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Review Article

Effects of parental attachment and sensory processing on child development. Systematic review

Efeitos do apego e do processamento sensorial no desenvolvimento da criança. Uma revisão sistemática

Efectos del apego y procesamiento sensorial en el desarrollo de niñas y niños. Una revisión sistemática

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Abstract

This review focuses on the intersection of two fundamental factors in child development: sensory processing and attachment. The rapid and profound transformations that occur in the brain during childhood influence emotional regulation, self-esteem, and the ability to establish healthy relationships. Following PRISMA guidelines, a systematic review was carried out to explore the relationship between sensory processing and attachment in boys and girls aged 0 to 14 years. The Web of Science, Scopus, Pubmed, and PsycINFO databases were searched using keywords related to attachment theory and sensory processing. Studies were selected from those available through May 2022. Of an initial 87 articles, 17 met the inclusion criteria and provided a variety of perspectives on the relationship between sensory processing and attachment in early childhood. A significant connection was identified between sensory processing disorder and attachment, highlighting the importance of vision in social development and communication, as well as effective parenting strategies, healthy attachment styles, and appropriate sensory processing. The idea that healthy attachment during childhood promotes the development of sensory processing is supported. The usefulness of sensory integration to improve relationships and guide future research and practices in occupational therapy is evident.

Keywords: Parent-Child Relations, Sensory Integration, Perception, Child Development, Child, Human Development.

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Resumo

Esta revisão se concentra na intersecção de dois fatores fundamentais no desenvolvimento infantil: o processamento sensorial e o apego. Transformações rápidas e profundas que ocorrem no cérebro durante a infância influenciam a regulação emocional, a autoestima e a capacidade de estabelecer relações saudáveis. Seguindo as diretrizes PRISMA, foi realizada uma revisão sistemática para explorar a relação entre o processamento sensorial e o apego em crianças de 0 a 14 anos. Foram utilizadas as bases de dados Web of Science, Scopus, Pubmed e PsycINFO, usando palavras-chave relacionadas à teoria do apego e ao processamento sensorial. Os estudos foram selecionados entre os disponíveis até maio de 2022. De um total inicial de 87 artigos, 17 atenderam aos critérios de inclusão e forneceram uma variedade de perspectivas sobre a relação entre o processamento sensorial e o apego na primeira infância. Foi identificada uma conexão significativa entre o transtorno do processamento sensorial e o apego, destacando a importância da visão no desenvolvimento social e na comunicação, bem como estratégias parentais eficazes, estilos de apego saudáveis e um processamento sensorial adequado. É apoiada a ideia de que um apego saudável durante a infância favorece o desenvolvimento do processamento sensorial. Se evidencia a utilidade da integração sensorial para melhorar as relações e orientar futuras pesquisas e práticas em terapia ocupacional.

Palavras-chave: Relações Pais-Filho, Integração Sensorial, Percepção, Desenvolvimento Infantil, Criança, Desenvolvimento Humano.

Resumen

Esta revisión se enfoca en la intersección de dos factores fundamentales en el desarrollo infantil: el procesamiento sensorial y el apego. Las transformaciones rápidas y profundas que ocurren en el cerebro durante la infancia influyen en la regulación emocional, la autoestima y la capacidad para establecer relaciones saludables. Siguiendo los lineamientos PRISMA, se llevó a cabo una revisión sistemática para explorar la relación entre el procesamiento sensorial y el apego en niños y niñas de 0 a 14 años. Se realizaron búsquedas en las bases de datos Web of Science, Scopus, Pubmed y PsycINFO, utilizando palabras clave relacionadas con la teoría del apego y el procesamiento sensorial. Los estudios se seleccionaron de los disponibles hasta mayo de 2022. De un total inicial de 87 artículos, 17 cumplieron los criterios de inclusión y proporcionaron una variedad de perspectivas sobre la relación entre el procesamiento sensorial y el apego en la infancia temprana. Se identificó una conexión significativa entre el trastorno del procesamiento sensorial y el apego, destacando la importancia de la visión en el desarrollo social y la comunicación, así como las estrategias parentales efectivas, los estilos de apego saludables y un procesamiento sensorial adecuado. Se respalda la idea de que un apego saludable durante la infancia favorece el desarrollo del procesamiento sensorial. Se evidencia la utilidad de la integración sensorial para mejorar las relaciones y orientar futuras investigaciones y prácticas en terapia ocupacional.

Palabras clave: Relaciones Padres-Hijo, Integración Sensorial, Percepción, Desarrollo Infantil, Niño, Desarrollo Humano.

Introduction

Human development is a process that encompasses all stages of life, from conception to death (Faas, 2018). Childhood is a key stage, since in the first years, the structure of the brain is formed and the first significant relationships with caregivers are established (Souza & Veríssimo, 2015; Peskin et al., 2011; Gafni-Lachter et al., 2022).

During these years, the most rapid and profound changes in the brain occur and contribute to proper emotional regulation, good self-esteem, and the ability to form healthy relationships in the future. Brain development depends on cognitive, physical and emotional experiences and is enhanced by a warm and stimulating environment. Therefore, it is important to guarantee an adequate environment in terms of health, education, language, affection, protection and security (Sánchez, 2015; Greven et al., 2019; Hendricks & McPherson, 2010; Vargas Nuñez, 2021).

Attachment theory

Attachment is the first emotional bond between a child and his or her caregiver and depends on communication and attention from the caregiver (Souza & Veríssimo, 2015; Moneta, 2014). It is a homeostatic regulatory system that seeks security and a feeling of care and protection (Steele et al., 1999). Attachment theory describes the impact of early experiences on the development of girls and boys through the relationship with their attachment figure or caregiver (Bowlby, 1989). A secure and close attachment leads to a satisfying relationship, while an insecure attachment can lead to problems throughout life (Moneta, 2014).

The theory of attachment would deal with a three-stage process: a) the first, without a doubt, depends on experience, a natural or automatic affective response, which integrates somatic sensations and images; b) a second moment has to do with the awareness of what is felt; and c) finally, it is a thought about oneself, realizing what happened (Holmes & Silver, 2010).

Kerley et al. (2022) suggest that there are four categories or attachment styles: secure, preoccupied, avoidant and fearful, associated with anxiety and avoidance (Table 1).

Table 1. Attatchment Styles.

Attatchmentstyles	Description	Anxiety	Avoidance
Secure	Warm and trusting relationship with caregivers, where the child feels safe and protected. Securely attached children seek physical contact and emotional support when they are anxious or in new situations.	Low levels	Low levels
Preoccupied	Insecure relationship with caregivers, where the child worries about their availability and attention. Girls and boys with a preoccupied attachment tend to be anxious and constantly need the presence of their caregivers to feel safe.	High levels	Low levels
Avoidant	There is a lack of interaction and attention on the part of caregivers, which leads to emotional avoidance on the part of the child. Girls and boys with a disengaged attachment tend to be reserved and avoid physical and emotional contact with their caregivers.	Low levels	High levels
Fearful	Tense and anxious relationship with caregivers, where the child experiences fear and uncertainty. Children with fearful attachment may be withdrawn and avoid physical and emotional contact with their caregivers.	High levels	High levels

Source: Own elaboration based on Guzmán-González et al. (2016); Kerley et al. (2022).

People with a secure attachment style experience greater trust and security in their relationships with their caregivers, feeling comforted by their presence (Fonagy, 2004). This attachment style is characterized by a sensitivity and contingent response on the part of the caregiver, availability, warmth, and connection (Botella & Corbella, 2005; Marazziti et al., 2008; Burke et al., 1987). According to studies, between 55% and 70% of girls and boys experience this attachment style (Botella & Corbella, 2005; Oliva Delgado, 2004).

People with a preoccupied attachment style show separation anxiety and are not reassured when reunited with their caregivers. They often try to exaggerate affection to secure attention. This style has been observed in 5-15% of girls and boys (Botella & Corbella, 2005).

People with an avoidant attachment style do not trust the availability of their caregiver and exhibit little anxiety during separation and little interest in reunion. Even if the caregiver tries to approach him, the person rejects him. This style has been observed in 20-30% of girls and boys (Botella & Corbella, 2005; Oliva Delgado, 2004).

People with a fearful attachment style show a lack of trust and may have emotional difficulties similar to people who have experienced painful separations (Botella & Corbella, 2005).

Attachment is important because it is the first relationship a person establishes with their caregiver and can have a lasting impact on their emotional life and future relationships. Furthermore, attachment style influences how they process information from the external environment (Moneta, 2014).

Sensory integration theory

Sensory integration theory, developed by Dr. A. Jean Ayres in the United States, is a multidisciplinary science that involves child psychiatry and neuroscience (Martínez, 2019). Sensory processing is the way a person processes sensory information received through the senses. The three primitive and early mature sensory systems (tactile, vestibular and proprioceptive) are important for their influence on development and performance. Sensory integration is the neurological process that organizes and analyzes sensations to allow effective use of the body in the environment. This process is influenced by genetic, biological, environmental factors and life experiences.

Sensory integration is the foundation for subsequent emotional, cognitive, motor and communicative development. Poor sensory integration can explain dysfunctional behaviors, such as difficulties participating in activities and problems with self-esteem and self-knowledge. Sensory information is processed in four main phases: registration, modulation/regulation, discrimination and integration developed in Figure 1 (Ayres, 2016; Navarrete-Muñoz et al., 2020; DeSantis et al., 2004; Diamant, 2021; Fernández-Pires et al., 2020).

Sensory processing influences a person's alertness and motor planning. The first two processes mainly affect the level of arousal, while the last two affect motor planning and praxis (Bellefeuille, 2006; Jorquera & Romero, 2016). This processing occurs sequentially, so a failure to register can have an impact on modulation, discrimination, integration, and ultimately the ability to respond adaptively (Ayres, 2016; Mubarak et al., 2017). Individuals process sensory information uniquely, which can affect their participation in daily activities. Effective sensory processing can promote maturity, neurological development, and adaptive capacity, which in turn can improve their performance on everyday tasks (Ayres, 2016).

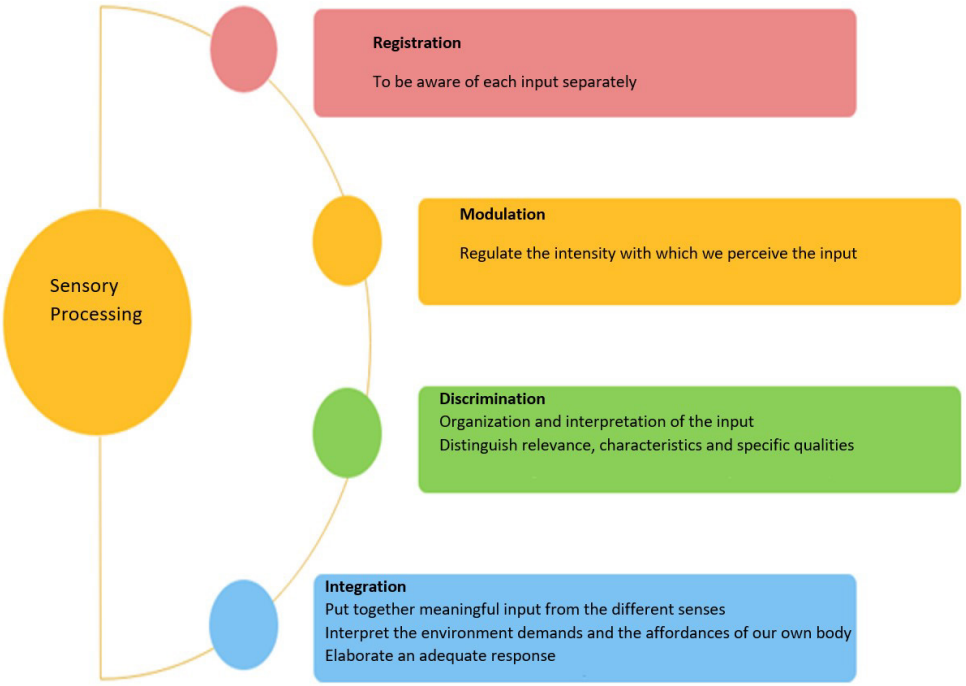

Figure 1. Phases of sensory processing.

Sensory integration and attachment

Recent research suggests a close relationship between sensory processing and attachment in girls and boys. Studies such as Walbam (2019) have found a correlation between tactile and auditory sensory processing and the ability to respond to stimuli with attachment in children. However, children with sensory processing disorders may have difficulty being regulated, which can result in problematic attachment behaviors. Despite these challenges, caregivers describe secure bonds with their children.

Additionally, research has shown that high parental stress and differences in sensory processing in children are related. Premature infants are at a higher risk for impaired sensory processing (Daily et al., 2019; Germain, 2018; Ruhrman et al., 2017).

Acosta Manjarres's (2020) research has also found that attachment and parenting patterns significantly influence the physical, social, and mental development of children, and should be evaluated by health professionals. In summary, the association between sensory processing and attachment provides an opportunity to support children's healthy development.

It has been established that parental attachment and parenting patterns significantly influence the physical, social, and mental development of children (Schoen et al., 2019). For health professionals seeking a developmental and family focus, it is important to evaluate how the sensory traits of the mother and child interact and how this interaction may affect family well-being (Gafni-Lachter et al., 2022; Jaegermann & Klein, 2010).

Furthermore, according to recent studies, the process of attachment development begins from conception and persists until death. During childhood, structural changes occur in the brain that are influenced by the experiences and learning it receives from the environment. Therefore, the emotional bond between a child and his or her parents

or caregivers is not permanent and may be affected by factors that can be positive or negative (Dageville et al., 2011).

Knowing the interaction between sensory processing and the attachment bond in child development is essential to understand its impact on children's well-being and personality formation. A systematic literature review allows for a comprehensive and rigorous evaluation of previous findings and can inform effective practices in this field. It is also valuable for professionals who work with children and parents, to help them make informed decisions and support their children's optimal development. The research question that guides this review is: What is the relationship between sensory processing and attachment in girls and boys from 0 to 14 years old?

Methodology

This study consists of a systematic review, which was carried out considering the essential elements of the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) statement. This methodology provides a set of essential elements to present the information, which helps ensure the clarity, transparency and reproducibility of the review (Liberati et al., 2009).

Eligibility criteria

All primary documents that dealt with the relationship between attachment and sensory processing in girls and boys aged 0 to 14 years, without mental health disorders, trauma, abuse or maltreatment, were selected, with complete texts, and avoiding duplicates.

Sources of information

The databases used were Web of Science, Scopus, Pubmed, and PsycINFO, considering articles published until May 2022, using the keywords: (a) Attachment, (b) Types of attachment, (c) Sensory processing, (d) Sensory integration, (e) Child population and, (f) Girls and boys.

Search strategies

The search was carried out on the titles, abstracts and keywords of the studies. During the initial search process, titles and abstracts of all potentially eligible studies were considered for analysis. An exhaustive review and selection of relevant articles for the research continued.

For the search strategy, variations in the search terms for the different databases specified in Spanish and English from “Attachment” OR “attachment patterns” OR “Attachment theory” OR “attachment styles” OR “attachment” were used. secure” OR “avoidant attachment” OR “disorganized attachment” OR “parent-child interaction”) AND TITLE-ABS-KEY (“sensory processing” OR “sensory integration” OR “sensory modulation” OR “sensory discrimination” OR “sensory systems “) AND ALL FIELDS (“Child*” OR “Little child*”) (Appendix A).

Selection process

The search was performed in four main databases by combining the Boolean operators “AND” and “OR” as necessary. A manual selection of the results obtained was

carried out to ensure that they met the desired focus and theme criteria. Data collection was conducted by one researcher and reviewed by a second to ensure reliability, objectivity, and accuracy of the selected studies.

Data collection process

The data were extracted from the selected studies, and the relevant aspects were detailed, such as: authors, year of publication, topic of interest, population studied, method used, and the main findings related to the relationship between attachment and sensory processing.

A qualitative synthesis of the data extracted from the selected studies was carried out. The results were organized and presented by thematic similarity to give an overview of the most important conclusions. This synthesis allowed us to identify and better understand the effects of attachment and sensory processing on the development of girls and boys, as reported in the existing literature.

The flow of studies through the different phases of the systematic review is presented below, described in Figure 2.

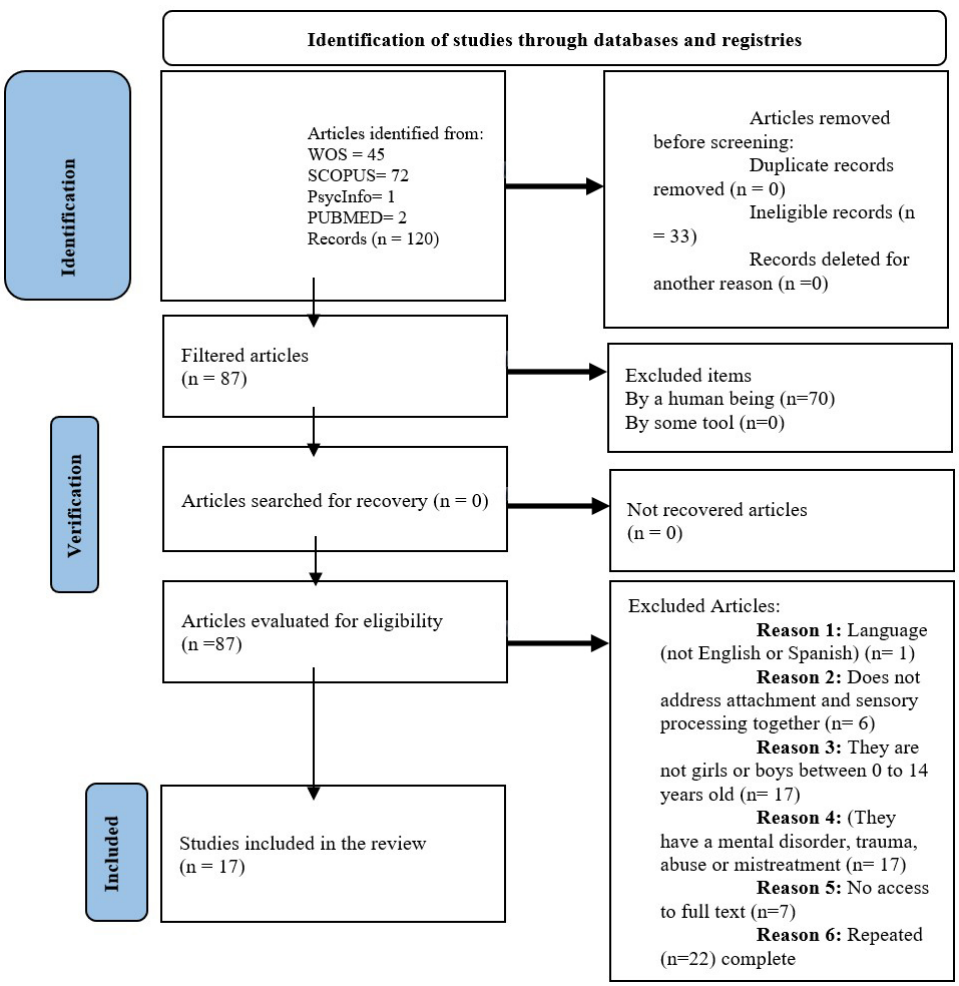

Figure 2. Search method, selection and inclusion of articles.

Synthesis method

Decision process for study eligibility

Each study chosen for the review underwent detailed analysis to ensure its relevance and compliance with established eligibility criteria. The review of the studies was carried out independently by two reviewers, and any disagreements were resolved by consensus.

Preparation of data for presentation and synthesis

Data extracted from each study included year of publication, authors, country of origin, purpose of the study, sample size and characteristics, study design, measures of attachment and sensory processing used, and main results.

Visualization of study results and synthesis

A table was used to synthesize and visualize the data extracted from each study. The table included details of the study and key findings related to the relationship between attachment and sensory processing.

Synthesis of results

A qualitative synthesis of the results of the individual studies was performed. This synthesis was based on the identification of common themes and differences between the results of the studies. Although a meta-analysis was not performed due to the heterogeneity of the studies, special attention was paid to the consistency of the findings and the identification of patterns in the results.

Exploration of heterogeneity

The heterogeneity of the studies was analyzed, especially in terms of the attachment and sensory processing measures used, the characteristics of the population studied, and the study designs.

Results

Study selection

During the systematic review process, 87 relevant articles were identified through searching the selected databases. Book chapters, conferences, and editorials were excluded. In addition, 22 duplicate articles were eliminated, 17 that did not jointly address the topic of attachment and sensory processing, and 1 that was in French. 17 articles that did not focus on childhood and those that included problems of mental health disorders, abuse and/or trauma were also discarded. Finally, 7 articles were excluded for which complete access was not available and only the abstract could be read. In the end, 17 chosen articles were analyzed and are presented in Table 2 below.

Table 2. Synthesis of main results.

Author and year	Title	Topic of interest	Methodology	Results
Burke et al. (1987)	Maternal role preparation: A program using sensory integration, infant-mother attachment, and occupational behavior perspectives	The Maternal Role Prevention (MRP) project demonstrates an innovative occupational therapy approach to increase maternal competence in first-time mothers.	Four-session program provides women with discussions, demonstrations, hands-on, and written materials covering topics related to their babies (attachment, sensory systems, developmental skills).	The program represents an opportunity for occupational therapists to combine the theory and practice of sensory integration with other compatible treatment perspectives and approaches.
Greenspan (1996)	The Development of the Ego: Biological and Environmental Specificity in the Psychopathological Developmental Process and the Selection and Construction of Ego Defenses	Differences in early sensory processing, integration and differentiation, contribute to ego characteristics, deficits in ego function, and the tendency to employ certain defenses.	The article develops methods to evaluate sensory and affective processing in different clinical populations, as well as the manipulation of experience in animal studies to investigate neuroanatomical and neurochemical patterns related to differences in the early sensory environment.	Verbal and affective vulnerabilities can be associated with thought disorders and obsessive-compulsive patterns, especially when combined with environments that tend to confuse affective meanings at the behavioral-gestural and symbolic levels.
Weatherston et al. (2002)	Becoming Whole: Combining Infant Mental Health and Occupational Therapy on Behalf of a Toddler with Sensory Integration Difficulties and his Family	Strengthen the development and well-being of infants and toddlers within safe and nurturing parent-child relationships.	The article presents fundamental beliefs and strategies that guide the practice of children's mental health and occupational therapy.	The study highlights the importance of strengthening the attachment relationship between parents and children during the first years and the importance of the practice of child mental health and occupational therapy in this process.
Salokorpi et al. (2002)	Is early occupational therapy in extremely pre-term infants of benefit in the long run?	To examine the effect of occupational therapy based on sensory integration (SI) and neurological development in extremely low birth weight infants. (ELBW).	126 children were grouped as matched pairs based on certain Developmental risk scores assessed at the age of 3 months. The intervention children had a 6-month period of occupational therapy from the corrected age of 6±12 months.	The follow-up showed that the social development of the intervention children was significantly better at the age of 12 months, but at the age of 2 years the groups had equal developmental scores on neurological, neuropsychological, and speech therapy assessments. The differences in neuropsychological and attachment outcome could not be explained by the high number of dropouts.
Glass (2002)	Development of the visual system and implications for early intervention	Attachment and bonding are mediated by eye contact.	The purpose of this article is to summarize the early development of the visual system within the context of the other sensory systems and premature birth and to relate this information to an address for early intervention.	Eye contact plays a crucial role in the development of attachment and bonding between parents and children. Research shows that eye contact allows children to develop important skills, such as the ability to negotiate physical space and learn to read. Even from early childhood, vision plays a dual role in social communication and language, both from the point of view of the speaker and the listener.

Table 2. Continued...

Author and year	Title	Topic of interest	Methodology	Results
Weiss (2005)	Haptic perception and the psychosocial functioning of preterm, low birth weight infants	Exposure of the premature and low birth weight infant to stimulating touch in the first months of life can improve neuropsychological outcomes and interact with other sensory perceptions.	Argument for the potential value of interventions that provide an enriched haptic experience specific to premature infants, an experience that can serve as a basis for subsequent psychosocial functioning.	These differential haptic perceptions predict psychosocial outcomes and whether various dimensions of touch facilitate or inhibit preterm infants' development and psychosocial functioning. They also influence and interact with other sensory perceptions to influence child outcomes.
Hendricks & McPherson (2010)	Early stages of musical development: Relationships between sensory integration dysfunction, parental influence, and musical disposition of a three-year-old 'maestro'	The case of a three-year-old boy, who suffers from the neurological disorder Sensory Integration Dysfunction, shows how the types of interactions between parents and children facilitated a high level of participation in music from an early age.	Case study. Parent diaries, emails, interviews and observations of the child at home were analyzed to map musical development.	The results document the high level of attention and support that the child received from his parents and suggest a prolongation of the period of "communicative musicality" that typifies the mother-child bond in infancy.
Cohen (2011)	Coming to our senses: The application of somatic psychology to group psychotherapy	Neurobiology, sensory processing and attachment theories help us understand how the sense of self develops somatically.	The principles of somatic therapies are applied to the practice of group therapy to work with attachment, disorders, transference impasse and trauma.	The material helps group members access their internal experiences. It shows how somatic integration can be effective when working with attachment disorders, transference impasse and trauma.
Landi et al. (2011)	Maternal neural responses to infant cries and faces: Relationships with substance use	Examines the relationship between maternal neural responses to infant cries and faces and substance use.	Functional magnetic resonance imaging to examine the neural response to infant emotional cues (faces and cries) in mothers who use substances compared to mothers who do not use substances. In response to both faces (of different emotional valence) and screams (of different levels of distress).	Substance use can decrease the mother's ability to respond appropriately to the baby's needs, including sensory input. Infant stimuli may be less perceptible to mothers who use substances, which may negatively affect attachment development.
Tirella et al. (2012)	Parent Strategies for Addressing the Needs of Their Newly Adopted Child	Reflections of 9 parents about strengths, challenges, and strategies in raising newborn toddlers adopted from another country.	Completed standardized assessments that measure child's social-emotional development, sensory processing, and parenting stress.	Adoptive families faced sensory challenges with their adopted children due to a lack of stimulation in orphanages. Adaptation and positive approach strategies were related to marital strength, family and community support. Early intervention and weekly therapy helped reduce the family's stress.

Table 2. Continued...

Author and year	Title	Topic of interest	Methodology	Results
Whitcomb et al. (2015)	Correlational Research to Examine the Relation Between Attachment and Sensory Modulation in Young Children	This study investigated whether there is a relationship between attachment and sensory modulation in young children.	68 children aged 3 to 6 years recruited through the local community. Caregivers were asked to complete a standardized behavioral inventory of parent-child and sensory modulation patterns.	The results revealed modest correlations between attachment and sensory modulation. These findings support a relationship between attachment and sensory modulation should be considered when evaluating and planning treatment for children with problems.
Rita et al. (2017)	Child and family-related predictors of psychological outcomes in children adopted from abroad; what is the role of caregiver time?	They study whether adopted children and family-related factors are associated with later psychological problems.	1,265 children who arrived in Finland before starting school.	The study found that caregiver attention time is an important factor in the psychological outcomes of adopted children. Additionally, age, gender, clinical symptoms (sensory processing problems), and family socioeconomic status also influence later behavioral problems.
Germain (2018)	Finding the Body of the Mind: Integrating Occupational Therapy's Theories of Mutual Regulation and Dysregulation into Psychotherapy	Search for studies that investigate the relationships between sensory processing and attachment patterns.	Theoretical analysis of sensory integration and sensory processing for the understanding and communication with parents of mutual dysregulation in relation to attachment patterns.	When integrated with psychodynamic formulations, a framework emerges that seeks to help parents identify signs of dysregulation within themselves and their children.
Walbam (2019)	Integrating Connection. A Mixed-Methods Exploration of Sensory Processing and Attachment	The association between sensory processing disorder and attachment by examining primary caregivers' perceptions of the attachment relationship.	Mixed method, 24 primary caregivers completed 3 questionnaires: a demographic profile, a sensory processing profile, and an attachment-related questionnaire. Of those 24, 12 were also interviewed qualitatively.	The findings suggest that there is a correlation between sensory processing and attachment, according to measurement scores, specifically with 3 sensory processing subscales; tactile sensitivity, auditory filtering and responsiveness to stimuli.
Branjerdporn et al. (2020)	Prenatal Predictors of Maternal-infant Attachment	To examine prenatal predictors of maternal-infant attachment that may provide potential avenues for assessment and intervention by occupational therapists.	60 women were evaluated during pregnancy and within one year after delivery in a cohort study. Independent t tests, correlations, and multivariable regression models were used.	Low-threshold maternal sensory patterns, more insecure adult attachment, and poorer quality of maternal-fetal attachment were correlated with less optimal maternal-infant attachment. Prenatal attachment quality was the best predictor of overall postnatal attachment in multivariate regression models.

Table 2. Continued...

Author and year	Title	Topic of interest	Methodology	Results
Branjerdporn et al. (2021b)	Maternal-Fetal Attachment: Associations with Maternal Sensory Processing, Adult Attachment, Distress and Perinatal Loss	The study focuses on the relationship between maternal sensory processing, maternal-fetal attachment, adult attachment, stress and perinatal loss.	Cross-sectional correlational study in pregnant women who completed questionnaires on: sensory processing, maternal-fetal attachment and adult attachment. Additionally, information on perinatal loss and perceived stress were collected.	Significant correlations were found between greater maternal-fetal attachment and more effective sensory processing, as well as lower stress and greater psychological well-being. Significant correlations were also found between effective sensory processing and greater adult attachment security.
Branjerdporn et al. (2021a)	Infant sensory patterns: associations with previous perinatal loss, maternal-fetal attachment and postnatal maternal sensory patterns	Infant sensory patterns and their associations with previous perinatal loss, maternal-fetal attachment, and postnatal maternal sensory patterns.	Prospective study with 57 women, surveyed during and after pregnancy. The relationship between prior perinatal loss, maternal sensory processing, and infant sensory patterns was investigated using chi-square tests and logistic regression analysis.	These findings are the first to suggest that prior perinatal loss, poorer quality of maternal-fetal attachment, and levels of maternal postnatal sensory patterns represent risk factors for infant sensory patterns that are "more than typical."

The articles are ordered by year of publication from oldest to newest.

Risk of bias

It is important to consider the possible biases that may influence the results of the studies examined, those identified are detailed below:

Sample Selection Bias: Several studies focused on very specific population groups, such as adopted children (Tirella et al., 2012; Rita et al., 2017), pregnant women (Branjerdporn et al., 2020, 2021a), and premature babies (Weiss, 2005). These findings cannot necessarily be generalized to the population as a whole.

Methodological Bias: The use of qualitative approaches was observed in some studies, such as case studies (Hendricks & McPherson, 2010) and diary and email analyzes (Hendricks & McPherson, 2010). Although these approaches provide valuable insights, they can also introduce bias in terms of subjective interpretations.

Self-Report Bias: Many of the studies analyzed depend on self-reporting by participants or their caregivers (Whitcomb et al., 2015; Tirella et al., 2012; Branjerdporn et al., 2020, 2021a). This method may be subject to recall bias, social desirability bias, and interpretation bias.

Publication Bias: Studies that show significant or positive results have a higher probability of being published. This can result in a biased representation of the available literature, tilting the evidence towards positive findings.

Temporal Bias: Older studies, such as those by Burke et al. (1987) and Greenspan (1996), may be based on theories or understandings that have been surpassed or modified over time. Additionally, variations in research practices and technologies over time may affect the comparability of studies.

Discussions

Research suggests that there is a relationship between sensory processing disorder and attachment bond. Especially in the perception of attachment in caregivers (Walbam, 2019), this relationship has been confirmed in other research, such as that of Germain (2018), who has integrated these findings to create a framework that helps parents identify signs of dysregulation in themselves and their children, and then take action.

Furthermore, this is confirmed by studies by Walbam (2019) and Germain (2018), who found that secure attachment relationships are related to good development of sensory processing. Furthermore, Branjerdporn et al. (2021b) found that dysregulation of sensory processing can negatively affect the quality of attachment between mother and child. Excessive sensory seeking in the child is related to previous perinatal losses and sensory sensitivity in the mother. Sensory avoidance in the child is also linked to a poorer quality of the attachment bond and greater sensory sensitivity in the mother.

According to Branjerdporn et al. (2021a), typical sensory patterns in babies can help occupational therapists provide support to pregnant women who have had previous perinatal losses. These professionals trained in this area can help promote positive maternal-fetal bonding and teach mothers how their own sensory patterns can affect their interactions with their baby. This research confirms the findings of other studies, such as those of Weatherston et al. (2002), Whitcomb et al. (2015), Germain (2018) and Salokorpi et al. (2002), which highlight the importance of Occupational Therapy in promoting sensory processing considering the different types of attachment.

It was discovered that there is a connection between how the mother processes sensory stimuli and her bond with her baby before birth. According to Branjerdporn et al. (2021b), mothers with very sensitive sensory patterns may have difficulty connecting with their baby before birth. This sensitivity can also negatively affect the relationship between parents and children in the future. Previous studies have found a correlation between sensory sensitivity in parents and less optimal parenting styles such as authoritarian and permissive styles.

The visual system is one of the most important and complex of the senses, and is fundamental for many skills, such as spatial exploration, reading, and art. Vision also plays an important role in social communication and language, as eye contact, facial expression, and gestures are important cues for the speaker and listener. Visual deficits and visual stimulation have a significant impact on the normal development of children. Due to the importance of vision in development, any visual dysfunction or visual stimulation approach can have broad consequences on the growth and development of girls and boys (Glass, 2002). This research confirms the findings of Germain (2018), Weatherston et al. (2002), Whitcomb et al. (2015) and Salokorpi et al. (2002) regarding the importance of the baby identifying non-verbal language to develop sensory processing and an attachment style appropriate for their childhood and subsequent development.

Parents reported working together to address their foster children's challenging behaviors, using effective strategies and community resources. This research confirmed what was found in these investigations by Branjerdporn et al. (2020), Salokorpi et al.

(2002), Whitcomb et al. (2015) and Walbam (2019), since it reaffirms the relationship between appropriate parenting strategies, healthy attachment styles and the expected sensory processing.

Conclusions

The systematic review showed that, although there are few studies that cover this topic, existing research concludes that parental attachment at an early age allows the development of adequate sensory processing in girls and boys. This relationship between maternal-fetal attachment and maternal sensory patterns has important implications for clinical practice, policy, and future research.

These results highlight the importance of integrating strategies to promote healthy attachment and the development of sensory processing in interventions with parents and caregivers. Occupational therapists and other health professionals should be equipped with the tools and knowledge to support these aspects of child development.

These findings highlight the need for policies that promote early interventions and support for families to foster secure attachment and healthy sensory processing in children. This may include appropriate parental leave policies, support programs for parents and caregivers, and accessible and affordable mental health and occupational therapy services.

Finally, these findings also have implications for future research. Despite the promising initial findings, further studies are needed to confirm and expand these results. This includes investigating attachment and sensory processing at different stages of development, such as adolescence and adulthood, and in different cultural and linguistic contexts. Additionally, future research could explore how clinical interventions can better support attachment and sensory processing in girls and boys.

As limitations of this systematic review, it only considered the population between 0 and 14 years of age, without considering relevant information in adolescence and adulthood. It is also suggested to review information in other languages and consider mental health diagnoses, where there could be relevant information on associations between problems in sensory processing, types of attachment, and disorders related to mental health.

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Author's Contributions

Francisco Bernal Rivas was responsible for the conceptualization and substantiation of the work, selection of the articles, analysis and data collection, and writing and review of the work. Daniela Avello-Sáez was responsible for reviewing the selected articles, data analysis, and writing and review of the work. All authors approved the final version of the text.

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Appendix A. Search codes.

IN WOS: 38

TOPIC ("Attachment" OR "attachment patterns" OR "Attachment theory" OR "styles of attachment" OR "secure attachment" OR "avoidant attachment" OR "disorganized attachment" OR "parent-child interaction") AND TOPIC ("sensory processing" OR "sensory integration" OR "sensory modulation" OR "sensory discrimination" OR "sensory systems") AND ALL FIELDS ("Child*" OR "Young child*")

IN SCOPUS: 46

TITLE-ABS-KEY ("Attachment" OR "attachment patterns" OR "Attachment theory" OR "styles off attachment" OR "secure attachment" OR "avoidant attachment" OR "disorganized attachment" OR "parent-child interaction") AND TITLE-ABS-KEY ("sensory processing" OR "sensory integration" OR "sensory modulation" OR "sensory discrimination" OR "sensory systems") AND TITLE-ABS-KEY ("Child*" OR "Young child*")

IN PubMed: 2

TITLE-ABS-KEY ("Attachment" OR "attachment patterns" OR "Attachment theory" OR "styles off attachment" OR "secure attachment" OR "avoidant attachment" OR "disorganized attachment" OR "parent-child interaction") AND TITLE-ABS-KEY ("sensory processing" OR "sensory integration" OR "sensory modulation" OR "sensory discrimination" OR "sensory systems") AND TITLE-ABS-KEY ("Child*" OR "Young child*")

IN PsycInfo: 1

TITLE-ABS-KEY ("Attachment" OR "attachment patterns" OR "Attachment theory" OR "styles off attachment" OR "secure attachment" OR "avoidant attachment" OR "disorganized attachment" OR "parent-child interaction") AND TITLE-ABS-KEY ("sensory processing" OR "sensory integration" OR "sensory modulation" OR "sensory discrimination" OR "sensory systems") AND TITLE-ABS-KEY ("Child*" OR "Young child*"

The same terms were used in the Spanish search, with the same combination of words. No results were found in any of the 4 databases.

TOPIC "Apego" OR "patrones de apego" OR "Teoría del apego" OR "estilos de apego" OR "apego seguro" OR "apego evitativo" OR "apego desorganizado" OR "interacción padre-hijo" AND TOPIC "procesamiento sensorial" OR "integración sensorial" OR "modulación sensorial" OR "discriminación sensorial" OR "sistemas sensoriales" AND ALL FIELDS "Niño*" OR "Niño pequeño*"