Degree Project

HÖGSKOLAN I SKÖVDE

Exploring the Impact of Parenting on Child Emotion Regulation: A Neuroscientific Exploration of Brain Structures and Mechanisms

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Student: Nicole Bovin

Rim Rabah

Supervisor: Roque Molina Marchese

Examiner: Sakari Kallio

Abstract

This review underscores the critical role of positive parenting in promoting healthy emotional development in children through its effects on neuronal circuitry development. By fostering secure attachment relationships and providing supportive environments, positive parenting practices contribute to the development of underlying neuronal mechanisms responsible for the development of emotional regulation skills. The identification of sensitive periods in brain development highlights the importance of early interventions aimed at enhancing parenting practices to optimize children's socioemotional outcomes. A literature search was done on Medline EBSCO, PubMed, and Web of Science and ultimately, three studies and one review were included in this review. Effects of positive vs negative parenting styles on children's emotion regulation were looked at. The review of the selected studies indicates that positive parenting practices, such as warmth, praise, and reduced psychological control, are associated with beneficial outcomes in children's emotional regulation. Specifically, these practices are linked to enhanced maturation of neural circuits, including the fronto-amygdala circuit and the connectivity between the amygdala and the medial prefrontal cortex, which are critical for managing emotional responses. Conversely, negative parenting styles, characterized by harshness and psychological control, are correlated with dysregulated emotional responses and less adaptive neural development in these areas. The findings highlight the profound impact of parenting styles on the neural and emotional development of children. Positive parenting not only supports healthier emotional regulation but also contributes to the development of neural mechanisms that underpin these skills. These insights underscore the importance of promoting supportive parenting practices and environments to foster emotional resilience and well-being in children. Further research is necessary to explore these dynamics across diverse populations and to refine strategies that encourage effective parenting approaches.

Keywords: Positive parenting, emotion regulation, child development, neural mechanisms, sensitive periods

Exploring Parentings' Impact on Child Emotional Regulation: A Neuroscientific Exploration of Brain Structures and Mechanisms

Adverse childhood environments constitute a significant risk factor for later mental health issues (Heim & Nemeroff, 2001; Moran et al., 2004). Evidence suggests that the quality of these environments produces changes in brain structure that play a crucial role in the development of mental health (Tupler & De Bellis, 2006). Recently, there has been a growing focus on how adverse childhood environments affect brain development highlighting the negative impact of these environments on brain circuitry and correlated behavior (Hart & Rubia, 2012; McCrory et al., 2010). While understanding why the effects of adverse childhood environments on brain development is crucial, it is equally important to consider the influence of positive childhood environments (Woolley & Grogan-Kaylor, 2006). Positive parenting, characterized by warmth and support from caregivers, has been identified as a significant factor in child outcomes. Supportive parenting has been defined as "parental behaviors toward the child, such as praising, encouraging and giving physical affection, which indicate to the child that he or she is accepted and loved" (Barnes et al., 2000, p. 176). The experience and exposure to supportive parenting in early life has been linked to positive cognitive, behavioral, and psychological development throughout life (Beckwith et al., 1992; Eshel et al., 2006; Landry et al., 2008).

Despite this evidence, there has been limited research on how positive parenting affects brain structure in children and adolescents. Some preliminary studies suggest that positive parenting has neurobiological effects, but the findings are inconsistent. For instance, while maternal support in early childhood may lead to larger hippocampal volumes in school-aged children, higher-quality parental care in early life could result in smaller hippocampal volumes during early-to-mid adolescence, along with other changes in brain structure (Luby et al., 2012; Rao et al., 2010). However, there are gaps in this research. Most studies focus on positive parenting during infancy and childhood, neglecting the crucial adolescent period. Adolescence is a time of significant neurodevelopment, making it particularly sensitive to environmental influences (Fuhrmann et al.,

2015). The objective in this review is to develop and analyze the effects of positive and negative parenting on emotional regulation (ER) in both young children (above the age of five) and in the critical adolescent period. Our review then conceptually connects to three important levels of investigation going from the psychological through the neurological to the behavioral. In this context, attention is paid to the effects of parenting on brain development with a focus on brain mechanisms and structures relevant for the execution of emotional regulation.

Parenting styles

Despite considerable advances in understanding parenting and its impact on child development, there is still debate over the best ways to define and assess it (Kuppens & Ceulemans, 2019). According to Smetana (2017), parenting styles involve the approaches parents take in interacting, disciplining, communicating, and responding to their child's behavior as they integrate them into their social group. Although parenting styles constitute a well-known concept in parenting research, two issues have largely been overlooked in existing studies (Smetana, 2017). In particular, the psychological control dimension, which refers to one aspect of parenting that involves attempts to manipulate a child's emotional and psychological states through intrusive, controlling, or coercive tactics, has rarely been explicitly examined in research studies. This means that researchers have not often included detailed and specific representations of psychological control and manipulation in their models of parenting. Consequently, there is limited insight into how both maternal and paternal practices interact in joint parenting styles and the effect of their combined impact on child development (Smetana, 2017).

For many years, parenting was described through broad, consistent, and stable styles. However, recent research focusing on different aspects of parenting has become more common because of worries that these styles might not fully account for contextual differences or apply equally across various groups according to Smetana (2017). These issues have sparked the development of newer, more detailed, and 'domain-specific' models that better address explicit

situations. These models aim to capture the nuances and variations in parenting practices more precisely by considering the particular contexts and environments in which parenting occurs. Instead of grouping all parenting behaviors into a single style, domain-specific models examine distinct components such as discipline, warmth, communication, or psychological control, thereby allowing for a better understanding of how different parenting practices influence child development in specific situations (Smetana, 2017).

However, most research has originally focused on a unidirectional analysis; the impact from parent to child. With advancements in statistical modeling, a more thorough examination of the dynamics involved in the parent-to-child relationship and vice versa are now possible. Thus, an important question regards the existence of both unidirectional and bidirectional possible causal effects that parenting style has on the child-parent dyad. One study by Moilanen et al. (2015) revealed substantial effects of adolescent behavior on permissive-indulgent parenting. In contrast, no reciprocal effects were observed for authoritative parenting, and bidirectional effects were noted for mother-rated authoritarian parenting but not when rated by children. This highlights the importance of understanding specific domains of parenting and their unique dynamics, emphasizing that parenting is not a one-size-fits-all practice and must be studied with attention to specific contexts and child characteristics (Moilanen et al., 2015).

Baumrind's well-known model of parenting styles (Baumrind, 1971; Baumrind et al., 2010) initially presented authoritative, authoritarian, and permissive types as a holistic integration of parenting practices, best analyzed using pattern-based approaches. Her initial classification of authoritative, authoritarian, and permissive parenting styles has been redefined and expanded, adding two more dimensions: demandingness and responsiveness. This redefinition has resulted in the introduction of a fourth style, known as rejecting-neglecting (McCoby, 1983). Supporters argue that authoritative parenting, characterized by high responsiveness and reasonable demands for mature behavior, is most effective for the development of children and adolescents across various

contexts and cultures (Baumrind et al., 2010; Sorkhabi & Mandara, 2013; Steinberg, 2001). Yet, this view is still debated. In light of criticism, Baumrind and her team have further refined the definition of authoritative parenting and distinguished between negative (e.g., coercive) and positive (e.g., confrontive) uses of parental authority (Baumrind, 2012; Sorkhabi & Middaugh, 2014).

Research supports the idea that both strict and overly lenient parenting styles tend to be less effective according to Herzog et al. (2015). For example, studies have found that mothers who use stricter parenting methods with their three-year-olds often see more behavioral and emotional problems in their children. While strict parenting can lead to such issues, overly lenient parenting may also fail to provide the structure necessary for healthy development. A lenient or permissive approach to parenting has been linked to children showing more negative emotions and immaturity (Herzog et al., 2015). Also, when parents show less warmth and affection, their children are more likely to experience negative feelings, such as low self-esteem and aggression.

A Positive parenting style, on the other hand, includes providing the child with a warm, loving, supporting and responsive environment (Matsudaira et al., 2016). Examples of parenting styles that fall under the category of positive parenting are emotion constructive, emotion responsive and emotion acceptive (Jespersen et al., 2021). This approach, characterized by warmth, consistent communication, and guidance, plays a crucial role in shaping a child's emotional regulation skills within the parent-child relationship (Kerr et al., 2019). Emotion regulation is a fundamental aspect of emotional intelligence, it involves skills crucial for self-awareness, understanding and managing of emotions, the appropriate modulation of emotions, and the recognition of others' emotional mental states (Kerr et al., 2019; Sheppes et al., 2015). It involves competencies to navigate and control emotional experiences, promoting psychological well-being.

Some of the skills include attentional deployment, which is an emotion regulation strategy, involving redirecting attention to regulate emotions, with distraction being a key form of this strategy according to McRae and Gross (2020). Distraction focuses on diverting attention away from

the emotional aspects of a situation, such as glancing at notes instead of an interviewer's face to reduce anxiety during an interview. Conversely, rumination involves repeatedly focusing on the causes and consequences of emotions, for example, mentally replaying a moment when the interviewer frowned. Cognitive change, another emotion regulation strategy, focuses on altering one's interpretation of a situation. Cognitive reappraisal involves reinterpreting an emotional situation, such as telling oneself that the interviewer was instructed not to give positive feedback to applicants. Furthermore, acceptance involves welcoming emotions with a non-judgmental attitude, for example noticing and cultivating curiosity about manifestations of anxiety during the interview. Finally, response modulation strategies aim to modify emotional responses. Expressive suppression involves preventing the outward expression of internal emotional states, for instance, maintaining a neutral facial expression to avoid showing disappointment. Physiological intervention directly alters emotion-relevant physiology through actions like slowing one's breathing rate to calm nerves. These strategies and skills, as outlined by McRae and Gross (2020), highlight different approaches to managing emotional responses in various situations. Together, they help individuals manage emotions effectively, fostering adaptive behaviors essential for healthy social and emotional development (Sheppes et al., 2015).

According to Matsudaira et al. (2016), positive parenting plays a pivotal role in the psychological and developmental trajectory of children, promoting positive psychological outcomes such as enhanced socialization, well-being, and desirable personality traits like extraversion, openness, agreeability, and conscientiousness. These personality traits are expected to be associated with health outcomes since they are considered adaptive (Hudek-Knežević & Kardum, 2009). Parental praise, a key component of positive parenting, serves as crucial verbal and social feedback, bolstering a child's self-esteem, self-efficacy, and motivation. It fosters a nurturing environment conducive to attachment and has been linked with various positive outcomes in children, including not only social and emotional competence but physical well-being as well. Moreover, parental praise plays an important role in language development, particularly noted in children from economically

disadvantaged backgrounds (Matsudaira et al., 2016). According to the same study, research has also demonstrated that parental praise, acting as a verbal stimulus, can impact a child's language development. For instance, it is observed that children experiencing language delays often receive considerably less parental praise compared to their peers with normal language development, particularly in families facing economic disadvantages. Hence, it is evident that parental praise plays a role in both the psychological and cognitive growth of children (Matsudaira et al., 2016).

Neural Correlates of Emotion Regulation

Behavioral and mental health outcomes are correlated with developmental sensitive periods, and can be explained as a period of time when a system in the brain is very sensitive/plastic and easily changes due to environmental cues (Werker & Hensch, 2015). Thus, Recognizing the neurocircuitry involved in the development of emotion regulation (ER) within relational settings is crucial for designing brain-based interventions aimed at enhancing ER in children and adolescents (Kerr et al., 2019). It is thought that sensitive periods happen in different parts of the brain during development, one example of this is seen in the visual cortex as it occurs in both rats and humans (Hensch, 2005). Existing research suggests that a sensitive period may also exist for emotional development (Gee, 2016). The same signals and mechanisms that regulate sensitive period plasticity in the visual cortex are also involved in the development of plasticity during sensitive periods in humans, including the formation of emotion circuitry in the brain (Callaghan & Tottenham, 2016). The same study suggests that the sensitive period in humans takes place during childhood and lasts to the adolescent stage when children start becoming more independent. This implies that parents have the biggest impact on their children's ER during early development. Much of our behavior is the result of the correlated and uncorrelated activity of different brain networks (Meehan & Bressler, 2012). Thus, the normal development related to the integrated functional connectivity of these networks is essential for adaptive behavior including ER (Sporns, 2013).

From the viewpoint of brain mechanisms and network circuitry, one of the “hubs” or central structures involved in emotion in the brain is the amygdala, involved in identifying, perceiving and producing emotion with a special role in experiencing and expressing fear (Callaghan & Tottenham, 2016; Phillips et al., 2003). The prefrontal cortex (PFC) is involved in higher cognitive functions like reasoning, planning and structuring our everyday life. It also plays a part in emotion regulation by supposedly dampening the amygdala’s reactivity signal, and thereby making the emotions less strong. The medial prefrontal cortex (mPFC) is said to be the area in the PFC that is the most central for ER or at least for stress buffering (lowering stress levels) (Callaghan & Tottenham, 2016).

Emotion regulation involves the capacities essential for understanding and managing one's own emotions, as well as recognizing and interpreting the emotions of others (Peña-Sarrionandia et al., 2015). These capacities help a person control their emotions to support adaptive behavior, which is crucial for healthy social and emotional growth (Kim et al., 2024). Developing strong ER skills during childhood and adolescence is particularly important, as these skills are linked to healthy relationships later in life (Kerr et al., 2019). Children learn ER through observing emotions in their parents and other people close to them (Morris et al., 2007). Parents actively guide their children's ER development through socialization efforts and specific behaviors tailored to emotional contexts (De Raeymaecker & Dhar, 2022). The emotional climate within the family significantly shapes ER development, with supportive environments fostering healthy strategies (Kerr et al., 2019). Cultivating ER during childhood and adolescence is significant, as it helps establish robust foundations for future relationships (Sheppes et al., 2015). Emotion regulation abilities correlate with diverse behavioral and mental health outcomes, including academic achievement, prosocial behavior, social skills, and the management of internalizing and externalizing behaviors (Sheppes et al., 2015). Parents commonly hold a pivotal position in fostering their children's ER. Given that ER is a process characterized by both dynamism and dyadic interactions, it evolves over time within the parent-child relationship (Kerr et al., 2019).

Emotion regulation researchers aim to identify the various ways individuals engage in ER and determine which strategies are most effective (successful in achieving an ER goal) and adaptive (associated with better long-term mental and physical health outcomes). The process model of emotion regulation, proposed by Gross (2015), serves as a useful descriptive framework. In the first level of this model, the emotion process is described sequentially in Figure 1: encountering relevant situations, paying attention to key aspects of those situations, appraising the situations in relation to active goals, and experiencing experiential, physiological, and/or behavioral responses. An example of where this model of ER as proposed by Gross (2015) can be observed is in a case of an individual participating in a job interview (situation), noticing the cool demeanor of the interviewer (attention), interpreting the coolness as a sign of displeasure (appraisal), and consequently experiencing fear, shortness of breath, and beginning to fidget (response). The feedback arrow in Figure 1 indicates that the output of the emotion generation cycle creates a new aspect of the situation (being in the interview while feeling afraid, short of breath, and fidgeting), which perpetuates the cycle (Gross, 2015).

Given that people can employ numerous ER strategies, what processes dictate their use? According to the process model (Gross, 2015), the ER cycle begins when there is a discrepancy between an individual's goal state (the emotional state they desire) and their actual (or anticipated) state. This discrepancy is recognized as an opportunity for regulation (1), prompting the selection of a regulation strategy from available alternatives (2). Once a strategy is chosen, it is implemented using specific tactics (3), and the entire process is monitored to determine if the regulatory goal is being achieved (4).

In the job interview example, identification involves recognizing the feeling of fear and the desire to feel excited, along with the belief that the emotion can be altered (See Figure 1). During selection, the individual decides to modify their expressive behavior instead of shifting their attention away from the interviewer. Implementation consists of increasing tension in facial muscles

to avoid displaying a worried expression. Monitoring includes self-reflection, such as asking, “Am I feeling more excited because I chose not to show my worry?” and observing environmental changes to determine whether to continue, stop, or switch to a different ER strategy. These processes are key to ER flexibility (Aldao et al., 2015; Bonanno & Burton, 2013; Pruessner et al., 2020).

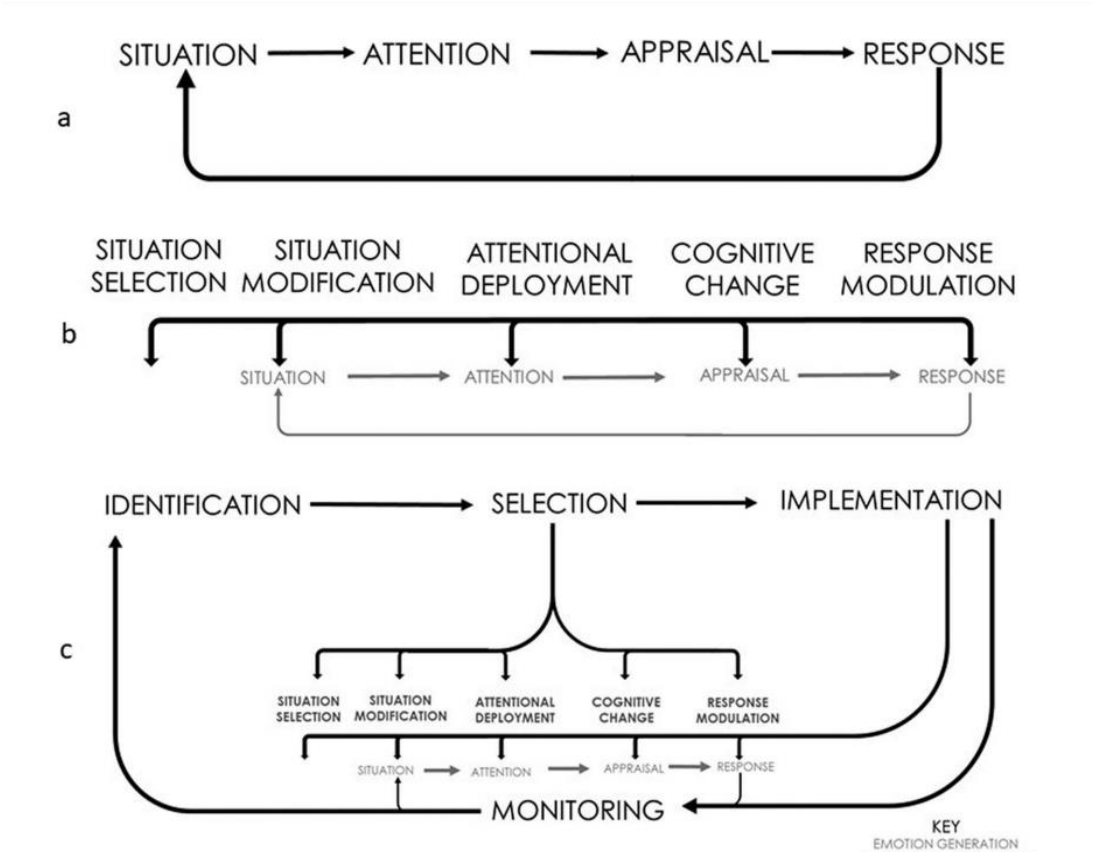


Figure 1. Process of Emotion Regulation (adapted from Uusberg et al., 2019). (a) A sequential model of emotion generation, (b) the five families of strategies that can be used for emotion regulation, categorized by the stage of emotion generation where they initially intervene, and (c) the process model of emotion regulation, detailing the four stages through which emotion regulation strategies are implemented. Feedback arrows indicate that these stages are continuously repeating cycles.

Emotional Stress Levels and the Developing Brain

The relevancy of stress levels for our functioning both physically and mentally is very determining. Stress has a tremendous effect on us as humans in many different ways as it influences our memory, cognition, immune system and much more (Yaribeygi et al., 2017). A well-known stress response is the “fight or flight” response which quickly helps us react when we are in a perceived

threatening situation. With this short-term effect, stress is actually helpful for us as it has a survival value. The problem with stress is when it becomes prolonged and something we cannot get a break from, that is when the chronicity of stress has a negative effect on our body and mind (Dhabhar, 2014).

Children in particular are very sensitive to stress and it can affect their development negatively if exposed to large amounts. Hanson et al. (2014) found that children exposed to early life stress (ELS) in the form of e.g. physical abuse, neglect or low socioeconomic status had smaller amygdala and hippocampal volumes compared to children without these adversities. The same study concluded that the more time children spent in institutional care (which is associated with neglect) the smaller their amygdala volumes tended to be. These differences in brain structure were associated with behavioral problems like socioemotional difficulties (Hanson et al., 2014).

McLaughlin et al. (2015) describes that children exposed to ELS often have negative outcomes like poor physical and mental health and atypical social functioning, furthermore, the development of the stress response system appears to be altered. Pagliaccio et al. (2014) investigated how children are affected by ELS while also being genetically predisposed to disorders like depression. The results showed that stress in early life in combination with genetics work together to predict higher cortisol levels and differences in hippocampal and amygdala volumes. Children were also more likely to experience difficulties in e.g. decision-making during emotion reappraisal, and the circuit between the amygdala and the dorso-lateral prefrontal cortex (DLPFC) becomes affected by early life adverse experiences (Warren et al., 2020).

Comparative animal studies research conducted on mammals investigated how the presence of an available vs unavailable parent affected normal emotional development in rodent pups. In one study by Callaghan and Tottenham (2016), the results showed that pups with available parents had lower stress levels when confronted with a new scent or situation, meaning that their amygdala activation was lower, resulting in a less fearful response (altered stress response). Rodents with

unavailable parents showed increased stress levels and amygdala activation, giving them a more fearful response. This suggests that rat parents' support and presence is important for the cub's developing brain. One conclusion that can be drawn from this study is that the amygdala and the prefrontal cortex are in a process of training and learning how to function and react to emotional cues. Parental circumstances for the raising of pups has a measurable effect on the way brain structures develop and function. A consequence of the pups being exposed to ELS resulting from unavailable parenting style is an increase in anxiety levels, fearful behaviors and hyper-vigilance in adolescence following the pups into adulthood (Warren et al., 2020).

The question is how much of this evidence from animal-based studies can be applied to humans. Thus, results from research conducted on humans raised under similar conditions does not reflect a clear correlation between type of emotionally oriented parenting and emotional development. Some have found hyper-reactivity of the stress response system after ELS, and others observed blunted reactivity or dissonance of the stress response. McLaughlin et al. (2014) presented causal evidence of a blunted stress response in children after ELS, specifically from living in an institution at an early age where neglect and deprivation was common. In the study children were randomized into either staying at the institution or being placed in foster care (FC), and children in high quality FC eventually displayed more normalized stress responses, suggesting that caregiving of quality can help the children back to a more normal state. Furthermore, the normalization of the stress response was most apparent if children were placed in FC before 24 months of age, indicating a sensitive period for the development of the stress system.

The influence maltreatment has on children's neural processes was studied with the use of fMRI. Results showed that children with maltreatment (emotional or physical) had a heightened response to negative emotional stimuli seen by larger activation in areas like the amygdala, thalamus, putamen and anterior insula, all areas that work together to help determine which information is important at the moment (McLaughlin et al., 2017). The study explains that the more

severe the maltreatment was, the greater the response to negative stimuli in the amygdala. Such a response is possibly explained by a heightened requirement for the brain to detect potential threats and relevant emotional information after exposure to threatening experiences.

McLaughlin et al. (2017) explained that the PFC showed a heightened activation during ER (which was not the case for non-maltreated children) for negative emotional stimuli, which points to the fact that maltreated children can regulate their emotions but it requires more effort than it does for non-maltreated children. Taking all of this into consideration, negative parenting styles where neglect is involved, or a negative parenting style that makes the child feel unsafe or scared can be a contributor to a child's brain not working or developing as it would compared to a child without any adverse experiences (Nelson et al., 2009).

A safe and secure developing brain

In exploring the landscape of child development, it's essential to consider not only the extreme cases of trauma and adversity but also the subtler shades of everyday parenting. The role of caregivers in shaping a child's emotional resilience extends beyond the prevention of negative outcomes; it encompasses the nurturing of a safe and secure environment where occasional human imperfections are part of the norm. Understanding this nuanced spectrum of parenting practices can reveal how even ordinary variations in warmth and support impact a child's emotional and neurological development. This text delves into the effects of such normative parenting variations, examining how they influence the developing brain's response to stress and fear, thereby highlighting the crucial role of supportive parenting in fostering emotional regulation and resilience. In the realm of parenting aimed at fostering a warm and secure environment, occasional instances of losing one's temper are acknowledged, recognizing the inherent imperfections in human behavior. This however does not mean that all humans are practicing a negative parenting style, rather the

imperfections are more of a human condition that adds a nuance to the definition of positive or negative parenting styles.

Regarding the effects of parenting style on adolescents, Romund et al. (2016) investigated how variations of (maternal) parenting affected adolescent emotional regulation in the absence of adverse experiences or mental disorders. Their results pointed towards having a parent who provided more warmth and support gave a less fearful response in the left amygdala while looking at fearful faces, compared to adolescents with parents who displayed less warmth and support. Their results are in line with animal studies displaying less fearfulness of the adult offspring of mothers with high maternal care (Caldji et al., 1998). These results are also similar to previous studies that relate the processing of negative facial expressions to a higher activity in the amygdala in adults and adolescents with a history of maltreatment from their childhood (Dannlowski et al., 2013; van Harmelen et al., 2013). In other words, the more parental warmth and support provided to a child, the less sensitive to negative stimuli they will be. This supportive parenting could help the child in the form of a buffering effect on stress. A study by Hostinar et al. (2014) revealed that children with supportive parents show a decreased level in the stress hormone cortisol if the parent was present during a stressful event. Since a child's prefrontal cortex (PFC) is not fully developed, the presence of a parent can guide and assist the child's ER, compensating for their still-maturing ability to manage ER processes more effectively than without it. This highlights the importance of parenting on children's' ER in not just adverse cases, but normative variations as well.

The Aim

This review aims to explore positive and negative parenting styles and the relationship it has to children's ER, with a specific focus on understanding the neural mechanisms and brain structures involved. Positive parenting is defined by providing the child with warmth and acceptance as well as a stable and loving home with supportive parents (Matsudaira et al., 2016). Whereas negative parenting is the opposite, making the child feel unsafe, insecure or ignored in their own home with

little to no parental warmth or acceptance (Jespersen et al., 2021). Information from our study could aid in the understanding of child development and parenting, but also of neuroscience and psychology. It explains the significant effect parenting has on children, and that it really does matter if they grow up in a more positive or negative family environment. This information is crucial both for individual families as well as schools and pre-schools.

Methods

Search strategy

The search string used was "emotion regulation AND Parenting AND fMRI", with restrictions set to abstract on Web of Science, but no restrictions on PubMed or MEDLINE EBSCO. The search was made in June of 2024 and gave the result of 135 articles on PubMed, 13 on MEDLINE EBSCO and 15 on Web of Science (total of 163 articles). The search results (or records) were saved and exported into Rayyan (Ouzzani et al., 2016). The 163 articles were scanned for duplicates and 27 were identified and removed. The articles remaining were screened by title and abstract and 126 were excluded because they did not meet the right inclusion criteria. 10 articles were sought for retrieval, and 8 were successfully retrieved. The final 8 articles underwent a full text screening and 4 were excluded, wrong population (2) and no access (2), making the sum of articles to be included in the review

Inclusion & Exclusion criteria

Both empirical (3) and review (1) articles were included, we only included peer reviewed studies available from the university databases or from open access. Further inclusion criteria were that the studies had to involve children in combination with what could either be considered positive or negative parenting, as well as the use of neuroimaging techniques. The articles had to look at

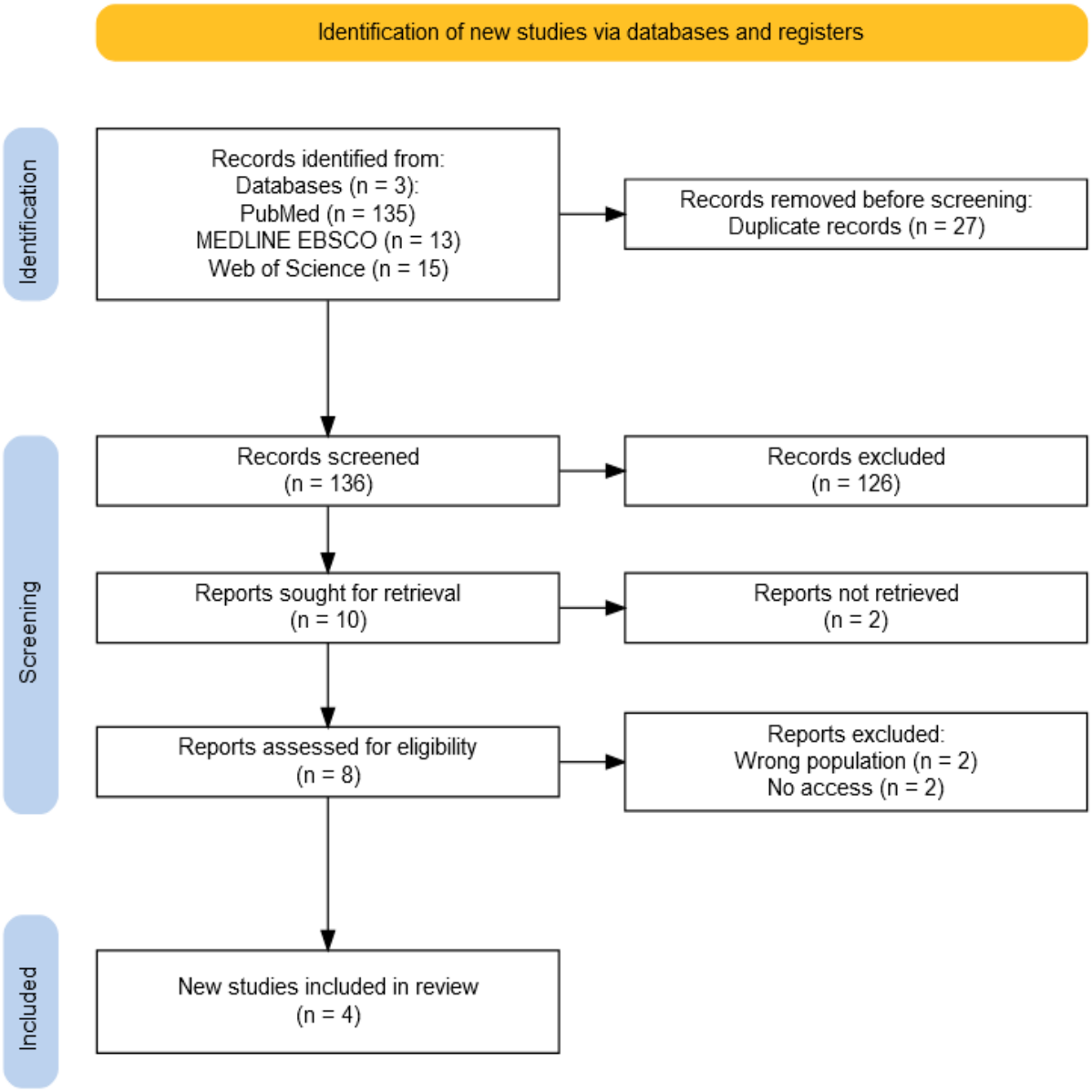
children's ER as a result of parenting styles. Articles chosen were in English and not published before 2010.

Data extraction

This review contains data extracted from four articles (three empirical studies and one review), and it is displayed in Table 1. It includes the first author's name, topic of interest and the methodology used, as well as the results from each article. Sample size, country of origin, neural correlates from fMRI and MRI data and study population were also extracted.

Figure 2

PRISMA Flow Diagram



Note: Literature search process illustrated by a PRISMA Flow Chart. From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372: n71. doi:10.1136/bmj. n71.

Results

Four articles met the inclusion criteria and were included in this review (see Table 1).

Study Characteristics

In the following, we will present the methods and results from three empirical studies and a review concerning the impact of parenting styles on emotion regulation and associated neural mechanisms and brain structures. Ages in the studies ranged from 5-18 with an exception of participating parents in some cases, in total there were 344 participants (counting only the children) with a sample size ranging from 27-290. Two studies were carried out in The United States and one in Japan. Participants were recruited by local advertisements and flyers in schools.

Parenting Style and Emotion regulation

The review conducted by Gee (2016) describes the critical role of parenting style in shaping emotion regulation through its effects on fronto-amygdala circuitry. It underlines how parental buffering influences emotional behaviors and stress reactivity, particularly during sensitive periods of heightened neuroplasticity early in life. The quality of parental care, whether positive or negative, can have lasting consequences on the maturation of the fronto-amygdala circuitry essential for emotion regulation. Disorganized or poor-quality caregiving is noted to lead to profound and enduring negative effects on emotional development, even after the termination of early life stressors. The relationship between parenting and emotion regulation is dynamic, with caregiving experiences interacting with the typical course of brain development at different stages, emphasizing the importance of parental influences on child emotional functioning throughout development.

Marusak et al. (2017) suggests that higher perceived parental psychological control is linked to alterations in children's emotion regulation, characterized by faster but less accurate responses to emotional conflict and reduced neural activity in the left anterior insula. These findings highlight the impact of parenting style on children's behavioral and neural processing of emotional conflict, with significant implications for understanding the development of emotion regulation.

Matsudaira et al. (2017) found that parental praise (considered to be a part of positive parenting) had a significantly positive impact, and was also correlated to gray matter volume in the left posterior insular cortex. Data from observed behavior also revealed a positive and significant correlation between personality traits and parental praise, traits such as conscientiousness and openness to experience were more common amongst the children of parents with higher parental praise scores.

Kerr et al. (2020) used a team task paradigm for establishing what brain regions are involved in emotion processing called the “TEAM task” (Testing Emotional Attunement and Mutuality task), it is an fMRI paradigm designed to assess emotional reactivity and regulation within parent-adolescent dyads. During the task, participants engage in a cooperative game where they must reconstruct a sequence of colored arrows displayed on a screen. Each trial includes feedback indicating both their own and their partner's performance. Importantly, the feedback for the partner is pre-programmed to show that the partner made an error in three out of the 17 trials, resulting in a monetary loss for both participants. This setup allows researchers to examine how each member of the dyad emotionally responds to the other's mistakes while simultaneously undergoing brain imaging, providing insights into the dynamics of emotional attunement and mutuality in their relationship. Based on this paradigm results indicate that the dorsolateral prefrontal cortex (dlPFC), anterior insula, fusiform gyrus, thalamus, and superior parietal lobule, were activated in both the parents and adolescents in response to the others’ error during the TEAM task. However, adolescents exhibited greater activation in the left amygdala compared to parents, indicating a possible developmental difference in emotional reactivity.

Measuring technique

Functional magnetic resonance imaging (fMRI) was used by three of the studies, and structural magnetic resonance imaging (MRI) was used in one study by Matsudaira et al. (2016) to measure brain activity and structure in the children. These imaging techniques provided insights into

the neural underpinnings of emotion regulation as influenced by a more positive or negative parenting style.

Neural Correlates of Emotion regulation

The findings by Gee (2016) explain that neural correlates of emotion regulation involve the fronto-amygdala circuitry and highlights the role of the amygdala and its connectivity with the medial prefrontal cortex (mPFC) in regulating emotional responses and behaviors. Additionally, it emphasizes how parental care influences amygdala reactivity, connectivity, and affective regulatory behavior, particularly during sensitive periods of heightened neuroplasticity. The fronto-amygdala circuitry is crucial for emotion regulation, and parental buffering plays a significant role in modulating this circuitry to shape emotional development and stress reactivity.

Marusak et al. (2017) describes that the neural correlates of emotion regulation involve various brain regions that play a role in processing and regulating emotions. Some key brain regions involved in emotion regulation include the amygdala, anterior insula (AI), dorsal anterior cingulate cortex (dACC), and rostral anterior cingulate cortex (rACC). These regions interact to regulate emotional responses, manage emotional conflicts, and modulate emotional experiences. Dysfunction in these neural circuits can lead to difficulties in emotion regulation and may contribute to emotional disorders.

Kerr et al. (2020) identifies several neural correlates of ER in parent-adolescent interactions during fMRI scanning. Both parents and adolescents showed robust activation in brain regions associated with affective circuitry and emotion regulation, including the anterior insula, medial superior frontal gyrus, and dorsolateral prefrontal cortex (dlPFC). Notably, positive parenting practices, as reported by adolescents, correlated with greater activation in the parents' ventromedial prefrontal cortex (vmPFC), a region linked to empathy and emotion processing. Additionally, a significant correlation was found between parents' and adolescents' brain activation in response to costly errors, particularly in the left anterior insula, indicating a shared emotional response. The

study also found that adolescents exhibited greater activation in regions related to emotional reactivity, such as the amygdala, and less activation in regions related to emotion regulation, like the dlPFC, compared to parents.

Matsudaira et al. (2016) suggests that the neural correlates to emotion regulation can be linked to the posterior insular cortex and that it is functionally connected to the amygdala. Furthermore, the posterior insula is known to be related to auditory function and is implicated in processing parental praise, which includes verbal auditory stimuli conveying parental emotions like affection and warmth. This connectivity may explain the correlation between parental praise and gray matter volume in the posterior insular cortex, highlighting its significance in emotion processing and regulation.

Table 1.

Content of Articles Included in Review

First Author & Year	Topic of Interest	Methodology	Measure	Results
Gee (2016)	Focuses on influences of parental care on fronto-amygdala circuitry and plasticity in emotion regulation across different developmental stages	They employed an approach that integrated evidence from cross-species studies, neuroimaging techniques, longitudinal research, and behavioral assessments to explore the relationship between parental care and fronto-amygdala circuitry in emotion regulation.	fMRI	Early caregiving challenges can accelerate brain circuit development, affecting children's emotional management and mental health later. This faster development may benefit children in difficult environments, enhancing adaptation and resilience. However, ending the sensitive caregiving period prematurely could limit future learning and adaptation, raising the risk of mental health issues during childhood and adolescence.
Marusak et al. (2017)	How parental psychological control affects children's reactions to emotional conflict. It investigates connections between these responses and behavior problems	27 children and adolescents (aged 9-16) assessed parenting perceptions and emotional responses. Participants engaged in an emotional congruence task. They indicated either the emotion, or gender of the face, varying from congruent to incongruent with “non-emotional” alternative as control.	fMRI	Children with psychologically controlling parents reacted faster but less accurately to emotional conflicts, with reduced neural responses in certain brain areas. Parental care did not affect these responses, and control did not extend to non-emotional tasks. Higher anxiety levels were linked to less response interference.
Matsudaira et al. (2016)	Gray matter volume changes in children with parents who use praise	290 children participated, their parents rated their praising behavior on a Likert scale. Children underwent MRI scans at two time points, the second one 3 years after the first. The children completed personality tests at time point 2, with age appropriate big five questionnaires.	MRI	Parental praise was significantly and positively correlated with conscientiousness and openness in children. Gray matter volume in the left posterior insular cortex showed a significant positive correlation with parental praise and a similar positive correlation was observed in the right hemisphere.
Kerr et al. (2020)	Neural correlates to positive parent-child relationship	27 adolescents aged 14-16, and 25 parents aged 30-50 were included. They performed a “TEAM” task (while undergoing fMRI), where they viewed colored arrows and reconstructed the order afterwards.	fMRI	A significant correlation was found between parents' brain activation in the ventromedial prefrontal cortex (vmPFC) and positive parenting practices. This was measured by the APQ-Pos scale, which was completed by the adolescent. Parents who were rated as exhibiting the most positive parenting practices showed the highest vmPFC activity when they received feedback that their adolescent child made a “costly error”.

Note: Costly error refers to the pre-programmed errors made by the partner in Team task. The APQ-Pos (Positive Parenting Subscale of the Alabama Parenting Questionnaire) is a questionnaire designed to assess various parenting practices, this one measures positive parenting behaviors, such as parental involvement, praise, and encouragement.

Discussion

Summary of findings

This review underscores the critical role of parenting styles, and that they play a pivotal role in shaping the neural mechanisms underlying emotion regulation in children and adolescents. Positive parenting practices, such as providing praise and minimizing psychological control, are associated with beneficial neural and behavioral outcomes. The findings of the cited studies in this review highlight the importance of early parental interventions and support for promoting optimal emotional and neural development in children. The findings also give support for the potential long-term benefits of positive parenting for children´s mental health and well-being. Therefore, the studies in this review have evidence that suggests a relatively strong correlation between positive parenting and enhanced emotional regulation.

Despite advances in understanding these parenting dynamics, there is still debate over the best ways to define and assess parenting styles. Researchers like Kuppens and Ceulemans (2019) have pointed out the complexities in capturing the nuances of parenting practices and their varying impacts on child development. This complexity is evident when examining how positive parenting influences specific neural circuits involved in emotion regulation, such as the fronto-amygdala circuitry.

The fronto-amygdala circuitry, comprising the amygdala and its connectivity with the medial prefrontal cortex (mPFC), plays a critical role in regulating emotional responses and behaviors. Gee (2016) underscores the importance of parental buffering in shaping this circuitry, particularly during periods of heightened neuroplasticity early in life. The amygdala is crucial for emotional reactivity, and its interaction with the mPFC is essential for modulating emotional responses. Positive parental care can enhance the maturation of these neural pathways, promoting effective emotion regulation, while disorganized or poor-quality caregiving can lead to long-lasting negative effects on emotional development. This highlights the role of the fronto-amygdala circuitry in stress reactivity and emotional development.

The anterior insula (AI) and various parts of the cingulate cortex, such as the dorsal anterior cingulate cortex (dACC) and rostral anterior cingulate cortex (rACC), are also integral to emotion regulation. Marusak et al. (2017) found that these regions are involved in managing emotional conflicts and modulating emotional experiences. Dysfunction in these circuits can result in difficulties with emotion regulation, potentially contributing to emotional disorders. The anterior insula is particularly noteworthy as it was observed to have reduced activity in children experiencing higher parental psychological control, which may impact the processing of emotional conflict. Additionally, Kerr et al. (2020) found that activation in the anterior insula correlated between parents and adolescents during emotion processing tasks, suggesting shared emotional responses within family dynamics.

Kerr et al. (2020) demonstrated that the dorsolateral prefrontal cortex (dlPFC) is involved in emotion regulation for both parents and adolescents. However, adolescents showed less activation in the dlPFC and greater activation in the amygdala, indicating a developmental difference in emotional reactivity and regulation compared to adults. This finding suggests that adolescents may rely more on emotional reactivity rather than regulatory processes, highlighting a potential target for interventions aimed at improving emotion regulation during this developmental stage.

The studies collectively show that positive parenting practices, such as parental praise and positive engagement, are associated with beneficial outcomes in children's neural development. Matsudaira et al. (2017) linked parental praise with increased gray matter volume in the left posterior insular cortex and positive personality traits, suggesting that supportive parenting enhances both brain structure and behavioral outcomes. Kerr et al. (2020) further identified that adolescents' reports of positive parenting correlated with increased activation in the parents' ventromedial prefrontal cortex (vmPFC), a region associated with empathy and emotion processing, underscoring the reciprocal influence of parent-child interactions on emotional development.

These studies demonstrate that parenting styles significantly influence the neural correlates of emotion regulation, with specific brain regions playing distinct roles in processing and modulating emotional responses. Understanding these neural mechanisms provides valuable insights into how parenting practices can shape emotional development and stress reactivity, offering potential avenues for interventions aimed at enhancing emotional regulation in children and adolescents.

Societal and Ethical Aspects

The influence of parenting on children's emotional regulation extends beyond individual families, impacting society as a whole. Understanding these dynamics is crucial for promoting healthy emotional development in future generations. Hu et al. (2014) speak about how healthy emotional development including ER is closely linked to mental health. This means that children with strong ER skills are less likely to experience anxiety, depression, and other mental health issues, possibly reducing the prevalence of these disorders later in life. ER also equips children with the resilience to cope with adversity, enhancing their ability to adapt, and succeed academically (Sheppes et al., 2015). Additionally, emotional development is key to building social skills, leading to healthier relationships and more positive interactions across personal, academic, and professional settings.

Parenting practices are deeply influenced by cultural norms and can vary significantly across different societies. These cultural differences shape perceptions of what constitutes "positive" or negative parenting and influence emotional development in children. Recognizing cultural differences is essential for creating inclusive parenting programs that include diverse practices while promoting emotional well-being. Socioeconomic status also plays a critical role, as families from low-income backgrounds may face stressors that hinder their ability to provide nurturing environments. Addressing these disparities is vital for ensuring equitable opportunities for all children to develop healthy ER skills. Community programs and support systems, such as parenting classes and mental health resources, could empower parents to foster emotional resilience in their children. There is an ethical obligation to ensure all families have access to these resources, and advocating for policies

that enhance access is crucial for creating a just and supportive environment. Neglecting children's emotional development has far-reaching consequences, including mental health challenges and broader societal impacts. By investing in the emotional well-being of children today, society can build a stronger foundation for healthier communities in the future.

Limitations

This review only has four articles (three empirical studies and one review) included which makes it difficult to generalize the findings. We chose to not include clinical populations of parents or children, and only included fMRI and MRI based studies. Another limitation refers to the lack of population variation included in the articles, which limits the scope of our review. The complexity of parenting styles imposes natural limitations because it is complicated to define exactly what fits into one style. The use of both positive and negative parenting styles could have been used in the studies, it would be difficult to know if that was the case, since the definition of positive parenting was based on participants' opinions and experience from parenting in daily life. The review mostly relied on studies conducted in westernized countries, a more diverse selection would be valuable to minimize biases influenced by e.g. culture, education levels or socioeconomic factor.

Future research

The studies on the fronto-amygdala circuitry and related brain regions highlight the critical role parenting plays in shaping emotion regulation and neural development. Future research could benefit from conducting longitudinal studies that track changes in these neural circuits throughout different stages of childhood and adolescence. This would help clarify how consistent patterns of parental behavior influence neural maturation over time. Additionally, exploring the impact of diverse parenting styles and cultural contexts can provide insight into whether certain practices universally enhance emotional development or if their effects vary across cultures (Lansford, 2022). Moreover, investigating how stress and challenges influence the development of brain circuits that control emotions can provide important understanding, especially about the factors that help reduce

negative effects. Research on individual differences in the ability to regulate emotions, and how these differences relate to variations in neural circuitry and parenting experiences, can help identify traits or neural patterns associated with better emotional outcomes.

The use of advanced neuroimaging techniques, such as functional connectivity MRI or diffusion tensor imaging, would enable more detailed exploration of the structural and functional connectivity of emotion regulation circuits. A particular focus on the developmental trajectories of emotion regulation in adolescents is crucial, given their unique neural and emotional reactivity patterns. Studies could investigate how changes in brain regions like the dorsolateral prefrontal cortex (dlPFC) and amygdala contribute to the transition from adolescence to adulthood. Lastly, given the modern challenges posed by digital media and technology, research on their impact on the neural development of emotion regulation circuits is increasingly important. Such studies could help develop guidelines for healthy media use within families.

Conclusion

This review aimed to investigate the hypothesis that positive parenting practices significantly influence children's emotional regulation and neural development. The evidence gathered from the four articles included in this review supports this hypothesis, demonstrating that positive parenting characterized by behaviors such as praise, emotional support, and reduced psychological control leads to beneficial outcomes in both emotional regulation and brain structure development in children.

Specifically, the findings indicate that children who experience positive parenting are more likely to develop effective emotion regulation skills, which are crucial for their overall mental health and well-being. These practices promote the maturation of critical neural circuits, particularly within the fronto-amygdala circuitry, which is essential for managing emotions. Furthermore, the review highlights that neglecting children's emotional development can have long-term negative consequences, not only for the individual but also for society as a whole.

In conclusion, the results underscore the importance of fostering positive parenting practices as a means to build a strong foundation for emotional resilience and healthy development in children. By investing in parenting education and support, we can enhance the emotional well-being of future generations, ultimately contributing to healthier communities.

Word count: 7265

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