, multiple codes were noted at the same time). Eventual disagreements were resolved by a third independent reviewer. Following this step, 66 articles were found eligible for full-text screening which was carried out by two reviewers resulting in 53 eligible articles to be included in this systematic review. Two additional articles were added from the references list leading to a total of 55 included articles. Relevant information regarding the selection process can be found in Figure 1.

The 55 included articles were then put on a separate spreadsheet and the following further information was retained: (1) country; (2) sample size; (3) population characteristics (e.g., mother-child, father-child, both parents and their child); (4) synchrony measures (behavioral/interaction, physiological, etc.); (5) keywords of each study.

To address the research questions, studies were categorized along specific axes prior to data analysis:

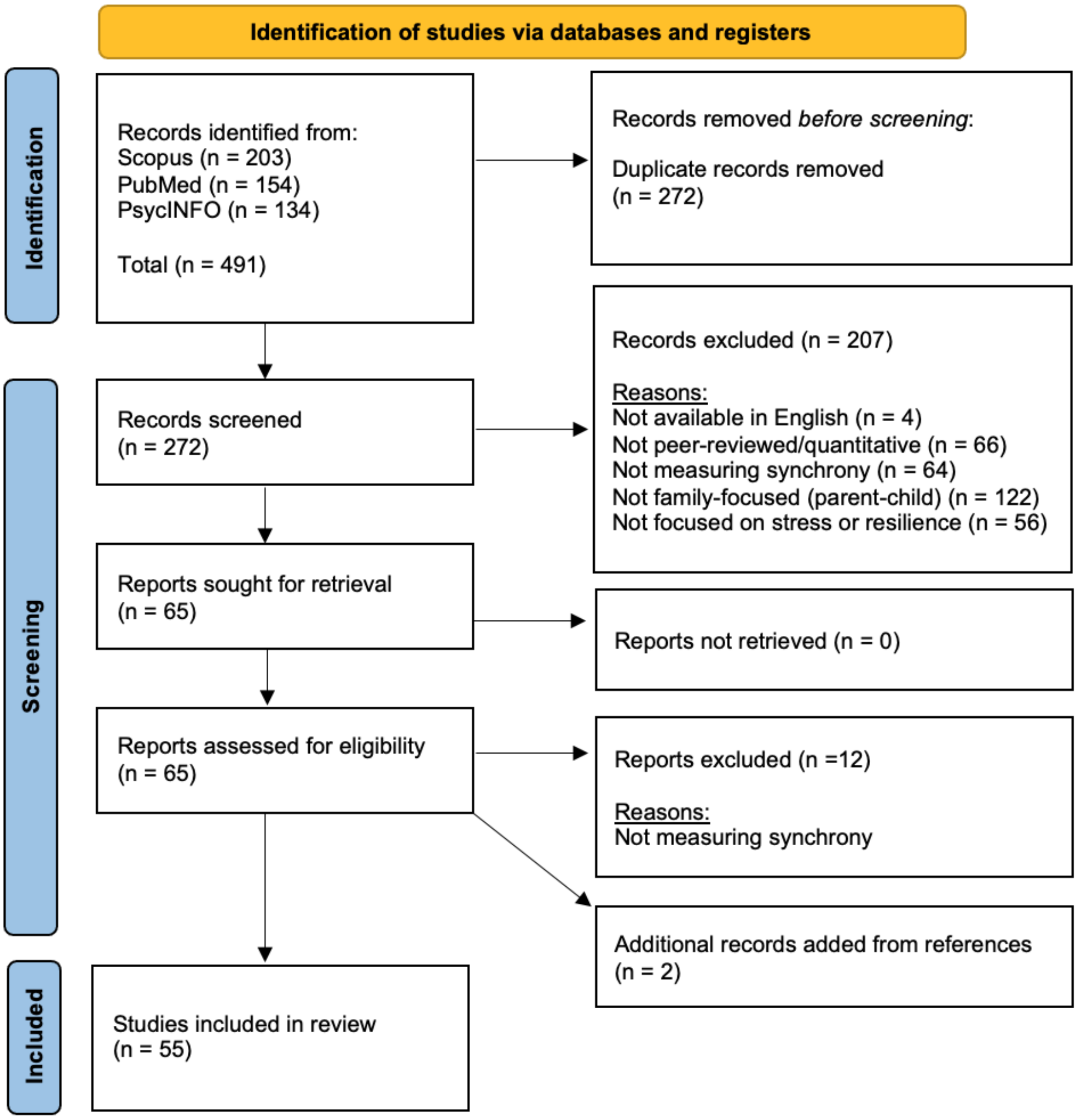
Task context: To examine associations between synchrony and stress regulation, studies were grouped according to whether they included stress-inducing tasks or free-play/baseline conditions during which stress responses were nevertheless measured. Stressor intensity (e.g., acute vs. chronic) and adversity type were not systematically coded due to variability and limited reporting across studies.

Type of synchrony: The most central axis of comparison was the type of synchrony assessed: behavioral, physiological, or neurophysiological, which allowed for structured interpretation of how each form of synchrony related to stress and resilience outcomes.

Caregiver type: Although most studies involved mother–child dyads, limiting analysis by caregiver type, a matrix was developed to map synchrony types, task contexts, and outcomes across the included studies.

This approach provided a systematic synthesis while maintaining theoretical alignment with the constructs under review.

Figure 1. PRISMA Flow Diagram of Studies Screening and Selection Process



Quality Assessment

To assess the quality of all retained studies, the short version of the "Appraisal Tool for Cross-Sectional Studies" (AXIS) (Downes et al., 2016; Sacolo et al., 2018) was used. This Critical Appraisal tool aims to investigate the quality and risk of bias in cross-sectional studies. The short version includes 10 items where answers vary from 0 and 1 indicating No and Yes, respectively, whether articles answered the criteria. The total score ranged between 1-4 (low), 5-7 (moderate), and 8-10 (high). The total score of the studies in the current paper ranged from moderate to high. All relevant details regarding the articles and the 10 items can be found in table 1 in the Appendix.

Although all included studies met minimum quality standards as assessed by the AXIS tool, study quality was not used to formally weight results in the synthesis. Instead, AXIS scores were considered during interpretation, and patterns observed in higher-quality studies were given greater attention when evaluating the consistency and robustness of findings.

Results

Sample Characteristics.

The total sample size of the included studies is 5,079. Of the 55 articles, 40 examined mother-child synchrony while 12 focused on parent-child synchrony, including either mothers or fathers in the sample. Only two studies specifically assessed father-child synchrony (Weisman et al., 2015; Weisman et al., 2013) and only one study evaluated triadic synchrony including both the mother and the father (León et al., 2024) The included articles were conducted in Brazil, Canada, China, Germany, Israel, Italy, Lebanon, the Netherlands, New Zealand, Singapore, the United Kingdoms, and the United States.

Children ranged from newborns (a few days old) to preadolescents (around age 12). Most studies focused on young children: of the 55 studies, 30 involved infants (0–12 months) and 12 involved toddlers (1–3.5 years), and only five involved children older than 6 years. Regarding family characteristics, 32 studies included populations at risk including families with low income or living below the poverty line; those at risk of child maltreatment; parents experiencing parenting-related difficulties; families and children exposed to trauma (e.g., war); and parents or children with symptoms of mental disorders, mostly anxiety or depression.

More details on the demographics of the sample can be found in Table 2 in the Appendix.

Tasks Used to Measure Synchrony

To assess behavioral or physiological synchrony, 26 studies used a free-play interaction task where parents were instructed to play with their child for a brief period of time like they would normally do on a daily basis. Most free plays lasted for 10 minutes using either toys from home or toys that experimenters provided (Abraham et al., 2021; Azhari et al., 2022; Azhari et al., 2019; Cabrera et al., 2021; Doiron et al., 2022; Feldman, Gordon, et al., 2011; Feldman et al., 2010; Fu et al., 2020; Gray et al., 2018; Hein et al., 2020; Im-Bolter et al., 2015; Kaitz et al., 2010; Lan et al., 2024; Lemus et al., 2022; León et al., 2024; Q. Liu et al., 2024; Motsan et al., 2021; Neumann et al., 2020; Oshri et al., 2021; Pratt et al., 2017; Schloß et al., 2019; Smith et al., 2022; Suveg et al., 2016; Tarullo et al., 2017; Thompson & Trevathan, 2009; Thompson & White, 2022; Vittner et al., 2018; Weisman et al., 2013; Zeegers et al., 2019). One study used a tangram construction task (Nguyen, H. Schleihauf, et al., 2020).

The following studies used stress-induced tasks: 11 studies used stress tasks such as the Face-to-Face Still-Face Paradigm (FFSF) (Busuito et al., 2019; Feldman et al., 2010; Ham & Tronick, 2009; Kaitz et al., 2010; Lotzin et al., 2015; MacLean et al., 2014; Mercuri et al., 2023; Montirosso et al., 2010; Pratt et al., 2015; Provenzi et al., 2016; Weisman et al., 2015); Two studies used the Parent-child Challenge Task (PCCT) (Brown et al., 2022; Fuchs et al., 2021); Four studies used the Strange Situation (Doba et al., 2022; Laurent et al., 2011; Laurent et al., 2012; Wu et al., 2024): One study used the DB.DOS: BioSync task (Hoyniak et al., 2021); Conflict Discussion task used by one study (Suveg et al., 2019); a frustration task and LEGO task that was unsolvable, each used once (Hale et al., 2023; Kerr et al., 2021) and one challenging task used once (Gray et al., 2024) Two studies used more than one task at the same time, such a free play and FFSF together (Feldman et al., 2010; Kaitz et al., 2010). Finally, five studies did not use any particular task but just extracted physiological measures such as hair sample to assess cortisol (Liu et al., 2017) or saliva sample to assess cortisol or salivary alpha-amylase (Clearfield et al., 2014; Davis & Granger, 2009; Middlemiss et al., 2012; Williams et al., 2013).

Moreover, regarding differences in the use of behavioral tasks across children's developmental stages, it was observed that most studies employed free-play paradigms regardless of the child’s age. However, paradigms such as the Face-to-Face Still-Face (FFSF) and the Strange Situation were exclusively used with infants, as was the investigation of specific behavioral cues like affective touch. In contrast, tasks involving problem-solving or parent–child discussions were conducted with older children (7–10 years old), while joint attention and teaching tasks were more commonly used with toddlers

More information on the nature of the task and the studies can be found in Table 3 in the Appendix.

Synchrony Computation

Throughout the articles, synchrony was analyzed using different statistical models. The ones that were mostly used were: Pearson's coefficient correlations, linear regressions, analyses of variance and covariance, multivariate analyses of variance, hierarchal regressions, and multilevel models/equations modeling. Details on tasks used per article, coding schemes, and quantification methods used can be found in Table 3 in the Appendix.

Narrative synthesis of the results

We report the results from the 57 selected studies along with the related theory and methodological framework. A summary of all articles can be found in Table 3 in the Appendix.

Following the research questions, the following part will be divided into three different parts: articles investigating the role of parent-child synchrony and stress, articles investigating the role of parent-child synchrony and psychopathology (depression and anxiety), and those investigating the role of parent-child synchrony and resilience.

The results are presented by type of synchrony (i.e., behavioral, physiological, neurophysiological).

Parent-child Synchrony and Stress

Twenty one studies investigated the role of parent-child synchrony and parenting stress while using free-play interaction between parents and children (Abraham et al., 2021; Azhari et al., 2022; Azhari et al., 2019; Cabrera et al., 2021; Doiron et al., 2022; Feldman, Gordon, et al., 2011; Feldman et al., 2010; Fu et al., 2020; Hein et al., 2020; Im-Bolter et al., 2015; León et al., 2024; Q. Liu et al., 2024; Neumann et al., 2020; Oshri et al., 2021; Pratt et al., 2017; Suveg et al., 2016; Tarullo et al., 2017; Thompson & Trevathan, 2009; Thompson & White, 2022; Weisman et al., 2013; Zeegers et al., 2019). Three other studies investigated parenting stress and maternal stress using scales during stress-induced tasks (Fuchs et al., 2021; Nguyen, H. Schleihauf, et al., 2020; Pratt et al., 2015). Eight studies investigated the role of distress or stress (unrelated to parenting stress) in parent-child synchrony using a stress-induced task (Brown et al., 2022; Busuito et al., 2019; Feldman et al., 2010;

Ham & Tronick, 2009; Hoyniak et al., 2021; Kerr et al., 2021; MacLean et al., 2014; Provenzi et al., 2016; Weisman et al., 2015). Six studies investigated the role of synchrony with stress by measuring cortisol (Clearfield et al., 2014; Davis & Granger, 2009; Liu et al., 2017; Middlemiss et al., 2012; Schloß et al., 2019; Tarullo et al., 2017; Wu et al., 2024).

Behavioral Synchrony

The following studies evaluated parenting stress using psychometric scales and assessed parent-child behavioral synchrony. In three studies a negative association between parenting stress using psychometric scales and parent-child synchrony was found, and one study revealed contradictory results. Three studies have highlighted the importance of interventions that aim to reduce the effect of parenting stress on the level of synchrony and the child's development.

Parenting stress was found to be a mediator between synchrony and child problem behavior, where a negative association between synchrony and parenting stress was found and a positive one between parenting stress and child problem behavior (Im-Bolter et al., 2015). Another study showed similar results where parenting stress was associated with less synchrony and less mutual reciprocity (Doiron et al., 2022). Paternal involvement was associated with decreased maternal distress and mothers and children synchronized better when mothers had a positive perception of paternal involvement and engagement with the child (Hein et al., 2020). León and colleagues (2024) found contradictory results where maternal parenting stress predicted greater parent-child synchrony. Another study that sought to tackle parenting stress using an intervention found that children tended to vocalize more post-intervention, after hearing their mother vocalize during a free-play interaction, hence increasing their responsiveness and synchrony (Zeegers et al., 2019). The role of mother-child synchrony and parenting stress was also investigated in an intervention to help children with Autism Spectrum Disorder better regulate their emotions, their developmental levels, and social interactions. Results indicated that synchrony may indeed play a role in interventions aimed at evaluating and working on interpersonal relationships within families (Fu et al., 2020). It was found that synchrony was one of the protective factors and was associated with a positive social adjustment regardless of the level of distress found in parents (Cabrera et al., 2021). Taken together, most studies suggested that higher parenting stress was associated with reduced synchrony, although a few studies reported contradictory associations.

The following studies evaluated stress in children while assessing parent-child behavioral synchrony. Three studies found that parent-child synchrony was associated with less emotional and behavioral problems in children.

Synchrony was associated with fewer behavioral problems in children and this may be due to the sensitivity of mothers as they help their children regulate their emotional responses (Cabrera et al., 2021). This was also supported by the findings of Kerr and colleagues (2021) where less emotional distress in infants was associated with father-child synchrony during a stress task. Synchrony experienced during the play episode predicted negative emotionality in children during the stress task as children may have felt distressed after losing the synchrony during the Still-Face episode (Provenzi et al., 2016). Several studies indicated that parent–child synchrony tended to be associated with better emotional regulation, though stressors could disrupt this process in some contexts.

The following studies evaluated parent-child behavioral synchrony, family interactions and emotion regulation during stress-induced tasks. Seven studies found that emotional regulation and positive affect during a stressful context were associated with high levels of synchrony.

In one study, it was found that dyads tend to increase their vocalization with each other as a way to regulate their interaction when faced with a stressful task (Weisman et al., 2015). Suveg and colleagues (2016) observed that when dyads were capable of regulating their stress responses, behavioral synchrony was high between these dyads during a play interaction task. Environmental factors and mental problems could be an influencing general factor at a familial relational level. In fact, urban mothers were found to have higher synchrony with their children compared to rural mothers and such a result might be attributed to cultural differences between rural and urban communities. The authors suggest that in rural communities there is less accessibility to mental health services which may influence how parenting style may differ from one community to another (Neumann et al., 2020). In cases where mothers have a good capacity of regulating their own level of arousal, behavioral synchrony can be found as mothers may attune to their child's emotions helping them recover from distress (Busuito et al., 2019). One study revealed that children who are able to regulate their emotional responses, more specifically the ability to control a response and not act upon it, may engage in greater behavioral synchrony with their parents and be more present in the interaction (Brown et al., 2022). Mother-child behavioral synchrony was associated with an increased time spent of children looking at their mothers' faces and, in turn, dyads who had a mutual gaze, were associated with an increase in positive affect leading to better emotional regulation in the infant (MacLean et al., 2014; Thompson & Trevathan, 2009).

Physiological Synchrony

The following studies assessed physiological synchrony in parents and children. Ten studies found an association between physiological synchrony and elevated levels of stress. One study showed that behavioral synchrony may play a role in cortisol response and physiological synchrony.

Maternal stress, measured with cortisol, was correlated with more intrusion with the child and with lower positive engagement synchrony. This can be explained by the fact that stress may prevent maternal sensitivity parenting (Tarullo et al., 2017). Maternal sensitivity was associated with stronger mother-child cortisol synchrony (Schloß et al., 2019). Another study found that mothers who learned that their child was in distress during sleep transition had an increased level of cortisol, which was in synchrony with their child's level of cortisol. However, the dyadic cortisol levels were asynchronized when the mother did not know that the child was distressed, meaning that the mother was not stressed when she was not aware that her son was in distress (Middlemiss et al., 2012). These results also align with other findings where mother and child stress related salivary alpha-amylase were correlated during free play (Davis & Granger, 2009). Another study found positive cortisol synchrony between mothers and children during a stress-inducing task (Wu et al., 2024). Furthermore, in cases where mother-child synchrony was present, it was shown that mother-child behavioral synchrony explained significant variance in the infant's cortisol down-regulation of cortisol response (Thompson & White, 2022). One study highlighted the significance of early parental synchrony in relation to stress in preschool children, as high parent-infant synchrony predicted lower child cortisol levels (baseline), and children with negative emotionality showed higher levels of cortisol, compared to those with lower negative emotionality, only in the context of low parental oxytocin levels (Abraham et al., 2021). Another study managed to find physiological synchrony where mother-child synchrony was found in high-risk samples due to chronic stress experiences where the risk context of the family moderated the association between mother and child cortisol synchrony (Liu et al., 2017). In another study, physiological synchrony was assessed by measuring cortisol where it was demonstrated that low socio-economic status or chronic stress in families was associated with more cortisol secretion as compared to high socio-economic status families (Clearfield et al., 2014). Another study found that parents who exert firm control showed vmHRV synchrony with their children, which in turn was associated with externalizing problems in children (Oshri et al., 2021). Pratt and colleagues (2017) found that child psychological stress was associated with maternal stress where higher cortisol synchrony was associated with greater stress. The relationship between oxytocin and stress highlights its participation in the mechanisms of social bonding across the lifespan (Feldman, Gordon, et al., 2011). In sum, many studies reported physiological synchrony when families were faced with stressors, with some evidence suggesting that early parental synchrony may buffer associations between child cortisol levels and stress regulation, though findings varied across contexts and measures.

The following studies evaluated physiological synchrony notably vagal tone or vmHRV in association with stress or during stress-induced tasks such as the FFSF paradigm. Five studies found an association between parent-child synchrony and physiological adaptability to stress.

Dyads experiencing father-child synchrony had high levels of HPA reactivity in children which was related to oxytocin as well as social gaze towards the father, which may indicate a good adaptability to stress (Weisman et al., 2013). Another study showed that when mother-child synchrony and child negative reactivity were present during a stress-task, a greater vagal withdrawal was reported allowing highly reactive children to develop adaptive strategies to cope with stress (Pratt et al., 2015). Touch synchrony between mother and child was also seen to be associated with higher infant vagal tone during free play and during a stress task. The vagal tone showed a greater suppression with the absence of touch synchrony (Feldman et al., 2010). Parental engagement was also assessed in a study where mothers who engaged in soothing the children after a stressful task. It could be demonstrated that skin conductance of mother and child were positively associated with behavioral synchrony (Ham & Tronick, 2009). Similar results were also reported, showing that changes in vmHRV in one partner may prompt changes in the other's partner vmHRV and synchronizing (Fuchs et al., 2021). Moreover, parent-child synchrony was seen to facilitate stress-coping strategies and adaptability in children.

Neural Synchrony

On a neural level, a few studies have found associations between parental stress and IBS in the prefrontal cortex (PFC) using fNIRS. Three studies found that parenting stress was associated with more IBS. Three other studies found that parenting stress was associated with less IBS.

Azhari and colleagues (2019) have reported that parenting stress was related to synchrony in the medial PFC left cluster (including left inferior frontal gyrus, the frontal eye field, and the dorsolateral PFC; areas involved in mental inferencing abilities), as parenting stress increases, synchrony decreases. In a more recent study , the same team (Azhari et al., 2022) highlighted differences in IBS related to parental stress in areas of the PFC; parents exhibiting stress showed greater IBS in the frontal left cluster and less IBS in the posterior right cluster during joint behavior. However, these studies used non-stressful tasks, and stress was measured only by questionnaires (Azhari et al., 2022; Azhari et al., 2019). Moreover, a study found that sociodemographic risk (i.e. as family income) was associated with lower IBS (lateral PFC) during a stress-induced task in preschoolers (Hoyniak et al., 2021). In line with these results, Liu and colleagues (2024) and Nguyen et al. (2020) found that IBS was weakened by parental distress. Indeed, maternal stress and child agency might play a significant role in IBS even bigger than trait-like factors, such as child temperament (Nguyen, H. Schleihauf, et al., 2020). Overall, although stress seems to influence IBS, mixed results were found regarding the direction of the association as some studies found that stress increased IBS and others found that it decreased IBS.

Parent-child Synchrony, Anxiety and Depression

Seven studies investigated the role of synchrony within dyads using free play interaction and anxiety and depression scales (Kaitz et al., 2010; Lan et al., 2024; Lemus et al., 2022; Pratt et al., 2017; Smith et al., 2022; Vittner et al., 2018). Eight studies investigated the role of synchrony using stress-induced tasks while measuring anxiety and depression using scales (Doba et al., 2022; Hale et al., 2023; Kaitz et al., 2010; Laurent et al., 2011; Laurent et al., 2012; Lotzin et al., 2015; Mercuri et al., 2023; Montirosso et al., 2010; Suveg et al., 2019). One study investigated the role of synchrony with anxiety by measuring cortisol levels (Williams et al., 2013).

Behavioral Synchrony and Anxiety

The following studies evaluated the role of anxiety in mother-child behavioral synchrony and found a positive association between anxiety and synchrony.

A study found that during a free play interaction, maternal anxiety symptoms were associated with behavioral mother-child synchrony only when mother's perceived stress was at a moderate level (Lemus et al., 2022). This finding was also supported by another study where mother with anxiety engaged in an exaggerated interaction (too frequent, too intense) during free play. Their infants showed less negative affect than children of non-anxious mothers during stress-induced tasks, but no significant result was reported at the level of behavioral synchrony (Kaitz et al., 2010). Montirosso and colleagues (2010) found that dyads showed high levels of synchrony after being separated during a paradigm task, indicating vigilance in the behavior of the dyads' members after perturbation/stress during the task. The positive association found between perceived stress with both behavioral and physiological synchrony may be explained by the fact that anxious mothers may be more aware of signals and cues sent by the child and would then be more responsive. Results highlighted that maternal anxiety was associated with parent-child behavioral synchrony.

Behavioral Synchrony and Depression

The following studies evaluated the role of maternal depression in mother-child behavioral synchrony. Three studies found a negative association between depression and synchrony and one study found that depression was associated with heightened levels of synchrony.

Lotzin and colleagues (2015) found that mothers with high scores of depression with higher levels of emotion dysregulation showed heightened levels of gaze synchrony with their children during a stress-induced task which may be due to intrusive behavior from the mother's side. Another study found that maternal depression may, however, be associated with low vocal, gaze and motor synchrony due to unresponsiveness during stress-induced tasks (Doba et al., 2022). Furthermore, during the FFSF paradigm, dyads scoring high on depression showed less affectionate touch than dyads lower on depression while the child was crying, but their tactile synchrony was still significantly higher (quantity and quality of touch while faced with stress) (Mercuri et al., 2023). The association between maternal depressive symptoms and behavioral synchrony was not significant in the findings of Hale and colleagues (2023) during a stress task. However, the authors found that maternal negative affect was associated with less behavioral synchrony, indicating that the children may react to their mother's negative affect by either disengaging from the task or by also showing negative affect, and in turn, decreasing behavioral synchrony.

Physiological Synchrony and Anxiety

The following studies evaluated the role of maternal anxiety in mother-child physiological synchrony. Two studies found that physiological synchrony was associated with more anxiety and one study has found skin-to-skin contact was associated with less anxiety.

Physiological synchrony was stronger in more anxious mothers as compared to less anxious ones during home-interactions (Smith et al., 2022). Mother and child cortisol secretion revealed to be synchronous as maternal anxiety and other aspects of family functioning (such as problem solving, communication and behavioral control) predicted the child's awakening cortisol pattern (Williams et al., 2013). The results of Vittner and colleagues (2018) highlighted that skin-to-skin contact was associated with an increase in oxytocin and a decrease in anxiety levels in parents and oxytocin was positively associated with behavioral synchrony and responsiveness: mothers and children with low levels of oxytocin were found to be less synchronous and responsive.

Physiological Synchrony and Depression

The following studies evaluated the role of depression in mother-child physiological synchrony. Four studies found an association between depression and physiological synchrony whereas one study did not find any association between the two.

Suveg and colleagues (2019) found that negative physiological synchrony was associated with high maternal depressive symptoms during a stress induced task. Another study also revealed that when physiological synchrony is low, greater maternal depressive symptoms are associated with child internalizing problems during free play (Lan et al., 2024). Children of mothers who shifted from lower depressive symptoms during pregnancy to higher symptoms showed more hypercortisolemic profiles and physiological synchrony (cortisol and salivary alpha-amylase) during stress tasks, than infants whose mothers shifted from higher to lower symptoms (Laurent et al., 2011; Laurent et al., 2012). In another study, no association between maternal depression and adrenocortical synchrony was found (Pratt et al., 2017).

Parent-child Synchrony and Resilience

Three studies investigated the role of synchrony in resilience measured through psychophysiological indices such as vagal tone (vmHRV/RSA) and behavioral co-(Gray et al., 2018; Motsan et al., 2021; Pratt et al., 2015), while one study focused on the intergenerational impact of maternal adversity (Gray et al., 2024).

Resilience was operationalized in complementary ways across these studies. In Motsan et al. (2021), resilience was explicitly defined as the absence of PTSD symptoms despite chronic early trauma exposure. It was operationalized via multi-level indicators, including higher behavioral synchrony, lower autonomic synchrony (reduced RSA coupling), and increased child RSA during synchronous moments. These patterns characterized resilient dyads and differentiated them from those with clinical PTSD. Gray et al. (2018) defined resilience implicitly through the absence of PTSD in trauma-exposed children, where greater physiological synchrony with caregivers during autobiographical memory recall (RSA concordance) was observed, suggesting co-regulation as a protective mechanism in contexts of early trauma. In Pratt et al. (2015), resilience was moderated by infant temperament. Among infants high in negative reactivity, those exposed to higher mother–infant synchrony exhibited greater vagal withdrawal and recovery, indexing more flexible autonomic regulation under stress. This suggests that resilience may emerge via synchrony-driven physiological calibration, particularly for temperamentally vulnerable children. Finally, in Gray et al. (2024), resilience was framed in terms of preserved parent–child physiological coordination despite maternal histories of adverse childhood experiences (ACEs). Higher-quality dyadic interactions buffered the association between maternal ACEs and disrupted RSA synchrony, highlighting relational quality as a resilience-promoting factor in the face of intergenerational risk. Collectively, these studies operationalize resilience through the preservation or enhancement of behavioral and physiological regulation across different risk profiles, with synchrony emerging as a key relational mechanism supporting adaptive functioning under stress.

Discussion

The current review aimed to highlight the role of synchrony within families, most specifically when faced with a stressful situation or when measuring stress within the family during interactional exchanges. Most of the included studies evaluated mother-child synchrony, while only two studies evaluated father-child synchrony. Moreover, most synchrony measurements were assessed on a dyadic level except for one study that assessed triadic synchrony.

Across studies, parent–child synchrony was often associated with positive affect and emotion regulation in both children and parents, though the strength and direction of associations varied by context and measurement approach. This aligns with one of the earliest works in this field where synchrony predicted better emotional development by providing emotion regulation to the child (Feldman, 2007a). As a result, and in some cases, low mother-child synchrony was shown to predict more problem behaviors, less attachment behavior as well as difficulties to regulate emotions (Feldman, 2007a). Results showed that parenting stress may be associated with less synchrony which aligns with previous studies where parents who have high levels of perceived stress show more negative affect and less involvement with their child than parents who score low levels of perceived stress (Barreto et al., 2024). These results were found in studies that evaluated parenting stress. However, studies that evaluated stress that affected the entire family system (during stress-inducing tasks or physiologically) found different results. When families faced a certain stressor such as a stress-induced task, family members were seen to increase their effort to synchronize and overcome their stress. This is in line with the Transactional Model of Stress and Coping where it is proposed that individuals may use resources at their disposal, such as their family members as a coping tool when facing stress (Lazarus, 1984). While faced with stressors, some families tend to increase their synchronous activities. This was a finding reported by several studies showing that synchrony increased following a stressful situation such as the Strange Situation or the FFSF task. Stress in that sense, was seen to shape the family system by pushing the family to synchronize with one another to confront specific situations that may disrupt the familial harmony. At the functional level, synchrony may play a compensatory role to maintain the stability of the family after being disrupted, as vmHRV synchrony between mother and child may act as a resilience factor (Lan et al., 2024).

Some psychopathologies such as maternal anxiety, were associated with elevated levels of synchrony. This finding may suggest that a certain level of maternal anxiety can help the mother be more aware of her child's need and attune to the child's emotional cues and in turn, initiate the synchrony with the child (Beebe et al., 2011; Lemus et al., 2022; Smith et al., 2022). In depression, a different pathway could be observed, where maternal depression and negative affect were associated with low levels of synchrony (Doba et al., 2022; Hale et al., 2023; Lotzin et al., 2015). Synchrony may also play a role in the levels of depression and distress. Low behavioral synchrony, more specifically, gaze synchrony, was seen to be associated with higher maternal depressive symptoms and greater maternal distress. Dyads where mothers had high levels of depression also showed lower levels of gaze and touch synchrony as well as higher gaze aversion (Beatrice Beebe et al., 2008; B. Beebe et al., 2008; Granat et al., 2017).

After being faced with a stressful task, dyads who synchronized with one another showed a reduction of stress levels. This characteristic aligns with the definition of family resilience given by McCubbin and McCubbin (1988), which consists of characteristics and properties of families that help them better face challenges and disruptions in times of crisis. This positive synchrony between parent and child may facilitate resilience (Lan et al., 2024), aligning with Feldman's proposal that biobehavioral synchrony was shown to sustain resilience (Feldman, 2020). These findings suggest that synchrony could serve a buffering role in the face of stress and hardships, potentially supporting resilience and family recovery after stressful situations, although more longitudinal evidence is needed to confirm this pathway.

Moreover, it is worth noting that of the 55 studies included, 42 involved infants and toddlers. This focus on young children is not surprising, given that biobehavioral synchrony plays a particularly crucial role during the first years of life (Feldman, 2012a, 2012c). Although, the findings did not reveal significant differences based on the child's age. Both behavioral and physiological synchrony were observed from infancy through childhood and the indices used to compute behavioral and physiological synchrony were similar (e.g., mutual gaze, affect, cortisol levels). Behavioral synchrony was generally associated with resilience and positive developmental outcomes, reflecting the quality of parent–child interactions, even when the family was facing stressful situations. In contrast, physiological synchrony was more frequently linked to negative outcomes, such as parental and child distress, parental depression or anxiety, and tended to exert adverse effects on children. These observations were further supported by longitudinal studies, which reported similar results across different ages (Abraham et al., 2021; Brown et al., 2022; Fuchs et al., 2021; Motsan et al., 2021). Only the expression of child distress in relation to disrupted synchrony appeared to vary with age. In early childhood, it was typically manifested through difficulties in emotion regulation or displays of negative affect, whereas in older children (around 10 years old), disrupted synchrony was associated with externalizing problems.

However, despite the apparent influence of synchrony – both positive and negative – on children's emotion regulation and potentially on resilience across developmental stages, only a few studies have investigated parent–child synchrony during childhood. This makes it difficult to compare the influence of synchrony and stress across child age and underscores the need for further research focusing on this developmental period, as synchrony may be a key factor in the emergence of behavioral problems and psychopathology.

The results found in the current review also raise several conceptual and methodological concerns. Although synchrony is commonly defined as the dynamic coordination of signals between two or more individuals and is typically associated with adaptive relational processes such as attunement, co-regulation, and bonding (Feldman, 2012d; Harrist & Waugh, 2002), this is not always empirically consistent. For instance, several studies included in this review reported elevated physiological synchrony in dyads characterized by heightened anxiety or intrusive parenting behaviors. In such cases, synchrony may emerge not from mutual regulation but from hypervigilance or emotional enmeshment, complicating the assumption that synchrony is inherently beneficial.

While the majority of studies converged on the finding that parenting stress and depression are associated with reduced behavioral synchrony, some contradictory results were observed. For example, León and colleagues (2024) reported that higher maternal parenting stress predicted greater synchrony, and Lotzin et al. (2015) found that maternal depression was associated with heightened gaze synchrony. Similarly, findings in the neural synchrony literature diverged, with some studies reporting stress-related reductions in inter-brain synchrony (e.g., Azhari et al., 2019; Nguyen et al., 2020) while others observed stress-related increases (e.g., Azhari et al., 2022). These apparent contradictions may reflect differences in how synchrony was operationalized (macro vs micro-analytic coding, behavioral vs physiological vs neural measures), the type of task (free play vs stress induction), and the sample characteristics (clinical vs community, child developmental stage, cultural or socioeconomic context). Moreover, elevated synchrony under conditions of high parental stress or depression may not necessarily indicate adaptive coordination but could reflect compensatory or intrusive interaction patterns. Thus, rather than indicating inconsistency, these divergent findings highlight the importance of contextual and methodological moderators when interpreting associations between stress, psychopathology, and parent–child synchrony.

These findings highlight the importance of specifying how synchrony is defined and measured, as behavioral, affective, and physiological synchrony reflect different processes, may not always align, and can vary in their functional significance depending on the context (Hoehl et al., 2021; Palumbo et al., 2017). Lack of clarity and consistency in definitions risks conflating divergent processes under the same label, thereby undermining the construct validity of synchrony and limiting comparability across studies. As emphasized in prior literature, the field would benefit from a unified taxonomy or framework that distinguishes types of synchrony and specifies their expected directionality and meaning across developmental stages and relational contexts (Davis et al., 2018). Such precision is especially important for future studies employing multi-modal approaches to synchrony (e.g., combining physiological and behavioral measures), where divergence or convergence across modalities can offer theoretically rich insights, but only if the constructs are clearly and consistently operationalized. Ultimately, greater definitional clarity will enhance the cumulative power of synchrony research, improve measurement sensitivity, and facilitate the translation of findings into clinical and developmental applications. Interestingly, in studies that measured both behavioral and physiological synchrony in parent–child dyads, findings often reveal a dynamic relationship between the two. In contexts of stress or when parents experience anxiety, dyads tend to exhibit higher physiological synchrony (e.g., vmHRV, cortisol), which is often linked to negative outcomes, and behavioral synchrony is typically lower. In contrast, during positive parent–child interactions (e.g., shared positive affect, parental support, and social adjustment), behavioral synchrony is more commonly observed and is associated with reduced distress (Pratt et al., 2015). This suggests that maintaining behavioral synchrony during stressful situations might be related to more resilient family dynamics. At the neurophysiological level, although only a few studies have explored the relationship between neural activation and behavior, the available evidence indicates that IBS is positively associated with behavioral synchrony (Azhari et al., 2022; Liu et al., 2024; Quiñones-Camacho et al., 2020). This suggests that IBS may facilitate coordinated social behaviors and be influenced by stress. Taken together, these findings highlight the importance of investigating synchrony through a multimodal lens. Such an approach might provide a more comprehensive understanding of synchrony's functional role, depending on the system examined (e.g., hormonal, neural, behavioral), the context (e.g., stress, adversity), and parent–child characteristics (e.g., sensitivity, resilience). Emerging models of multimodal synchrony further support the relevance of this integrative approach (Gordon et al., 2024).

However, the definitional and methodological inconsistencies outlined above also posed a challenge to quantitative synthesis. Although the number of studies included in the present review might suggest the feasibility of a meta-analysis, this approach was not pursued due to substantial heterogeneity in synchrony measurement, study designs, and outcome operationalizations. The included studies employed widely varying paradigms (e.g., free play, stress induction), assessed different forms of synchrony (behavioral, physiological, neural), and reported outcomes such as stress and resilience using disparate constructs, ranging from cortisol reactivity to vmHRV, self-reported symptoms, or clinical diagnoses. These divergences precluded the identification of a sufficient number of comparable effect sizes needed for meta-analytic aggregation (Valentine et al., 2010). As the field moves toward more consistent frameworks and measurement approaches, future meta-analyses may become more viable and informative, particularly in clarifying when and how different forms of synchrony function as markers of adaptation or dysregulation. Greater definitional precision and methodological alignment across studies will be key to supporting such cumulative efforts.

Strengths and Limitations

The methodology of the current study has various strengths. This systematic review focused on synchrony within a familial context while also including stress measurements (either stress induced tasks or general stress measurements via psychometric scales). Notably the findings provide insight family dynamics and how family members may react to certain stressors. This study also highlights the discrepancies in the literature when it comes to synchrony and recommends clearly defining synchrony and using standardized terminologies when referring to either behavioral or physiological synchrony.

However, this study is not without limitations. First, the current systematic review included only articles published in English, which may have excluded relevant findings published in other languages and thus introduced a language bias. Second, a critical limitation lies in the predominant focus of the literature on mother–child dyads, with only two studies assessing father–child synchrony and a single study examining triadic interactions involving both parents and the child. This represents a substantial theoretical and methodological gap. Fathers are not merely secondary caregivers but active co-regulators who contribute uniquely to their child's emotional regulation, especially in the context of stress and challenge (Kerr et al., 2021). Studies that have included fathers show patterns of physiological synchrony (vmHRV) that are comparable to those observed in mother–child dyads, suggesting that fathers are equally capable of providing relational scaffolding through coregulatory processes. Studies that have included fathers show patterns of physiological synchrony comparable to those observed in mother–child dyads, suggesting that fathers are equally capable of providing relational scaffolding through coregulatory processes. At the behavioral level, father–child synchrony during play and problem-solving tasks has been linked to children's emotional regulation and social competence, with evidence that fathers' characteristic style of stimulating and challenging interactions provides a unique context for practicing regulatory skills (Feldman, 2003, 2015; Paquette, 2004).

The underrepresentation of fathers in synchrony research not only narrows our understanding of family dynamics but also reinforces outdated gendered assumptions about caregiving. Including father–child dyads more systematically would allow for a richer and more comprehensive understanding of how different caregiver roles interact with child regulation and resilience. Moreover, the majority of studies assessed synchrony on a dyadic level, even when both parents were present, leading to conclusions based on isolated subsystems rather than the family as a dynamic, interconnected system. Triadic interactions, which reflect the full relational context in which the child is embedded, remain largely unstudied. This is particularly problematic given evidence that family-level synchrony (e.g., mutual coordination of attention, affect, and behavior) across both parents and the child, may reveal emergent dynamics that cannot be reduced to dyadic exchanges, such as the negotiation of alliances, turn-taking among three partners, or patterns of inclusion and exclusion (Corboz-Warnery, 1999; Favez et al., 2006). These triadic processes may shape how children learn to navigate complex social environments and regulate emotions within group contexts. At the same time, studying triadic synchrony poses unique methodological challenges: coding requires capturing simultaneous interactions among three individuals, which complicates both behavioral micro-coding (e.g., assigning turn-taking or affective states across multiple partners) and physiological analyses (e.g., aligning three time-series). The lack of standardized analytic frameworks has further limited cumulative progress in this area. Future research should therefore prioritize the inclusion of triadic designs and the development of analytic approaches capable of capturing synchrony as a multilateral process, particularly when investigating resilience, stress transmission, and emotion regulation within the family system. Finally, operational definitions of synchrony varied widely across studies, ranging from global macro-coding systems to physiological indicators (e.g., vmHRV, cortisol), and from time-series based analyses to composite synchrony scores. This variability further complicates cross-study comparisons and highlights the need for consistent, multimodal, and developmentally grounded operationalizations of synchrony.

Finally, although all studies scored moderate to high quality on the AXIS tool, it is notable that over half of the included studies (52 of 55) received a score of 0 on the item assessing whether the sample size was adequately justified. This pattern likely reflects broader methodological challenges in research involving parent–child dyads, particularly in observational or physiological paradigms, where recruitment, consent, and data collection are often labor-intensive and constrained by ethical and logistical considerations (Oh et al., 2017). While the absence of sample size justification does not necessarily imply poor methodological quality, it does underscore the limitations in statistical power and generalizability that may characterize much of the current literature. It is therefore essential to emphasize that larger sample sizes, while generally desirable, do not inherently guarantee higher methodological quality or theoretical contribution. What is needed are power analyses calibrated to the specific design, level of analysis (behavioral, physiological, neurophysiological), and research questions of synchrony studies. Such practices would not only enhance the robustness of findings but also enable more nuanced examinations of moderators such as developmental stage, clinical risk profiles, or cultural context. As the field progresses, greater attention to sample size justification and integration of power analysis into the research workflow will be critical for advancing cumulative knowledge and refining theoretical models of synchrony, stress, and resilience.

Another limitation concerns the screening process. Although two reviewers independently assessed titles/abstracts and full texts and resolved disagreements by consensus, we did not calculate inter-rater agreement statistics (e.g., percent agreement or Cohen’s kappa). This omission limits the transparency with which the consistency of study selection can be evaluated. Future reviews in this area would benefit from formally reporting inter-rater reliability indices to strengthen methodological rigor.

Conclusion

Given the links between parental psychopathology and parent-child synchrony, this systematic review increased our understanding of the relationship between synchrony and stress and resilience. Furthermore, it also emphasizes the great need for the design of synchrony-based interventions, as previously suggested. This highlights the potential importance of family synchrony as a one relational pathway through which families may adapt to challenges. The results also show how stress affects and shapes the family where parent adapt to the child's stress response and vice versa.

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Contributions

MS conceptualized and designed the study also drafted the manuscript. MS and FC both screened the articles. SG and FC supervised the project. MDL, MR, MP and RDR provided feedback. All authors read and approved the final version of the manuscript.

Declaration of interest

The authors declare no competing interest.

Data sharing

All information related to the selected articles and the excluded ones can be provided by contacting the corresponding author.

List of abbreviations

HPA: Hypothalamic-Pituitary-Adrenal

vmHRV: vagally mediated Heart Rate Variability

PNS: Parasympathetic Nervous System

IBS: Interbrain Synchrony

PFC: Prefrontal Cortex

References

Abraham, E., Zagoory-Sharon, O., & Feldman, R. (2021). Early maternal and paternal caregiving moderates the links between preschoolers' reactivity and regulation and maturation of the HPA-immune axis. *Developmental Psychobiology*, *63*(5), 1482-1498. https://doi.org/https://doi.org/10.1002/dev.22089

Ainsworth, Bell, S. M., & Stayton, D. F. (1974). Infant-mother attachment and social development: Socialization as a product of reciprocal responsiveness to signals.

Ainsworth, M. D. S., Blehar, M. C., Waters, E., & Wall, S. N. (2015). *Patterns of attachment: A psychological study of the strange situation*. Psychology press. https://doi.org/ https://doi.org/10.4324/9780203758045

Alonso, A., McDorman, S. A., & Romeo, R. R. (2024). How parent–child brain-to-brain synchrony can inform the study of child development. *Child development perspectives*, *18*(1), 26-35.

Appelhans, B. M., & Luecken, L. J. (2006). Heart rate variability as an index of regulated emotional responding. *Review of general psychology*, *10*(3), 229-240. https://doi.org/https://doi.org/10.1037/1089-2680.10.3.2

Azhari, Bizzego, A., & Esposito, G. (2022). Parent–child dyads with greater parenting stress exhibit less synchrony in posterior areas and more synchrony in frontal areas of the prefrontal cortex during shared play. *Social Neuroscience*, *17*(6), 520-531.

Azhari, A., Leck, W. Q., Gabrieli, G., Bizzego, A., Rigo, P., Setoh, P., Bornstein, M. H., & Esposito, G. (2019). Parenting Stress Undermines Mother-Child Brain-to-Brain Synchrony: A Hyperscanning Study. *Sci Rep*, *9*(1), 11407. https://doi.org/10.1038/s41598-019-47810-4

Barreto, S., Wang, S., Guarnaccia, U., Fogelman, N., Sinha, R., & Chaplin, T. M. (2024). Parent Stress and Observed Parenting in a Parent-Child Interaction Task in a Predominantly Minority and Low-Income Sample. *Arch Pediatr (Lisle)*, *9*(1), 308. https://doi.org/10.29011/2575-825x.100308

Beebe, B., Badalamenti, A., Jaffe, J., Feldstein, S., Marquette, L., Helbraun, E., Demetri-Friedman, D., Flaster, C., Goodman, P., & Kaminer, T. (2008). Distressed mothers and their infants use a less efficient timing mechanism in creating expectancies of each other's looking patterns. *Journal of Psycholinguistic Research*, *37*, 293-307. https://doi.org/DOI 10.1007/s10936-008-9078-y

Beebe, B., Jaffe, J., Buck, K., Chen, H., Cohen, P., Feldstein, S., & Andrews, H. (2008). Six-week postpartum maternal depressive symptoms and 4-month mother-infant self- and interactive contingency. *Infant Ment Health J*, *29*(5), 442-471. https://doi.org/10.1002/imhj.20191

Beebe, B., Messinger, D., Bahrick, L. E., Margolis, A., Buck, K. A., & Chen, H. (2016). A systems view of mother-infant face-to-face communication. *Dev Psychol*, *52*(4), 556-571. https://doi.org/10.1037/a0040085

Beebe, B., & Steele, M. (2016). How does microanalysis of mother–infant communication inform maternal sensitivity and infant attachment? In *Maternal Sensitivity* (pp. 141-160). Routledge.

Beebe, B., Steele, M., Jaffe, J., Buck, K. A., Chen, H., Cohen, P., Kaitz, M., Markese, S., Andrews, H., Margolis, A., & Feldstein, S. (2011). Maternal Anxiety Symptoms and Mother-Infant Self- and Interactive Contingency. *Infant Ment Health J*, *32*(2), 174-206. https://doi.org/10.1002/imhj.20274

Birk, S. L., Stewart, L., & Olino, T. M. (2022). Parent–child synchrony after early childhood: A systematic review. *Clinical Child and Family Psychology Review*, *25*(3), 529-551.

Bowlby, J. (1969). Attachment and loss: Vol. 1. Attachment. In: Basic books.

Bowlby, J. (2008). *Attachment*. Basic books.

Bright, M. A., Granger, D. A., & Frick, J. E. (2012). Do infants show a cortisol awakening response? *Developmental Psychobiology*, *54*(7), 736-743.

Brown, K. M., Ram, N., & Lunkenheimer, E. (2022). The influence of children's effortful control on parent-child behavioral synchrony. *J Fam Psychol*, *36*(6), 907-918. https://doi.org/10.1037/fam0001010

Busuito, A., Quigley, K. M., Moore, G. A., Voegtline, K. M., & DiPietro, J. A. (2019). In sync: Physiological correlates of behavioral synchrony in infants and mothers. *Dev Psychol*, *55*(5), 1034-1045. https://doi.org/10.1037/dev0000689

Cabrera, N. J., Hennigar, A., Alonso, A., McDorman, S. A., & Reich, S. M. (2021). The Protective Effects of Maternal and Paternal Factors on Children's Social Development. *Advers Resil Sci*, *2*(2), 85-98. https://doi.org/10.1007/s42844-021-00041-x

Clearfield, M. W., Carter-Rodriguez, A., Merali, A. R., & Shober, R. (2014). The effects of SES on infant and maternal diurnal salivary cortisol output. *Infant Behav Dev*, *37*(3), 298-304. https://doi.org/10.1016/j.infbeh.2014.04.008

Corboz-Warnery, A. (1999). *The primary triangle: A developmental systems view of mothers, fathers, and infants*. BasicBooks.

Creavy, K. L., Gatzke-Kopp, L. M., Zhang, X., Fishbein, D., & Kiser, L. J. (2020). When you go low, I go high: Negative coordination of physiological synchrony among parents and children. *Developmental Psychobiology*, *62*(3), 310-323.

Criss, M. M., Pettit, G. S., Bates, J. E., Dodge, K. A., & Lapp, A. L. (2002). Family adversity, positive peer relationships, and children's externalizing behavior: a longitudinal perspective on risk and resilience. *Child Dev*, *73*(4), 1220-1237. https://doi.org/10.1111/1467-8624.00468

Czeszumski, A., Eustergerling, S., Lang, A., Menrath, D., Gerstenberger, M., Schuberth, S., Schreiber, F., Rendon, Z. Z., & König, P. (2020). Hyperscanning: a valid method to study neural inter-brain underpinnings of social interaction. *Frontiers in human neuroscience*, *14*, 39.

Davis, Bilms, J., & Suveg, C. (2017). In sync and in control: A meta-analysis of parent–child positive behavioral synchrony and youth self-regulation. *Family process*, *56*(4), 962-980.

Davis, E. P., & Granger, D. A. (2009). Developmental differences in infant salivary alpha-amylase and cortisol responses to stress. *Psychoneuroendocrinology*, *34*(6), 795-804. https://doi.org/10.1016/j.psyneuen.2009.02.001

Davis, M., West, K., Bilms, J., Morelen, D., & Suveg, C. (2018). A systematic review of parent–child synchrony: It is more than skin deep. *Developmental Psychobiology*, *60*(6), 674-691.

Deater-Deckard, K. (2008). *Parenting stress*. Yale University Press.

DePasquale, C. E. (2020). A systematic review of caregiver-child physiological synchrony across systems: Associations with behavior and child functioning. *Dev Psychopathol*, *32*(5), 1754-1777. https://doi.org/10.1017/s0954579420001236

Doba, K., Pezard, L., & Nandrino, J. L. (2022). How do maternal emotional regulation difficulties modulate the mother–infant behavioral synchrony? *Infancy*, *27*(3), 582-608.

Doiron, K. M., Stack, D. M., Dickson, D. J., Bouchard, S., & Serbin, L. A. (2022). Co-regulation and parenting stress over time in full-term, very low birthweight preterm, and psycho-socially at-risk infant-mother dyads: Implications for fostering the development of healthy relationships. *Infant Behavior and Development*, *68*, 101731.

Downes, M. J., Brennan, M. L., Williams, H. C., & Dean, R. S. (2016). Development of a critical appraisal tool to assess the quality of cross-sectional studies (AXIS). *BMJ open*, *6*(12), e011458. https://doi.org/10.1136/bmjopen-2016-011458

Favez, N., Frascarolo, F., & Fivaz-Depeursinge, E. (2006). Family alliance stability and change from pregnancy to toddlerhood and marital correlates. *Swiss Journal of Psychology*, *65*(4), 213-220.

Feldman, R. (2003). Infant–mother and infant–father synchrony: The coregulation of positive arousal. *Infant Mental Health Journal: Official Publication of The World Association for Infant Mental Health*, *24*(1), 1-23.

Feldman, R. (2007a). Parent-infant synchrony and the construction of shared timing; physiological precursors, developmental outcomes, and risk conditions. *J Child Psychol Psychiatry*, *48*(3-4), 329-354. https://doi.org/10.1111/j.1469-7610.2006.01701.x

Feldman, R. (2007b). Parent–infant synchrony: Biological foundations and developmental outcomes. *Current directions in psychological science*, *16*(6), 340-345.

Feldman, R. (2012a). Bio-behavioral synchrony: A model for integrating biological and microsocial behavioral processes in the study of parenting. *Parenting*, *12*(2-3), 154-164.

Feldman, R. (2012b). Oxytocin and social affiliation in humans. *Hormones and behavior*, *61*(3), 380-391.

Feldman, R. (2012c). Parent-infant synchrony: A biobehavioral model of mutual influences in the formation of affiliative bonds. *Monographs of the Society for Research in Child Development*, *77*(2), 42-51.

Feldman, R. (2012d). Parenting behavior as the environment where children grow.

Feldman, R. (2015). The adaptive human parental brain: implications for children's social development. *Trends in Neurosciences*, *38*(6), 387-399.

Feldman, R. (2017). The Neurobiology of Human Attachments. *Trends Cogn Sci*, *21*(2), 80-99. https://doi.org/10.1016/j.tics.2016.11.007

Feldman, R. (2020). What is resilience: an affiliative neuroscience approach. *World Psychiatry*, *19*(2), 132-150.

Feldman, R., Gordon, I., & Zagoory-Sharon, O. (2011). Maternal and paternal plasma, salivary, and urinary oxytocin and parent-infant synchrony: considering stress and affiliation components of human bonding. *Dev Sci*, *14*(4), 752-761. https://doi.org/10.1111/j.1467-7687.2010.01021.x

Feldman, R., Granat, A., Pariente, C., Kanety, H., Kuint, J., & Gilboa-Schechtman, E. (2009). Maternal depression and anxiety across the postpartum year and infant social engagement, fear regulation, and stress reactivity. *J Am Acad Child Adolesc Psychiatry*, *48*(9), 919-927. https://doi.org/10.1097/CHI.0b013e3181b21651

Feldman, R., Greenbaum, C. W., & Yirmiya, N. (1999). Mother–infant affect synchrony as an antecedent of the emergence of self-control. *Developmental psychology*, *35*(1), 223.

Feldman, R., Magori-Cohen, R., Galili, G., Singer, M., & Louzoun, Y. (2011). Mother and infant coordinate heart rhythms through episodes of interaction synchrony. *Infant Behavior and Development*, *34*(4), 569-577.

Feldman, R., Singer, M., & Zagoory, O. (2010). Touch attenuates infants' physiological reactivity to stress. *Dev Sci*, *13*(2), 271-278. https://doi.org/10.1111/j.1467-7687.2009.00890.x

Fu, L., Weng, J., Feng, M., Xiao, X., Xiao, T., Fu, J., Qiu, N., Li, C., Da, Y., & Ke, X. (2020). Predictors of Change in Play-Based Communication and Behavior Intervention for High-Risk ASD: The Role of Mother-Child Dyadic Synchrony. *Front Pediatr*, *8*, 581893. https://doi.org/10.3389/fped.2020.581893

Fuchs, A., Lunkenheimer, E., & Lobo, F. (2021). Individual differences in parent and child average RSA and parent psychological distress influence parent-child RSA synchrony. *Biol Psychol*, *161*, 108077. https://doi.org/10.1016/j.biopsycho.2021.108077

Gadassi Polack, R., Joormann, J., Orbach, M., Silverman, W. K., & Lebowitz, E. R. (2021). Maternal Depression and Mother-Child Oxytocin Synchrony in Youth with Anxiety Disorders. *Res Child Adolesc Psychopathol*, *49*(3), 381-392. https://doi.org/10.1007/s10802-020-00744-2

Gordis, E. B., Margolin, G., Spies, L. A., Susman, E. J., & Granger, D. A. (2010). Interparental aggression and parent-adolescent salivary alpha amylase symmetry. *Physiol Behav*, *100*(3), 225-233. https://doi.org/10.1016/j.physbeh.2010.01.006

Gordon, I., Tomashin, A., & Mayo, O. (2024). A theory of flexible multimodal synchrony. *Psychological review*.

Granat, A., Gadassi, R., Gilboa-Schechtman, E., & Feldman, R. (2017). Maternal depression and anxiety, social synchrony, and infant regulation of negative and positive emotions. *Emotion*, *17*(1), 11-27. https://doi.org/10.1037/emo0000204

Gray, S. A., Miller, J. G., Glackin, E. B., Hatch, V., & Drury, S. S. (2024). Parent–child relationship quality buffers the association between mothers' adverse childhood experiences and physiological synchrony. *Journal of Child psychology and Psychiatry*.

Gray, S. A. O., Lipschutz, R. S., & Scheeringa, M. S. (2018). Young Children's Physiological Reactivity during Memory Recall: Associations with Posttraumatic Stress and Parent Physiological Synchrony. *J Abnorm Child Psychol*, *46*(4), 871-880. https://doi.org/10.1007/s10802-017-0326-1

Hadley, L. V., & Ward, J. A. (2021). Synchrony as a measure of conversation difficulty: Movement coherence increases with background noise level and complexity in dyads and triads. *Plos one*, *16*(10), e0258247.

Hale, M. E., Morrow, K. E., George, A. M., Gayer, A., Caughy, M. O., & Suveg, C. (2023). Maternal negative affect moderates behavioral and physiological synchrony in Latinx and Black mother-child dyads. *Dev Psychobiol*, *65*(5), e22394. https://doi.org/10.1002/dev.22394

Ham, J., & Tronick, E. (2009). Relational psychophysiology: lessons from mother-infant physiology research on dyadically expanded states of consciousness. *Psychother Res*, *19*(6), 619-632. https://doi.org/10.1080/10503300802609672

Hari, R., Himberg, T., Nummenmaa, L., Hämäläinen, M., & Parkkonen, L. (2013). Synchrony of brains and bodies during implicit interpersonal interaction. *Trends in cognitive sciences*, *17*(3), 105-106.

Harrist, A. W., & Waugh, R. M. (2002). Dyadic synchrony: Its structure and function in children's development. *Developmental review*, *22*(4), 555-592.

Hein, S., Bick, J., Issa, G., Aoude, L., Maalouf, C., Awar, A., Nourallah, S., Zonderman, A. L., Householder, S., & Katsovich, L. (2020). Maternal perceptions of father involvement among refugee and disadvantaged families in Beirut, Lebanon. *Plos one*, *15*(3), e0229670.

Helm, J. L., Miller, J. G., Kahle, S., Troxel, N. R., & Hastings, P. D. (2018). On Measuring and Modeling Physiological Synchrony in Dyads. *Multivariate Behav Res*, *53*(4), 521-543. https://doi.org/10.1080/00273171.2018.1459292

Hibel, L. C., Granger, D. A., Blair, C., & Cox, M. J. (2009). Intimate partner violence moderates the association between mother–infant adrenocortical activity across an emotional challenge. *Journal of Family Psychology*, *23*(5), 615.

Hoehl, S., Fairhurst, M., & Schirmer, A. (2021). Interactional synchrony: signals, mechanisms and benefits. *Soc Cogn Affect Neurosci*, *16*(1-2), 5-18. https://doi.org/10.1093/scan/nsaa024

Holroyd, C. B. (2022). Interbrain synchrony: on wavy ground. *Trends in Neurosciences*, *45*(5), 346-357.

Hoyniak, C. P., Quiñones-Camacho, L. E., Camacho, M. C., Chin, J. H., Williams, E. M., Wakschlag, L. S., & Perlman, S. B. (2021). Adversity is linked with decreased parent-child behavioral and neural synchrony. *Developmental Cognitive Neuroscience*, *48*, 100937.

Im-Bolter, N., Anam, M., & Cohen, N. J. (2015). " Mother–child synchrony and child problem behavior": Erratum.

Imel, Z. E., Barco, J. S., Brown, H. J., Baucom, B. R., Baer, J. S., Kircher, J. C., & Atkins, D. C. (2014). The association of therapist empathy and synchrony in vocally encoded arousal. *J Couns Psychol*, *61*(1), 146-153. https://doi.org/10.1037/a0034943

Isabella, R. A., & Belsky, J. (1991). Interactional synchrony and the origins of infant-mother attachment: a replication study. *Child Dev*, *62*(2), 373-384. https://www.ncbi.nlm.nih.gov/pubmed/2055128

Kaitz, M., Maytal, H. R., Devor, N., Bergman, L., & Mankuta, D. (2010). Maternal anxiety, mother-smithinfant interactions, and infants' response to challenge. *Infant Behav Dev*, *33*(2), 136-148. https://doi.org/10.1016/j.infbeh.2009.12.003

Kerr, M. L., Rasmussen, H. F., Smiley, P. A., Buttitta, K. V., & Borelli, J. L. (2021). The development of toddlers' emotion regulation within the family system: associations with observed parent-child synchrony and interparental relationship satisfaction. *Early Childhood Research Quarterly*, *57*, 215-227.

Kochanska, G., Aksan, N., Prisco, T. R., & Adams, E. E. (2008). Mother–child and father–child mutually responsive orientation in the first 2 years and children's outcomes at preschool age: Mechanisms of influence. *Child development*, *79*(1), 30-44.

Kudinova, A. Y., Woody, M. L., James, K. M., Burkhouse, K. L., Feurer, C., Foster, C. E., & Gibb, B. E. (2019). Maternal major depression and synchrony of facial affect during mother-child interactions. *J Abnorm Psychol*, *128*(4), 284-294. https://doi.org/10.1037/abn0000411

Lan, Q., Zhang, C., Lunkenheimer, E., Chang, S., Li, Z., & Wang, L. (2024). Maternal postnatal depressive symptoms and children's internalizing problems: The moderating role of mother-infant RSA synchrony. *Dev Psychopathol*, *36*(4), 1776-1788. https://doi.org/10.1017/S0954579423001153

Laurent, H. K., Ablow, J. C., & Measelle, J. (2011). Risky shifts: How the timing and course of mothers' depressive symptoms across the perinatal period shape their own and infant's stress response profiles. *Development and psychopathology*, *23*(2), 521-538.

Laurent, H. K., Ablow, J. C., & Measelle, J. (2012). Taking stress response out of the box: stability, discontinuity, and temperament effects on HPA and SNS across social stressors in mother-infant dyads. *Dev Psychol*, *48*(1), 35-45. https://doi.org/10.1037/a0025518

Lazarus, R. S. (1984). *Stress, appraisal, and coping* (Vol. 464). Springer.

LeBouef, T., Yaker, Z., & Whited, L. (2023). Physiology, autonomic nervous system. In *StatPearls [Internet]*. StatPearls Publishing.

Leclere, C., Viaux, S., Avril, M., Achard, C., Chetouani, M., Missonnier, S., & Cohen, D. (2014). Why synchrony matters during mother-child interactions: a systematic review. *Plos one*, *9*(12), e113571. https://doi.org/10.1371/journal.pone.0113571

Lemus, A., Vogel, S. C., Greaves, A. N., & Brito, N. H. (2022). Maternal anxiety symptoms associated with increased behavioral synchrony in the early postnatal period. *Infancy*, *27*(4), 821-835. https://doi.org/10.1111/infa.12473

León, G. A., Morris, A. R., Gilbertson, C. H., Turner, A., Betron, H., Ortega, L. D., Guillemette, S., Kuhil, S., Wang, J., & Demenko, V. (2024). Glee in threes: Positive affect synchrony in parent-infant triads is moderated by maternal hair cortisol and parenting stress. *Infant Behavior and Development*, *76*, 101976.

Liu, Han, Z. R., Xu, J., Wang, Q., Gao, M., Weng, X., Qin, S., & Rubin, K. H. (2024). Parenting links to parent–child interbrain synchrony: a real-time fNIRS hyperscanning study. *Cerebral Cortex*, *34*(2), bhad533.

Liu, C. H., Fink, G., Brentani, H., & Brentani, A. (2017). An assessment of hair cortisol among postpartum Brazilian mothers and infants from a high-risk community in São Paulo: Intra-individual stability and association in mother–infant dyads. *Developmental Psychobiology*, *59*(7), 916-926.

Liu, Q., Zhu, S., Zhou, X., Liu, F., Becker, B., Kendrick, K. M., & Zhao, W. (2024). Mothers and fathers show different neural synchrony with their children during shared experiences. *NeuroImage*, *288*, 120529.

Lotzin, A., Romer, G., Schiborr, J., Noga, B., Schulte-Markwort, M., & Ramsauer, B. (2015). Gaze synchrony between mothers with mood disorders and their infants: maternal emotion dysregulation matters. *Plos one*, *10*(12), e0144417.

Lunkenheimer, E. S., Olson, S. L., Hollenstein, T., Sameroff, A. J., & Winter, C. (2011). Dyadic flexibility and positive affect in parent–child coregulation and the development of child behavior problems. *Development and psychopathology*, *23*(2), 577-591.

MacLean, P. C., Rynes, K. N., Aragon, C., Caprihan, A., Phillips, J. P., & Lowe, J. R. (2014). Mother-infant mutual eye gaze supports emotion regulation in infancy during the Still-Face paradigm. *Infant Behav Dev*, *37*(4), 512-522. https://doi.org/10.1016/j.infbeh.2014.06.008

Masten. (2014). Global perspectives on resilience in children and youth. *Child development*, *85*(1), 6-20.

Masten, & Monn, A. R. (2015). Child and family resilience: A call for integrated science, practice, and professional training. *Family relations*, *64*(1), 5-21.

Mayo, O., & Gordon, I. (2020). In and out of synchrony-Behavioral and physiological dynamics of dyadic interpersonal coordination. *Psychophysiology*, *57*(6), e13574. https://doi.org/10.1111/psyp.13574

McCoby, E. (1983). Socialization in the context of the family: Parent-child interaction. *Handbook of child psychology*, *4*, 1-101.

McCubbin, H. I., & McCubbin, M. A. (1988). Typologies of resilient families: Emerging roles of social class and ethnicity. *Family relations*, 247-254.

Mercuri, M., Stack, D. M., Mantis, I., Moszkowski, R., & Field, T. M. (2023). Maternal and infant touching behaviours during perturbed interactions: Associations with maternal depressive symptomatology and infant crying. *Infant Behav Dev*, *71*, 101821. https://doi.org/10.1016/j.infbeh.2023.101821

Middlemiss, W., Granger, D. A., Goldberg, W. A., & Nathans, L. (2012). Asynchrony of mother-infant hypothalamic-pituitary-adrenal axis activity following extinction of infant crying responses induced during the transition to sleep. *Early Hum Dev*, *88*(4), 227-232. https://doi.org/10.1016/j.earlhumdev.2011.08.010

Moher, D., Liberati, A., Tetzlaff, J., Altman, D. G., & PRISMA Group*, t. (2009). Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *Annals of internal medicine*, *151*(4), 264-269.

Moher, D., Shamseer, L., Clarke, M., Ghersi, D., Liberati, A., Petticrew, M., Shekelle, P., Stewart, L. A., & Group, P.-P. (2015). Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015 statement. *Syst Rev*, *4*(1), 1. https://doi.org/10.1186/2046-4053-4-1

Montirosso, R., Borgatti, R., Trojan, S., Zanini, R., & Tronick, E. (2010). A comparison of dyadic interactions and coping with still-face in healthy pre-term and full-term infants. *Br J Dev Psychol*, *28*(Pt 2), 347-368. https://doi.org/10.1348/026151009x416429

Morris, A. S., Silk, J. S., Steinberg, L., Myers, S. S., & Robinson, L. R. (2007). The Role of the Family Context in the Development of Emotion Regulation. *Soc Dev*, *16*(2), 361-388. https://doi.org/10.1111/j.1467-9507.2007.00389.x

Motsan, S., Bar-Kalifa, E., Yirmiya, K., & Feldman, R. (2021). Physiological and social synchrony as markers of PTSD and resilience following chronic early trauma. *Depression and anxiety*, *38*(1), 89-99.

Neumann, A. A., Desmarais, E. E., Iverson, S. L., & Gartstein, M. A. (2020). Ecological contributions to maternal-infant functioning: Differences between rural and urban family contexts. *Journal of community psychology*, *48*(3), 945-959.

Nguyen, Bánki, A., Markova, G., & Hoehl, S. (2020). Studying parent-child interaction with hyperscanning. *Progress in brain research*, *254*, 1-24.

Nguyen, Kungl, M. T., Hoehl, S., White, L. O., & Vrtička, P. (2024). Visualizing the invisible tie: Linking parent–child neural synchrony to parents' and children's attachment representations. *Developmental science*, *27*(6), e13504.

Nguyen, Schleihauf, Kayhan, E., Matthes, D., Vrtička, P., & Hoehl, S. (2020). The effects of interaction quality on neural synchrony during mother-child problem solving. *cortex*, *124*, 235-249.

Nguyen, Schleihauf, H., Kayhan, E., Matthes, D., Vrticka, P., & Hoehl, S. (2020). The effects of interaction quality on neural synchrony during mother-child problem solving. *cortex*, *124*, 235-249. https://doi.org/10.1016/j.cortex.2019.11.020

Nguyen, Schleihauf, H., Kungl, M., Kayhan, E., Hoehl, S., & Vrtička, P. (2021). Interpersonal neural synchrony during father–child problem solving: an fNIRS hyperscanning study. *Child development*, *92*(4), e565-e580.

Northrup, J. B., & Iverson, J. M. (2020). The development of mother-infant coordination across the first year of life. *Dev Psychol*, *56*(2), 221-236. https://doi.org/10.1037/dev0000867

Oh, A. Y., Davis, T., Dwyer, L. A., Hennessy, E., Li, T., Yaroch, A. L., & Nebeling, L. C. (2017). Recruitment, enrollment, and response of parent–adolescent dyads in the FLASHE study. *American journal of preventive medicine*, *52*(6), 849-855.

Oshri, A., Liu, S., Huffman, L. G., & Koss, K. J. (2021). Firm parenting and youth adjustment: Stress reactivity and dyadic synchrony of respiratory sinus arrhythmia. *Dev Psychobiol*, *63*(3), 470-480. https://doi.org/10.1002/dev.22019

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., & Brennan, S. E. (2021). The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *International journal of surgery*, *88*, 105906.

Palumbo, R. V., Marraccini, M. E., Weyandt, L. L., Wilder-Smith, O., McGee, H. A., Liu, S., & Goodwin, M. S. (2017). Interpersonal autonomic physiology: A systematic review of the literature. *Personality and social psychology review*, *21*(2), 99-141.

Papp, L. M., Pendry, P., & Adam, E. K. (2009). Mother-adolescent physiological synchrony in naturalistic settings: within-family cortisol associations and moderators. *J Fam Psychol*, *23*(6), 882-894. https://doi.org/10.1037/a0017147

Paquette, D. (2004). Theorizing the father-child relationship: Mechanisms and developmental outcomes. *Human development*, *47*(4), 193-219.

Patterson, G. R. (1982). Coercive family process. *(No Title)*.

Patterson, G. R., Reid, J. B., & Dishion, T. J. (1992). *Antisocial boys* (Vol. 4). Castalia Publishing Company.

Pauly, T., Gerstorf, D., Wahl, H.-W., & Hoppmann, C. A. (2021). A developmental–contextual model of couple synchrony across adulthood and old age. *Psychology and Aging*, *36*(8), 943.

Pratt, M., Apter-Levi, Y., Vakart, A., Kanat-Maymon, Y., Zagoory-Sharon, O., & Feldman, R. (2017). Mother-child adrenocortical synchrony; Moderation by dyadic relational behavior. *Horm Behav*, *89*, 167-175. https://doi.org/10.1016/j.yhbeh.2017.01.003

Pratt, M., Singer, M., Kanat-Maymon, Y., & Feldman, R. (2015). Infant negative reactivity defines the effects of parent-child synchrony on physiological and behavioral regulation of social stress. *Dev Psychopathol*, *27*(4 Pt 1), 1191-1204. https://doi.org/10.1017/S0954579415000760

Priel, A., Djalovski, A., Zagoory-Sharon, O., & Feldman, R. (2019). Maternal depression impacts child psychopathology across the first decade of life: Oxytocin and synchrony as markers of resilience. *Journal of Child psychology and Psychiatry*, *60*(1), 30-42.

Provenzi, L., Olson, K. L., Montirosso, R., & Tronick, E. (2016). Infants, mothers, and dyadic contributions to stability and prediction of social stress response at 6 months. *Developmental psychology*, *52*(1), 1.

Quiñones-Camacho, L. E., Fishburn, F. A., Camacho, M. C., Hlutkowsky, C. O., Huppert, T. J., Wakschlag, L. S., & Perlman, S. B. (2020). Parent–child neural synchrony: a novel approach to elucidating dyadic correlates of preschool irritability. *Journal of Child psychology and Psychiatry*, *61*(11), 1213-1223.

Ramseyer, F., & Tschacher, W. (2008). Synchrony in dyadic psychotherapy sessions. *Simultaneity: Temporal structures and observer perspectives*, 329-347.

Ramseyer, F., & Tschacher, W. (2011). Nonverbal synchrony in psychotherapy: coordinated body movement reflects relationship quality and outcome. *J Consult Clin Psychol*, *79*(3), 284-295. https://doi.org/10.1037/a0023419

Reindl, V., Gerloff, C., Scharke, W., & Konrad, K. (2018). Brain-to-brain synchrony in parent-child dyads and the relationship with emotion regulation revealed by fNIRS-based hyperscanning. *NeuroImage*, *178*, 493-502.

Ruttle, P. L., Serbin, L. A., Stack, D. M., Schwartzman, A. E., & Shirtcliff, E. A. (2011). Adrenocortical attunement in mother-child dyads: importance of situational and behavioral characteristics. *Biol Psychol*, *88*(1), 104-111. https://doi.org/10.1016/j.biopsycho.2011.06.014

Ryan, R. M. (1995). Psychological needs and the facilitation of integrative processes. *J Pers*, *63*(3), 397-427. https://doi.org/10.1111/j.1467-6494.1995.tb00501.x

Ryan, R. M., & Deci, E. L. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *Am Psychol*, *55*(1), 68-78. https://doi.org/10.1037//0003-066x.55.1.68

Sacolo, H., Chimbari, M., & Kalinda, C. (2018). Knowledge, attitudes and practices on Schistosomiasis in sub-Saharan Africa: a systematic review. *BMC Infect Dis*, *18*(1), 46. https://doi.org/10.1186/s12879-017-2923-6

Schloß, S., Müller, V., Becker, K., Skoluda, N., Nater, U. M., & Pauli-Pott, U. (2019). Hair cortisol concentration in mothers and their children: roles of maternal sensitivity and child symptoms of attention-deficit/hyperactivity disorder. *Journal of Neural Transmission*, *126*(9), 1135-1144.

Shin, H., Park, Y. J., Ryu, H., & Seomun, G. A. (2008). Maternal sensitivity: a concept analysis. *J Adv Nurs*, *64*(3), 304-314. https://doi.org/10.1111/j.1365-2648.2008.04814.x

Smith, C., Jones, E. J., Charman, T., Clackson, K., Mirza, F., & Wass, S. (2022). Anxious parents show higher physiological synchrony with their infants. *Psychological Medicine*, *52*(14), 3040-3050.

Stroup, D. F., Berlin, J. A., Morton, S. C., Olkin, I., Williamson, G. D., Rennie, D., Moher, D., Becker, B. J., Sipe, T. A., & Thacker, S. B. (2000). Meta-analysis of observational studies in epidemiology: a proposal for reporting. Meta-analysis Of Observational Studies in Epidemiology (MOOSE) group. *Jama*, *283*(15), 2008-2012. https://doi.org/10.1001/jama.283.15.2008

Suveg, Braunstein West, K., Davis, M., Caughy, M., Smith, E. P., & Oshri, A. (2019). Symptoms and synchrony: Mother and child internalizing problems moderate respiratory sinus arrhythmia concordance in mother-preadolescent dyads. *Dev Psychol*, *55*(2), 366-376. https://doi.org/10.1037/dev0000648

Suveg, Shaffer, A., & Davis, M. (2016). Family stress moderates relations between physiological and behavioral synchrony and child self-regulation in mother–preschooler dyads. *Developmental Psychobiology*, *58*(1), 83-97.

Swingler, M. M., Perry, N. B., Calkins, S. D., & Bell, M. A. (2014). Maternal sensitivity and infant response to frustration: the moderating role of EEG asymmetry. *Infant Behav Dev*, *37*(4), 523-535. https://doi.org/10.1016/j.infbeh.2014.06.010

Tarullo, A. R., St John, A. M., & Meyer, J. S. (2017). Chronic stress in the mother-infant dyad: Maternal hair cortisol, infant salivary cortisol and interactional synchrony. *Infant Behav Dev*, *47*, 92-102. https://doi.org/10.1016/j.infbeh.2017.03.007

Thompson, Schneider, C. J., Rocha-Hidalgo, J., Jeyaram, S., Mata-Centeno, B., Furtado, E., Vachhani, S., Pérez-Edgar, K., & Perlman, S. B. (2024). Constructing the “Family Personality”: Can Family Functioning Be Linked to Parent–Child Interpersonal Neural Synchronization? *Journal of personality*.

Thompson, L. A., & Trevathan, W. R. (2009). Cortisol Reactivity, Maternal Sensitivity, and Infant Preference for Mother's Familiar Face and Rhyme in 6-Month-Old Infants. *J Reprod Infant Psychol*, *27*(2), 143-167. https://doi.org/10.1080/02646830801918463

Thompson, L. A., & White, B. (2022). Social Network and Behavioral Synchrony Influences On Maternal and Infant Cortisol Response. *J Hum Behav Soc Environ*, *32*(5), 574-590. https://doi.org/10.1080/10911359.2021.1931618

Valentine, J. C., Pigott, T. D., & Rothstein, H. R. (2010). How many studies do you need? A primer on statistical power for meta-analysis. *Journal of Educational and Behavioral Statistics*, *35*(2), 215-247.

Van Huisstede, L., Winstone, L. K., Ross, E. K., & Crnic, K. A. (2019). Developmental trajectories of maternal sensitivity across the first year of life: Relations among emotion competence and dyadic reciprocity. *Parenting*, *19*(3), 217-243.

Vittner, D., McGrath, J., Robinson, J., Lawhon, G., Cusson, R., Eisenfeld, L., Walsh, S., Young, E., & Cong, X. (2018). Increase in Oxytocin From Skin-to-Skin Contact Enhances Development of Parent-Infant Relationship. *Biol Res Nurs*, *20*(1), 54-62. https://doi.org/10.1177/1099800417735633

Wass, S. V., Smith, C. G., Clackson, K., Gibb, C., Eitzenberger, J., & Mirza, F. U. (2019). Parents mimic and influence their infant's autonomic state through dynamic affective state matching. *Current biology*, *29*(14), 2415-2422. e2414.

Weisman, Chetouani, M., Saint-Georges, C., Bourvis, N., Delaherche, E., Zagoory-Sharon, O., Cohen, D., & Feldman, R. (2015). Dynamics of non-verbal vocalizations and hormones during father-infant interaction. *IEEE Transactions on Affective Computing*, *7*(4), 337-345.

Weisman, Zagoory-Sharon, O., & Feldman, R. (2013). Oxytocin administration alters HPA reactivity in the context of parent-infant interaction. *Eur Neuropsychopharmacol*, *23*(12), 1724-1731. https://doi.org/10.1016/j.euroneuro.2013.06.006

Williams, S. R., Cash, E., Daup, M., Geronimi, E. M., Sephton, S. E., & Woodruff-Borden, J. (2013). Exploring patterns in cortisol synchrony among anxious and nonanxious mother and child dyads: A preliminary study. *Biological Psychology*, *93*(2), 287-295.

Woody, M. L., Feurer, C., Sosoo, E. E., Hastings, P. D., & Gibb, B. E. (2016). Synchrony of physiological activity during mother-child interaction: moderation by maternal history of major depressive disorder. *J Child Psychol Psychiatry*, *57*(7), 843-850. https://doi.org/10.1111/jcpp.12562

Wu, M., Liang, X., Dong, S., Zhang, J., & Wang, Z. (2024). Infants' cortisol reactivity and infant–mother cortisol synchrony in urban Chinese families: The role of maternal control strategy. *Psychoneuroendocrinology*, *168*, 107108.

Yale, M. E., Messinger, D. S., Cobo-Lewis, A. B., & Delgado, C. F. (2003). The temporal coordination of early infant communication. *Dev Psychol*, *39*(5), 815-824. https://doi.org/10.1037/0012-1649.39.5.815

Zeegers, M. A. J., Potharst, E. S., Veringa-Skiba, I. K., Aktar, E., Goris, M., Bogels, S. M., & Colonnesi, C. (2019). Evaluating Mindful With Your Baby/Toddler: Observational Changes in Maternal Sensitivity, Acceptance, Mind-Mindedness, and Dyadic Synchrony. *Front Psychol*, *10*, 753. https://doi.org/10.3389/fpsyg.2019.00753

Appendix

Table 1 Appraisal Took for Cross-Sectional Studies (AXIS), short version for study assessment (listed alphabetically).

Author (years)	Scores for each item										Total score	Quality rating
	1	2	3	4	5	6	7	8	9	10		
Abraham et al. (2021)	1	1	0	1	1	1	1	1	1	1	9	High
Azhari et al. (2019)	1	1	0	1	1	1	1	1	1	1	9	High
Azhari et al. (2022)	1	1	0	1	1	1	1	1	1	1	9	High
Brown et al. (2022)	1	1	0	1	1	1	1	1	1	1	9	High
Busuito et al. (2019)	1	1	0	1	1	1	1	1	1	1	9	High
Cabrera et al. (2021)	1	1	0	1	1	1	1	1	1	1	9	High
Clearfield et al. (2014)	1	1	1	1	1	1	1	1	1	0	9	High
Davis and Granger (2009)	1	1	0	1	0	1	1	1	1	1	8	High
Doba et al. (2022)	1	1	0	1	1	1	1	1	1	1	9	High
Doiron et al. (2022)	1	1	0	1	1	1	1	1	1	1	9	High
Feldman et al. (2010)	1	1	0	1	1	1	1	1	0	0	7	Moderate
Feldman, Gordon, et al. (2011)	1	1	0	1	1	1	1	1	1	1	9	High
Fu et al. (2020)	1	1	0	1	1	1	1	1	1	1	9	High
Fuchs et al. (2021)	1	1	0	1	1	1	1	1	1	1	9	High
Gray et al. (2018)	1	1	0	1	1	1	1	1	1	1	9	High
Gray et al. (2024)	1	1	0	1	1	1	1	1	1	1	9	High
Hale et al. (2023)	1	1	1	1	1	1	1	1	1	1	10	High

Ham and Tronick (2009)	1	1	0	1	1	1	1	1	0	1	8	High
Hein et al. (2020)	1	1	0	1	1	1	1	1	1	1	9	High
Hoyniak et al. (2021)	1	1	0	1	1	1	1	1	1	0	8	High
Im-Bolter et al. (2015)	1	1	0	1	1	1	1	1	0	1	8	High
Kaitz et al. (2010)	1	1	0	1	1	1	1	1	1	1	9	High
Kerr et al. (2021)	1	1	0	1	1	1	1	1	1	1	9	High
Lan et al. (2024)	1	1	0	1	1	1	1	1	1	1	9	High
Laurent et al. (2011)	1	1	0	1	1	1	1	1	1	1	9	High
Laurent et al. (2012)	1	1	0	1	1	1	1	1	0	1	8	High
Lemus et al. (2022)	1	1	0	1	1	1	1	1	1	1	9	High
León et al. (2024)	1	1	0	1	1	1	1	1	1	1	9	High
Liu et al. (2017)	1	1	0	1	0	0	1	1	1	1	7	Moderate
Q. Liu et al. (2024)	1	1	1	1	1	1	1	1	1	1	10	High
Lotzin et al. (2015)	1	1	0	1	1	1	1	1	1	1	9	High
MacLean et al. (2014)	1	1	0	1	1	1	1	1	1	1	9	High
Mercuri et al. (2023)	1	1	0	1	1	1	1	1	1	1	9	High
Middlemiss et al. (2012)	1	1	0	1	0	1	1	1	0	1	7	Moderate
Montirosso et al. (2010)	1	1	0	1	1	1	1	1	1	1	9	High
Motsan et al. (2021)	1	1	0	1	1	1	1	1	1	1	9	High
Neumann et al. (2020)	1	1	0	1	1	1	1	1	1	0	8	High
Nguyen, H. Schleihauf, et al. (2020)	1	1	0	1	1	1	1	1	1	1	9	High
Oshri et al. (2021)	1	1	0	1	0	1	1	1	1	1	8	High

Pratt et al. (2015)	1	1	0	1	1	1	1	1	1	1	9	High
Pratt et al. (2017)	1	1	0	1	1	1	1	1	1	1	9	High
Provenzi et al. (2016)	1	1	0	0	1	1	1	1	1	1	8	High
Schloß et al. (2019)	1	1	0	1	1	1	1	1	1	1	9	High
Smith et al. (2022)	1	1	0	1	0	1	1	1	1	0	7	Moderate
Suveg et al. (2016)	1	1	0	1	1	1	1	1	1	1	9	High
Suveg et al. (2019)	1	1	0	1	1	1	1	1	1	1	9	High
Tarullo et al. (2017)	1	1	0	1	1	1	1	1	1	1	9	High
Thompson and Trevathan (2009)	1	1	0	1	1	1	1	1	0	1	8	High
Thompson and White (2022)	1	1	0	1	1	1	1	1	1	1	9	High
Vittner et al. (2018)	1	1	0	1	1	1	1	1	1	1	9	High
Weisman et al. (2013)	1	1	0	1	1	1	1	1	1	0	8	High
Weisman et al. (2015)	1	1	0	0	1	1	1	1	1	1	8	High
Williams et al. (2013)	1	1	0	1	1	1	1	1	1	1	9	High
Wu et al. (2024)	1	1	1	1	1	1	1	1	1	1	10	High
Zeegers et al. (2019)	1	1	0	1	1	1	1	1	1	1	9	High

Note.

0=No, 1=Yes

Questions related to each item

Introduction

(1) Were the aims/objectives of the study clear?

Method

(2) Was the study design appropriate for the stated aim(s)?
(3) Was the sample size justified?
(4) Was the target/reference population clearly defined? (Is it clear who the research was about?)
(5) Were the risk factor and outcome variables measured correctly using instruments/measurements that had been trialed, piloted or published previously?
(6) Were the methods (including statistical methods) sufficiently described to enable them to be repeated?

Results

(7) Were the results presented for all the analyses described in the methods?

Discussion

(8) Were the authors' discussions and conclusions justified by the results?
(9) Were the limitations of the study discussed?

Other

(10) Was ethical approval or consent of participants attained?

Table 2. Socio-demographic characteristics of the samples included in the studies

Study	Age range of children	Gender children (% male)	Age range of parents (in years)	Family composition / parent marital status	Parent-child biologically related	Country (study)	Ethnicity (parent)	Socioeconomic status (education)	Socioeconomic status (annual income or other mention)	Specificity of the sample
Abraham et al. (2021)	T1= 5-29 months T2= 36-55 months	T1= not reported T2= 55.3%	T1= 29-45 T2= not reported	Father- father (n = 46) Mother-father (n = 48)	Yes (F-F= one father related; M-F = both)	USA	Caucasian	Beyond high school (college or university) father-father: 87.7% Mother-father: (M= 90.9%, F=63.7%)	Monthly salary > 10 000 NIS Father- father (87.7%) Mother-father (M = 75.7%, F= 86.8%)	General population
Azhari et al. (2019)	36 – 48 months	Not reported	Over 21 (mean =34.4)	Not reported	Yes	Singapore	Not reported	Not reported	Not reported	General population
Azhari et al. (2022)	2 – 4 years	Not reported	Over 21 Mothers 34.9 (mean) Fathers: 38.1 (mean)	Living in the same house	Yes	Singapore	Not reported	Not reported	Not reported	General population
Brown et al. (2022)	2.5 – 4 years	Not reported	Not reported	Married 66.7%, with living together 12.7%, single 11.3%, separated or divorced 8.7%, unknown/unreported 0.6%	Not reported	USA	73% Caucasian, 14% Latinx, 3% Multiracial, 3% African American, 3% Native American, 1% Asian, and 3% unknown	Median of associate's degree	Income average of $30,000 to $39,000	Population at risk: oversampled for lower income, higher parent stress, and child maltreatment risk
Busuito et al. (2019)	6 months	57%	32.0 (SD=1.7),	Married 95%	Yes	USA	75% non-Hispanic White, 8% African American, and 17%	Average years of education 17.1 (SD=4.4)	Not reported	General population

							Asian, Hispanic or more than one race			
Cabrera et al. (2021)	9 –21 months	Not reported	Over 18	Cohabiting	Not reported	USA	Not reported	First-grade reading level in either English or Spanish	Annual family income < $75,000	At risk population
Clearfield et al. (2014)	6 –12 months	High SES group: 69% Low SES group: 62%	Not reported	Not reported	Not reported	USA	High SES: 88% Caucasian, 6% Hispanic, 6% Indian Low SES: 94%, Caucasian, 6 % Hispanic	Not reported	Not reported	At risk population: the low SES group was assessed by a questionnaire and qualified for state assistance for housing or food
Davis and Granger (2009)	2 – 24 months T1 = 2 months T2 = 6 months T3 = 12 months T4 = 24 months	Not reported	29.3 (SD= 5.1)	Married (T1: 81.8% - T4: 86.4%)	Not reported	USA	40.9% Non-Hispanic white, 28.6% Hispanic, 18.2% Asian, 12.3% Other	High school or equivalent: T1: 90.5% - T4: 100% College graduate: T1: 61.9% - T4: 45.5%	Annual family income $0 to $30,000 T1 :9.6% - T4: 19.1% $60,001 and $100,000 T1: 52.3% - T4: 23.8%	General population
Doba et al. (2022)	6 months	52.8%	22 - 42	Married living in the same house 94.4 %	Yes	France	French	University degree 58.2%, high school 14% and high school incomplete 27.8%	Not reported	General population
Doiron et al. (2022)	T1= 6 months T2= 12 months T3= 18 months T4= 48-months	Full-term: 45.8% Preterm: 52.4% Psycho-socially at-risk :42.5%	Full-term: 30.23 (SD= 5.01) Preterm: 32.51 (SD= 5.56) At-risk: 29.16 (SD= 3.34)	Over the course of infant's first 4 years, % divorce or separation: Full-term: 15 % Preterm: 20% At-risk: 13%	Yes	Canada	Full-term: White 89.60 %, Black 2.10 %, Asian 4.20 % and Hispanic 4.20 % Preterm: White 54.10 %, Black 23.00 %, Hispanic 1.50 %, Middle Eastern 6.60 %, and Asian 4.90 % At-risk: White 100%	Full-term: 14.52 years of education (SD = 2.06) Preterm: 13.00 years of education (SD = 2.11)	Not reported	General population vs. Parents with family histories of psycho-social risk

								At-risk: 12.94 years of education (SD = 2.09)		
Feldman et al. (2010)	6 months	47%	28.9 (SD = 4.0)	Married or cohabitating with the infant's father	Yes	Israel	Not reported	14.6 years of education (SD = 2.3)	Not reported	General population
Feldman, Gordon, et al. (2011)	4 – 6 months	Not reported	Mothers: 28.7 (SD= 5.29) Fathers: 29.1 (SD= 4.28)	Not reported	Yes	Israel	Not reported	Mothers: 15.17 years of education (SD = 2.47) Fathers: 15.50 years of education (SD = 2.73)	Not reported	General population
Fu et al. (2020)	13 – 30 months	78.5%	25 – 42	Not reported	Not reported	China	Not reported	Not reported	Not reported	ASD or at high risk of ASD
Fuchs et al. (2021)	T1 = 2.5 years T2 = 3.03 years	47%	Not reported	Married 66%, living together 13% separated or divorced 9 %, and single 12 %	Not reported	USA	White 65 % , Latinx 22 %, Black 2 %, Native American 2 %, Multi-racial 8 % and Other or Unknown 1 %	Mean education level = associate's degree	$30,000 to $39,000 / year (82% used government assistance)	Oversampled for risk (including income status 200 % or less of the federal poverty level, Child Protective Services involvement, or higher life stress)
Gray et al. (2018)	3 – 6 years	61.9%	Not reported	Not reported	Not reported	USA	Black 67%, White 19% and Mixed Race or Other 14%	Not reported	Not reported	Trauma-exposed children
Gray et al. (2024)	3 – 5 years	50.6%	30.11 (SD= 5.48)	Single/ never married 59.3%	Yes	USA	Black/African American 82.9%, White 9.8%, other 7.3%	High school 36.6%, diploma/GED: 26.0% and college degree 9.8%	household income <185% of the federal poverty line	Families with low income
Hale et al. (2023)	5 – 9 years	Not reported	34.48 (SD= 6.39)	Being in a romantic relationship 82.0%	Not reported	USA	Latinx 74%, Black 26 % (in total 66.9% mothers were born outside USA)	high school diploma/GED 58.0%, incomplete high school 13.0% and master's degree 4.0%	$5,000 - $100,000 / year 56.4% below $30,000	General population Including families with low income
Ham and Tronick (2009)	5 months	61%	33 (SD=5)	Not reported	Not reported	USA	Diversity in race and ethnicity	Not reported	Not reported	General population

Hein et al. (2020)	2.05 - 7.93 years	51.9%	32.36 (SD= 5.82)	Living with child 'father 90.4%	Not reported	Lebanon	Born outside Lebanon 31.7%	Not reported	Fathers employed 84.6%	Vulnerable populations including families with low income and refugees
Hoyniak et al. (2021)	4 – 5 years	54.8%	Not reported	Married 77%, separated/divorced 5%, no contact 5%, co-parenting 5% and other 4%)	Yes (93%)	USA	White 69%, Black/African American 21%, Asian 1%, and Bi- or Multi-racial 10%	High School degree or less 13%, some college/associate's degree 26%, bachelor's degree 26% and master's degree or higher 38%	less than $20,000 15%, $20,000 – $39,000 16%, $40,000 – $59,000 13%, $60,000 – $99,000 23%, over $100,000 33%	General population with a focused-on adversity
Im-Bolter et al. (2015)	6 – 10 years	Clinic: 40% Non-clinic: 60%	Not reported	Not reported	Not reported	Canada	White (clinic = 68 %; non-clinic = 76 %)	Not reported	Index for Occupations in Canada Clinic: 47.85 (SD = 11.42) Non-clinic 54.24 (SD =14.48)	Children who have been consecutively referred to a children's mental health centre (80 % for behavioral problems) vs. non-clinic group
Kaitz et al. (2010)	6 months	Anxious = 47.1 % Control = 45.8%	20–40	Married 100%	Not reported	Israel	Israeli (anxious = 71.5 %; control = 83.1 %)	Average years of education Anxious: 15.66 (SD = 1.71) Control: 15.19 (SD = 2.39)	Not reported	Clinically anxious mothers vs. control
Kerr et al. (2021)	18 – 27 months	48%	Not reported	Married 72.0% and cohabitating 22.7%	Not reported	USA	White/Caucasian (F= 52.1%; M=67.6%) and Hispanic (F=47%; M=40.0%)	Not reported	less than $40,000 - $120,000	General population
Lan et al. (2024)	T1: 6 months T2: 24 months	T1: 51.8% T2: 52.2%	28.85 (SD= 4.70)	Married 90.3%	Not reported	China	Chinese (ethnic Han) 99%	Incomplete high school 53%, high school diploma 23%, and college or university degrees 24%	Below ¥40,000 47% and ranging from ¥40,000 to ¥70,000 39%	Families living in a rural environment including low-to-middle SES class families

Laurent et al. (2011)	T1 = 5 months T2 = 18 months	42%	24 (SD=4.5)	Single mothers	Yes	USA	European American 80%	Not reported	mean household income of $9,634 per year (below the federal poverty line)	Mothers at risk for parenting problems
Laurent et al. (2012)	18 months	Not reported	24 (SD= 4.7)	Not reported	Yes	USA	Caucasian 80 %, African American 4%, Latina 7%, Native American 4%, Asian 1%, other 5%	4-year college degree 21 %, attended some college 43%, and had a high school degree or less 36%	31% on government assistance, 21% reporting a yearly household income of $10,000, 70% reporting $10,000 – $40,000, and only 9% reporting $40,000	High-risk, low socioeconomic status
Lemus et al. (2022)	2.8 – 3.8 months	Not reported	Not reported	Not reported	Not reported	USA	Not reported	Not reported	Above poverty line on average	Families with low income
León et al. (2024)	6 months	Not reported	Not reported	Married 84%	Yes	USA	Identified as ethnic minorities (M = 55%, F =49%)	Bachelor’s degree (M= 42%, F= 50%)	Not reported	Ethnic minorities
Liu et al. (2017)	12 months	Not reported	Not reported	Living with partner 46.4%, single 30.4%, Married 21.4%	Yes	Brazil	Not reported	Primary education 30.4%, High school or College 57.1%,	Average income 48.2%, low income, 30.4 %, high income 21.4%	High-risk sample
Q. Liu et al. (2024)	3 – 4 years	Not reported	Mothers: 34.89 (SD=4.23) Fathers: 38.08 (SD =3.79)	Not reported	Not reported	China	Not reported	Not reported	Not reported	General population
Lotzin et al. (2015)	4 – 9 months	57.4%	32.2 (SD=5.4)	Living with partner 76.5%, no partner 14.7%, living apart 8.8%	Yes	Germany	European Caucasian 98.5%, African 1.5%	Years of education 15.2 (SD=3)	≤ 1000 13.2 %, 1001–2000 19.1%, 2001–3000 35.3 %, ≥ 3001 26.5% (euros)	Mothers diagnosed with depression

MacLean et al. (2014)	3.5 - 4.5 months	55%	26.7 (SD=6.1)	Not reported	Yes	USA	White 25.3%, Hispanic/Latino 57%, African American 3.8%, Other or not specified 13.9%	Less than high school 21.5%, High school 17.7%, At least one year of college 27.8%, College degree 19%, Some graduate school 1.3%, Master's degree or higher 6.3%, No response 6.3%	Under $10,000 12.7%, $10,000–$30,000 38%, $30,000–$50,000 12.7%, $50,000–$70,000 13.9%, Over $70,000 13.9 %, No response 8.9%	General population
Mercuri et al. (2023)	16 –18 weeks	49%	24.88 (SD= 5.97)	Not reported	Not reported	USA	Hispanic 46%, Black 46%, White 8%	On average completed secondary level education	On average of low socioeconomic status (M = 3.8 on Hollingshead)	Mothers with depressive symptomatology
Middlemiss et al. (2012)	4 – 10 months	44%	28.1 (SD=5.9)	Not reported	Yes	New Zealand	Pakeha (European ancestry) 55.2%, Maori ancestry 17.2%, European or Canadian 3.4%, Middle Eastern 3.4%, African 3.4%	Completed high school 34.5%, technical training 20.7%, university 27.6%	Ranged from NZ$11,000 to NZ$71,000 or above, with 31.0% $71,000 more	Mothers reported difficulties with infants' sleep routine or expressed parenting
Montirosso et al. (2010)	6.8 - 9.9 months	Not reported	Full-term:33 (SD=4.7) Pre-term:32 (SD=3.6)	Not reported	Yes	Italy	Not reported	Years of education Full-term = 14.0 (SD=2.9) Pre-term = 12.3 (SD=2.8)	SES Full-term:68 (SD=17.4) Pre-term: 61 (SD=23.8)	Pre-term vs. Full-term children
Motsan et al. (2021)	11 – 13 years	PTSD =52% Resilient = 62% Control = 35%	PTSD =41.5 (SD=4.98) Resilient =39.22 (SD=6.23) Control = 41.14 (SD=4.66)	Married PTSD =96% Resilient = 88% Control = 92%	Not reported	Israel	Not reported	High-school or above PTSD = 26% Resilient = 27% Control = 14%	Not reported	War-exposed children
Neumann et al. (2020)	T1 = 21 –28 months T2 = 33-41 months T3= 47-59 months	Rural =54% Urban =53%	Rural =28.71 (SD=5.43) Urban =35.91 (SD=3.44)	Not reported	Not reported	USA	Predominantly Caucasian (> 82%)	Average years of education Rural =15.87 (SD=2.36) Urban =16.25 (SD=1.89)	Middle SES Rural =38.46 (SD=27.77) Urban =37.29 (SD=25.41)	Urban vs. Rural populations
Nguyen, H. Schleihauf, et al. (2020)	5 – 6 years	45%	36.26 (SD =4.81)	Not reported	Yes	Germany	Caucasian 100%	University degree 57%	Not reported	General population

Oshri et al. (2021)	9 – 12 years	47.5%	35.51 (SD = 6.51)	Not reported	Include caregivers (90% mothers)	USA	African American 75.2%, Caucasian 10.9%, Hispanic/Latino 8.9%, and other 4.0%	Not reported	Below 200% of the federal poverty level	Families with low socioeconomic status
Pratt et al. (2015)	5 months	51%	29.18 (SD = 4.6)	Married (91%) or cohabitating with the child's father	Not reported	Israel	Israeli–Jewish 100%	Completed high school	Middle-class	Mothers with depressive symptoms
Pratt et al. (2015)	5 – 7.5 years	51%	Mothers = 38.66 (SD = 4.40) father = 41.04 (SD = 4.74)	Married (91%) or cohabitating with the child's father	Not reported	Israel	Not reported	Completed high school	Above poverty line	Mothers with depressive symptoms
Provenzi et al. (2016)	6 months	Not reported	29.38 (SD=38)	Married (98.8%) or cohabitating with the child's father	Not reported	Not reported	Not reported	Average years of education 14.47 (SD=2.32)	Middle to upper class SES = 45 (SD=10.59)	General population
Schloß et al. (2019)	4 – 5 years	58%	Not reported	Not reported	Not reported	Germany	Not reported	No completed education (M=0.9 %, F= 0%), Basic education (M=7.2 %, F=18.5%), Vocational qualification (M=36.9 %, F=19.4%), High school (M=18.0%, F=27.8), College (M=36.9%, F=34.3%)	Full time (M=18.0%, F=85.5%), Part time (M=53.2%, F=2.7%), None (M=27.9%, f=11.8%)	Children with ADHD symptoms
Smith et al. (2022)	310 – 411 days	Low anxiety (LA)= 42% High anxiety (HA)= 47%	Not reported	Not reported	Not reported	UK	White British > 51%	Postgraduate (LA=36%, HA=27%), Undergraduate (LA=56%, HA=47%), FE qualification (LA=0%, HA=4%), A-level (LA=0%, HA=7%)	Under £16k (LA=27%, HA=31%),£16–£25k (LA=24%, HA=31%), £26–£35k (LA=20%, HA=9%),£36–£50k (LA=11%, HA=11%)	Mothers with anxiety symptoms
Suveg et al. (2016)	3 – 5 years	58.7%	30.44 (SD = 5.98)	Married 45.20%, reported they had never been married 41.90%, separated 3.20%, divorced 5.40%, widowed 2.20%, engaged 2.20%.	Yes	USA	Black 47.30%, Caucasian 44.10%, Asian 1.10%, Hispanic 2.20%, and other.5.40%	Junior high school graduates 1.10%, General Educational Development certificate 16.10%, high school graduates 12.90%, college training 22.60%, college graduates 26.90% and graduate school training 20.40%	$0–$19,999 41.90%, $20,000 - $39,99920.40%, $40,000- $79,999 18.30%, above 80,00019.40%	General population
Suveg et al. (2019)	9 – 12 years	Not reported	35.30 (SD= 6.71)	Never married 40.2%, married 33.3%, divorced or	Mothers (90.8%)	USA	African American 77.0%, Caucasian 14.9%, Hispanic 6.9%, and “Other” 1.1%.	Advanced degree 1.1%, completed high school 24.1%, some high school 19.5%,	Family’s income level was below 200% of the federal poverty level	Families with low income

				separated 24.1%, widowed 2.3%				some college 39.1%		
Tarullo et al. (2017)	5.86 - 7.53 months	51%	33.41 (SD=4.01)	Not reported	Not reported	USA	Caucasian 80.5%, Asian 8.5%, Black 5.9%, Hispanic 2.5%, Native American 0.8%, Multiracial 1.7%	College degree or higher 87.4%	Income-to-needs ratio 5.90 (SD=3.44)	General population with a focused on chronic stress
Thompson and Trevathan (2009)	6 months	46%	Not reported	Not reported	Not reported	USA	Hispanic 42.7%, non-Hispanic (majority Caucasian) 57.3%	Not reported	Not reported	General population
Thompson and White (2022)	T1= 1 - 2 months T2 = 3 months	Not reported	24.8 (SD = 6.2)	Not reported	Not reported	USA	Hispanic or Latino 50%, Non-Hispanic Caucasian 41%, 'other'9%	Years of education 14.9 (SD = 2.9)	Not reported	General population
Vittner et al. (2018)	3 and 10 days	68%	M= 32 (SD=1.13) F= 33 (SD=1.38)	Married (M=82%, F=82%), single (M=18%, F=18%)	Yes	USA	Asian (M=3%, F=3%), Black (M=11%, F=14%), Hispanic (M=18%, F=14%), White (M=68%, F=68%)	High school (M=7%, F=11%), some college (M=32%, F=43%), 4 years of college (M=29% F=35%), graduate school (M=32%, F=11%)	Employed full-time (M=69%, F=88%)	Preterm children in a neonatal intensive care unit
Weisman et al. (2013)	5 months	48%	29.7 (SD=4.2)	Married to child's mother 100%	Yes	Not reported	Not reported	Not reported	Educated middle-class	General population
Weisman et al. (2015)	5 months	Not reported	29.7 (SD=4.2)	Not reported	Not reported	Not reported	Not reported	Not reported	Not reported	General population
Williams et al. (2013)	7 – 12 years	48%	37.44 (SD = 6.06)	Married 66.67%, divorced and single 3.70%, divorced and remarried 7.41%, separated 11.11%, never married 11.11%	Not reported	USA	European American 77.8%, African American 22.2%	Median maternal education level college graduate.	Median gross family income $60,000–70,000	Mothers and children with anxiety symptoms
Wu et al. (2024)	T1= 6 months T2 = 12 months	52%	32.8 (SD = 3.9)	Not reported	Not reported	China	Not reported	less than senior high, school 1%, senior high school 2 %, junior college 29 %, bachelor's degree 41 %, master's degree or higher 27 %	$10,044 24 %, $16,740 36 %, $25,110 25 %, $33,480 10 %,	Urban Chinese families

Zeegers et al. (2019)	Infants = 4- 15 months Toddlers = 2 –3 years	Infants 55% Toddlers 71%	35.06 (SD = 4.19)	Not reported	Not reported	Netherlands	Dutch 72%, European-other 6%, non-European 22%	University degree 44%, college degree 46%, secondary vocational education degree 4%, high school diploma 4%	Working 48%, sick leave or without a job 26%, stay-at-home mothers 20%, student 2%, on parental leave 2%	Mothers diagnosed with mental disorders including depression, anxiety and PTSD

Note.

M: mothers; F: fathers; SES: socioeconomic status.

Table 3. Studies Included in the Current Review (listed alphabetically).

Study	Sample	Age of children (in years)	Synchrony	Method	Physiological measurements	Coding (behavioral synchrony)	Computation	Outcome
Abraham et al. (2021)	47 PC	T1 = 1 < T2 = 3.36	Behavioral Physiological	Free interaction Laboratory Temperament Assessment Battery "fear paradigm"	Cortisol	Coding Interactive Behavioral Manual (CIB)	Generalized estimating equations	High parent-infant synchrony predicted lower cortisol in children. Negative emotionality linked with greater baseline cortisol levels only when parental oxytocin levels were low.
Azhari et al. (2019)	31 MC	3	(neuro)physiological	Video co-viewing Parenting Stress Index - Short Form	fNIRS (IBS)	None	GLM	Parenting stress reduced mother-child inter-brain synchrony in the medial left cluster of the PFC.
(Azhari et al., 2022)	31 MC 29 FC	3.5	(neuro)physiological	Free interaction Parenting Stress Index - Short Form	fNIRS (IBS)	An in-house coding scheme (joint vs no joint dyadic behaviors)	ANCOVA	Dyads with higher parenting stress were associated with higher levels of IBS during joint segment of play.
Brown et al. (2022)	150 MC	Time 1:2.5 Time 2: 3 Time 3: 4	Behavioral	Parent-child Challenge Task (PCCT)	None	An in-house coding scheme	Multilevel model	Parents' positive behaviors facilitate real-time synchrony.
Busuito et al. (2019)	140 MC	<1	Behavioral Physiological	FFSF paradigm	Skin conductance & vmHRV	Modified Monadic phase coding system	Repeated measures generalized linear model (GLM)	Behavioral synchrony was associated with lower parasympathetic reactivity levels in children and higher parasympathetic reactivity levels in mothers.
Cabrera et al. (2021)	156 PC	<2	Behavioral	Free interaction	None	Qualitative Ratings for Parent-Child Interaction	Multiple regression	Maternal dyadic synchrony was associated with social adjustment.
Clearfield et al. (2014)	32 MC	<1	Physiological	None	Cortisol	None	ANOVA	Low socio-economic mothers and infants show lower cortisol synchrony.

Davis and Granger (2009)	85 MC	<2	Physiological	None	Cortisol	None	Pearson's coefficient correlation	Maternal and infant cortisol levels (measured through saliva were correlated.
Doba et al. (2022)	72 MC	<1	Behavioral	FFSF paradigm	None	An in-house coding scheme	Multivariate analysis of variance (MANOVA) & Partial least squares path model	Maternal anxiety mediated the association between difficulties in regulating emotions in mother and synchrony in the dyads.
Doiron et al. (2022)	163 MC	<2	Behavioral	Free interaction	None	Revised Relational Coding System (RRCS)	MANOVA & multilevel growth modelling	Parental stress was correlated with less synchrony and reciprocity.
Feldman et al. (2010)	53 MC	<1	Behavioral Physiological	FFSF Paradigm Free interaction	Cortisol	An in-house coding scheme	Repeated measure ANOVA	Touch synchrony was associated with higher infant vagal tone
Feldman, Gordon, et al. (2011)	112 PC	<1	Behavioral Physiological	Free interaction	Oxytocin	Computerized System used by previous studies	Pearson's coefficient correlation	Oxytocin (plasma and saliva) was associated with parent-infant social engagement, affect synchrony and positive communication.
Fu et al. (2020)	70 MC	<1	Behavioral	Free interaction	None	An in-house coding scheme	Hierarchal multiple regression analysis	Parenting stress and mother-infant dyadic synchrony predicted the efficacy of an evidence-based intervention.
Fuchs et al. (2021)	150 PC	Time 1: 2.05 Time 2: 3.03	Physiological	Parent-child Challenge Task	vmHRV	Dyadic Interaction Coding System	Intradyad dynamics model	Mother-child vmHRV was shaped by maternal distress.
Gray et al. (2018)	247 CC	5.08	Physiological	Observation task	vmHRV	An in-house coding scheme	Repeated measure mixed model analysis & generalized linear model	Children with trauma exposure exhibited high levels of physiological synchrony with their parents.
Gray et al. (2024)	123MC	4.31	Physiological	Challenging task	vmHRV	None	Multilevel path analysis	High quality dyadic relationship buffered the association between maternal adverse childhood experiences and synchrony.
Hale et al. (2023)	100 MC	6.83	Behavioral Physiological	Play interaction	vmHRV	Mutual Affectivity Scale	Multiple linear regression	Maternal negative affect was associated with weak behavioral synchrony and negative vmHRV synchrony.
Ham and Tronick (2009)	18 MC	<1	Behavioral Physiological	FFSF Paradigm	Skin Conductance vmHRV	Infant and Caregiver Engagement Phases (ICEP)	Correlation analysis	During still-face episode skin conductance concordance (SCC) was correlated to infant negative engagement. While SCC was correlated with behavioral synchrony during reengagement. Maternal vmHRV was correlated with infant negative engagement.
Hein et al. (2020)	104 MC	4.34	Behavioral	Free interaction	None	An in-house coding scheme	GLMPath model	High perception of paternal involvement was associated with better mother-child synchrony, higher levels of maternal well-being and lower maternal distress.

Hoyniak et al. (2021)	151 (115) CC	4.85	Behavioral (neuro)physiological	Stress-inducing task DB-DOS: Biosync task Adversity (sociodemographic risk and familial risk)	fNIRS (IBS)	An in-house coding scheme	Pearson's coefficient correlation	Adversity was associated with lower parent-child synchrony and sociodemographic risk was associated with lower IBS during the stress-inducing task.
Im-Bolter et al. (2015)	42 MC	7.84	Behavioral	Free interaction	None	Adaptation of the Mutually Responsive Orientation (MRO) & a 5-point dyadic rating of synchrony	Pearson's coefficient correlation	Low mother-child synchrony was found in the clinical group and parenting stress mediates the association between synchrony and behavioral problems in children.
Kaitz et al. (2010)	93 MC	<1	Behavioral	Free interaction FFSF paradigm Play with a stranger	None	Adaptation from the Rating Scale of Interactional Style (RSIS)	Multivariate and univariate analysis GLM & univariate repeated measures GLM	Mothers with anxiety show hyperarousal characteristic which affects infant's coping (less likely to show negative affects) during stressful situations.
Kerr et al. (2021)	75 PC	1.6	Behavioral	Teaching task	None	NCAST PCI-Teach assessment tool	Path model	Father-child synchrony was associated with lower levels of distress in infants.
Lan et al. (2024)	166 MC	<1	Physiological	Free interaction	vmHRV	None	Multilevel structural equation model	Maternal depression was associated with child internalizing problems when vmHRV synchrony was low.
Laurent et al. (2011)	86 MC	<1	Physiological	Strange Situation	Cortisol	None	Multilevel analysis	Low cortisol levels in infants were correlated with higher mother-child synchrony.
Laurent et al. (2012)	18 MC	1.5	Physiological Behavioral	Strange situation	Cortisol	NCAS PCI-Teach Assessment Tool	Hierarchal linear model	Cortisol synchrony was found during stress session.
Lemus et al. (2022)	81 MC	<1	Behavioral	Free interaction	None	Coding Interactive Behavioral Manual (CIB)	Bivariate correlations & regression model	Maternal anxiety symptoms in mothers reporting moderate levels of perceived stress were positively associated with behavioral synchrony.
León et al. (2024)	70MFC	<1	Behavioral Physiological	Free interaction	Cortisol	Triadic Microanalytic Protocol	Dynamic Structural Equation Modeling	Mother-child affect synchrony tends to be enhanced by mothers showing higher cortisol levels and higher parenting stress, but infants overall show less positive affect.
Liu et al. (2017)	56 MC	1	Physiological	None	Cortisol	None	Analysis of variance (ANOVA)	Maternal and infant hair cortisol were highly associated in a high-risk sample.

Q. Liu et al. (2024)	62 PC	3.5	Behavioral (neuro)physiological	Free play interaction Video co-viewing Parenting Stress Index-Short Form	fNIRS (IBS)	Emotional Availability Scale (EAS)	Pearson's coefficient correlation	Neural and behavioral synchrony was weakened by parental distress and child difficulty.
Lotzin et al. (2015)	68 MC	<1	Behavioral	FFSF paradigm	None	Maternal Regulatory Scoring System (MRSS) & Infant Regulatory Scoring System (IRSS)	ARIMA & Multilevel Randon Coefficient Model	Maternal emotional dysregulation was associated with heightened mother-infant gaze synchrony.
MacLean et al. (2014)	84 MC	<1	Behavioral	FFSF paradigm	None	An in-house coding scheme & previously used scale	Multilevel model	Mutual mother-infant gaze was associated with an increase in positive affect.
Mercuri et al. (2023)	41 MC	<1	Behavioral	FFSF paradigm Separation	None	Caregiver-Infant Touch Scale (CITS) & Infant Cry Scale (ICS)	Mixed analysis of variance (ANOVA) & Pearson's coefficient correlation	Dyads showed positive patterns of tactile synchrony during infant distress episode. Depressive symptoms were associated with less maternal and infant touch and lower rate of infants crying.
Middlemiss et al. (2012)	25 MC	<1	Physiological	None	Cortisol	None	Pearson's coefficient correlation	Mother-child cortisol levels were synchronized when child was distressed during sleep transition and were asynchronized when mother did not know of the child's distress.
Montirosso et al. (2010)	50 MC	<1	Behavioral	FFSF paradigm	None	Infant and Caregiver Engagement Phases (CEP)	Pearson's coefficient correlation	Dyads showed a higher level of synchrony during the Reunion episode after the stressor of the SF.
Motsan et al. (2021)	232 MC	Time 1: 2.76 Time 2: 7.68	Behavioral Physiological	Joint video attention task	vmHRV	Previously used scales	Hierarchal linear model	Resilient mother-child dyads exhibited higher behavioral synchrony and lower autonomic synchrony.
Neumann et al. (2020)	189 MC	<1	Behavioral	Free interaction	None	Sensitivity/responsiveness & synchrony/reciprocity	Bivariate correlations & analysis of covariance (ANCOVA)	Urban mothers scored higher on synchrony with their children compared to rural mothers.
Nguyen, H. Schleihauf, et al. (2020)	42 MC	5.08	(neuro)physiological Behavioral	Solving-problem task: tangram task General Stress Level Questionnaire Children's Behavior Questionnaire (CBQ)	fNIRS (IBS)	Coding System for Mother-Child interactions (CSMCI) INTAKT (mother-child interaction)	Linear mixed model	Higher IBS during cooperation was associated with higher behavioral reciprocity. IBS was attenuated by maternal stress and (marginally) enhanced by child agency.

Oshri et al. (2021)	101 PC	10.27	Physiological	Discussion Task	vmHRV	None	Multilevel Equation Models (ESM)	Dyadic vmHRV synchrony was associated with youth externalizing problems.
Pratt et al. (2015)	122 MC	<1	Behavioral Physiological	Free interaction	vmHRV	An in-house coding scheme	Structural equation modeling (SEM)	Vagal withdrawal was found when mother-infant synchrony and infant negative reactivity were high. Higher behavioral synchrony was associated with reduced distress.
Pratt et al. (2017)	97 MC	6.33	Physiological Behavioral	Free interaction	Cortisol	Coding Interactive Behavioral Manual (CIB)	Multilevel model	Mother-child reciprocity was associated with less physiological synchrony.
Provenzi et al. (2016)	100 MC	<1	Behavioral	FFSF paradigm	None	Infant Regulatory Scoring System (IRSS) & Maternal Regulatory Scoring System (MRSS)	Repeated-measure ANOVA & Multiple forward regression	Infant's response to repeated social stress was predicted by earlier infant stress response, infant behavior during the play and dyadic synchrony.
Schloß et al. (2019)	198 PC	4	Physiological Behavioral	Free interaction	Cortisol	Adaptation from the Mannheim Rating Scale for the Assessment of Mother-Child Interaction	Hierarchal multiple regression analysis	Maternal sensitivity and responsiveness were associated with mother-child cortisol.
Smith et al. (2022)	68 MC	<1	Physiological	Interaction	vmHRV	An in-house coding scheme	Cross-correlation analyses	Higher physiological synchrony was found in anxious dyads.
Suveg et al. (2016)	93 MC	3.47	Physiological Behavioral	Free interaction	Interbeat Interval	Mutual Affectivity Scale	Autoregressive Integrated Moving Average (ARIMA)	Child self-regulation was negatively associated with physiological synchrony and positively associated with behavioral synchrony.
Suveg et al. (2019)	87 MC	10.36	Physiological	Trier Social Stress Task Conflict Discussion	vmHRV	None	Multilevel model	vmHRV synchrony was positively associated with low levels of maternal depression.
Tarullo et al. (2017)	121 MC	<1	Physiological Behavioral	Free interaction	Cortisol	Microcoded interactions	Pearson's coefficient correlation	Mothers with high cortisol levels showed less behavioral synchrony with their children.
Thompson and Trevathan (2009)	94 MC	<1	Behavioral Physiological	Free interaction	Cortisol	Maternal-infant interaction coding system	Pearson's coefficient correlation	Decreasing infant cortisol reactivity and greater maternal sensitivity were associated with greater looking time at mother's face (preference for mother's face).
Thompson and White (2022)	133 MC	<1	Behavioral Physiological	Free interaction	Cortisol	Affex Manual	Hierarchal linear regression analysis	Lower levels of cortisol in children were associated with higher MC synchrony.

Vittner et al. (2018)	28 PC	<1	Physiological Behavioral	Free interaction	Oxytocin Cortisol	Dyadic Mutuality Code (DMC)	Repeated measures analysis of variance (RM-ANOVA)	Oxytocin levels were associated with more synchrony and responsiveness. Skin-to-skin contact was associated with an increase of oxytocin levels in fathers, mothers and infants, and a decrease of cortisol in infants.
Weisman et al. (2013)	35 FC	<1	Behavioral Physiological	Free interaction	Oxytocin Cortisol	An in-house coding scheme	Pearson’s coefficient correlation	Oxytocin neuropeptide (OT) administrated to fathers increased their cortisol steroid (CT) response to stress paradigm. OT in infants experiencing high father-infant synchrony was associated with higher HPA reactivity and social gaze. The opposite relation direction was found in infants experiencing low social synchrony.
Weisman et al. (2015)	35 FC	<1	Behavioral Physiological	FFSF paradigm	Cortisol	Vocalization duration, empty pause duration, overlap ratio, synchrony ratio	Correlation analysis & linear mixed models	Fathers contributed to the infant’s vocalization synchrony. Cortisol modulated the interaction.
Williams et al. (2013)	27 MC	9.13	Physiological	None	Cortisol	None	Bivariate correlations	Positive cortisol synchrony was found between mother-child.
Wu et al. (2024)	115MC	<1	Physiological	None	Cortisol	None	Multilevel model	Positive cortisol synchrony between dyads was found during the stress condition.
Zeegers et al. (2019)	50 MC	<1	Behavioral	Free interaction	None	An in-house coding scheme	Multilevel regression model	Positive synchrony was found between mother-child vocalization.

Note.

Sample: MC: Mother-child; FC: Father-child; CC: Caregiver-child (caregiver could be: mother or father, adoptive mother or father or other caregivers); PC**:** Parents-child

Measurement: FFSF: Face-to-Face Still-Face; ECG: Electrocardiogram, vmHRV: Vagally-mediated Hear Rate Variability; fNIRS: Functional near-infrared spectroscopy; IBS: inter-brain synchrony; SCC: skin conductance concordance