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Normative range parenting and the developing brain: A scoping review and recommendations for future research

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Abstract

Studies of early adversity such as trauma, abuse, and neglect highlight the critical importance of quality caregiving in brain development and mental health. However, the impact of normative range variability in caregiving on such biobehavioral processes remains poorly understood. Thus, we lack an essential foundation for understanding broader, population-representative developmental mechanisms of risk and resilience. Here, we conduct a scoping review of the extant literature centered on the question, "Is variability in normative range parenting associated with variability in brain structure and function?" After removing duplicates and screening by title, abstract, and full-text, 23 records were included in a qualitative review. The most striking outcome of this review was not only how few studies have explored associations between brain development and normative range parenting, but also how little methodological consistency exists across published studies. In light of these limitations, we propose recommendations for future research on normative range parenting and brain development. In doing so, we hope to facilitate evidence-based research that will help inform policies and practices that yield optimal developmental trajectories and mental health as well as extend the literature on the neurodevelopmental impact of early life stress.

KEYWORDS
brain development, caregiving, fMRI, MRI, parenting

1 | INTRODUCTION

There is widespread agreement that caregiving has a profound impact on development. A robust body of literature dating back to the early 20th century details how variation in caregiving across species impacts outcomes for physical and mental health (Bowlby, 1958; Harlow, 1961; Harlow & Zimmermann, 1959; Lorenz, 1935). From these seminal studies arose a number of theoretical models of caregiving in humans. For example, Ainsworth proposed that caregiving is best conceptualized in terms of parent-child attachment, which she described along three broad styles of insecure-ambivalent, insecure-avoidant, and secure (Ainsworth, 1969). In another influential model, Baumrind proposed that caregiving is best indexed by parenting behavior, which he described along the three broad styles of authoritative, authoritarian, and permissive (Baumrind, 1967).

Abbreviations: BOLD, blood oxygen level-dependent; dMRI, diffusion magnetic resonance imaging; DTI, diffusion tensor imaging; fMRI, functional magnetic resonance imaging; HPA, hypothalamic-pituitary-adrenal; mPFC, medial prefrontal cortex; MRI, magnetic resonance imaging; PRISMA-ScR, PRISMA extension for scoping reviews.

Following Baumrind, Maccoby and Martin developed a model that is best supported by empirical data and most widely adopted in contemporary research (1983). This model describes four styles of parenting: authoritative, authoritarian, indulgent, and uninvolved. These styles center on two continuous dimensions of parent behavior: *care* and *control. Care*, also commonly called warmth, sensitivity, or responsiveness, describes the extent to which parents are accepting of and sensitive to their child's emotional and developmental needs (Baumrind, 1991; Maccoby & Martin, 1983). *Control*, also commonly called demandingness, monitoring, or protection, refers to the extent to which parents control their children's behavior or demand maturity (Baumrind, 1991; Maccoby & Martin, 1983). These two dimensions interact both within and between caregivers and ultimately yield a range of patterns of parental values and practices as care and control are necessarily balanced within a family (Baumrind, 1991; Maccoby & Martin, 1983).

Robust evidence in the decades since the theoretical model of Maccoby and Martin was proposed portrays clear links between variability in normative range parenting and clinical outcomes across development. Parenting marked by *low care* and *low control* (i.e., "uninvolved") is generally associated with poorest developmental outcomes, such as increased rates of juvenile delinquency (Steinberg, 2001), increased risk for anxiety and mood disorders, and poorer emotion regulation (Tottenham, 2018; Zeanah et al., 2009). It is in the most extreme cases within this quadrant—the lowest care and lowest control families—where early life stressors (e.g., trauma, abuse, neglect) often occur. Parenting characterized by *low control* but *high care* (i.e., "indulgent") is associated with heightened risk for internalizing problems (Williams et al., 2009); diminished self-control, self-esteem, and academic achievement (Lamborn et al., 1991; Power, 2013); and greater aggression and substance use (Lamborn et al., 1991; Power, 2013). Children of parents described as displaying *low care* and *high control* (i.e., "authoritarian") are more susceptible to substance use and depressive disorders (Calafat et al., 2014; Glozah & Pevalin, 2014; King et al., 2016; Rothrauff et al., 2009); tend to be less self-reliant and less socially accepted by peers (Lamborn et al., 1991; Steinberg et al., 1992, 1994); and on average have lower grades in school across ethnic groups (Dornbusch et al., 1987; Steinberg et al., 1989). In contrast, the most positive developmental outcomes are generally observed among children of parents who exhibit *high care* and *high control* (i.e., "authoritative"). On average, these children show greater psychological well-being with regard to emotional stability, adaptive coping, and life satisfaction (Maccoby & Martin, 1983; Power, 2013); exhibit lower rates of depressive symptoms, substance use, and externalizing problems (Maccoby & Martin, 1983; Williams et al., 2009); and show better school performance and overall academic achievement (Nyarko, 2011; Spera, 2005; Steinberg et al., 1992). These findings suggest that, although not an easy task, children benefit when parents balance safety concerns with fostering autonomy; balance support with overindulgence; and in doing so create an optimal child-rearing environment via high care and high control (Darling, 1999; Power, 2013).

Given the impact of such variability in normative range parenting on socioemotional outcomes, there has been increased interest in investigating the parent–child relationship in relation to the development of brain circuits associated with these outcomes. These efforts may be particularly useful in identifying differences in brain development associated with variability in normative range parenting that emerge before behavioral problems and/or represent targets for early intervention. The largest and most relevant extant body of literature describes the brain developmental correlates of extreme deviations in early caregiving manifested as early life stress, including trauma, abuse, neglect, and prolonged parental separation. Across species, there are consistent and robust findings demonstrating a relationship between caregiving-related adversity and the developing brain (Gee, 2016; Gee & Casey, 2015; Green et al., 2010; McLaughlin et al., 2010, 2015; Tottenham, 2014, 2018; Tottenham & Gabard-Durnam, 2017). In particular, many studies have focused on associations between disruptions in caregiving and the structural and functional development of the corticolimbic circuit supporting socioemotional functioning, stress responsivity, and motivated behavior (Herringa et al., 2013; McLaughlin et al., 2016; Silvers et al., 2016). Within these circuits, the amygdala and ventral striatum play a critical role in establishing predictive associations between the environment and the experience of threat and reward, respectively, including the generation of adaptive behavioral and physiological responses, while the medial prefrontal cortex (mPFC) plays an important role in effecting top-down integration and regulation of threat and reward signaling from the amygdala and ventral striatum.

Corticolimbic circuitry undergoes marked changes over the course of childhood and adolescence. While subcortical regions including the amygdala and ventral striatum typically mature relatively earlier, prefrontal regions such as the mPFC undergo more protracted development (Casey et al., 2019; Gee et al., 2018; Luna et al., 2015; Mills et al., 2014; Mills et al., 2016). Available evidence suggests that these differing maturational timecourses and the associated connections between subcortical and prefrontal regions lead to patterns of motivated behavior unique to adolescence (i.e., emotion regulation, stress reactivity, reward processing; Casey et al., 2016; Dahl & Gunnar, 2009; Galvan et al., 2006; Gee et al., 2018; Hare et al., 2008; Hartley & Somerville, 2015; Silverman et al., 2015).

In the presence of early life stress, however, typical development often goes awry. Numerous studies have reported links between early caregiving adversity with alterations in structure, function, and connectivity of the mPFC, amygdala, ventral striatum, and hippocampus (Eluvathingal et al., 2006; Goff et al., 2013; Hanson, Albert, et al., 2015; Hanson, Hariri, et al., 2015; Hanson, Nacewicz, et al., 2015; Sheridan et al., 2012; Tottenham, 2014). Evidence suggests that these disruptions in frontolimbic circuitry are associated with alterations in hypothalamic-pituitary-adrenal (HPA) axis function (Gee et al., 2013; Gunnar et al., 2009; Koss et al., 2014; Moriceau et al., 2009) and threat- and reward-related motivated behavior (reviewed in Gee et al., 2018; Tottenham & Galvan, 2016).

Such studies of extremely early life stress highlight the importance of quality caregiving in the development of brain circuits supporting emotional behavior and mental health. However, the impact of less extreme variability in caregiving on such biobehavioral processes remains relatively poorly understood. Given the clear evidence that parenting impacts clinical and behavioral outcomes, and that caregiving in its most extreme forms impacts brain development, explicitly examining brain development in relation to normative range parenting is essential for optimizing well-being in youth. The prevalence of clinically impairing psychopathology is increasing over time (Goldman et al., 2018; Merikangas et al., 2010; NAMI: National Alliance on Mental Illness, 2019; Social Security Administration Research, Statistics, & Policy Analysis, 2017; Tucci & Moukaddam, 2017). While genetic predisposition and stressful life events contribute to psychopathology onset, early life environment likely does as well. Investigating how normative range parenting impacts brain development is one avenue for better delineating optimal caregiving environments for healthy social, emotional, and psychological functioning.

To address this question, we conducted a scoping review of the literature examining the functional and structural brain correlates of normative range variability in parenting style and behavior. Defined by Tricco et al., a scoping review is a type of knowledge synthesis that seeks to "examine the extent (that is, size), range (variety), and nature (characteristics) of the evidence on a topic or question; determine the value of undertaking a systematic review; summarize findings from a body of knowledge that is heterogeneous in methods or discipline; or identify gaps in the literature to aid the planning and commissioning of future research" (Tricco et al., 2018). Although still a relatively new technique for research synthesis, a scoping review is most appropriate for a broader exploration of limited extant literature, while providing a more conservative and thorough investigation than a standard narrative review (Arksey & O'Malley, 2005; Daudt et al., 2013; Levac et al., 2010; Tricco et al., 2018). Our primary objective was to build upon the work of research examining early life stress, which has shown *that* parenting matters, and directly examine and synthesize what the existing literature indicates regarding *how* parenting matters. For the purpose of this review, normative parenting was defined as upbringing in the absence of early life stress including trauma, physical abuse, sexual abuse, neglect, and prolonged family separation (e.g., institutionalization, foster care). Our review was further grounded in the theoretical framework developed by Maccoby and Martin by focusing on parenting along the dimensions of care and control (Maccoby & Martin, 1983); however, we did not limit our search to include only these constructs in order to capture any literature relevant to parenting style or behavior. Numerous other constructs arose from our search, both related to (e.g., sensitivity, support, warmth) and separate from (e.g., cohesion, conflict, touch frequency) care and control. With regard to the brain, we focused on three functional MRI measures (activity during experimental tasks, connectivity during experimental tasks, and intrinsic connectivity in the absence of experimental tasks) and two structural MRI measures (gray matter volume and cortical thickness).

2 | METHODS

2.1 | Data sources and search strategy

This scoping review centered on the research question, "Is variability in normative range parenting associated with neural function and structure in human offspring?" All review processes were conducted in accordance with the PRISMA extension for scoping reviews (PRISMA-ScR; Tricco et al., 2018). The initial search was conducted on February 5, 2019 in three electronic databases: MEDLINE/PubMed, Scopus, and PsycInfo. The search was tailored to the specific requirements of each database. The search query consisted of three primary sets of terms: (a) *parenting*: parent*, caregiv*, maternal, paternal, family, familial; (b) *neuroimaging*: fMRI, MRI, dMRI, DTI; and (c) *psychological relevance*: psycholog*, psychiatr*, psychopathology. The search query also consisted of terms preceded by the Boolean operator "NOT" in order to exclude large numbers of studies deemed irrelevant and/or outside the scope of the present study. A complete list of search terms and syntax is provided in the supplemental materials (Table S1). The search query included only peer-reviewed empirical articles, published in English, in samples of human subjects. Citations from all three databases were imported into bibliographic manager Zotero (version 5.0.60), wherein duplicate citations were manually removed and merged.

2.2 | Data charting and screening

Data selection, screening, full-text review, and synthesis were conducted by a single reviewer (MJF) who was not blind to record author or journal name throughout the reviewing process. The first level of screening involved the examination of articles for relevance and inclusion criteria by title and abstract only. Articles for which no abstracts were available were included for further screening in the full-text review. During the full-text review, each article was read in its entirety to (a) further screen for relevance and inclusion criteria, and (b) extract relevant data for subsequent qualitative analysis and synthesis. Reasons for exclusion during all stages of data charting and screening are detailed in Table 1.

2.3 | Data characterization and synthesis

Citations were imported into Microsoft Excel (version 16.22) for citation management, data organization, and qualitative and descriptive statistical analyses. Extraction of data pertinent to the research question was conducted throughout the full-text review and was recorded in Microsoft Excel.

3 | RESULTS

3.1 | Search and selection

The original search yielded 1,411 potentially relevant records. 814 records remained after the removal of duplicates. Of these 814 records, 40 met inclusion criteria after screening by title and abstract. A large number of citations were excluded upon the title and abstract screening as several terms used in the search algorithm also corresponded to other study parameters; a complete list of topics deemed irrelevant and/or beyond the scope of the present review can be found in Table 1. These 40 records were then procured for full-text review. After data characterization, 23 articles were included in the final analysis. The flow of records from identification through final inclusion is depicted in Figure 1.

TABLE 1 Reasons for exclusion during title/abstract screening and full-text review

1. Non-normative caregiving[a]
a. Trauma
b. Abuse (verbal, physical, sexual)
c. Neglect
d. Institutionalization
e. Explicit focus on parental mental illness
f. Left-behind children (e.g., refugee)
2. Unavailable/irrelevant offspring neuroimaging data
a. Parent neuroimaging data
b. Fetal neuroimaging data
3. No parenting style data available
a. Parent-reported outcomes only
b. Focus on demographics
e.g., Socioeconomic status, educational attainment, social standing, intelligence
c. Attachment style rather than continuous parenting dimensions
4. Primary focus otherwise irrelevant/outside scope of the present review
a. Preterm birth
b. Nutrition
c. Sleep
d. Prosociality
e. Language processing
f. Dementia
g. Offspring mental illness
5. Not peer-reviewed empirical article
a. Review
b. Book or book chapter
c. Case study
d. Symposium

[a]We excluded studies in which non-normative caregiving was the sole focus of the paper, or in which authors oversampled for childhood trauma. We did not exclude studies that happened to include participants who had been exposed to these examples of early life stress.

3.2 | Characteristics of included records

A summary of general characteristics, parenting assessment methodologies, and neuroimaging assessment methodologies of the 23 included records is reported in Tables S2–S4, respectively. The 23 included records reported on 19 independent data sets in total. The timeline of data collection for each independent data set is illustrated in Figure 2. The number of assessments, age of child at assessment, and age range of sample at assessment varied widely. Eleven included records also reported on child behavioral or clinical outcome; however, because not all records included such outcome data, these non-neuroimaging outcomes are not discussed in the present review. Further details of each individual study can be found in Tables 2–4.

3.3 | Functional activity (Table 2)

Ten included records examined parenting in relation to task-related functional activity as indexed by blood oxygen level-dependent (BOLD) signal change (Coan et al., 2013; Farber

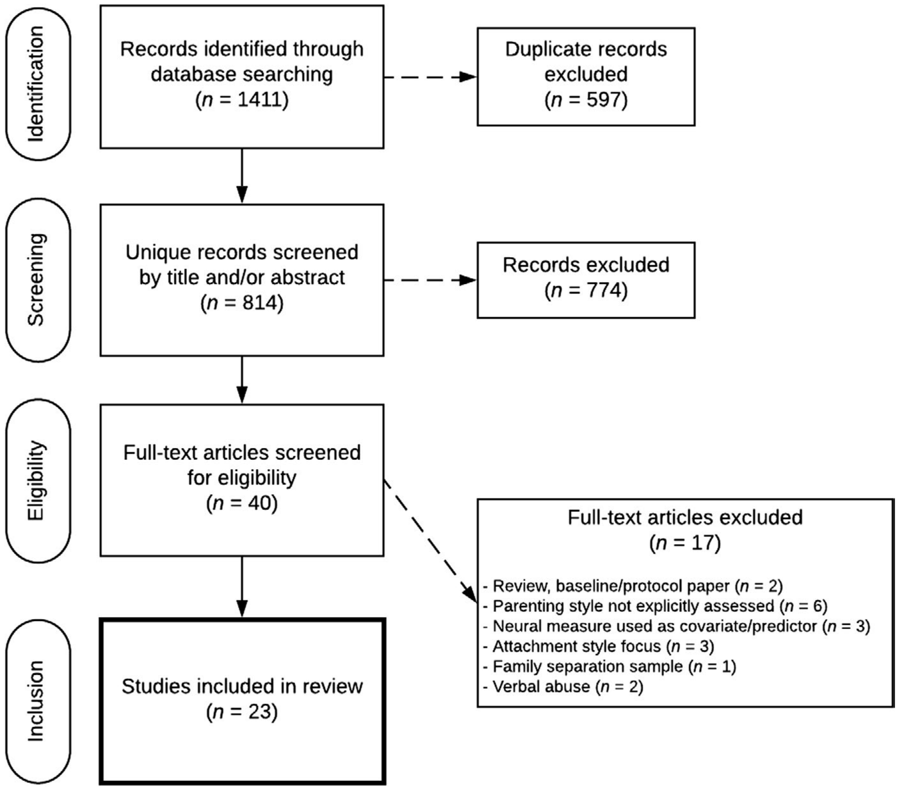

FIGURE 1 PRISMA-ScR flowchart of record identification and selection process for the scoping review

et al., 2018; Gollier-Briant et al., 2016; Kim-Spoon et al., 2017; Lauharatanahirun et al., 2018; McCormick et al., 2016; Qu et al., 2016; Romund et al., 2016; Taylor et al., 2006; Telzer et al., 2013). Although varying in exact task design, these studies primarily investigated three constructs: (a) behavioral control/inhibition, (b) goal-directed behavior, and (c) threat responsivity. Inconsistent associations were observed between parenting and brain activity associated with responding to threat. For example, increased parental warmth or similar constructs were associated with relatively decreased (Romund et al., 2016) and relatively increased (Farber et al., 2018) amygdala activity. This could stem from differences in task, age range, and precise parenting construct assessed (i.e., maternal warmth and support vs. family affective responsiveness). Regardless, these studies suggest altered activity within a corticolimbic circuit including the amygdala and prefrontal cortex as well as the insula, which supports interoception. Studies exploring parenting in relation to goal-directed behavior reported that increased familial obligation and positive parenting are associated with decreased activity in the ventral striatum (Qu et al., 2016; Telzer et al., 2013), which plays a critical role in associative learning and the translation of motivation into action, while increased parental knowledge and decreased household chaos are related to increased insula activity (Lauharatanahirun et al., 2018). Although findings related to the ventral striatum and insula are less mixed than those related to the amygdala, it is worth noting that these studies varied in task and age range as well. Last, increased prefrontal activity associated with cognitive control and response inhibition was consistently associated with greater *control*-related parenting constructs (e.g., parental control, family obligation, household stability; Kim-Spoon et al., 2017; McCormick et al., 2016; Telzer et al., 2013). Collectively, these studies of task-based activation reveal mixed findings between normative range parenting and threat responsivity, relatively consistent findings with goal-directed behavior, and consistent findings with behavioral control/inhibition.

3.4 | Functional connectivity (Table 3)

Only one included record examined how functional connectivity between brain regions was modulated by an experimental task (Gee et al., 2014), and three included records examined parenting in relation to intrinsic functional connectivity (Brauer et al., 2016; Degeilh et al., 2018; Graham et al., 2015), which assesses the strength of correlated activity between brain regions when participants are "at rest" or otherwise not engaged by an experimental task. Although small in number, these studies converge to suggest positive associations between maternal touch frequency and within-network patterns of intrinsic connectivity (Brauer et al., 2016) and negative associations between maternal caregiving quality and parental conflict and between-network patterns of intrinsic connectivity (Degeilh et al., 2018; Graham et al., 2015). It is possible that such associations are indicative of stronger communication between regions within networks supporting specific processes (e.g., cognitive control) but less efficient modulation in the ability of different networks to selectively engage or disengage as needed

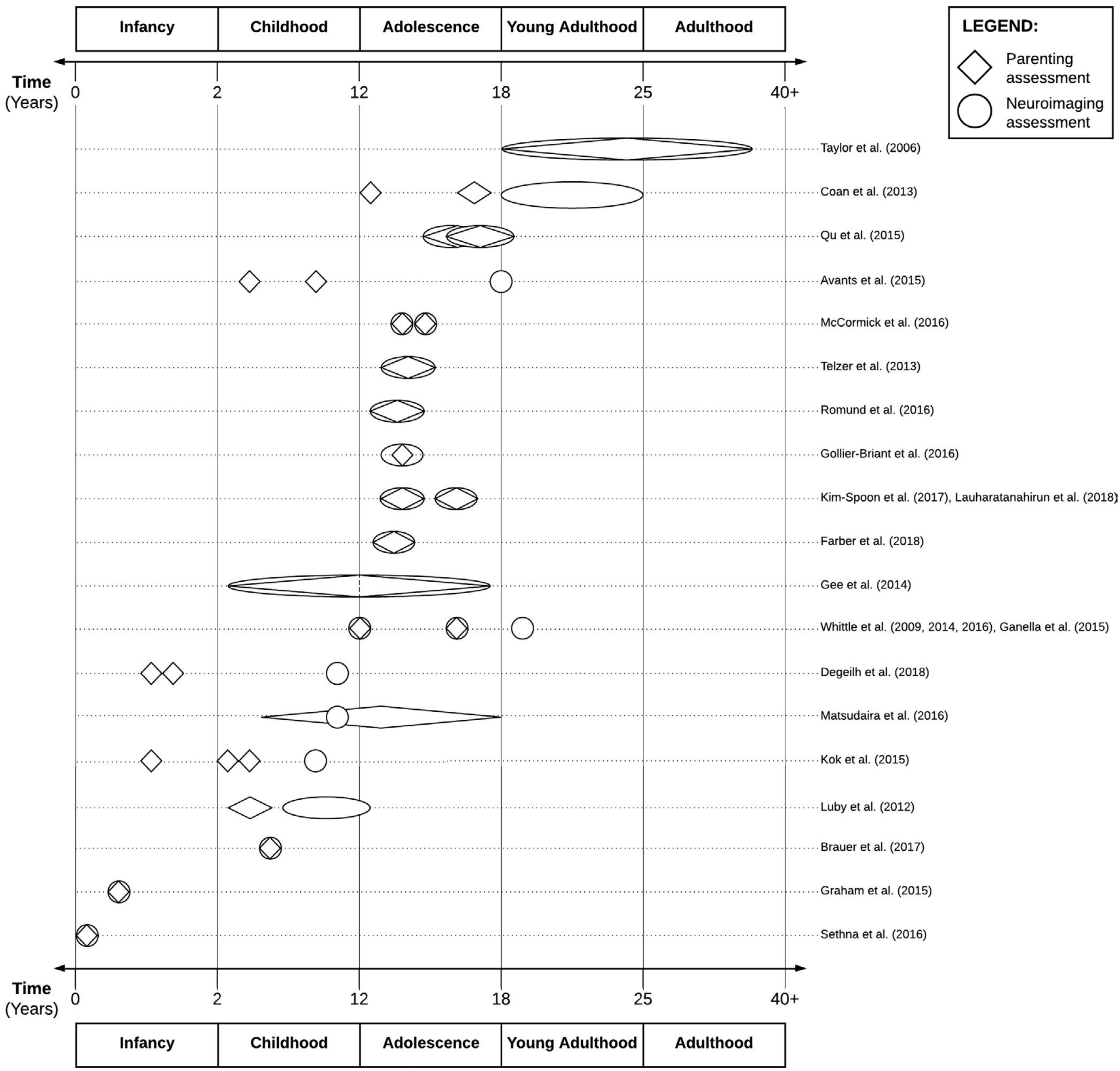

FIGURE 2 Timelines of measurement and data collection for all independent datasets (*n* = 19). The 23 included records reported on 19 independent datasets in total, as multiple studies utilized the same datasets. Each study timeline shows the range of child age at time of parenting assessment and neuroimaging assessment

(e.g., salience detection and cognitive control). As with studies of functional activation, such possibilities are speculative given the vast range in study methodology. Moreover, the varied age ranges at the time of scanning further limit the ability to draw clear conclusions from these findings.

3.5 | Brain structure (Table 4)

Eight included records explored parenting in relation to volumetric estimates of brain structure (Ganella et al., 2015; Kok et al., 2018; Luby et al., 2012; Matsudaira et al., 2016; Sethna et al., 2017; Whittle et al., 2009, 2014, 2016), and four included records investigated parenting in relation to cortical thickness (Avants et al., 2015; Kok et al., 2018; Whittle et al., 2014, p. 201; Whittle et al., 2016). No studies utilizing DTI to assess white matter structural integrity met full inclusion criteria. With regard to volumetric measures, some studies reported positive associations between higher parental care and brain volume, while others reported negative or non-significant associations. As with the functional data, it is difficult to determine the extent to which these inconsistencies are due to the broad age range across records (3 months–19 years) and/or different methods of indexing parenting and brain volumes. The associations between parenting and cortical thickness appear similarly mixed. Some studies reported a positive association between higher parental care and cortical thickness, while others reported that care is associated with greater thinning of the cortex over time. Again, varied methodologies across a small number of studies obscure the nature of these inconsistencies.

4 | DISCUSSION

Research on extreme deviations in early life caregiving has provided valuable insight into the effects of early adversity on brain development and risk for psychopathology. However, much has remained unknown about the impact of normative range variation in parenting on these same processes. The goal of this paper was to review available studies examining associations between normative variation in parenting style and behavior and both brain function and structure. This paper provides the first step in this process by conducting a scoping review to clarify the need for a more detailed systematic review. We identified 23 studies, which varied widely in terms of research question, methodological approach, and findings. Likely because of this variability and the small number of studies, clear links between parenting and the brain were not identified. Rather, the current state of research necessitates a discussion of possible limitations to progress and formulation of recommendations for facilitating future research that may more clearly establish links between normative parenting and the brain.

4.1 | Limitations of existing research

What is striking from this review is not only how few studies have explored associations between the brain and normative range parenting, but also how little methodological consistency exists across these studies. With regard to parenting, studies varied in: (a) number of assessments, (b) age at assessment(s), (c) parent(s) assessed, (d) method of assessment, and (e) construct assessed. With regard to the brain, studies varied in: (a) number of assessments, (b) age at assessment(s), (c) type of neuroimaging acquired, and (d) approach to data analysis. Studies also varied in sample size and covariates. Methodological diversity is not necessarily a limitation—indeed, parenting is incredibly complex and should be studied in all of its multifaceted complexity. However, it is worth noting that such methodological diversity within an already limited body of existing literature both makes attempting replication difficult and helps explain the absence of consistent findings at this time. As Marek et al. (2020) noted in their recent preprint advocating for very large samples to identify true brain-behavior associations, it will remain difficult to make clinically relevant progress unless we can combine across studies, which necessitates a finite set of measures. We next consider some specific limitations before outlining a potential path forward.

The first and perhaps most pressing barrier to a thorough investigation of this research question is feasibility, which we address in detail below in making recommendations for future research. Briefly, an ideal study design by which to assess the impact of normative range parenting on brain development would start with a population-representative birth cohort that is followed longitudinally over the lifespan with multiple data collection timepoints including neuroimaging data; structured clinical interviews of parent(s) and offspring; observed parent–child interactions; in-home interviews; child- and parent-reported parenting data; and genetic data from all family members. Suffice it to say that such a data set is not and will not be easy to come by. We certainly do not fault any authors of the included records for their research designs, which already are resource-intensive.

Second, publication bias may limit the available literature. It is theoretically possible that brain development is only impacted by caregiving at its most extremes, leading to the publication of only those studies examining the developing brain in relation to more severe variations in parenting such as trauma, abuse, or neglect. This would imply that the developing brain is robust to the influence of caregiving except in its most extreme forms, a possibility that seems unlikely given a vast literature on broader environmental influences on brain development (Belsky & Haan, 2011; Belsky & Pluess, 2009; Cicchetti, 2015; Tottenham, 2018) and the notable influence of normative range parenting on socio-emotional behavior and psychopathology (Ainsworth, 1969; Baumrind, 1967; Bowlby, 1958; Darling, 1999; Maccoby & Martin, 1983; Power, 2013). We appreciate the substantial barriers to publication, particularly in the case of null findings. Nevertheless, recent trends in the field toward open science and preprint publications make the present an apt time to revisit previous projects and make them publicly available in the service of advancing our collective understanding of this to date relatively unexplored question. To this end, we hope that researchers having measures of parenting and neurodevelopment will consider revisiting their data and publishing even null findings.

Relatedly, neuroimaging standards of practice are constantly in motion. From a technological and methodological standpoint, the field has advanced even in the time since many of the included records were published. While neuroimaging studies of 10–30 subjects were once accepted as the norm, issues of low statistical power and high false-positive rates have resulted in concerted efforts to increase sample sizes and attempt replication whenever possible (Lieberman & Cunningham, 2009; Vul et al., 2009; Yarkoni, 2009). Better acquisition protocols

TABLE 2 Characteristics and findings of records reporting associations between parenting and functional activity (n = 10). NR = Not Reported

	Study characteristics				Parenting assessment	
Study	**Cohort type**	***N***	**% Male**	**Race/Ethnicity**	**Age(s)**	**Assessment type**
Farber et al. (2018)	Community - high or low risk for MDD	232	50%	58% White, 26% Hispanic, 5% Black	13–15 years	Child-report
Gollier-Briant et al. (2016)	Community	685	46%	NR	14 years	Child-report
Romund et al. (2016)	Community	83	49%	NR	13–16 years	Child-report
Coan et al. (2013)	Community	22	50%	64% White, 36% Black	13 years; 16–17 years	Parent-report; Observed nteraction
Taylor et al. (2006)	Community	30	40%	NR	18–36 years	Child-report
Kim-Spoon et al. (2017)	Community	167	53%	80% White, 13% Black, 7% Other	13–14 years	Child-report
McCormick et al. (2016)	Community	20	65%	NR	14 years; 15 years	Child-report
Telzer et al. (2013)	Community	48	43%	100% Hispanic	14–16.5 years	Child-report
Lauharatanahirun et al. (2018)	Community	167	53%	80% White, 13% Black, 7% Other	13–15 years; 14–16 years	Child-report
Qu et al. (2015)	Community	23	35%	NR	15–17 years; 16–18 years	Child-report

(e.g., multiband) and preprocessing strategies (e.g., motion scrubbing) than those employed by many of the records included in this review are now available. Consistent findings across the available literature, albeit comprised of a small number of studies, may be lacking because of such methodological limitations.

Last, while we aimed to be comprehensive in our review of the literature, practical considerations required that we disregard a number of variables that could inform the research question of interest in meaningful ways. For example, we did not address the potential influence of genetics in the present review despite known genetic influences on both brain and behavior (Plomin et al., 2008; Rakic, 1988). Similarly, we did not explore the potentially bidirectional nature of parenting and the possibility that child temperament and parent temperament interact to influence parent behavior, which then influences child brain development. We also did not examine interactions between parenting and socioeconomic status, which is known to impact parenting (Roubinov & Boyce, 2017). Additionally, we did not explicitly investigate differences by race and ethnicity, which will be especially important for future work to explore given the known differences in parenting among families of varied racial and cultural backgrounds (Berger et al., 2005; Julian et al., 1994; Robinson & Harris, 2013). Genetic predisposition, child temperament, socioeconomic status, culture, race, and ethnicity, and family structure may moderate the relationship between parenting and the brain. Given the

		Neuroimaging			
Assessment focus	**Temporal window**	**Age(s)**	**Measure**	**Task construct**	**Findings**
Broad home environment	NR	13–15 years	Task activity	Threat/valence	Higher familial affective responsiveness + lower external life stress: lower amygdala reactivity to angry facial expressions
Broad home environment	NR	13–15 years	Task activity	Threat/valence	No significant association with family-related negative life events
Maternal only	Concurrent	13–16 years	Task activity	Threat/valence	Higher maternal warmth and support: lower amygdala reactivity to fearful facial expressions
Broad home environment; Maternal only	Concurrent	18–25 years	Task activity	Threat/valence	Higher maternal support: lower OFC, IFG, and left insula reactivity during exposure to threat with social support
Broad home environment	NR	18–36 years	Task activity	Threat/valence	Lower household chaos and conflict: lower amygdala reactivity to fearful and angry facial expressions + increased right vlPFC activity to emotion labelling
Both parents, combined, Broad home environment	Concurrent	13–14 years	Task activity	Control/ inhibition	Higher parental control + lower household chaos: higher neural cognitive control (i.e. low BOLD interference-related signal)
Broad home environment	Past month; Concurrent	14 years; 15 years	Task activity	Control/ inhibition	Higher family conflict + lower family cohesion: higher longitudinal increases in left vlPFC activity during cognitive control
Broad home environment	NR	14–16.5 years	Task activity	Control/ inhibition, Risk/reward	Higher family obligation: higher dlPFC activity during behavioral inhibition; Higher family obligation: lower risk-related VS activity
Broad home environment	Concurrent	13–15 years; 14–16 years	Task activity	Risk/reward	Higher parental knowledge + lower household chaos: higher insula activity during risk-processing
Both parents, combined	Past month	15–17 years; 16–18 years	Task activity	Risk/reward	Higher parental support and child disclosure + lower conflict: higher longitudinal decreases in VS reactivity to rewards

limited number of studies otherwise identified, however, we think it is premature to integrate such variables in examining links between normative parenting and the brain.

Finally, it is important to note that all stages of data screening and analysis were conducted by a single reviewer (MJF), which naturally leaves results vulnerable to bias. The sole reviewer's methods were rigorously scrutinized by both co-authors as well as other collaborators (see acknowledgments). Moreover, following the PRISMA guidelines for a scoping review further limits potential bias by providing discrete search parameters. Nevertheless, these findings reported herein would benefit from independent evaluation—ideally with the inclusion of new articles having been published since this review was conducted.

4.2 | Implications

Despite these limitations, the relationship between normative range parenting and brain development remains a critically important area of study. It has long been demonstrated that the first two decades of life are vital in determining how the brain will develop to support behavior. Moreover, the extent of neural plasticity and associated capacity for change during these early years is unique to the lifespan; the brain is more susceptible to environmental factors—for better or for worse—during the first two decades of life than any other time period. Importantly, brain development is hierarchical and thus even small perturbations early in life can have broad effects later through a cascade of interrelated processes

TABLE 3 Characteristics and findings of records reporting associations between parenting and functional connectivity (n = 4). NR = Not Reported

	Study Characteristics				Parenting Assessment	
Study	Cohort type	*N*	% Male	Race/Ethnicity	Age(s)	Assessment type
Gee et al. (2014)	Community	23/30	40%	37.7% White, 32.1% Black, 15.1% Asian, 5.7% American Indian, 9.4% Other	4–10 years, 11–17 years	Task condition, Child-report
Graham et al. (2015)	Community - oversampled for conflict	23	65%	82.6% White, 21.7% Hispanic, 17.4% Mixed/ Other	6–12 months	Parent-report, Observed interaction
Brauer et al. (2016)	Community	43	56%	NR	5 years	Observed interaction
Degeilh et al. (2018)	Community	28	40%	77.1% White	13 months; 15 months	Observed interaction

(Casey et al., 2019; Thelen, 2005; Tottenham, 2018). Through a better understanding of how normative range parenting is associated with changes in brain structure and function, we can leverage this knowledge to promote positive changes during periods in which the developing brain is most open to environmental influence. That is, strengthening parenting in the first two decades of life holds the potential to create lifelong neural scaffolding for resilience.

The relationship between parenting and brain development has clinical implications. Mental illness across the lifespan is embedded within a broader family context. The salience of family context may be most readily apparent when treating child and adolescent patients, but the same is true of adult patients as well. A preschool-aged girl with anxiety requires active work with parents to extinguish learned fears and safety concerns. A high school-aged young man with anhedonic depression requires parent support to aid in successful behavioral activation outside of therapy. A middle-aged person with volatile romantic relationships requires exploration and understanding of how their upbringing contributed to their conceptualization of partnership. Regardless of a patient's age, clinical interventions nearly always involve the examination of patterns learned in early life within the home environment and among caregivers. Thus, deepening our understanding of how various parenting styles and behaviors impact biobehavioral outcomes is essential to optimizing mental health treatments.

The American Psychological Association (APA) last provided guidelines for parenting practices in 2012, encouraging parents to attend to and praise good behavior; ignore minor misbehavior and prevent misbehavior when possible; educate themselves on normative developmental milestones; implement consequences that are brief, calm, and immediate; teach children how to cope with demands; and take time for themselves (Novotney, 2012). While most of these guidelines remain true, they can be further refined and advanced by identifying trajectories of brain development associated with variability in normative range parenting that provide a foundation for understanding developmental biomarkers of risk and resilience, which can then be translated to work with patients and parents of patients across clinical contexts.

Such a foundation has implications at the policy level as well. An ongoing cultural narrative surrounds the notion of “helicopter parenting,” in which parents pay extremely close attention to their child's experiences and problems, often intervening before their child has an opportunity to handle the challenge independently. There is an increasing debate over the extent to which parental protection is beneficial to child development, and the point at which involvement veers into over-involvement. Indeed, some evidence suggests that overprotection can have negative consequences such as increased rates of depression and anxiety and decreased life satisfaction and general psychological well-being for children in certain circumstances (LeMoyne & Buchanan, 2011; Schiffrin et al., 2014). In a somewhat reflexive response to this style of parenting, others advocate for “free range parenting” (i.e., encouraging children to function independently and with limited parental supervision, in accordance with their age of development and with a reasonable acceptance of realistic personal risks) and “rewilding” (i.e., encouraging children to explore nature independently; Flynn, 2018; Outside Magazine & Online Editors, 2018; Prichep, 2018). Of course, most parents will fall in-between these extremes and express caregiving more consistent with the above-mentioned APA guidelines. Nevertheless, this debate continues and even has been raised within law- and policy-making. In 2018, Utah became the first U.S. state to protect free-range parenting by passing a state law changing the definition of

		Neuroimaging		
Assessment focus	Temporal window	Age(s)	Measure	Findings
Maternal only	NR	4–10 years; 11–17 years	Task connectivity	Viewing maternal stimuli: lower amygdala activity + more mature amygdala-mPFC connectivity in children
Both parents, combined	Since birth	6–12 months	Intrinsic connectivity	Higher parental conflict: stronger positive PCC-amPFC and PCC-amygdala connectivity
Maternal only	Concurrent	5 years	Intrinsic connectivity	Higher maternal touch frequency: stronger positive STS-dmPFC connectivity
Maternal only	Concurrent	10 years	Intrinsic connectivity	Higher quality maternal behavior (i.e. greater mind-mindedness, greater autonomy support): stronger negative DMN-SN connectivity

neglect (Flynn, 2018). In this and similar cases, law- and policy-makers are challenged with decisions requiring an appropriate determination of whether parents were too harsh or appropriately protective; too permissive or effectively supporting autonomy. There is a similar ongoing debate regarding the effects of family leave policy on child well-being (Bartel et al., 2018; Burtle & Bezruchka, 2016; Ferrante, n.d.). Such debates beg the question of whether the effects of parenting may be U-shaped in reality, such that extremely high *or* extremely low parental care or control has a negative impact, while striking a balance yields optimal outcomes. The scientific community can leverage evidence-based research to inform and advocate for policies that will yield optimal developmental trajectories, and such advocacy will benefit from increasing our understanding of how normative parenting affects the brain.

4.3 | Recommendations for future research

In light of these existing gaps in the literature and the clear need for improved understanding of the research question, we propose the following recommendations for the continued investigation of normative range parenting and brain development. First, we recommend a conservative approach to neuroimaging that emphasizes phenotypes readily collected in most studies and populations, such as high-resolution measures of brain structure (e.g., gray matter volume, cortical thickness, surface area, and fractional anisotropy) and intrinsic functional connectivity. Striving for such data harmonization will allow for attempts to replicate observed associations, which is critical for any clinically meaningful applications. Similarly, neuroimaging protocols should be administered to large samples providing adequate power to identify likely small effects and protect against false positives. Successfully translating research into the development of clinically meaningful biomarkers of risk or resilience is further dependent on establishing and employing measures with good test-retest reliability (Enkavi et al., 2019; Hedge et al., 2018; Nord et al., 2017; Plichta et al., 2012).

An equally conservative and thorough approach should be taken in measuring normative range parenting. In related research, a recent meta-analysis (Baldwin et al., 2019) found poor agreement between prospective and retrospective measures of childhood maltreatment. Similar discrepancies may be characteristic of retrospective versus prospective reports of normative parenting as well. Acquiring observational or in-home data continues to be the gold standard for gathering objective data of any kind, and parenting is no exception. However, it is reasonable to expect that, for most researchers, acquiring observational data on parent-child dyads will not be feasible. Moreover, as the expected sample size for neuroimaging studies grows, obtaining observational parenting data on a full sample of participants becomes increasingly difficult. In the absence of more objective parenting data, we recommend that researchers collect questionnaire data from as many family members as well as others familiar with the family dynamics (e.g., close neighbors, grandparents) as possible. Researchers can then combine these multi-informant reports to identify shared variance that may provide better insight into parenting than child- or parent-report alone. As many studies have questionnaire data available as rated by only one observer (i.e., child-report or parent-report but not both), researchers should take great care in interpreting and framing observed associations with brain development. Studies examining child-report as opposed to parent-report, or retrospective versus prospective measures, may be addressing different research questions.

TABLE 4 Characteristics and findings of records reporting associations between parenting and brain structure (n = 9). NR = Not Reported

	Study characteristics				Parenting assessment	
Study	**Cohort type**	***N***	**% Male**	**Race/Ethnicity**	**Age(s)**	**Assessment type**
Sethna et al. (2017)	Community	39	51%	82.1% White, 10.3% Asian, 2.6% Black, 5.1% Mixed race	3–6 months	Observed interaction
Luby et al. (2012)	Case controlled - preschool MDD versus. healthy	92	53%	NR	4–7 years	Observed interaction
Matsudaira et al. (2016)	Community	225	52%	NR	5–18 years	Parent-report
Whittle et al. (2009)	Community - oversampled for tempermental risk	113	51%	NR	11–15 years	Observed interaction
Ganella et al. (2015)	Community - oversampled for tempermental risk	91	54%	NR	12 years; 15 years	Observed interaction; Child-report
Kok et al. (2015)	Community	191	50%	NR	1 yr; 3 years; 4 years	Observed interaction
Whittle et al. (2014)	Community - oversampled for tempermental risk	188	51%	NR	12 years	Observed interaction
Whittle et al. (2016)	Community - oversampled for tempermental risk	166	51%	NR	12 years	Observed interaction
Avants et al. (2015)	Prenatal cocaine exposure, otherwise healthy	52	48%	100% Black	4 years; 8 years	In-home interview, Observational checklist

Last, a return to theoretical frameworks of parenting may be useful in building common ground from which researchers can investigate normative range parenting and the developing brain. Fifty years have passed since Baumrind (1967) originally proposed the three parenting style model that was later expanded upon by Maccoby and Martin (1983). Despite many decades of research, these remain the only parenting styles with a strong empirical basis (Power, 2013). Much of the challenge in synthesizing results across the records included in this review stemmed from the wide variety of parental constructs assessed. We think an increased focus on the specific dimensions of parental *care* and *control* will facilitate the convergence of research findings with meaningful implications for development and well-being. The Parental Bonding Instrument (PBI; Parker et al., 1979) is one example of a validated child-reported measure designed to assess care and control, but we encourage researchers to utilize tools appropriate to their specific research questions and data sets.

5 | CONCLUSIONS

Although the existing literature is limited and the path forward not without obstacles, the prospects for better understanding the associations between normative range parenting, brain development, and risk for psychopathology are promising. This review highlights studies that have attempted to delineate associations between normative parenting and brain development and finds encouragement in the existence of numerous data sets with the capacity to further explore these links. As importantly, there appears to be a growing interest in doing so. Moreover, the shift toward large-scale, open-source developmental data sets such as the Adolescent Brain Cognitive Development (ABCD; Casey et al., 2018) and the Lifespan Human Connectome Project-Development (HCP-D; Somerville et al., 2018) studies are poised to facilitate this research (Marek et al., 2020). Such data sets would be strengthened even further by adding explicit measures exploring parental

		Neuroimaging		
Assessment focus	**Temporal window**	**Age(s)**	**Measure**	**Findings**
Maternal only	Concurrent	3–6 months	Volume	Lower maternal sensitivity: smaller subcortical volume (males and females), Higher positive communication and engagement: smaller cerebellar volume (males only)
Maternal only	Concurrent	7–13 years	Volume	Higher maternal support: larger hippocampal volume
Both parents, combined	Concurrent	10 years	Volume	Higher parental praise: larger left posterior insulate cortex volume
Maternal only	Concurrent	11–15 years	Volume	Higher maternal punishing response: larger OFC and left dACC volume (males and females) and larger right amygdala volume (males only)
Maternal only; Broad home environment	Concurrent; NR	16 years; 19 years	Volume	Higher maternal dysphoria: increased pituitary volume growth over time
Both parents, separately	Concurrent	8 years	Volume, Cortical thickness	Higher parental sensitivity: larger total brain volume; Higher parental sensitivity: increased precentral, postcentral, caudal middle frontal, and rostral middle frontal gyri thickness
Maternal only	Concurrent	12 years; 16 years	Volume, Cortical thickness	Higher maternal warmth and support: reduced right amygdala volume growth over time; Higher maternal warmth and support: increased OFC thinning (males and females) and right ACC (males only) over time
Maternal only	Concurrent	12 years; 16 years; 19 years	Volume, Cortical thickness	Higher maternal aggression: decreased Nacc volume over time (males only); Higher maternal aggression: increased SFG, superior parietal lobe, and supramarginal gyrus thickness growth over time (males only)
Broad home environment	Concurrent	18 years	Cortical thickness	Higher environmental stimulation: thinner fusiform cortext and lateral inferior temporal lobe

care and control. Furthermore, since the time this literature review was conducted, several studies have been published which advance our understanding of associations among parenting and neurodevelopment (Farber et al., 2019; Hidalgo et al., 2019; Kopala-Sibley et al., 2020; Tiemeier et al., 2020). These publications further confirm the increasing interest in this research domain and provide further cause for optimism regarding exploring parenting as a means of delineating optimal developmental trajectories.

Our hope is that this review will not only illuminate the existing research examining this question, but also establish an agenda for advancing future research on how normative parenting shapes brain development. A foundation of developmental trajectories associated with caregiving extremes has been laid; we must now build a comparable body of work investigating trajectories associated with normative range parenting that is as comprehensive, systematic, and rigorous. In doing so, we have the opportunity to better understand how parenting can be leveraged to promote optimal brain development and ultimately mental health and well-being through clinical practice and policy.

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CONFLICT OF INTEREST

The authors declare no competing financial or other interests.

DATA AVAILABILITY STATEMENT

The data supporting the results of this paper are archived and publicly available via GitHub: https://github.com/mjfarber/MAP. Because this manuscript is a scoping review rather than an original empirical report, there are no relevant stimuli or computer code necessary to allow readers to reproduce the methodology discussed. The corresponding author (MJF) is available to answer questions or provide clarification regarding data and methods upon request.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

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