

Special Issue Article

Caregiver–child proximity as a dimension of early experience

Whitney Barnett, Clare L. Hansen, Lauren G. Bailes and Kathryn L. Humphreys 

Department of Psychology and Human Development, Vanderbilt University, Nashville, TN, USA

Abstract

Human infancy and early childhood is both a time of heightened brain plasticity and responsivity to the environment as well as a developmental period of dependency on caregivers for survival, nurturance, and stimulation. Across primate species and human evolutionary history, close contact between infants and caregivers is species-expected. As children develop, caregiver–child proximity patterns change as children become more autonomous. In addition to developmental changes, there is variation in caregiver–child proximity across cultures and families, with potential implications for child functioning. We propose that caregiver–child proximity is an important dimension for understanding early environments, given that interactions between children and their caregivers are a primary source of experience-dependent learning. We review approaches for operationalizing this construct (e.g., touch, physical distance) and highlight studies that illustrate how caregiver–child proximity can be measured. Drawing on the concepts proposed in dimensional models of adversity, we consider how caregiver–child proximity may contribute to our understanding of children’s early experiences. Finally, we discuss future directions in caregiver–child proximity research with the goal of understanding the link between early experiences and child adaptive and maladaptive functioning.

Keywords: caregiver–child; early experience; parent–child; proximity; touch

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As an altricial species, humans require caregivers for survival, and compared to nonhuman primates, the duration of time human offspring are dependent on their parents and other caregivers is substantially greater (Humphrey, 2010). This prolonged period of dependence on caregivers highlights the first years of life as a crucial time for development and underscores how variations in care during this period may affect children’s health and functioning throughout the lifespan. The necessary components for survival (protection from harm and provision of food, shelter, and clothing) require at least some degree of physical contact or closeness between children and those who care for them. In addition, expected experiences like the receipt of caregiver provided stimulation and nurturance, typically in the form of touch, play, and conversation, require close proximity between caregivers and children. The present review highlights research on caregiver–child proximity from multiple scholarly disciplines and seeks to highlight the importance of characterizing early caregiving experiences for later adaptive and maladaptive functioning.

The devastating consequences experienced by children in institutional care (orphanages) related to the absence of close contact with a caregiver in early life make clear that caregiving interactions are foundational to healthy development across domains. Children reared in orphanages, given the high child-to-caregiver ratios and rotating staff, tend to receive reduced responsive adult interactions and touch (Zeanah et al., 2008). Yet, some children in institutional care form secure attachment relationships with those who care for them (Smyke et al., 2010), indicating the possibility that even in

these depriving settings some children were likely receiving adequate attention from a reliable caregiver. Variation in the quality of caregiving interactions is not only found among institutional settings; children living in families range widely in their caregiving experiences. Of the over 600,000 U.S. children who have maltreatment reports each year, approximately 75% are classified as “neglect” (U.S. Department of Health & Human Services, Administration for Children and Families, Administration on Children, Youth and Families, Children’s Bureau, 2021), indicating that despite residing in families, many children experience supervisory, medical, and/or psychosocial deprivation. Assessing children’s physical contact with those that care for them is a crucial aspect of understanding their early environment.

In this article, we (briefly) review: (1) studies of caregiver–child proximity across disciplines (e.g., anthropology, clinical psychology, developmental science), (2) predictors of patterns of caregiver–child proximity, (3) child outcomes linked to variation in proximity with a caregiver, and (4) how proximity may be considered in relation to current conceptualizations of early experience, and specifically, dimensional models of adversity. Additionally, we highlight the breadth and variety of measurement methods applied to studying caregiver–child proximity (see Figure 1 and Table 1). Figure 1 provides a visual description of how measurement of caregiver–child proximity may be operationalized, specifically relating to assessments of close contact (e.g., infant carrying, duration carried), caregiver–child touch (e.g., frequency, duration, and quality of touch), and physical distance (e.g., caregiver–child distance during activities, frequency of “check-ins”). Table 1 provides details of proximity measurement (e.g., use of sensors to track spatial proximity, self-report measures of frequency of touch between parents and children) used in a selected sample of studies to illustrate the

Corresponding author: Kathryn L. Humphreys, email: k.humphreys@vanderbilt.edu

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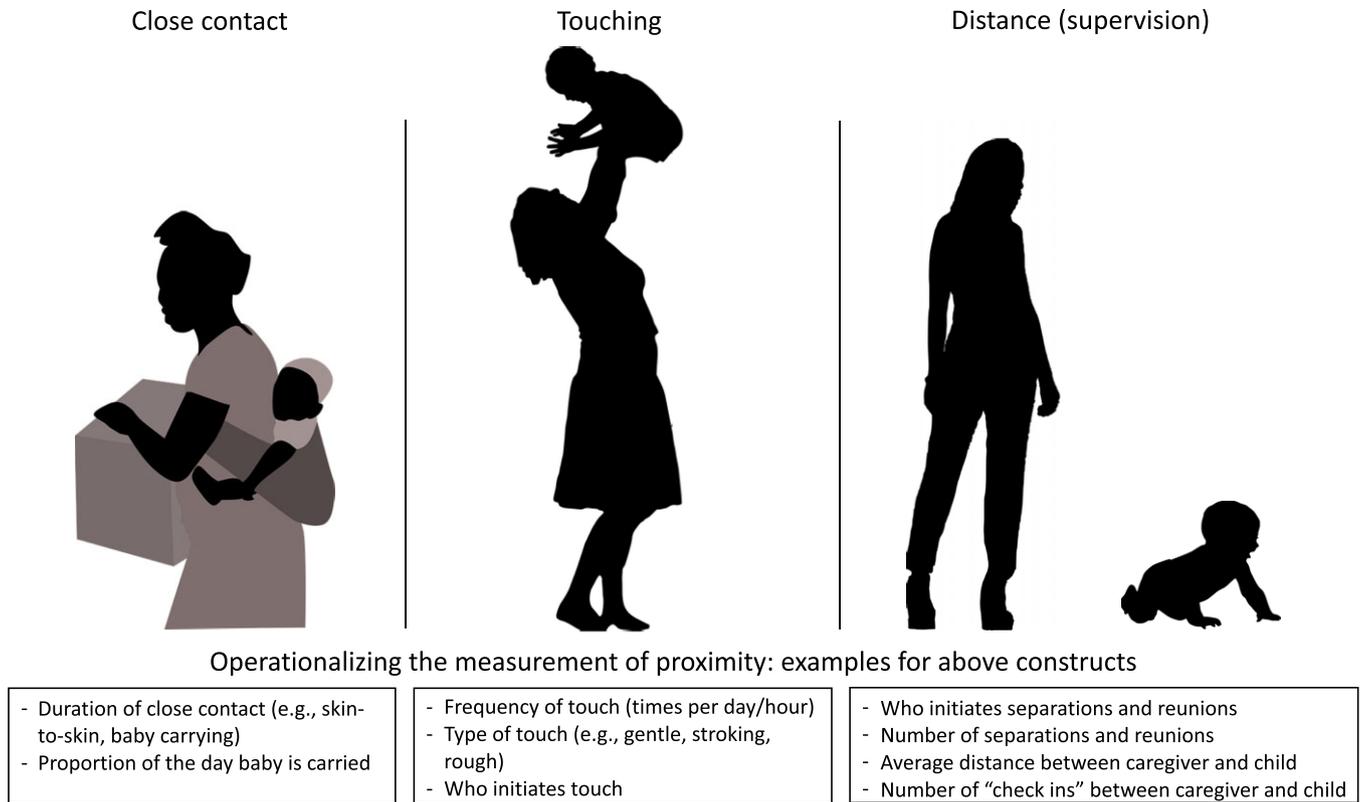


Figure 1. Approaches to operationalizing caregiver–child proximity. Common methods of measuring caregiver–child proximity include quantifying duration of close contact, baby carrying, or skin to skin contact; frequency of touching; distance between caregiver–child dyads; caregiver supervision of child.

breadth of measurement methods and highlight the variety of tools applied to assessing caregiver–child proximity.

It is important to note that the majority of literature identified in this review includes mother–child dyads. Though differences based on caregiver gender or relationship to the child is an important area of study (see future directions for additional discussion), when not discussing specific studies we use the term “caregivers” to be inclusive of biological parents (e.g., mothers, fathers) as well as other caregivers (e.g., adoptive and foster parents or other family members in a caretaking role). Given the breadth of literature on mother–child interactions, caregiving style, and breastfeeding, the review focuses only on studies measuring proximity (e.g., touch, distance). This review aims to highlight the relevance of caregiver–child proximity to the study of early experience and the importance of capturing variation in caregiver–child proximity for later adaptive and maladaptive functioning.

Contextualizing caregiver–child proximity within dimensional models of early experience

Situating early caregiving environments (including proximity) within dimensional frameworks enables us to test hypotheses about whether specific features of early caregiving are related to child outcomes. The majority of research studies on early adversity consider either a single type of adverse experience (e.g., physical abuse), group experiences like abuse and neglect together in a “maltreatment” category, or count up the types of events experienced using a cumulative approach (for review and discussion of frameworks of adversity, see [McLaughlin et al., 2021]). Dimensional models, an alternative approach, jointly consider

similar experiences along dimensions of severity to capture like forms of adversity (McLaughlin et al., 2021). The dimensional model of adversity (DMAP) focuses on threat and deprivation (McLaughlin et al., 2014), and has gained a growing body of empirical evidence (including from this special issue) that supports the use of a dimensional framework for linking early environmental experiences to specific outcomes. Another dimensional approach, developed by Ellis et al. (2009), characterizes environments along dimensions based on environmental harshness and unpredictability. Harsh environments, broadly defined as externally caused levels of morbidity-mortality, and unpredictable environments (i.e., variation in harshness over time), are theorized to be fundamental in influencing early development. Utilizing extant dimensional frameworks to characterize caregiver–child proximity emphasizes the importance of capturing both qualitative (e.g., type of touch, responsive care) and quantitative (e.g., frequency of touch, physical distance) aspects of proximity to better characterize children’s early caregiving environment along a continuum of lived experiences (e.g., enriched to deprived, harsh to nurturing, predictable to unpredictable).

In our view, variation in caregiver–child proximity most clearly aligns with the dimension of deprivation. Expected experiences like the receipt of caregiver-provided stimulation and nurturance (King et al., 2019), typically in the form of touch, play, and conversation, require close proximity between caregivers and children. Conversely, the absence of close caregiver–child proximity is most strikingly observed in studies of children in institutional care; care associated with devastating consequences for later functioning (Goldman et al., 2020; van IJzendoorn et al., 2020). In the following review, we present research characterizing caregiver–child

Table 1. Example cases to illustrate measurement approaches for assessing caregiver–child proximity

Citation	Method of proximity assessment	Child age	Main proximity findings
Egmore et al. (2019)	Mother–infant interaction videos and motion capture system (8-camera optoelectronic registration system) were used during 10 min videos of face-to-face interaction. The motion capture system used markers placed on Velcro straps (for moms) or onto a hat and body stocking (for infants) at the head, wrists, elbows, and shoulders of both actors. Head distance and velocity of arm movement were captured in 1/60 s intervals. Variables examined included interpersonal distance (distance between mother and infant's heads), speed of maternal arm movement, and speed of infant arm movement.	Assessed at 4 months	Speed of infant arm movement and head distance were greater during negative infant affect (compared to positive). Speed of arm movement in mothers with depression was slower than in mothers without depression, possibly limiting maternal engagement with infants of mothers with depression.
Guida et al. (2021)	Mother–Infant Interaction Kinect Analysis (MIKA) was used to characterize baby position relative to caregiver, movement, and initiation of approach/separation by mother or child. MIKA uses RGB-D sensors based on the coupling of an RGB video camera with an infrared depth sensor. This approach enables extraction of skeleton data to detect positioning and body movements (i.e., position of arms, trunk, head, and legs). Automated quantitative data of both mother and child positioning and movement were recorded, including tracking spatial proximity or distance and the dynamic flow of interactions. Measures included distance and velocity of approach and separation, proportion of initiation of approach or separation by mother and child and distance during these.	Assessed at 34 months	Changes in interpersonal distances between caregiver–child pairs across specific conditions (i.e., a free play session, a task-oriented activity, and an emotionally arousing condition) suggests that patterns of interpersonal distance may (at least partially) depend on the interaction context.
Koukounari et al. (2015)	Parent–Infant Caregiving Touch Scale (PICTS), is a parent self-report questionnaire measuring type and frequency of caregiver–infant touch. This 12-item measure asks about the following touching behavior: how often the mother stroked her baby's back, head, tummy, arms, and legs, and how often she picked up, cuddled, rocked, kissed, held, talked to, watched or left her baby to lie down. Frequency is assessed on a 5-point Likert scale with the following options: Never; Rarely; Sometimes; Often; A Lot.	Assessed at 5 and 9 weeks, with follow-up at 7 months	Three factors for the PICTS were identified reflecting stroking, holding, and affective communication. These were correlated at 5 and 9 weeks. All three factors showed configural and metric invariance, indicating validity.
Salo et al. (2021)	Wearable, infrastructure-free device measuring interpersonal distance (TotTag); TotTags are small (78 mm × 48 mm × 20 mm; 58 g), wireless devices that provide proximity data using ultra-wideband (UWB) radio signals, Bluetooth for connectivity and an SD card for data storage. To enable continuous measurement of distances, the TotTag performs ongoing “neighbor discovery” to capture distance between any two wearers of the device within range. This ongoing measurement results in a distance value for each pair for every second the devices are able to detect one another.	Assessed in children age 12–30 months	This pilot study found wide variability in caregiver–child distance within and across dyads. Proportion of time spent in close proximity (<3 ft) was associated with child exposure to more adult words and conversational turns.

proximity along a dimension and associated child outcomes. Further discussion situating caregiver–child proximity within dimensional frameworks is presented at the end of this review.

Theoretical perspective across disciplines

Nonhuman primate research

Research on nonhuman primates has improved our understanding of caregiver–offspring relationships, underlying neurobiological processes linked to proximity, and the severe impact of caregiver separation on young offspring. In this section, we present results from studies across different species of nonhuman primates involving aspects of caregiver–offspring relationships related to proximity. A typical physical relationship for primate infants is full and continuous contact with their mother (Pryce, 1996). Although carrying behavior is varied across species,

caregivers in many primate species (e.g., macaques, titi monkeys, squirrel monkeys, and chimpanzees) maintain tactile bonds and engage in significant carrying behaviors with their infants (Ross, 2001). Seminal work by Harlow (1958) found that caregivers are necessary not only for the provision of sustenance, but also for providing physical support and nurturance to infants. Compared to human infants, most nonhuman primates are born with relatively developed motor skills, which allows them to engage in grasping behaviors and cling to their mother's fur within minutes after being born (Ross, 2001; Trevathan & McKenna, 1994). Some have speculated that the relative infrequent crying observed in mammalian infants is due to their ability to maintain closeness to their mothers (Esposito et al., 2013). Thus, for nonhuman primates, the ability to maintain closeness is not solely determined by the mothers' specific and overt actions, but also by proximity seeking in their infants.

Changes in proximity across developmental stage in nonhuman primates

Across species of nonhuman primates, differences in caregiver–offspring proximity can be seen as responsive to age and developmental stage of the offspring. As marmoset infants age, parents (mothers and fathers) initiate separations, which encourage socialization and development (Ingram, 1977). For example, initiating times of physical separation may be deliberate for marmosets, who, at around the third week of life, gradually begin to place their infants on tree branches and move away for short periods of time (Ingram, 1977). This behavior increases until, at around 6 weeks of age, the infant marmoset becomes comfortable climbing off their caregiver and inducing separations and reunions on their own (Ingram, 1977). However, despite marmoset infants experiencing a shift from wearing (e.g., infant traveling on its mothers back) to nonwearing (e.g., infant independent locomotion) parents continue to maintain supervision over their infants, as parents restrict their offspring’s movements and retrieve their infants if they travel too far away (Ingram, 1977). In macaque infants, as they gain more autonomy in movement, mothers closely supervise their infants and demonstrate protective behaviors (Hinde & Spencer-Booth, 1967). Controlled separation, characterized by allowing infants to move independently and explore their environment with continued maternal supervision, promotes infant independence and development.

Costs and benefits to maintaining proximity

It is important to consider that there are costs and benefits to maintaining constant close contact. For example, closer proximity improves feeding for the infant, whereas greater distance provides more opportunities for the mother to complete her own feeding activity (Altmann, 1980; Johnson, 1986). In baboons, as infants’ age, given the energy expended to carry infants, mothers begin to transition their infants from being carried constantly, to independent locomotion under the mother’s close supervision, with proximity between infant and mother increasing until the infants are around 8 months old, when they are old enough to feed independently and no longer rely on their mothers for survival (Altmann & Samuels, 1992). Mothers who carry infants orally or whose infants engage in fur-clinging (called “riders”), such as marmoset, langurs, and some strepsirrhine species, exude more caloric energy than species such as lemurs, aye-ayes, and marmosets, who leave their infants in nests parked in trees (called “parkers”). However, infant riders tend to have lower mortality rates than parkers, suggesting that there are some species benefits to the extra energy expenditure (Ross, 2001).

Separation and reunion in nonhuman primates

As nonhuman primate infants age, mothers spend less time engaging in constant proximity with their infants. Although patterns of behaviors may be species dependent, most nonhuman primate species engage in periods of mother–offspring separation, supervision, and reunions. Researchers have explored infant physiological and behavioral reactions to forced separation, characterized as maternal deprivation; though the duration of separation has varied considerably in experimental studies (for additional reviews, see Parker & Maestripieri, 2011; Zhang, 2017). This line of research has been crucial for highlighting the importance of close contact (Harlow, 1958), as it allows for causal assessments to be made about infants during the absence of caregiving. Even brief separations of primate infants from their mother can represent a severe stressor (Pryce, 1996). Separation reactions in Goeldi’s monkeys

includes a marked increase in motor behavior and activity of the HPA axis (Dettling et al., 1998). When the infant Goeldi’s monkeys were reunited with their mothers, their stress reactions were reduced, suggesting that parental separation may be a powerful stressor for them (Hennessy, 1986). Similarly, infant squirrel monkeys repeatedly separated from their mothers showed sustained high levels of cortisol and increasing agitated activity in response to separation (Coe et al., 1983). Even under separation periods of 3 hr, marked changes are noted in infant monkeys, such as lowered body temperature, hormonal stress responses, and cardiac arrhythmias (Coe et al., 1985). In a study of infant marmosets, those who experienced daily separation and deprivation of their parental caregivers exhibited increased stress responses and lethargic behaviors in response to reward systems (delivery of banana flavored milk following response to visual stimuli), behaviors similar to the symptoms of major depressive disorder (Pryce et al., 2004). Infant rhesus macaques who experience maternal separation can exhibit chronic behavioral repercussions, such as poor social skills, gaze aversion, self-injury, and huddling (Suomi & Harlow, 1972). Infant rhesus macaques separated from mothers for more than 1 week additionally showed “despair” behaviors (e.g., quiet, withdrawn state; Gunnar et al., 1981). Reactions to separation appear to first include attempts to locate and reunite with one’s mother (Hennessy, 1986). Following separation, infant squirrel monkeys exhibited more proximity seeking behavior with the mother upon reunion than monkeys who had not been separated (Hennessy, 1986), perhaps to reduce the risk for future separations. A wide range of physiological and behavioral responses, including increased proximity seeking behavior from infants, have been observed following forced separation of primate infants from their mothers, indicating the potency of separation as a severe stressor. Given the degree to which primate infants rely on their caregivers for survival (Esposito et al., 2013; Ross, 2001), these stress responses to separation seem to provide critical signals to both mother and offspring regarding the importance of maintaining a close physical relationship for survival.

In addition to studies of parental separation, researchers have also investigated how nonhuman infants function when they are raised without their mother using research designs including isolation, peer-reared, and other-adult reared contexts. Early work investigating rearing experiences looked at how isolation impacted infant development, specifically investigating total isolation (e.g., no visual, auditory, or tactile contact) and partial isolation (e.g., caged separately but with auditory and visual contact). These extreme manipulations appear to cause severe cognitive and emotional deficits, as well as self-injurious behaviors (Cross & Harlow, 1965; Harlow et al., 1965; Mitchell et al., 1966). Due to ethical concerns, isolation studies were stopped, and the focus turned to comparison of rearing approaches. For example, comparing mother-reared versus nursery-reared or peer-reared (Champoux et al., 1989; Clarke, 1993), and mother-reared versus surrogate-reared (Kraemer et al., 1991; e.g., use of an inanimate object or other “replacement” caregiver). These rearing histories appear to impact primate infants’ behavioral and physiological reactions to stress or separation. For example, rhesus macaque infants reared by their mothers respond to separation with protest reactions, while infants reared via an inanimate surrogate respond with a despair reaction (Kraemer et al., 1991). Rhesus monkey infants who were raised in a nursery setting, as opposed to a mother-reared setting, displayed higher cortisol levels at age 4 weeks (Champoux et al., 1989), whereas mother-reared rhesus monkeys had higher levels

of adrenocorticotrophic hormone (a hormone that stimulates the production of cortisol) following a stressful situation (caging transition) compared to peer-reared (Clarke, 1993); the peer-reared monkeys were physiologically less responsive to this stressful situation, possibly showing an inappropriate response to a stressful situation compared to mother-reared monkeys, underscoring the considerable influence of mothers on their infants' physiological regulation of stress. Additionally, there are also differences based on rearing condition among those not provided maternal care. For instance, surrogate-peer reared (which combines peer-rearing and a surrogate mother) macaques engage in more foraging behavior, more environment exploration, and less partner clinging than peer-reared infants (Brunelli et al., 2014). These studies provide evidence of a range of adverse outcomes in nonhuman primate infants that are not mother-reared, however, provision of some caregiving (e.g., peer-reared vs. surrogate/isolation) may represent an intermediate level of support on a continuum.

Human evolution

There are several species-specific features of humans, compared to living nonhuman primate species, that likely contribute to unique patterns of proximity between children and their adult caregivers. Human evolution involved several critical changes in body architecture, of which both pelvic changes associated with bipedalism and increases in brain size had consequences for early interactions between parents and offspring (Wall-Scheffler et al., 2007). The relatively larger adult human brain combined with pelvic changes resulted in an evolutionary compromise, necessitating smaller and less mature brains at birth (Trevathan & McKenna, 1994). Human infants are born with only 25% of their brain volume compared to 45% in chimpanzees (Fernandes & Woodley of Menie, 2017; Trevathan & McKenna, 1994). As a result, newborn human infants, relative to other species, are more vulnerable at birth and reliant on caregivers for an extended period of time for their survival. The evolution of fur-clinging or infant carrying across species enables the close physical support required for survival. For example, in nonhuman primates, fur-clinging has evolved several times independently, suggesting the evolutionary advantage of the infant being physically attached to its mother (Klopfer & Boskoff, 1979; Nakamichi & Yamada, 2009). In humans, adult carrying of infants may have emerged in relation to the gradual decrease in human body hair over the course of evolution (which prevents fur clinging) along with less developed motor skills at birth in human infants (Amaral, 2008; do Amaral, 1989).

Compared to practices such as infant parking, infant carrying has high energetic cost but has been used throughout human evolutionary history (Ross, 2001), indicating evolutionary advantages which recompense for the energetic expenditure (Berez et al., 2020). These advantages include reduced crying, body movement, and heart rate in infants while being carried, a phenomenon also seen in most mammalian species known as the mammalian transport response (Esposito et al., 2013). Close proximity aids other important components of human infant caregiving including feeding (Anderson & Starkweather, 2017). For example, in addition to breastfeeding, which requires proximity, the relatively late age at which permanent molar teeth develop in human children means that they are highly dependent upon caregivers for processing food to ease digestion (Sellen, 2007). In summary, human evolution led to greater offspring vulnerability in early life, relative to other primate species. The need for adults to feed, protect, and soothe

children requires prolonged proximate caregiving throughout infancy and early childhood (Pavard et al., 2007).

Infant development

As infants (age <12 months) develop, their relationship with their caregiver changes. As noted above, the presence of a caregiver is a species-expected feature of human infancy. Physical touch is a prominent component of early caregiver–infant interaction from birth and is believed to be fundamental to how children explore and interact with their environment (Gallace, 2012). Affective interpersonal touch, specifically slow, gentle touch (e.g., a hug or caress) likely promotes social and cognitive competencies in early development (Fairhurst et al., 2014; Tuulari et al., 2019; Walker & McGlone, 2013), including secure attachments (Sullivan et al., 2011). Attachment theory asserts that a behavioral system has evolved to keep infants close to their caregivers and safe from harm; a central tenet is that young children require a close relationship with a primary caregiver for social and emotional development (Bowlby, 1969). The attachment system is foundational for promoting survival of young infants, in part due to increased proximity to the caregiver, which better allows for infants' needs to be met. The relationships developed over frequent, regular interactions marked by caregiving that predictably meets infant needs are the foundation of attachment relationships. Attachment representations are characterized by expectations of the attachment figure as a source of support, and care, and early experiences with parental care guide children's proximity seeking behavior (Bowlby, 1973). In particular, attachments are characterized by two classes of behaviors: attachment behaviors and exploratory behaviors (Ainsworth & Bell, 1970), both of which have clear implications for proximity.

Attachment behaviors reflect physical closeness between caregivers and children, including proximity seeking behaviors. Exploratory behaviors reflect children's comfort leaving the attachment figure to explore the environment. In part, the comfort to leave the caregiver is facilitated by the child knowing that the caregiver will be within close proximity should threat emerge in the child's environment (i.e., should the attachment system be activated). Attachment theorists have used the "circle of security" to characterize caregiver–child proximity patterns (Powell et al., 2013). In this, caregivers serve as a *secure base* where children feel confident in exploring their environment because they trust that their caregiver will be able to provide a "safe haven" in times of need. During this environmental exploration, infants "check in" with their caregivers by either moving physically closer to them periodically or by visually checking in. In these interactions, uncertainty about the environment may prompt children to check in and danger triggers the drive to seek safety and close proximity to the caregiver.

Changes in caregiver–child proximity across developmental stages

Caregiver–child interactions, including the type of contact (e.g., gentle touch, infant carrying) and amount of time in close proximity, change dramatically over the course of the first months and years of life. The specific competencies of the developing child may be a central driver of this change. At birth, newborn infants are wholly dependent on their caregivers to meet all of their basic physical needs. Their frequent feeding and diaper changes require continual monitoring and physical touch by their caregiver. Infant

crying changes drastically over the first few months of life, peaking at, on average, 3 hr of crying per day when infants are around 6 weeks of age, and steadily declining to about 1 hr per day by the time infants reach 12 weeks (Kurth et al., 2011). In many cases, infant crying is primarily soothed by actions that require touch, whether that is feeding, removal of wet or soiled diapers or clothing, or being held and rocked. Especially during early stages of development, touch is a primary source of communication, conveying different meanings through the duration, velocity, and frequency of physical contact (Hertenstein, 2002; Kirsch et al., 2018). Caregiver playful touch has been shown to increase infant positive affect (Egmoose et al., 2018) and to calm infants in pain or discomfort (Bellieni et al., 2007). During early infancy (i.e., ages 0–3 months), infants do not discriminate between caregivers or show strong preferences for one caregiver over another (Ainsworth et al., 1978). However, this begins to change from 4 to 5 months of age as infants show preferences for familiar caregivers. At this age, infants visually seek out their caregivers and may get restless and exude cues (e.g., cooing, fussing) in order to achieve proximity with familiar and preferred caregivers (Ainsworth et al., 1978; Bowlby, 1982).

Additionally, caregivers define the structure of infants' physical environment through the wearing or physical placement of infants (e.g., what toys are available, amount of infant access). For example, childrearing practices involving touch impact the trajectory and timing of sitting; earlier independent sitting (e.g., by 5 months) is associated with caregiver exercise and massage of their infants (Karasik et al., 2015). Further, infants appear to walk sooner if mothers deliberately exercise upright skills (e.g., holding and allowing upright positioning, leg and foot movement) as part of a daily routine, compared to infants not exposed to this exercise (Hopkins & Westra, 1990). Similarly, comparing an exercise intervention group (parents instructed to provide stepping or sitting exercises to infants) to a control group (no exercise instructions), infants in the experimental group stepped more and sat upright for longer after 7 weeks of the intervention (Zelazo et al., 1993). In turn, the development of motor skills, such as sitting up or standing independently, as well as the onset of independent ambulation, affect the access children have to their environment by providing new or increased opportunities for interacting with objects and learning (Adolph & Franchak, 2017). Further, as infants gain locomotive skills, mothers no longer need to provide constant assistance during interactions, allowing infants to engage in greater self-directed behaviors (Thurman & Corbetta, 2017). When infants begin crawling, or other independent movement (e.g., scooting or creeping), they gain more control over their location and engage in more object and environmental exploration (see Campos et al. [2000] for a review) involving traveling greater distances from their mother, though mothers tend to remain within a close distance (e.g., within arm's reach) to supervise and provide support as their infants became experienced crawlers (Thurman & Corbetta, 2017). As infants reach ages 7–12 months, in addition to the development of independent ambulation (e.g., crawling and scooting), stranger weariness also emerges. Rather than just exhibiting restlessness in response to caregiver absence, infants actively seek out touch and proximity of familiar caregivers (Ainsworth et al., 1978; Tracy & Ainsworth, 1981), often clinging to familiar caregivers in the presence of unfamiliar people.

Around 11–12 months, clear-cut attachment to one or more caregivers is evident. Ainsworth et al. (1978), building upon Bowlby's theory of attachment (Bowlby, 1969), introduced the Strange Situation Procedure, a series of separation and reunion episodes between the caregiver and infant, which helped to

characterize patterns of behavior that reflect caregiver–child attachment classifications. The majority of infant–caregiver dyads (an estimated 60% [Moullin et al., 2014] of epidemiological samples of dyads in the U.S.) display patterns of *secure attachments*, such that the infant exhibits distress when their caregiver leaves as well as calms quickly after being reunited with the caregiver. A recent study reported that 25% of dyads are characterized as insecurely attached (i.e., insecure-resistant or insecure-avoidant classifications; Moullin et al., 2014). Dyads who are classified as insecure-resistant typically display behaviors that reflect infant anger at caregivers for leaving. These infants seek proximity with their caregivers upon reunion (e.g., asking to be held), but may also push their caregiver away while being held (Ainsworth et al., 1978). Dyads classified as insecure-avoidant are characterized by infants who appear not distressed by the caregiver's departure and who do not seek proximity with their caregivers during the reunion (Ainsworth et al., 1978). Patterns of proximity seeking are, in fact, a necessary component to making attachment classifications; though the quality of interactions during times of close proximity are also salient for forming attachment classifications.

Proximity changes associated with locomotion in children

As children transition to walking, they have even greater autonomy regarding their physical location, enabling frequent arrivals and departures from their caregiver. Walkers move more, play more, and interact more with mothers than do crawlers, and walkers travel three times the distance of crawlers (Karasik et al., 2014). The ability to walk both increases the distance (how far away) between child and mother while also changing their interactions (Karasik et al., 2011, 2014). Walking infants engage in more interactive bids with toys and mothers (Clearfield, 2011; Clearfield et al., 2008; Karasik et al., 2011), as well as explore their environments further. These moving bids are more likely to get a response from the parent and promote interaction between parent (mother or father) and infant (Walle, 2016). Further, child-initiated separations and reunions provide opportunities to activate the attachment system. Children who feel secure in exploring their environment may physically check-in with their caregiver who is close in proximity. Over time, the distance between children and their caregiver tends to increase (Karasik et al., 2011, 2014) and time spent apart or in independent activity increases (Melson & Kim, 1990). Thus, the developmental transition to walking requires a change in the pattern of proximity, as caregivers are tasked with engaging in new ways with their infant while maintaining supervision (and therefore some degree of physical closeness).

Although physical touch has been found to decrease as infants gain the ability of independent locomotion (Ferber et al., 2008), children and mothers interact more through gaze, vocalizations, and bids for attention, all requiring continued proximity, even as close physical contact decreases (Clearfield, 2011; Karasik et al., 2011, 2014). For example, as their children begin to walk, mothers are observed to engage in increased labeling, gesturing, and use of action words (Olson & Masur, 2011; Tamis-LeMonda et al., 2007). As noted by a review of parental supervision and child risk of injury, caregivers who provide direct attention (visual and auditory), stay within reach of the child and maintain this attention and distance (e.g., provide these continually) are most likely to ensure child safety (Petras et al., 2009). In summary, the nature of proximity and contact between mother and child in early development changes substantially with the acquisition of independent ambulation, with a significant impact on caregiver–

infant interactions. Assessing how children gain independence (e.g., whether children initiate more and longer separations from their caregivers vs. whether parents initiate fewer reunions) both across time and between families may be helpful for understanding the link between changes in independent exploration and increases in experience-dependent learning.

Potential predictors of proximity

While there appear to be universal aspects of human infancy and the caregiving behaviors required to survive, children's experiences vary widely. Caregiver-child proximity patterns are likely influenced by a wide range of environmental, societal, cultural, and personal influences. Here we focus on a few specific areas to provide examples of how these may impact or shape proximity, specifically, we discuss parenting across cultures, parental leave, and maternal psychopathology (specifically depression) in relation to caregiver-child proximity. We provide details (see Table 2) regarding the method of proximity measurement and definition used from a representative sample of studies related to predictors of proximity, including what outcomes or constructs were investigated in relation to proximity.

Cultural differences related to proximity

Culture (i.e., a pattern of beliefs and behaviors that are shared by a group of people that serve to regulate their daily living; Bornstein, 2012) influences caregiver cognitions that in turn shape caregiving practices (Harkness et al., 2007). Patterns of childrearing reflect adaptations to the society's specific setting, needs, and beliefs (Bornstein, 2012). Furthermore, practical (e.g., availability of infant equipment [bouncers; exersaucers]; Maudlin et al., 2012) and policy differences across and within countries (e.g., availability of paid parental leave or access to affordable, high-quality child-care; Bornstein, 2012; Clark et al., 1997; Gaias et al., 2012) also impact parenting practices, influencing the amount of time and types of interactions that occur in close child and caregiver proximity.

Cultural variation in infant carrying

One area in which cultural variation has been well-studied is in relation to infant carrying, and the influence of carrying decisions on close physical contact between infants and their caregivers. Although there are variations within cultures, in Western societies, infants are estimated to experience close physical contact with caregivers for approximately 2 hr of the day (Dotti Sani & Treas, 2016). In many non-Western cultures, infants have close physical contact with caregivers for the majority of their day (Hewlett & Lamb, 2009), specifically through long durations of caregivers carrying their infant on their body. This has been seen in many parts of Africa (Hewlett et al., 1998), Asia (Wu et al., 2017), and Central and South America (Conklin & Morgan, 1996; Lowe et al., 2016). For example, in Ghanaian culture, mothers wrap their infants onto their backs for most of the day (Kärtner et al., 2008; Keller et al., 2004; Owusu-Ansah et al., 2019); whereas other cultural practices involve carrying infants in slings, strapped to the front of the caregiver's body, including both forward and caregiver-facing positioning (Russell, 2014). The degree of early contact between mother and child is likely important to child outcomes, attachment styles, and caregiver-child relationships. For example, more close, physical contact between mother and child has been prospectively linked to secure attachment relationships (Weiss et al., 2000).

Equipment use and caregiver-child proximity

Furthermore, infant care methods and use of infant equipment in Western societies may help to explain the reduced time caregivers are in close physical contact with their infants relative to non-Western societies. For example, differences may arise from sleeping practices (reduced use of co-sleeping, i.e., not sharing a bed with caregiver) or infant care methods that are more prevalent in Western societies such as feeding of infant formula and use of infant equipment (Bigelow & Williams, 2020), which may reduce physical contact between parent and child. Studies have reported widespread use of infant equipment, for example, both at home and in childcare settings in the U.S. (Fay et al., 2006; Hallam et al., 2018; Siddicky et al., 2020). Use of bouncers, car seats, and infant swings can help to soothe and entertain children as well as allow caregivers to engage in other tasks (e.g., cooking, showering), thus providing a safe and convenient way for caregivers to continue daily activities made more difficult while holding or wearing an infant. However, such equipment increases distal forms of interaction between infants and mothers (e.g., vocalizations, expressions; Keller et al., 2009) and limits physical closeness (Little et al., 2019; Maudlin et al., 2012), with implications for caregiver-child interactions. For example, a study of 23 4-12-month-old infants and mothers found that mothers were more responsive to their infants' cues when they were worn on mother's body than placed in a seating device (Little et al., 2019). Thus, the use of infant equipment (more prevalent in Western cultures) likely impacts a range of caregiver-child interactions, including the amount of time spent in close proximity (both in terms of close physical contact and physical distance).

Cultural goals and caregiver-child interactions

Cultural goals related to desired developmental outcomes may additionally influence variation in interaction styles between caregivers and infants (Keller et al., 2004). Western cultures tend to encourage autonomy and independence, with caregiver-infant proximity characterized by parents often engaging in frequent verbal and face-to-face interactions with their infants. This style differs from parents in non-Western cultures, who tend to value social sensitivity and interconnectedness, where caregiver-child interactions are characterized by close physical contact and affective tuning between parents and infants (Tronick et al., 1987). Keller et al. (2009) investigated cultural models and parenting styles across three groups: finding that urban, middle-class families from Western communities (Euro-American, German and Greek; representing a cultural model of independence) practice more distal parenting styles, rural farming families with less formal education (Cameroonian and Indian; representing an interdependent cultural model) practice more proximal parenting, and non-Western urban families in communities that prioritize relatedness (Costa Rican, Chinese, and Indian; representing the model of autonomous relatedness) express a combination of distal and proximal styles (for further detail see Keller et al., 2009). Importantly, patterns of caregiving practices were not homogeneous within cultures as individual characteristics, beliefs, and parenting goals impact caregiver-child proximity within cultural groups. These differences in proximal versus distal caregiving behaviors are associated with differences in developmental outcomes. Infants exposed to more proximal caretaking have demonstrated early development of compliance and obedience as toddlers, whereas distal caretaking was associated with earlier development of self-recognition (Keller et al., 2004). Multiple studies have similarly found differences in caretaking behavior when

Table 2. Examples from literature investigating predictors of caregiver-child proximity

Citation	Region	Method of proximity assessment	Child age	Variables measured in relation to proximity	Main proximity findings and outcomes
Ferber et al. (2008)	Asia	A caregiving session (10 min mother-child video) was recorded. Coding was done using The Touch Scoring Instrument which records the frequencies of 9 categories of touch (e.g., rough handling, passive touch, stimulation) were micro-coded within 30-s frames.	Assessed at 3, 6, 9, and 12 months	Developmental trajectories of maternal touch and dyadic reciprocity	The amount of maternal touch of all forms, including stimulating, affectionate, and instrumental touch, decrease over the first year of life. The data also suggest that mothers who tend to touch more are likely to use all forms of touch more frequently than those who provide less touch. The frequency of affectionate touch predicted dyadic reciprocity.
Fogel et al. (1988)	Asia, North America	Videos (2 min) of maternal-infant face-to-face play in a laboratory setting, coding included touch (e.g., touch, stroke, tap, reposition infant) and two derived variables were created – proportional duration (percentage of total time) and rate per minute (frequency per total time).	Assessed at 3 months	Maternal expressiveness and infant response	American mothers displayed greater and longer gaze and vocalizations with their infants, while Japanese mothers engaged in closer proximity and greater expressiveness with their infants.
Keller et al. (2004)	Africa, Europe, South America	Mother-infant free play interaction videos were coded (at 3 months), coding was done across four parenting systems for each 10 s interval to assess rates of body contact, body stimulation, face-to-face interactions, and mutual eye contact. Final scores were a ratio indicating the percentage of 10-s intervals during which the behavior occurred.	Assessments at 3 months and 18–20 months	Cultural differences in parenting styles and child self-regulation and self-recognition	Interpersonal distance (comprised of body contact and body stimulation variables) was highest in Nso (Cameroon), lower in Costa Rican, and lowest in Greek mothers. Children who experience more proximal parenting (higher body contact and stimulation) tended to demonstrate more self-regulation at 18–20 months of age, whereas children who experience more distal parenting (greater face-to-face exchange and object stimulation) tended to demonstrate more self-recognition at 18–20 months of age.
Malphurs et al. (1996)	North America	Three-minute-long free play video with mother and infant. Touch was coded for each 10 s interval and categorize into three types based on frequency: negative (e.g., rough poking, rough pulling, or shaking), no touch (no contact or inadvertent contact such as adjusting baby's clothing), and positive touch (e.g., gentle stroking or playful touch).	Assessed at 3 months	Maternal depressive symptoms	Patterns and type of touch differed between mothers with depression and without depression as well as intrusive and withdrawn mothers. Specifically, intrusive mothers with depression demonstrated more negative touch toward their infants that the withdrawn mothers with depression. Mothers with moderate (vs. severe) depression showed more positive touch, with no differences noted for negative touch. Intrusive mothers without depression spent more time negatively touching their infant than the withdrawn mothers without depression and spent less time not touching their infants.
Mantis et al. (2019)	North America	Videos of Still-Face and Separation procedures were done and coded using the Caregiver Infant Touch Scale (CITS), which records 8 types of touch (e.g., stroke, pat, squeeze, shake) and their frequency. These coded categories of touch were later clustered in terms of affectionate/nurturing and playful/stimulating touch.	Assessed at 4 months	Type and frequency of touch in mothers with high versus low levels of depression	Mothers with higher levels of depressive symptoms engaged in less frequent touch following the still face period in the Still-Face procedure and displayed less playful or stimulating touch. Mothers with lower levels of depressive symptoms maintained stable levels of touching across both interaction periods.
Owusu-Ansah et al. (2019)	Africa, North America	Canadian sample: mothers were requested to provide 6 hr/day of skin-to-skin contact (SSC) during the first week of life, then 2 hr/day until 1 month. A control group was given no direction but both groups recorded daily how much SSC they provided. Ghanaian sample: women were encouraged during prenatal checkups to provide SSC and kept daily dairies of how much SSC was provided to infants through 1 month. Ghanaian mothers were divided into high and low SSC groups based on a median split of the amount of SSC reported during the infants' first month.	Assessed at 1 and 2 months (Canadian); 6 weeks (Ghanaian)	Responsiveness during the Still Face Procedure	In both Ghanaian and Canadian samples, infants across high/low and SSC/control groups showed the still face effect with their visual attention. Ghanaian infants with high SSC (but not those with low SSC) showed the still face effect with their affect, responding with smiles. Whereas Canadian infants showed the still face effect with nondistress vocalizations. Smiling reactions in Ghanaian infants may related to increased responsiveness of mothers related to increased physical proximity through SSC.

comparing distinct cultural groups, noting that German and American mothers respond to their infants primarily through vocalizations and facial expressions whereas Cameroonian, Japanese, and Kenyan mothers engage through physical touch and closeness with their infants (i.e., patting, kissing, hugging; Fogel et al., 1988; Kärtner et al., 2008, 2010; Richman et al., 1992). These differences in caregiving behaviors by cultural group may reflect cultural goals for infant development and norms within cultures, with implications for patterns of caregiver–child proximity.

Notably, even when comparing geographically similar cultural groups, distinct differences can be found in the infants' early care environment, often based on necessity or cultural practices (e.g., hunting communities will engage in more infant carrying because they are moving more frequently and over greater distances than in a farming community where infants can be left stationary within the caregiver's visual field). For example, when comparing African tribes from similar settings, caregiver–infant interactions in the Aka cultural group (hunter gatherers) are characterized by close caregiver–infant proximity through infant carrying, frequent feeding, and proximal touch (Hewlett et al., 1998). The Ngandu (farmers) infants tend to experience less physical touch and were picked up and held at approximately half the rate of Aka infants, but experienced more distal communication, such as smiles and vocalizations with their caregivers (Hewlett et al., 1998). Thus, although there are universal infant needs that dictate broad caregiving behavior (e.g., providing safety and nourishment) there are a wide range of behaviors that differ both within and across cultural groups, which are relevant to understanding differences in caregiver–child proximity.

Policies related to caregivers

Cultural expectations and state supported opportunities for parental leave and childcare are also associated with patterns of caregiver–child proximity. Policies associated with opportunities for parental leave and childcare are often closely tied to and interrelated with cultural norms and expectations. Attitudes can both inform and reflect policy (Manza & Cook, 2002). For example, paternity leave and longer periods of maternity leave are found in countries where expectations about division of childcare labor are more equitable (Li et al., 2021). Similarly, where incentives are offered for fathers to take paternity leave, a greater proportion do, which has been linked to more equitable domestic labor between mothers and fathers (Craig & Mullan, 2010). Among high income countries, the U.S. is unique in reduced likelihood of paid parental leave, offering less time off, and fewer federal policies in place that support new mothers (e.g., guaranteed paid leave, shorter periods of leave) than other industrialized countries (Plotka & Busch-Rossnagel, 2018). In Finland, for example, government programs offer options of federally subsidized day cares and both maternity and paternity leave, and 99% of all Finnish children are cared for at home by their parents for their first year of life, dropping to 40% at age five (Finnish Ministry of Social Affairs and Health, 2006). In the U.S., 53% of children under 1 year of age are cared for at home by their parents, dropping down to 27% for children aged 1–5 years (U.S. Department of Education, National Center for Education Statistics, 2019). The provision of relatively long maternity and paternity leave supports a home environment where infants have the opportunity to engage in close proximity to both parents, instead of primarily the mother, as is the norm in many countries

(Flacking et al., 2010; Gaias et al., 2012). Only approximately half of all countries make any leave available to fathers, and the majority provide less than 3 weeks (Heymann et al., 2017). Gender disparities in paid parental leave may reinforce the idea that women are primarily responsible for caregiving and studies have shown that fathers who take paid leave are more involved in childcare, not only during that leave, but later in the child's life, which may in turn influence cultural and gender norms of proximity between each caregiver and the child (Nepomnyaschy & Waldfogel, 2007; O'Brien, 2009). Public policies regarding paid parental leave can therefore either facilitate or hinder the availability of one or both parents to spend time at home with their children in early life. Such policies, related to and influenced by cultural norms about caregiving and gender roles, plausibly impact the potential for physical proximity and the quantity of time caregivers and infants spend together.

Maternal depression

Importantly, there are individual differences based on maternal or child characteristics that impact how caregivers or children may elicit or respond to proximity and touching behaviors. Here we focus on exploring these in relation to maternal depression. Major depressive disorder is a common psychological disorder characterized by mood, cognitive, and physical symptoms over at least a 2-week period (American Psychiatric Association, 2013). The lifetime prevalence of depression is approximately 8% of American adults (Brody et al., 2018); in a given year, 7.5 million adults living with children suffer from depression and an estimated 15 million children live in households with parents experiencing major or severe depression (National Research Council (US) and Institute of Medicine (US) Committee on Depression, 2009). One of the proposed mechanisms linking parental depression to more negative child outcomes is through caregiving behaviors (Gotlib et al., 2020), including altered tactile interactions. Previous research has indicated that mothers with depression exhibit more negative caregiving behavior (e.g., intrusive or withdrawn) and less positive caregiving behavior (e.g., responsive or sensitive; Field, 2010; Forman et al., 2007; Murray et al., 2010). Further, mothers with depression appear to touch their infants less often and with less affection (Ferber et al., 2008) as well as engage in more rough touching (e.g., poking, tickling, rough pulling; Malphurs et al., 1996) compared to mothers without depression. However, there is heterogeneity of touching styles in mothers with depression, as not all mothers with depression engage in over-stimulating or intrusive touch (Mantis et al., 2019). Different patterns of infant touch can also be seen from mothers who experience subclinical, transitional depressive symptoms following childbirth (e.g., “baby blues”). These mothers have been shown to give less stimulating and affectionate touch to their infants (Ferber, 2004). Infants of mothers with depression tend to touch themselves more often, perhaps compensating for a lack of touch or the more negative touch behaviors from their mother (Hentel, 2000; Herrera et al., 2004). These differences in caregiving interactions, specifically seen through altered tactile relationships between mothers with depression and their infants, illustrate the potential impact individual differences (e.g., depression) may have on caregiver–child proximity.

Though we only focus on specific illustrative examples, caregiving practices related to caregiver–child proximity (e.g., carrying behavior, touch, interaction style) are influenced by a wide range of societal, cultural, and individual differences.

Table 3. Examples from literature investigating caregiver–child proximity and child outcomes

Citation	Method of proximity assessment	Child age	Variables explored in relation to proximity	Main proximity findings
Anisfeld et al. (1990)	Random assignment to soft baby carriers (more contact) or infant seats (less contact).	Assessments 1 day after birth, at 2, 3.5, and 13 months	Maternal responsiveness, attachment security	Membership in the baby carrier group was associated with greater attachment security between mother and infant.
Dickstein et al. (1984)	Physical distance between mother and infant measured during mother–child interactions and coded (for each minute) on a 3-point scale representing (1) mother-child >2 feet apart (2) <2 feet apart, or (3) in physical contact.	Assessed at 19.5 months	Maternal referencing, proximity seeking	There was a negative association between referencing and proximity such that infants closest to their mothers referenced the least.
Smyke et al. (2002)	Comparison of three groups: toddlers in standard institutional care, toddlers in an institution “pilot unit” with a higher caregiver–child ratio, and toddlers in home settings with no history of institutional care.	Assessed in children age 11–70 months	Signs of disturbed relatedness	Children on the typical unit (standard care) had significantly more signs of disordered attachment than children in the other two groups.
Tanaka et al. (2021)	Assignment to more physical contact (mothers instructed to actively touch infant, e.g., holding, lifting) or less physical contact (mothers instructed to stay physically separate from infant, e.g., play peek a boo). Affectionate touch was a composite score based on frequency coding for type of touch in 30 s intervals from videos of mother–child interactions.	Assessed at 6–8 months	Social stimuli, social engagement with strangers, and object exploration	Those in the more physical contact group and infants experiencing more affectionate touch showed less evasive behavior to a stranger and more object exploration.
Williams and Turner (2020)	Assignment to high physical contact group (babywearing) or low physical contact group (reading assignment).	Assessed at 2–4 weeks old, follow-up at 7 months	Attachment security	Mother–infant dyads in the high physical contact group were more likely to have a secure attachment relationship and less likely to have a disorganized attachment relationship at the age 7 month follow-up, as compared to those in the low physical contact condition.

Outcomes related to proximity

Specific developmental experiences related to caregiver–child proximity, such as nurturing touch, or secure, physically close relationships, or conversely, absent or neglectful caregiving relationships, have implications for child functioning. Here we briefly review child outcomes associated with characteristics of caregiver touch (e.g., type and frequency), use of infant equipment, child separations from a caregiver, and children in institutional care to describe the adaptive and maladaptive outcomes related to specific experiences of proximity (or deprivation) in caregiver–child relationships. In Table 3, we provide details of a subset of illustrative studies investigating proximity and child outcomes, specifically how proximity was operationalized, age of assessment and the main findings.

Touch

The benefits of touch for a child’s development have been demonstrated in multiple research studies (see Table 3, which highlights specific examples, including methods used to operationalize proximity). The type of touch (e.g., massage or soothing touch and low versus moderate pressure) and frequency of touch between caregivers and children are differentially associated with child outcomes indicating that specific characteristics of touch, and not merely the act of touching, are significant. For example, low-weight infants who received moderate pressure touch compared to low pressure touch gained more weight (Field et al., 2006). Similarly, massage therapy appears to impact a range of physiological and biological processes and has been linked to improved growth and development in preterm infants, decreases in stress hormones, and increased immune function following massage (see review by

Field et al., 2010). Additionally, frequency of touch appears to be important and has been linked to exploration behavior, language development and brain structure. For example, a study comparing a high and low touch group, found that infants who experienced more frequent touch, specifically affectionate touch were more likely to engage in object exploration and to socially engage with strangers (Tanaka et al., 2021). Another study found that infant vocabulary word learning appeared to be facilitated when words were paired with caregiver touch (Seidl et al., 2014). Finally, in a study of 5-year-olds, frequency of maternal touch during a maternal–child interaction was associated with stronger connectivity of the posterior superior temporal sulcus and other nodes in the social brain (Brauer et al., 2016). Touch is not only a critical means of communicating openness, engagement, and warmth (Oveis et al., 2009), type and frequency of touch appear to be important for child physical and emotional development. For an in-depth discussion of touch, see reviews by Cascio et al. (2019) and Blackwell (2000).

Use of infant equipment

Use of infant equipment (e.g., bouncers, car seats, and infant swings), provides a convenient way for caregivers to engage in other activities, while keeping their child entertained and safe. Widespread use of these devices has been reported, particularly in Western settings such as the U.S. (Fay et al., 2006; Hallam et al., 2018; Siddicky et al., 2020), with implications for caregiver–child proximity, both increasing distance and duration of time spent apart (Little et al., 2019; Maudlin et al., 2012). The relative increase in the availability and use of infant holding devices or equipment (e.g., bouncers, highchairs) may impact rates of baby carrying/wearing in Western settings, with potential implications

for attachment. A small, randomized trial of women provided either infant carriers ($n = 23$) or plastic seats ($n = 26$) found late differential rates of relationships classified as secure by the time infants were 1 year old (83% vs. 38%; [Anisfeld et al., 1990]); the same study found that baby carrying was associated with less solo vocalizations and periods of crying, as well as later social smiling behaviors. The degree of early contact (i.e., amount of affectionate touch during feeding) between mother and infant is prospectively linked to secure attachment relationships (Bigelow & Williams, 2020; Weiss et al., 2000). Foundational to secure attachment is a physically close caregiver–child relationship, allowing for caregiver responsiveness to infant cues, for a caregiver that predictably meets their infant’s needs, for moderation of infant distress, and the provision of a secure base.

Caregiver–child separation

A recent review of caregiver–child separations (e.g., forced separation due to war, parent emigration for economic opportunities, parent death) highlights a link between child separation from their caregiver and a range of negative consequences, including cognitive, social-emotional, and mental health domains (Waddoups et al., 2019). Multiple studies have investigated type of separation (e.g., voluntary as in migration for work or where related to traumatic experiences for the child) and associated child outcomes (Waddoups et al., 2019). Outcomes experienced from differing experiences of separation may vary based on several factors, including the context of the separation (see Humphreys, 2019 for review). Differing factors that can influence related outcomes for the child include the length of separation (Loman et al., 2009), the nature of the family structure post separation, and the availability of an alternative reliable caregiver (Wiese & Burhorst, 2007), if the separation was voluntary (Valtolina & Colombo, 2012; Venta et al., 2021), and whether the separation is accompanied by a separate trauma (Bouza et al., 2018; Waddoups et al., 2019). For a detailed review of type of caregiver–child separation and associated outcomes, see Waddoups et al. (2019).

Child outcomes associated with institutional care

Children raised in institutional settings, specifically where caregiving and associated physical touch and responsive interactions are limited (Smyke et al., 2002), have exhibited higher risk for behavioral, emotional, and social problems (van IJzendoorn et al., 2020). While myriad negative outcomes are associated with exposure to institutional care, it is the lack of responsive care from a dedicated adult that is believed to be the primary cause of poor outcomes following orphanage care. Furthermore, while rates of psychiatric disorders are higher among those with any exposure, and prolonged exposure, to institutional care (Humphreys et al., 2015; Zeanah et al., 2008), children in institutional care are at particularly increased risk for disorders of disturbed relatedness (including reactive attachment disorder [RAD] and disinhibited social engagement disorder [DSED]; Guyon-Harris et al., 2019; Humphreys et al., 2017; Zeanah & Gleason, 2015).

Notably, a diagnosis of RAD is characterized by a departure from expected patterns of proximity seeking; children with RAD do not seek out or accept comfort when it is provided (Zeanah & Smyke, 2008). A diagnosis of RAD requires insufficient care in early life, making it one of the few disorders with a known environmental etiology (American Psychiatric Association, 2013). For DSED, patterns of proximity seeking are also altered, though

children with DSED seek out close contact with unfamiliar adults (American Psychiatric Association, 2013); some have termed this behavior “indiscriminate friendliness” (e.g., Chisholm, 1998). The neurobiological correlates of DSED are not well-known, though some speculate that increased proximity seeking with adults is adaptive when children have no strong primary relationships (Zeanah & Gleason, 2015). These outcomes are rare and are only found among children without access to a regular and at least somewhat responsive adult caregiver, leading to calls to promote children’s resilience to adversity by first prioritizing family placements and ensuring that caregivers are consistently available (Humphreys et al., 2021).

Summary of cross-disciplinary research

In summary, in the above review of caregiver–child proximity literature we aimed to discuss methods of characterizing caregiver–child proximity, predictors and outcomes of these patterns, and extant research related to caregiver–child proximity across disciplines. Across primate species and human evolutionary history, close contact between infants and caregivers is species-expected and required for survival, nurturance, and stimulation. In many primate species, mothers maintain close and continuous contact with their infant offspring to ensure survival. Studies of primate infant separations from their mothers have shown increased physiological markers of stress, behavior indicative of depression or despair and underscore the crucial biological need for the infant to maintain close contact with its mother. Though, similar to patterns in human caregiver–child proximity, physical distance between primate caregivers and their offspring increases with maturation as offspring become more independent.

As an altricial species, human infants are uniquely dependent on caregivers for feeding, nurturance, and safety, requiring a prolonged close physical relationship for longer periods of time compared to nonhuman primate infants, from birth and lasting for several years. Further, multiple caregiver behaviors related to proximity with their child (e.g., affectionate touch, provision of a secure base, soothing) are believed to be essential components for adaptive child functioning. Changes in caregiver–child proximity are both dependent on child developmental stage (e.g., increased distance between caregiver and child as children begin to crawl or walk) as well as help to mold developmental outcomes (e.g., increased autonomy in children of parents who practice more distal caretaking). Importantly, multiple studies have investigated variations in caregiver–child proximity (e.g., affectionate versus rough touch, distal versus proximal caretaking, infant carrying, children raised with or without a dedicated caregiver); these variations in caregiving have been shown to significantly impact child adaptive and maladaptive outcomes. More work is needed to better characterize these variations in care and understand how these may be situated within a dimensional framework as well as when and how aspects of proximity in caregiver–child relationships impact children.

Caregiver–child proximity within dimensional frameworks

Dimensional models of early experience, which consider children’s environments along dimensions of severity (i.e., low to high), provide a useful framework to understand the importance of characterizing children’s early environments along a continuum. For example, the DMAP (McLaughlin et al., 2014), which focuses on threat and deprivation, has clear relevance to studies that have

investigated children in institutional care. The devastating impact of deprivation (e.g., lack of a consistent, nurturing caregiver) can clearly be seen in studies of children in institutionalized care. Less clear is how (and at what point) features of caregiver–child proximity in relatively more typical contexts (e.g., within caregiver–child relationships where depression impacts touch) may be representative of deprived care and when this may impact child outcomes. The interactions that occur between children and their caregivers that are essential for typical and healthy development all occur when children and caregivers are within close proximity of each other (e.g., at least some level of responsive interactions; physical soothing when distressed). Thus, when caregivers and children are infrequently in close proximity, this may represent deprived care, though much work is needed to understand at what point infrequent proximity may impact the child and how. One approach to capturing the complexity of experience–outcome associations is described in the neglect–enrichment continuum (Humphreys et al., 2018; King et al., 2019), where the association between more input and healthy development may plausibly take on several forms. For example, consider the input of nurturing touch by a caregiver. Three potential models on the relationship between this form of touch and healthy or adaptive development include: (1) the threshold model, (2) linear model, and (3) diminishing returns model.

First, the threshold model is a binary characterization of caregiving as either neglectful or not neglectful, perhaps consistent with the “good enough” parent (Winnicott, 2002) perspective, and that children likely will have different outcomes, whether they received enough (or not) nurturing touch. Second, the linear model is characterized by a steady, linear trajectory between enrichment and healthy development. In this model, children are expected to benefit from experiencing greater amounts of nurturing touch, and that the benefits of more touch would be equivalent across the full range of experience. Third, the diminishing returns model proposes that the association between environmental enrichment and children’s healthy development is nonlinear, and changes based on the level of enrichment. Specifically, on the lower end of the continuum (i.e., greater deprivation), the association between environmental enrichment and healthy development is the steepest such that the per increment gain in developmental outcomes from increases nurturing touch would be more substantial than the same amount of change in nurturing touch at the higher (i.e., more enriched) end of the continuum. These models provide a useful theoretical framework to consider how experience–outcome associations may be characterized to better understand the influences of early experiences on child outcomes.

Given the broad ways in which proximity can be characterized, understanding critical points along the continuum is paramount to inform how (and when) proximity may adversely impact child outcomes. Further, how this continuum may translate to child functioning remains far from clear and may differ based on the operationalization of caregiver–child proximity. Perhaps due to difficulties in measurement, some researchers of child maltreatment have observed the relative “neglect of neglect” (see Dubowitz, 1994). This is particularly notable given that neglect leaves no visible marks or bruises but has a devastating impact. Key to characterizing a lack of care is the ability to understand what contact is insufficient, thus there is a need to define (and measure) what caregiving is “good enough” (Humphreys, 2019). Implicit in issues of measurement is understanding the quality of interaction (e.g., high levels of close caregiver–child proximity do not necessarily translate into positive interactions). Indeed, harsh and

threatening (and worse) caregiver–child interactions occur in close proximity. Notably, infants (<12 months) are at the highest risk for child maltreatment and fatalities (U.S. Department of Health & Human Services, Administration for Children and Families, Administration on Children, Youth and Families, Children’s Bureau, 2021), perhaps due not only to the high level of dependence on adults for survival, but also the significant demands and physical closeness required for meeting infant needs. Sadly, the types of injuries identified in autopsies following the deaths of maltreated children indicate that their parents are those most often responsible (e.g., shaken baby syndrome/abusive head trauma; [Antoniotti et al., 2019; U.S. Department of Health & Human Services, Administration for Children and Families, Administration on Children, Youth and Families, Children’s Bureau, 2021]).

Early caregiver–child interactions provide a roadmap, of sorts, for children as they navigate the larger world. The quantity and quality of the interactions shape children’s view of themselves with the goal of producing well-rounded individuals who are capable of surviving and reproducing in the outside world. The DMAP model discussed above (McLaughlin et al., 2014) is concerned with *how* these experiences may impact child development (see Ellis et al., *in press* in this issue for a more detailed discussion). Drawing from a life history theory, Ellis et al. (2009) propose a harshness/unpredictability model which describes *why* variations in caregiving may occur. This model proposes that environmental harshness and environmental unpredictability are two key dimensions of individual experience, influenced by evolutionary adaptations (e.g., “ancestral cues”) and ecological contexts (e.g., neighborhood quality, socioeconomic status), which shape the strategies that individuals employ when making decisions about resource allocation. These dimensions of harshness (externally caused levels of morbidity–mortality) and unpredictability (spatial–temporal variation in harshness) are proposed as important determinants of variations in caregiving behavior and as significantly influential for early development. For example, environmental harshness has been shown to impede or undermine high-quality caregiver–child relationships including proximity; parental effort (e.g., co-sleeping effort, time spent breastfeeding, parental responsiveness) was found to be lower in cultures higher in environmental hazards, such as pathogen stress, famine, and warfare (Quinlan & Quinlan, 2007). Conceptually, the DMAP model and the harshness/unpredictability model can be integrated to provide a more comprehensive understanding of the *how* and *why* of development (Ellis et al., *in press*), with implications for measuring proximity in caregiver–child relationships as it relates to deprivation (e.g., low cognitive stimulation) and for understanding why variations in proximity within caregiving relationships exist.

Future directions and conclusion

The expansive research on caregiver–child proximity across fields demonstrates the relevance of this topic to the study of early experience. Methodological challenges in assessing caregiver–child proximity limit our ability to measure the full breadth of these experiences to comprehensively characterize the child’s environment. Like with many difficult to operationalize constructs, there is little agreement on how to measure it, the timescales and child ages at which it should be measured, and which parties merit attention (see Tables 1–3 which demonstrate the breadth of proximity measurement across studies). Gaining confidence in the assessment is a necessary step in order to be more clearly able to

understand the effects of caregiver–child proximity on children’s adaptive and maladaptive outcomes. From a dimensional framework, where less proximity with a caregiver may be a marker of deprivation, lower levels of proximity between a caregiver and child, particularly early in life, may result in maladaptive outcomes. Nevertheless, evidence of increased autonomy among children whose parents practice distal forms of parenting (Keller et al., 2004) suggest that there may be trade-offs between caregiver support and independence, making it less clear whether a child’s response to lower support is adaptive versus maladaptive (and likely this depends on context; [Frankenhuis et al., 2020]). Further, probing these associations may require nuanced characterizations of the environment (e.g., understanding the relative and combined impact of physical distance, physical contact, quality of touch, proximity experiences across nonmaternal caregivers, cultural and individual differences and how each of these change over time and as a function of developmental stage and motor competencies). These questions are key to understanding children’s complex experiences and how these experiences influence child outcomes. There are many avenues for future research, including methodological and theoretical/empirical considerations, that we suggest may be useful to fill important gaps linking variation in early experiences to child functioning.

Methodological considerations for future research

Few studies employ multiple methods to assess proximity or touch, and methods vary greatly, making it difficult to generalize findings (see Brzozowska et al., 2021 for a review of research approaches to measure touch). The development of new methodological tools offers opportunities for research on caregiver–child proximity, enabling more efficient measurement of movement, distance, and touch (see Table 1 for description of measurement methods). Video interactions have long been a gold standard; however, these methods are limited in that they are intrusive and may impact naturalistic behavior. Video is often limited to specific environments (e.g., a laboratory setting or participant’s home), impacting the ability to record caregiver–child proximity and interactions in places that are more likely to evoke attachment systems (e.g., playground or park). New methods that measure interpersonal distance and are not limited to video-capture technology are critical for the progression of this area of research. Devices that facilitate recording of distance between caregivers, such as the MIIKA (see Table 1; Guida et al., 2021), provide opportunities for researchers to record nuances in caregiver–child proximity in a laboratory setting (recording multiple aspects of proximity including distance, frequency, and speed of approaches or separations). However, tools that precisely measure proximity in a laboratory setting may be difficult to use in more ecologically valid contexts (e.g., within caregiver homes or in childcare settings).

Methodological challenges to assessing proximity motivated our development of the TotTag (part of the SociTrack system; [Biri et al., 2020]). The TotTag, a small infrastructure-free, wearable device, uses time-of-flight technology to continuously measure physical distance between wearers within cm accuracy (Salo et al., 2021). This tool facilitates our ability to characterize children’s physical environments, specifically proximity relationships between children and multiple caregivers in an ecologically valid setting (e.g. while at home). Further, with such tools, we can characterize the lack of a physically available caregiver; filling an important gap related to early adversity given that assessing the presence of something (e.g., physical abuse) is much clearer than assessing

the absence of something (e.g., insufficient contact with a caregiver). This ability to better measure the lack of a physically available caregiver has clear relevance to studies investigating child neglect or differentiating levels of deprivation of children in institutional care.

Defining “caregiver” in caregiver–child proximity research

Most studies on caregiver–child relationships select a single caregiver (considered “primary”, though how that is precisely defined varies by study). It is understandable that researchers tend to focus on mothers, given that in most contexts biological mothers are the primary caregiver; in the U.S., a recent study found that mothers spend approximately three times more hours weekly on childcare compared to fathers (Schoonbroodt, 2018). Further, workload discrepancies have gotten worse during the COVID-19 pandemic (Petts et al., 2021). However, the proverb, “it takes a village to raise a child,” points to a truism that multiple adults (and sometimes older children) are responsible for the care of infants and young children. From this lens, understanding children’s contact with caregivers should be inclusive of multiple caregivers. A significant proportion of journal articles identified in our review of literature on caregiver–child proximity focused on mother–child proximity, with few considering other caregivers, including fathers. The focus on single caregiver interactions (usually mother–child proximity) has the potential to discount the influence of other caregivers (e.g., fathers, grandparents, babysitters, and early childcare professionals) on children’s experiences and related outcomes. Where some studies have included father–child proximity, results have shown few differences between mothers and fathers in terms of child touch or proximity. However, the differences found may be important to understand what implications this has for the parent–child relationship, and thus, for child outcomes. For example, one study found no difference in proximity between mother–child and father–child dyads, however, did find that fathers touched their children more often during a play-related storytelling task (Aznar & Tenenbaum, 2016). This is in line with research showing that fathers tend to be more physical, tactile, and playful than mothers (Power & Parke, 1983; Schoppe-Sullivan et al., 2013), and that when fathers spend time with their children, the primary activity is play (Bartanusz & Šulová, 2003; Bronte-Tinkew et al., 2008). A similar study found no differences in touch or proximity between mothers or fathers and their children within families, but did find higher frequency of touch and closer proximity in families whose infants had received kangaroo care compared to families whose infants had not (Feldman et al., 2003). The relatively few differences seen between mothers and fathers in terms of proximity may imply that inter- rather than intra-family differences are important. However, these studies still leave a significant gap regarding the impact of nonparental caregivers and families that are not similarly composed (e.g., same sex couples, single parent households or multigenerational households).

Family structures vary widely across cultures and contexts, and thus, only focusing research efforts on one caregiver may fail to fully capture children’s experiences. The prevalence of children living in multigenerational households is increasing (Pilkuskas, 2012). Inclusion of multiple caregivers is critical for answering lingering questions about the dynamics of caregiver–child proximity from a family-systems perspective (Brown, 1999). Additionally, it may be important to consider proximity dynamics of caregivers and children in daycares or preschools, where many children spend a considerable portion of time and where quality of care

impacts a range of child outcomes (Bradley & Vandell, 2007). In these settings and across caregivers within families, tools such as the TotTag are able to capture the proximity between multiple device wearers, allowing for assessments of behaviors when multiple caregivers are simultaneously present (relative to one-on-one interactions), how the presence of siblings may influence patterns of caregiver–child proximity, and generally how different families navigate childcare and supervisory responsibilities in their “village.”

Tracking longitudinal changes in caregiver–child proximity

Considering the time scale in which to assess the physical distance between a child and their caregiver could require nearly two decades of observation in order to cover the period from birth to adulthood, with potentially important exchanges like a gentle brush of a tear off a child’s cheek occurring in a single second. The relevant time scales, from seconds, minutes, hours, months, and years, make it difficult to study and most research takes place over a single brief laboratory visit. An important exception to this format is the work done by investigators in developmental science who have studied infants and parents across the transition from sitting to crawling and walking (Northrup & Iverson, 2019; Tamis-LeMonda et al., 2001; Walle, 2016). Though the primary focus on these studies is to examine changes in interactions as a function of motor milestones, they offer insight into how individual differences in interaction patterns, including across time, may have important implications for future work with caregiver–child proximity. Recently, Hoch et al. (2021), identified two patterns of mother–infant movement using automated video technology in the laboratory to track dyad movements during laboratory-based free play, a “mother-follow” pattern, characterized by infant-led movement where mothers followed and a “yo-yo” pattern where infant and mother movement brought them closer together and further apart in equal measure. Though this study did not include assessments about potential differences driving these observed patterns, the tools used in the assessment of caregiver–child interactions and ability to classify dyads based on these patterns suggests that patterns in caregiver–infant locomotion can be captured in real time and show unique patterns of proximity. In addition to tracking changes across development, longitudinal research is needed to better understand how (and when) proximity impacts children’s adaptive and maladaptive outcomes.

Finally, it is critical that future work considers how this interacts with other aspects of early experience caregiving (e.g., stimulating talk and play). Specifically, models of proximity that integrate multiple modes of stimulation may be important for characterizing how caregiver–child proximity represents another dimension of children’s experiences. Salo et al. (2021) documented a small positive association between exposure to adult speech and caregiver–child conversational turns while an adult was in close proximity (<3ft), indicating that while caregiver-involved forms of stimulation or enrichment are related they are far from interchangeable. Given that there may be unique contributions to child functioning of stimulation, characterized as cognitive versus emotional (King et al., 2019), assessing multiple forms of caregiver involvement may allow for better mapping of what aspects of interactions with a caregiver influence specific domains of functioning. It may also be useful to consider how caregivers respond to children when expressing distress versus nondistress (see Leerkes et al., 2012), as close contact during times in which a child is contently playing with some toys may be intrusive, whereas physical distance to the

child in response to their distress would be insensitive. This case illustrates that the degree of physical distance and contact is likely to vary based on context. Developing study designs that allow us to examine these possibilities, including outside of the lab and in children’s natural environments, remains an important step.

Conclusions

In summary, caregiver–child proximity is an important dimension of children’s early life experience. Given the foundational nature of early caregiver interactions, aspects of caregiver–child proximity may be important for the child’s development of adaptive and maladaptive functioning. Children reared in environments where proximate, nurturing caregiving relationships are lacking, seem to experience maladaptive functioning across domains. On the other hand, caregiving relationships where an adult functions as both a secure base to encourage independent exploration and a safe haven to welcome the child’s return promotes the development of attachment security, an important protective factor for long-term functioning. Methodological challenges have limited our ability to characterize the myriad aspects of caregiver–child relationships; however, technological advances provide novel opportunities to address this gap in knowledge. Improved understanding of how (and when) patterns of proximity between caregivers and children impact functioning requires research to comprehensively characterize aspects of proximity. This area of research holds promise to improve our understanding of how aspects of proximity relate to dimensions of early experience, most notably the neglect–enrichment continuum, and the influence of these early experiences on child outcomes.

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