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Sensitive Responsiveness and Multiple Caregiving Networks Among Mbendjele BaYaka Hunter-Gatherers: Potential Implications for Psychological Development and Well-Being

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Attachment theory postulates that there is a particular style of caregiving that, because of its interaction with our evolved psychology, is most likely to result in healthy psychological development. Attachment research has been criticized because most studies have been conducted with Western populations. Critics argue this has (a) overemphasized the importance of sensitive responsive caregiving and (b) limited our understanding of multiple nonmaternal caregiving (allomothering). Here, we analyze the extent of sensitive responsiveness and structural properties of allomothering networks among Mbendjele hunter-gatherers who reside in the Republic of Congo. Humans lived as hunter-gatherers for the majority of our evolutionary history, thus studying contemporary hunter-gatherers can offer insight into the caregiving children may be psychologically adapted to. Based on 12-hr focal follows of 18 children (0–4 years old; 10 male), we constructed caregiving networks across the domains of responding to crying, physical contact, interactive care, and proximity. Crying was virtually always responded to rapidly via comforting and never via scolding. Children received physical contact and care for the majority of the day. Allomothering accounted for 40%–50% of caregiving in each domain. While allomaternal networks were large, they were highly concentrated—the majority of a child's allocare was provided by just a few caregivers. Due to high caregiver:child ratios, "sharing" of caregivers was limited—a child typically had several allomothers who directed a majority of their allomaternal effort to him/her. These findings add to our understanding of the level and sources of sensitive responsive caregiving that children may be evolutionarily primed to expect.

Public Significance Statement
Children may be evolutionarily primed to expect exceptionally high levels of physical contact and care, swift soothing responses to their crying, and personal attention from several caregivers beyond their biological parents. Therefore, the provision of affordable high-quality childcare support, which goes beyond effective supervision, should be prioritized. Higher caregiver:child ratios and stability of key caregivers in nurseries and institutional care may be important for minimizing risks to well-being.

Keywords: sensitive responsiveness, hunter-gatherers, allomothering, childcare, attachment theory

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In recent years, there has been growing interest in evolutionary perspectives on child development, and the conditions (including caregiving) that children are psychologically adapted to. The concept of the expected human childhood describes the range of conditions that have been encountered frequently enough over our evolutionary history such that they have shaped our evolved psychological and developmental mechanisms (Frankenhuis & Amir, 2022). If humans have typically had plentiful access to some social or environmental resource throughout our evolutionary history, we may be "evolutionarily primed to expect" such access. That is to say, if an individual now experiences relatively lower access to that resource, this may result in the activation of evolved psychological responses associated with adversity (which may or may not still be adaptive); or if access is low enough, it may lead to psychological dysregulation. However, Frankenhuis and Amir (2022, p. 488) note their concern that the conceptualization of the expected conditions of childhood "has been untethered from, rather than anchored in, evidence from other disciplines, including history, anthropology, and primatology."

The idea that there may be a particular form(s) of caregiving that is harmonious with our evolved psychology and optimal for development is not a new one. It was popularized by Bowlby's theory of attachment, which remains a dominant theoretical paradigm through which the relationship between caregiving and psychological development is understood (Bowlby, 1969). Attachment theory posits that based on early life interactions with caregivers, primarily the mother, children develop secure or insecure attachments. Securely attached children carry trusting internal working models of others, seek closeness (proximity and physical contact) to their caregiver for comfort, but have the confidence to explore the environment knowing their caregiver will be available if required. Secure attachment is predictive of a vast array of positive outcomes across the domains of cognition, behavior, relationships, and mental health (Bowlby, 1988; Mikulincer & Shaver, 2012; Ranson & Urichuk, 2008; Sroufe, 2005). Sensitive responsive caregiving—the ability to notice, correctly interpret, and promptly respond to infant signals to effectively meet their needs—has been emphasized as essential for the development of secure attachment (Bell & Ainsworth, 1972; de Wolff & van Ijzendoorn, 1997; Dunst & Kassow, 2014; Mesman et al., 2018); and described by the World Health Organization (WHO) as a "requirement for healthy neurophysiological, physical and psychological development" (WHO, 2004, p. 1).

Research on attachment and sensitive responsiveness has been criticized because the vast majority of studies have been conducted in WEIRD (western, educated, industrialized, rich, and democratic) populations (Henrich et al., 2010; Keller et al., 2018; Schmidt et al., 2021). As such, most of this work has been centered around the mother–child relationship, or more recently the role of both biological parents (Ahnert & Schoppe-Sullivan, 2020; Dagan & Sagi-Schwartz, 2021; Howes, 1999). This is a major shortfall since nonmaternal multiple caregiving (allomothering) was normative for most of human evolutionary history, yet our understanding of its role in development remains limited (Dagan & Sagi-Schwartz, 2021; Kramer, 2010; Meehan & Hawks, 2013). Other critics have argued that this Western bias has overemphasized the importance of sensitive responsiveness, and generated a narrow conception of optimal caregiving which ignores the importance of cultural context (Keller et al., 2018; Vicedo, 2017). Therefore, understanding what particular form(s) of caregiving, if any, humans are psychologically adapted to requires research outside of WEIRD contexts.

Here, we study caregiving of infants and toddlers (0–4 years old) among Mbendjele hunter-gatherers who reside in the rainforests of the Northern Republic of Congo. We seek to partially address the aforementioned criticisms by examining the level of sensitive responsiveness, and how its provision is structured within multiple caregiving networks. Humans lived as hunter-gatherers for more than 95% of our species' evolutionary history (Kelly, 2013). Thus, contemporary hunter-gatherers can offer insight into the form(s) of caregiving that children may be psychologically adapted to (Chaudhary & Swanepoel, 2023). It is essential to stress that hunter-gatherers are not "living fossils," they are contemporary human populations each with their own unique history. It is only because their subsistence relies on hunting and gathering, as was the case for all human societies prior to 10,000 years ago, that they can be informative for understanding some aspects of human ways of life during our prehistory; they are not, however, "relics of the past" (Kelly, 2013). It is important to exercise caution when extrapolating from their lifestyles to the past. Even when it comes to subsistence, hunter-gatherers now have new opportunities unavailable to ancestral pre-Neolithic populations (e.g., access to iron for toolmaking via trade with nonforager populations), and face different challenges (e.g., bans on hunting endangered species) (Lewis, 2002).

Nevertheless, identifying discordances between hunter-gatherer childcare practices and those of well-studied WEIRD societies may still offer valuable insight into the factors which affect children's vulnerability to adverse psychological outcomes. Indeed, it has recently been argued that contemporary hunter-gatherers are valuable models in public health research, and such research has the potential to provide preventive health solutions (Chaudhary & Salali, 2022; Pontzer et al., 2018). Of course, it cannot be assumed that discordances always increase vulnerability to health problems, for instance in cases where psychological traits exhibit high phenotypic plasticity. Thus, studying hunter-gatherer caregiving represents an important first step in identifying discordances with WEIRD societies. In our discussion, we then refer to other psychological research that offers clues as to whether discordance effects likely exist.

It is also important to highlight that hunter-gatherer societies exhibit substantial diversity in their behavioral and cultural adaptations, so assumptions of uniformity are misplaced. However, given their shared subsistence, it is unsurprising that ethnographers have pointed out similarities in their descriptions of hunter-gatherer child-rearing practices, since these are salient when considered in contrast with non-hunter-gatherer populations (Konner, 2005). There are existing studies of caregiving styles in hunter-gatherers, the majority of which are restricted to a handful of societies, principally the Aka from the Central African Republic, the Efe from the Democratic Republic of the Congo (DRC) and the !Kung from Namibia (e.g., Hewlett et al., 1998; Konner, 2005; Tronick et al., 1987). In cases where comparable data from these societies are available, we refer to them in our discussion.

The Present Study

As described above, caregiving and development research has been criticized for its WEIRD bias. It is argued that this has led to the narrow view that sensitive responsiveness is always best, and also a poor understanding of multiple caregiving (Dagan & Sagi-Schwartz, 2021; Keller et al., 2018; Schmidt et al., 2021; Vicedo, 2017). The aim of this study is to further our understanding of the

levels of sensitive responsiveness and the structure of multiple caregiving networks that children may be adapted to. To this end, our analysis focuses on (a) levels of sensitive responsiveness to crying; (b) levels of closeness and close care; (c) multiple caregiving network structure with respect to (a) and (b). Below we outline in more detail how each of these analyses is relevant to our understanding of psychological development and well-being.

Sensitive Responsiveness to Crying

Sensitive responsiveness is argued to be a key to the development of secure attachment, and is associated with numerous other positive cognitive, social, and behavioral outcomes (de Wolff & van Ijzendoorn, 1997; Mesman et al., 2018). Responsiveness to distress has been demonstrated as more influential on these outcomes than responsiveness to other infant signals (Leerkes et al., 2012). However, debates around the optimal responsiveness to distress are longstanding and ongoing. Cross-cultural psychologists argue that sensitivity is not always the best, and societies respond to crying differentially for the achievement of culture-specific socialization goals (Keller et al., 2018). Even research in WEIRD populations produces inconsistent findings on the effects of leaving babies to "cry it out" (e.g., Bilgin & Wolke, 2020). It is also not uncommon for parents to worry that too much responsiveness can spoil a child, inhibit the development of independence, or lead to behavioral problems (M. A. Barnett et al., 2010; Burchinal et al., 2010).

Understanding patterns of hunter-gatherer responsiveness can shed light on how children may be evolutionarily primed to interpret different levels of, and approaches to, responsiveness, for example, as overwhelming, comforting, neglectful, and so forth. Here, we examine the rate, speed, and method of response to the crying of Mbendjele infants and, importantly, toddlers too since cross-cultural differences become more pronounced after early infancy (Keller et al., 2018).

Closeness and Care

The importance of proximity, contact, and interactive care is emphasized by attachment theorists (Anisfeld et al., 1990; W. Barnett et al., 2022; Dunst & Kassow, 2014; Harlow, 1958). They each help caregivers to develop a sophisticated sensitivity to a child's array of signals and an understanding of how different responses to these signals are received by the child (Anisfeld et al., 1990; Little et al., 2018). Moreover, it is the availability of proximity and contact that provides children with the trust that caregivers will be available when required, which is a key for the formation of secure attachment.

Studying hunter-gatherers can offer insight into just how much closeness and close interactive care (see Method section for definition) children may have been receiving for most of our evolutionary history. We analyze how much time Mbendjele infants and toddlers spend in proximity, physical contact, being held, and receiving close care from caregivers.

Multiple Caregiving Network Structure

The need to move caregiving and attachment research beyond the mother–infant bond toward an understanding of multiple caregiving networks has been increasingly stressed by developmental psychologists (Forslund et al., 2022; Thompson, 2021; van Ijzendoorn, 2005). Recent studies of paternal attachment have shown that attachments beyond the mother are possible, can be formed via domain-specific caregiving rather than requiring involvement in all aspects of care, and can be psychologically beneficial (Dagan & Sagi-Schwartz, 2021; Grossmann et al., 2002; Schmidt et al., 2021). Conversely, studies of children in institutional care suggest that exposure to too many caregivers can have negative outcomes for attachment, brain growth, and cognition (Bakermans-Kranenburg, 2021; van IJzendoorn et al., 2020). Other aspects of caregiver networks, such as low caregiver:child ratios in day care settings, have also been associated with adverse outcomes (Sagi et al., 2002). Our understanding of the structure of multiple caregiving networks, particularly those of intermediate size, and its effects on development remains limited (Bakermans-Kranenburg, 2021; Dagan & Sagi-Schwartz, 2021).

It is well established that multiple caregiving is a core human adaptation and extensive among hunter-gatherers (Hrdy, 2009; Kramer, 2010). However, there is little research into the structural properties of hunter-gatherer caregiving networks. Here, we construct domain-specific allomothering networks across the domains of responding to crying, physical proximity, physical contact, and close care. We analyze each network's size, caregiver:child ratio, level of caregiver sharing, and concentration of care (see Method section for definitions). We also highlight the demographic characteristics of the allomothers in each network, and whether they are genetically related to the child(ren) for whom they care. These analyses can help elucidate the number of caregivers, stability and diversity in caregiver identity, and caregiver:child ratios children may be adapted to cope with; and the extent of their need for personal attention.

Finally, we examine the combined contribution of allomothers across each caregiving domain. Support for mothers has numerous benefits for children such as reducing the risk of neglect and abuse, buffering against family adversity, and improving maternal well-being which in turn enhances maternal care (Larose et al., 2021; Morita et al., 2021; Wren et al., 2021). Identifying the relative involvement of allomothers can improve our understanding of the level of support mothers have typically had access to over human evolutionary history; and in turn how much support may be required to safeguard mothers, and their offspring, well-being.

Method

This study has full approval from the Ethics Committee of University College London (UCL ethics code: 3086/003). Informed consent was obtained from all participants (or their parents in the case of nonadults) either via a thumbprint or pen mark depending on which the participant was more comfortable with. Research permission was granted by the Republic of Congo's Ministry of Scientific Research. These data were collected between March and July 2014.

We report any missing data, include a table defining all the variables in our study, and describe all statistical analyses, why specific analyses were chosen, and why various analyses were not conducted. All analyses were conducted using R Version 4.2.1; social networks were constructed using the package igraph and visualized using the software Gephi Version 0.9; all other figures were created using ggplot2. Permutation tests were conducted using the exactRankTests package and Friedman's tests using the tidyr package. Processed data (anonymized summary data for each child) and syntax are available at

https://osf.io/e867b/. This study's design and its analysis were not preregistered.

Study Population

The Mbendjele are a subgroup of the BaYaka meta-population residing in rainforests of the Northern Republic of Congo. They are immediate-return hunter-gatherers—they do not store food and are highly mobile and egalitarian. Their subsistence relies on hunting, fishing, gathering, and honey collecting (Chaudhary et al., 2016). Hunting and honey collecting are principally carried out by men, and fishing and gathering by women. Prior to adolescence, children may collect easy-to-acquire foods such as fruits and mushrooms, and girls may accompany women on fishing and gathering trips. While some Mbendjele have become sedentarized and market integrated, the communities studied here remain mobile and forest-dwelling; though, forest products are sometimes traded for manioc, alcohol, and cigarettes with visiting individuals from neighboring Bantu populations (Knight et al., 2021; Salali et al., 2020).

The Mbendjele live in multifamily camps consisting of a number of huts in which nuclear families reside, with low average dyadic genetic relatedness between coresident adults (Dyble et al., 2015). Marriage is principally monogamous with some incidence of polygyny (Chaudhary et al., 2015). Camp size tends to vary from 20 to 80 individuals. On average, BaYaka women have just over six live births but child mortality is high. Infants are typically weaned between the ages of 2–3, but there is substantial variation.

Data Collection

The data presented in this study are derived from focal follow observations of 18 children (10 male and four weaned), ages 0–4 years old, living in three camps (see Figure S1 in the online supplemental materials for map). We chose this age range because we had informally observed that until approximately 4 years of age, children receive close hands-on interactive care rather than just supervision. Details on the age and sex of each focal child can be found in Table S1 in the online supplemental materials.

Focal Observations

Each child was observed for 12 daylight hours, split into three segments: morning (6 a.m.–10 a.m.), midday (10 a.m.–2 p.m.), and late afternoon (2 p.m.–6 p.m.). The three segments occurred on different days to minimize potential biases resulting from atypical days. For each hour, there was 45 min of observation followed by a 15-min break. Standard focal sampling techniques were employed—a child was observed for 20 s and then all relevant information was recorded during the subsequent 10 s (Altmann, 1974). The information recorded is listed in Table 1.

For several focal children, there were brief interruptions in observation, details of the duration of observation for each focal child can be found in Table S1 in the online supplemental materials. Even for children for whom there were no observation interruptions, data were only collected for nine of the 12 daylight hours because 15-min breaks were taken after every 45 min of observation. Thus for all children, regardless of whether there were any observation interruptions or not, calculations (e.g., time being held) were extrapolated from a proportion of observation time into an absolute number of hours over a 12-hr daylight period. For instance, if a child was being held for 4.5 of the 9 hr of observation, we present this as 6 hr of being held during the 12 daylight hours.

Aging

The Mbendjele do not keep track of their age in years. Age estimates were calculated for all members of the study population by creating relative age lists with the communities, as well as potential age ranges for all participants. The age ranges were based on dental development, whether their birth happened before/after a memorable event with a known date, and sibling birth others. This information was then integrated using a Gibbs sampling framework producing probability distributions for the age of each participant, which were then collapsed into point estimates based on the mean. For full information and a validation of this method, see Diekmann et al. (2017). We categorize caregivers into "life stage" groups—we consider them subadults if they are under 18 years old and do not have a long-term spouse with whom they share a household; postreproductive if they are older than 50; and adults if they do not fall into the former two categories.

Relatedness

We conducted genealogical and reproductive history interviews with all adults in each camp. Participants were asked to provide the name and sex of their grandparents, parents, parents' siblings, siblings, offspring, and spouse(s), including those that were deceased. Once these data were collected it was possible to determine the coefficient of relatedness for each dyad within each camp. Here, we consider a caregiver as genetically related if they share a coefficient of relatedness of $r \geq .125$ (e.g., a granduncle or first cousin) with the focal child.

Analysis

For each child, the information in Table 2 was extracted from the observational data. From this, we produced summary statistics, which are presented separately for children under 1.5 years old and those 1.5–4 years old. This division was chosen because many of the existing studies of hunter-gatherer caregiving are restricted to infants under 18 months (e.g., Hewlett et al., 1998; Ivey, 2000; Meehan, 2005; Tronick et al., 1987). However, we expect that allomothering likely becomes more important during late infancy and early childhood as children become less reliant on their mothers' milk. In our sample, up until 1.5 years of age infants breastfed at some point every waking hour, and after this age the frequency of breastfeeding gradually reduces.

Sample sizes were large enough to test for differences between the two age groups in crying responsiveness since these analyses can be conducted at the event level (each crying bout is treated as a data point). We used chi-square and proportion tests to analyze differences in the crying response rate, speed, method, and allomaternal contribution to responding across age groups. Given that only 18 children were followed, it was not possible to test for statistical differences between these age groups for the other variables which are at the individual level, for example, whether the mean time spent in physical contact with a caregiver was significantly different between children in the two age groups. Therefore, we conducted regressions examining the association of age (as a continuous variable) with all variables listed in Table 2 relating to closeness and close care; allomaternal

Table 1
Information Recorded During Focal Follow Observations

Variable	Notes
Child status	
Crying	
Awake	
Alone	No caregivers in proximity (within 3 m and eyeshot).
Any close care received + who provided the care	Close care is care that requires closeness and involves interaction with the infant (e.g., holding, bathing, and affection) such that it limits the caregiver's ability to engage in other tasks.
Carrying/holding	Carrying refers to when a carer is holding a child while walking.
Soothing	This typically takes the form of yodeling to a child while drumming on their back, but other behaviors such as rubbing a child's back would also be coded as soothing.
Medical/hygiene	For example, bathing a child or giving *bwanga* (forest medicine)
Breastfeeding	
Feeding	In addition to physically putting food in the child's mouth, here feeding also includes handing food to the child.
Physical affection	Kissing, hugging, or stroking.
Play	What constitutes play involved judgment of the researcher. Play could involve instruments such as spinning tops or throwing sticks or play without instruments such as "peek-a-boo" or hanging a child upside down.
Teaching	Teaching refers to instances where the caregiver is altering their behavior in any way to seemingly facilitate learning by the child. Teaching can range from verbal instruction to subtle changes in behavior to promote transmission of a skill, for example, intentionally cracking a nut very slowly to emphasize the motion, and doing so in a position at the center of a child's gaze.
Dressing	
Any passive care received + who provided the care	Passive care refers to any care which does not prevent caregivers from engaging in other tasks.
Proximity	A caregiver is considered proximate if the child is less than three meters away and within eyeshot. This variable captures instances when a caregiver is able to supervise a child and intervene if required.
Watching	The caregiver has focused their gaze on the child.
Physical contact	Any part of the caregiver's body is touching any part of the child's body.
Vocalizing	The caregiver is vocally producing any audible sound directed at the child.

contribution; and number of allomothers. For each regression, polynomials of age were tested as predictors and reported if they reduced the model's Akaike information criterion score. Despite the small sample size, we detected numerous significant age-related effects, nevertheless, these should be treated as preliminary.

Network Analyses

Relationships, or "ties," within a social system are often nonindependent; social network analysis permits a deeper understanding of relationships by placing them within the broader network context (Page et al., 2017; Pinter-Wollman et al., 2014). In turn, it is possible to go beyond analysis at the dyadic level and incorporate indirect connections (the relationships of the individuals whom you have relationships with) and higher-order relationships. For example, individuals A and B may have the same number of social ties with others, but A has ties with individuals who have many ties themselves, whereas the opposite is true of B. Higher-order relational information like this can have important implications for the operation of social systems and outcomes for individuals within them. Taking the example above, if the network represented ties between children and caregivers, despite A and B having the same number of caregivers, A may receive much less personal attention than B since A's caregivers are busy caring for many other children.

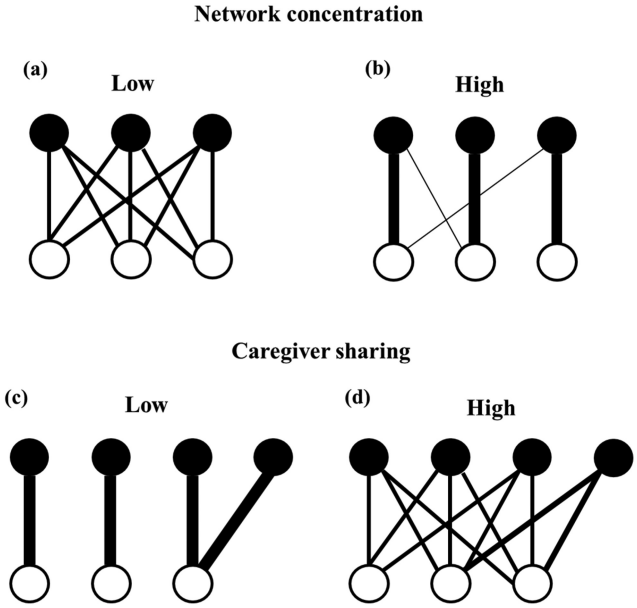
In social network analysis, individuals are represented as nodes, and ties between individuals as edges. Directed networks are those in which an edge is not bidirectional, for example, in a money lending network there is a donor and a recipient thus it may be important to capture the direction of this relationship. Weighted networks allow weighting of edges based on some property of the relationships, for example, edge weight could be proportional to the amount of money the donor lends the recipient. It is also possible to specify node and edge attributes, for example, the age of each node in a network, or whether an edge connecting two nodes represents a dyad living in the same versus a different household, and so forth.

We constructed domain-specific (responding to crying; proximity; physical contact; and close care) multiple caregiving networks based on the amount of care provided by each potential allomother to each focal child. This produced a total of 12 networks—Four Domains × Three Camps. Networks were directed (care could only be provided from potential allomothers to children), and weighted (the amount of care in each child-allomother dyad was integrated). Weights in the responding to crying networks were based on the number of each child's crying bouts each allomother responded to; the other three networks were based on the amount of time each allomother was in proximity to; physical contact with; and providing close care to each child. The node attributes specified in the networks were whether a node was a child versus allomother, age group (children only), sex (allomothers only), and life stage (allomothers only). The only edge attribute specified other than weight was relatedness status, that is, whether a child and allomother were related. All children over four were considered as potential allomothers, that is, we did not blindly exclude the possibility that they could provide care. Mbendjele children begin providing sensitive and responsive care as young as 4 years old, usually after the birth of a sibling (Mesman et al., 2018; Salali et al., 2019). When conducting our network

Table 2
Statistics Produced for Each Focal Child

Variable	Notes
Responsiveness to crying	
Time spent crying (minutes per day)	
Whether a crying bout was responded to	If crying events were separated by more than 2 min of no crying, they were considered separate bouts.
Speed of response to each bout (seconds)	
Method of response to each bout	The actions observed by the caregiver were coded into five categories: (a) comfort (soothe, hold, carry, and affection), (b) nurse/feed, (c) stimulate (play and vocalize), (d) attend to need (hygiene/medical or dress if either of these appeared to be the source of discomfort), (e) control (scold the child; command them to stop crying, restrict their behavior). These categories are very similar to those outlined by Kruger and Konner (2010). If there were two responses, for example, holding and affection, both were recorded.
Closeness and care	
Time spent alone (minutes)	
Time spent being held (hours)	
Time spent in physical contact with a caregiver (carer hours)	A carer hour accounts for the fact that occasionally there may be multiple sources of close care or contact simultaneously. For instance, if a child was being soothed by one carer while being fed by another carer continuously for a 2-min period, this would count as four carer minutes of close care.
Time spent receiving close care (carer hours)	
Multiple caregiving network structure	
Number of allomothers	A child's number of allomothers in each network. In network terminology, this is the mean "in-degree" of child nodes in the network—"in-degree" refers to the number of nodes that a focal node is connected to. This is calculated for each caregiving domain and each age group.
Allomother characteristics	Children's mean number of male and female; related and unrelated allomothers; subadult, adult, and postreproductive allomothers. This involves identifying the number of allomother nodes with the above attributes (sex and life stage) that each child node is connected to, and then calculating the mean across all children. In the case of relatedness, it involves identifying the number of edges with the attribute "related" that each child node has and then calculating the mean across all children. In the online supplemental materials, we also provide a more comprehensive multilayered breakdown—children's mean number of connections to allomother nodes that fulfill multiple attribute criteria, for example, being male (node) *and* subadult (node) *and* unrelated (edge). These are calculated for each caregiving domain and each age group. Finally, we calculated the median coefficient of relatedness between recipients of care and allomothers of each life stage. In some cases, the coefficients of relatedness in an allomother–child dyad deviated slightly from the following values: .5/.25/.125/.0625/0, because of multiple paths of relatedness. In such cases, it was rounded down to the closest of the above values. For example, if a child's paternal uncle is also their mother's second cousin, then the coefficient of relatedness between the child and uncle is rounded down from .28125 (.25 + .03125) to .25.
Allomaternal contribution (%)	The mean percentage of children's total care provided by all allomothers (rather than mothers) across the domains of physical contact, close care, responding to crying, and holding. In the case of responding to crying, there were instances where mothers and allomothers jointly responded to crying. Therefore, we calculate the percentage of bouts responded to by mothers alone; allomothers alone; and mothers and allomothers together.
Caregiver:child ratio	The ratio of allomothers (individuals providing any care) to children. These ratios only include allomother nodes who are connected to at least one child node—individuals older than four who did not provide care (in the specific domain of that network) to any children were not counted as allomothers. These are calculated for each caregiving domain in each camp.
Network concentration	We use the term concentration to represent the skew in the proportion of a child's care provided by each of their allomothers. It can be considered on a spectrum from low (all of a child's allomothers are equally involved) to high (virtually all of child's allocare is provided by just one allomother, and the rest of the allomothers have very little involvement). To capture this construct, we present the mean allomaternal involvement (proportion of a child's total allomaternal care) provided by a child's first to eighth most involved allomothers, respectively. In network terms, this involves weighting each edge according to the proportion of a child's care provided by an allomother, such that the sum of the weights of all edges connected to a given child node is equal to 1. Then, each of a given child node's edges is ranked according to their weight. Finally, the mean weight of all children's top ranked edge is calculated, this is then repeated for edges ranked 2–8, respectively. Note that in cases where a child node has less than eight connections the "non-existent edges" have a weight of zero. This is calculated for the proximity, physical contact, and close care networks, and for each age group. See Figure 1a and 1b for a graphical representation of network concentration.
Caregiver sharing	To assess the degree to which children "share" their allomothers, we calculate the proportion of an allomother's total allomaternal effort (the sum of all allocare s/he provides to all children) received by each child they care for. We then calculate the mean "share" of allomaternal effort children receive from their first to eighth most involved allomothers. In network terms, this is calculated in the same way as network concentration (see above), except that edges are instead weighted by the proportion of an allomother's care provision received by each child, rather than the proportion of a child's allocare provided by each allomother. This is calculated for the close care network and each age group. See Figure 1c and 1d for a graphical representation of caregiver sharing.

Figure 1
Graphical Representation of Network Characteristics



Note. In each hypothetical network diagram, white nodes are children and black nodes are allomothers. Edges are directed and represent care provided from allomothers to children. Edge weights in the "network concentration" networks (a & b) reflect the proportion of a child's allocare provided by an allomother. In the "caregiver sharing" networks (c & d), edge weights reflect the proportion of an allomother's allocare provision received by a child.

analyses, only potential allomothers who actually did provide allocare were then considered as allomothers.

Across the three camps, we were able to observe 18 of the 21 children under 4 years old. We had to leave Camp 1 earlier than expected for logistical reasons and therefore two of the children were not observed; and in Camp 3 we did not observe one child whose mother was very ill at the time. Table 2 presents the network information that was calculated.

We also used paired-sample permutation tests to examine whether there were significant differences in children's mean number of male versus female allomothers, and related versus unrelated allomothers across each network. Paired-sample permutation tests were chosen since Shapiro–Wilk tests showed the data were nonnormal and because the data included many ties. Friedman's were used to test whether there were significant differences in children's mean number of subadult versus adult versus postreproductive allomothers in each network. Thus, 12 tests were conducted (allomother sex, relatedness, and life stage across four caregiving domains); to correct for multiple testing we applied a false discovery rate (FDR) p value adjustment.

Results

Responding to Crying

Infants under 18 months cried for a mean time of 21.8 min (SD = 7.7) and those between 1.5 and 4 years old for 14.2 min (SD = 15.8) during the 12 daylight hours. Across all children, a total of 289 crying bouts were observed. After excluding bouts where some close care was already being provided and those which self-resolved within 30 s, 220 bouts remained. Of these 220 cases, a response was initiated in all but three cases (98.6% of bouts). Two of those three cases self-resolved within a minute, and there was just one case in which a child was left to cry it out for 13 min. Responses were rapid, and by interpolating the interval data, we estimate that almost 50% of crying bouts were responded to within 10 s and 90% within 25 s (Figure 2b). Speed of response did vary by age, for instance, the probability that a crying bout of a child under 1.5 years was responded to within 25 s was 93.4% versus 68.5% for children 1.5–4 years old (proportion test: $p < .001$).

Comforting, which includes soothing, holding, and affection, was the most common method of response across the sample (Figure 2a); soothing usually takes the form of yodeling to the child while drumming on their back. A chi-square post hoc test showed that comforting was more common as a response to the crying bouts of 1.5-year-olds than 1.5- to 4-year-olds ($p = .014$), although after applying an FDR p value adjustment the result was just shy of significance ($p = .055$).

Proximal caregiving strategies are characterized by bodily proximity and tactile care, whereas distal strategies involve more verbal and object stimulation, that is, communication via the distant senses (Keller et al., 2009). Given the interest in proximal soothing versus distal stimulation as forms of sensitive responsiveness (see Discussion), it is noteworthy that comforting responses are almost seven times as common as stimulating responses (proportion test: $p < .001$).

After comforting, nursing/feeding was the next common response across age groups, and stimulating or attending to a need was much less common. It is striking that there was not a single instance of a controlling response, that is, a caregiver restricting the child's distress or scolding them. We have seen this occur outside the context of this study, but it is very rare.

In summary, crying is almost always responded to swiftly, typically via comforting and nursing/feeding, distal stimulation is rare, and controlling responses are virtually nonexistent.

Closeness and Close Care

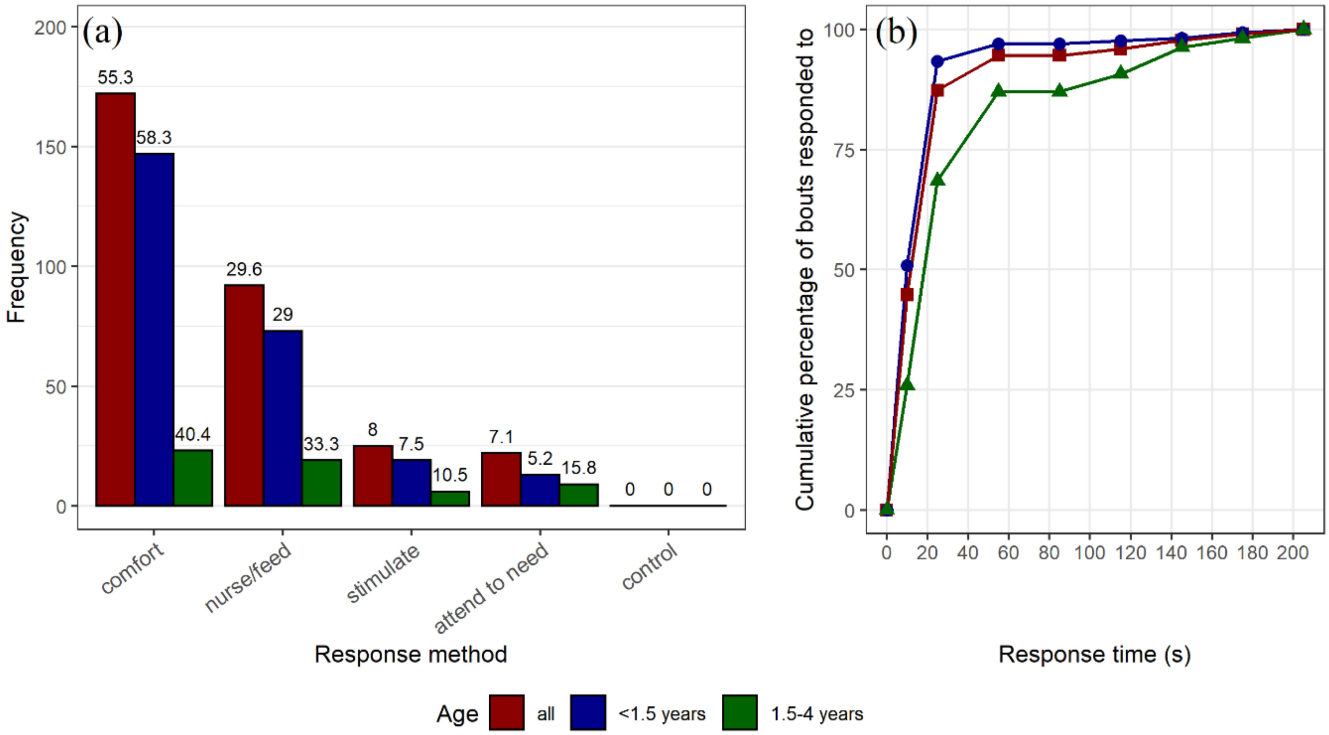
Infants under 1.5 years old spent an average of only 14.7 min ($SD = 20.9$) alone, that is, without someone within 3 m proximity and eyeshot. They are in physical contact (9.2 hr) with someone, and receive close care (8.8 hr) for approximately three-quarters of daylight hours, and are held for over 5 hr. As expected, children between 1.5 and 4 years old experience less closeness and close care, but both remain very substantial (Table 3). They are still only alone for 35.7 min ($SD = 25.8$) and are in physical contact with someone for more than half the day (7.0 hr). Correspondingly, when age is treated as a continuous variable, it is significantly negatively associated with time in physical contact ($\beta = -1.17$, $p = .022$), receiving close care ($\beta = -2.19$, $p = .002$), and being held ($\beta = -1.62$, $p = .002$).

Allomaternal Contribution

Across age groups, mothers responded to just under half of crying bouts alone, and allomother(s) responded to more than 40% without maternal involvement, in the remaining cases mothers and allomothers responded together (Figure 3). Proportionally, mothers responded alone to slightly more bouts in the older age group, but there were no statistically significant differences across age groups

Figure 2

Method and Speed of Responses to Crying



Note. Numbers above the bars represent percentages. "All" refers to the entire sample. See the online article for the color version of this figure.

($\chi^2 = 0.65$, $p = .722$), nor any association when age was treated as a continuous variable (see Table S2 in the online supplemental materials).

Allomothers are responsible for 39%–46% of close care, holding, and physical contact (Table 3). These contributions are not simply a reflection of paternal care—fathers only provide 5.5%–5.7% of each of the three forms of care to children under 1.5 years old. Among 1.5- to 4-year-olds, fathers provide 3.5% of close care and holding, and 8.4% of physical contact. When age is treated as a continuous variable an interesting trend emerges. Across each of our three measures, the allomaternal contribution consistently has a quadratic relationship with child's age, peaking just prior to age two. The relationship with the quadratic of age was significant for physical contact ($p = .008$) and close care ($p = .033$), and approached significance for holding ($p = .095$). Table S2 in the online supplemental materials provides coefficients and p values of the age and age^2 predictors.

The Structure of Allomaternal Networks

We constructed allomaternal networks across four caregiving domains in each of the three camps. Figure 4 is an example of the Camp 2 networks; see Figures S2 and S3 in the online supplemental materials for the network diagrams of the other two camps. It provides a graphical representation of the general trends we present below relating to network ratios, size, concentration, and caregiver sharing. In the case of network size, concentration, and caregiver sharing, we present descriptive statistics by combining data from each camp's networks, rather than individually for each camp.

Network Ratios

Across camps and network domains, there are many more allomothers than children (Table 4).

Network Size

The mean number of allomothers (in-degree) a child has in the proximity, physical contact, close care, and crying response networks are 14.4 ($SD = 6.0$), 7.2 ($SD = 4.0$), 7.9 ($SD = 3.8$), and 2.5 ($SD = 1.6$), respectively (Figure 5). These figures were very similar across age groups except in the crying response networks—children under 1.5 years old had 3.3 ($SD = 1.5$) allomothers whereas those between 1.5 and 4 years old had only 1.7 ($SD = 1.3$); see Figure 5. This closely matches the fact that the former had an average of 20.3 crying bouts over the observation period, compared to 10.7 bouts among the 1.5- to 4-year-olds. Correspondingly, when age is treated as continuous it is significantly negatively associated with a child's number of allomothers in the crying response network ($\beta = -.77$, $p = .025$).

While a child's number of allomothers in the other networks appears similar across the age groups, the regressions with age as a continuous predictor highlight a trend that matches the relationship between age and allomaternal contribution. Specifically, the quadratic of age is significantly associated with a child's number of allomothers

Table 3
Closeness, Close Care, and Allomaternal Involvement

	Close care		Held		Physical contact	
Age group (years)	Total (hr)	% Allomother	Total (hr)	% Allomother	Total (hr)	% Allomother
<1.5	8.8 (2.8)	41.9 (25.6)	5.3 (2.2)	39.3 (31.5)	9.2 (2.0)	40.3 (25.8)
1.5–4	3.9 (2.2)	42.8 (25.1)	1.8 (1.4)	40.3 (36.8)	7.0 (2.3)	45.3 (21.5)

Note. The values presented in the "Total" columns are the mean number of carer hours; standard deviations are shown in parentheses.

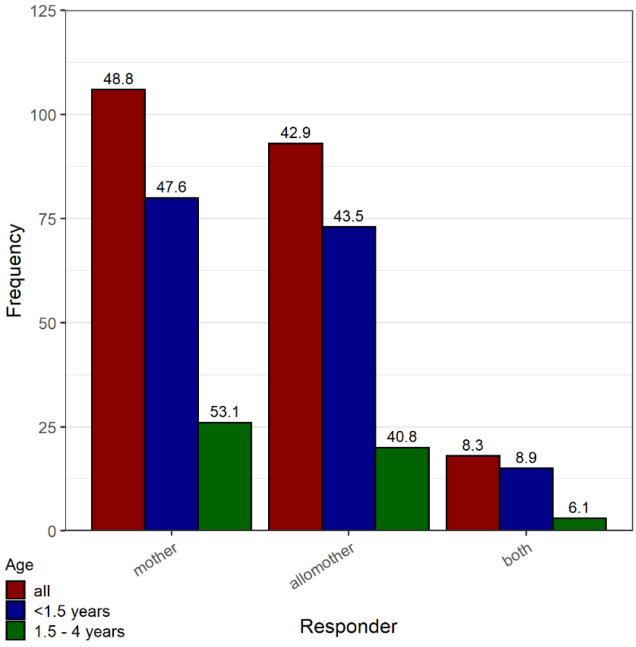
in the close care ($p = .010$) network, and almost significant in the physical contact network ($p = .063$); in both cases the number of allomothers peaks just prior to age two. There is no significant association between age and a child's number of allomothers in the proximity network ($p = .637$). Table S2 in the online supplemental materials includes the coefficients and p values of the age and age^2 predictors.

Allomother Demographics and Relatedness Status

While sample sizes are too small to test for differences in allomaternal characteristics across age groups, the descriptive statistics suggest if such differences are present they are not substantial (Table 5). Across both age groups, children have more related than unrelated allomothers in each caregiving domain, except for proximity. With respect to allomaternal life stage, children have fewer postreproductive allomothers than subadult and adult allomothers across all domains of caregiving. The mean number of adult allomothers is higher than subadult allomothers in the domains of proximity and crying response, approximately equal in the domain of physical contact, and lower in the domain of close care. As with kinship status, these allomother life stage trends are consistent across age groups in each caregiving domain. The relatedness of allomothers does not vary systematically with their life stage. The only notable consistency is that when 1.5- to 4-year-olds receive any form of care from a subadult allomother, it is most frequently from an older sibling ($r = .5$), interestingly this is not the case for infants under 18 months of age.

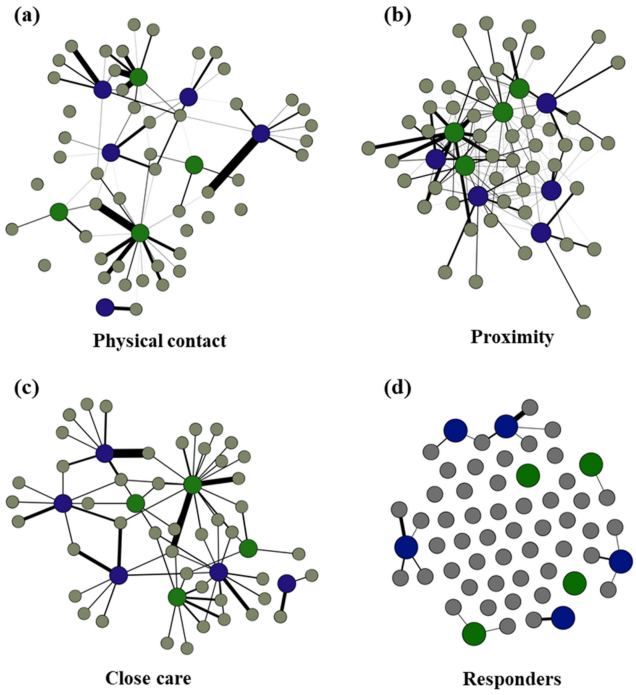
There does seem to be an age group difference with respect to allomother sex (Table 5). While for infants under 1.5 years, the mean number of female allomothers is higher than male allomothers across each caregiving domain, for children ages 1.5–4 years, this is only true in the case of proximity. A more detailed nested breakdown of allomaternal characteristics is available in Tables S3–S6 in the online supplemental materials, which presents the mean number of allomothers in each permutation of life stage, sex, and relatedness status. For example, it shows

Figure 3
Who Responds to Crying



Note. Numbers above the bars report percentages. See the online article for the color version of this figure.

Figure 4
Allomaternal Networks Across Caregiving Domains in Camp 2



Note. Large blue nodes are children under 1.5; large green nodes are children 1.5–4 years. Small gray nodes are potential caregivers. Edge thickness reflects the amount of care provided by an allomother to a child. (a–c) The amount of time engaged in that domain of caregiving. (d) The number of crying bouts a caregiver responded to. See the online article for the color version of this figure.

Table 4
Ratio of Allomothers to Children in Each Domain of Caregiving in Each Camp

Camp	Proximity	Physical contact	Close care	Crying response
1	42:5	30:5	20:5	16:6
2	50:9	43:9	45:9	16:9
3	24:4	20:4	22:4	10:4

the mean number of subadult allomothers who are male and also related in the physical contact network.

By combining age groups, it was possible to test for significant differences in allomaternal characteristics. The sample size is still limited to $n = 18$, thus results must be treated as preliminary, nevertheless, numerous significant trends emerged (Table S7 in the online supplemental materials).

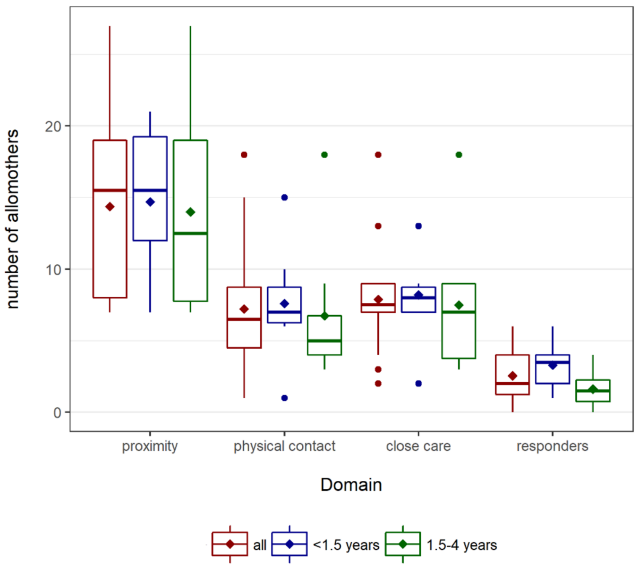
The key trends that emerge are that children have significantly more related than unrelated allomothers in the crying response network; significantly more female than male allomothers in the all networks except the crying response network; and significant differences in the number of allomothers at different life stages in all networks, notably postreproductive allomothers are consistently the fewest in number by some margin.

Network Concentration

The concentration of allomothering networks is high across domains, that is, the relative contributions of allomothers to a child's care are highly skewed. In the physical contact and close care networks, a child's most involved allomother provides more than 50% of their allocare, and the second most involved provides approximately 25%; in both networks more than 90% of their allocare is restricted to the contributions of four allomothers (Figures 4 and 6). Thus, while the mean number of allomothers a child has in these networks is between 7 and 8, some of them have little involvement. These overarching trends are very similar across the two age groups (Figure 6), we report the specific distributions of care for each age group in Table S8 in the online supplemental materials.

Unsurprisingly the proximity network is less concentrated as a child will often be in proximity to numerous individuals at the same time (Figures 4 and 6). The combined contribution of a child's two most involved allomothers is approximately 50%, and it is only after including the contributions of a child's eighth most involved allomothers that 90% of their proximity to caregivers is accounted for.

Figure 5
Allomothers Per Child Across Caregiving Domains



Note. "Responders" refers to allomothers who respond to crying. Diamonds represent means. See the online article for the color version of this figure.

Caregiver Sharing

Our results show that children do share allomothers rather than have access to unique nonoverlapping sets of allomothers (Figures 4 and 7). That is not to say that all allomothers in the network are evenly distributing their allomaternal effort across all children; allomaternal effort is clearly highly structured. Children tend to have one allomother whose close care they do not share with any other children. This then steadily declines, for example, they receive 50% and 20% of the allomaternal effort of their fourth most and eighth most involved allomothers, respectively (Figure 7). As would be expected given the lower overall amount of allomaternal care received, the level of caregiver sharing appears higher for 1.5- to 4-year-olds than under 1.5-year-olds. It is unclear why there is a spike at the sixth most involved allomother, this may just be a quirk of the data rather than reflecting any real trend. Table S9 in the online supplemental materials provides the specific distributions of caregiver sharing for the two age groups.

Discussion

Here we investigated three aspects of caregiving among the Mbendjele, specifically: (a) responses to distress, (b) closeness and close care, and (c) the structure of allomothering networks across caregiving domains. Crying was virtually always responded to, usually very swiftly; and responses typically took the form of comforting or feeding, rarely stimulating, and never controlling. Levels of closeness and close care were exceptionally high, children were virtually never alone and spent extensive amounts of time in physical contact, receiving close care and being held. Allomothers provided 40%–50% of total care across each of the domains examined. While allomaternal network size varied across domains, care within networks was highly concentrated—children had a few core caregivers responsible for the vast majority of their care. There was some sharing of allomothers; but typically, a child had several allomothers who directed a majority of their respective allomaternal effort to him or her. Below we consider the implications of these findings for our understanding of children's psychological developmental and well-being, and their relevance to debates in the field.

We reemphasize here that contemporary hunter-gatherers are not "living fossils," they are modern human populations who occupy a subsistence mode that overlaps with that of pre-Neolithic populations. At points in our discussion, we suggest that some of the

Table 5
Allomaternal Characteristics

Age group (years)	Related	Unrelated	Subadult	Adult	Postreproductive	Male	Female
Proximity							
<1.5	6.4 (2.2)	8.3 (4.2)	4.3 (1.7) [$r = .125$]	7.4 (2.9) [$r = .0625$]	3.0 (1.9) [$r = 0$]	6.0 (2.9)	8.7 (3.0)
1.5–4	5.1 (2.5)	8.9 (5.7)	3.6 (1.9) [$r = .5$]	7.5 (3.6) [$r = 0$]	2.9 (2.8) [$r = 0$]	6.0 (3.2)	8.0 (4.2)
Physical contact							
<1.5	4.6 (2.1)	3.0 (2.1)	3.1 (1.5) [$r = .125$]	3.0 (1.8) [$r = .1875$]	1.5 (1.4) [$r = .125$]	2.9 (1.8)	4.7 (1.8)
1.5–4	4 (2.1)	2.8 (3.8)	2.9 (1.7) [$r = .5$]	2.8 (2.2) [$r = .09375$]	1.1 (1.6) [$r = .0625$]	3.5 (2.2)	3.3 (2.5)
Close care							
<1.5	4.7 (1.9)	3.5 (2.3)	3.6 (1.4) [$r = .125$]	3.0 (1.8) [$r = .125$]	1.6 (1.6) [$r = .125$]	3.0 (1.3)	5.2 (2.1)
1.5–4	4.0 (2.2)	3.5 (3.8)	3.5 (1.7) [$r = .5$]	3.1 (1.8) [$r = .0625$]	0.9 (1.6) [$r = .0625$]	3.8 (2.1)	3.8 (2.6)
Crying responders							
<1.5	2.5 (0.9)	0.8 (1.1)	1.1 (1.2) [$r = .0625$]	1.4 (0.8) [$r = .25$]	0.8 (1.0) [$r = .125$]	1.0 (1.0)	2.3 (0.6)
1.5–4	1.4 (1.2)	0.3 (0.4)	0.8 (1.0) [$r = .5$]	0.9 (0.6) [$r = .125$]	0.0 (0.0) [NA]	1.1 (0.8)	0.5 (1.0)

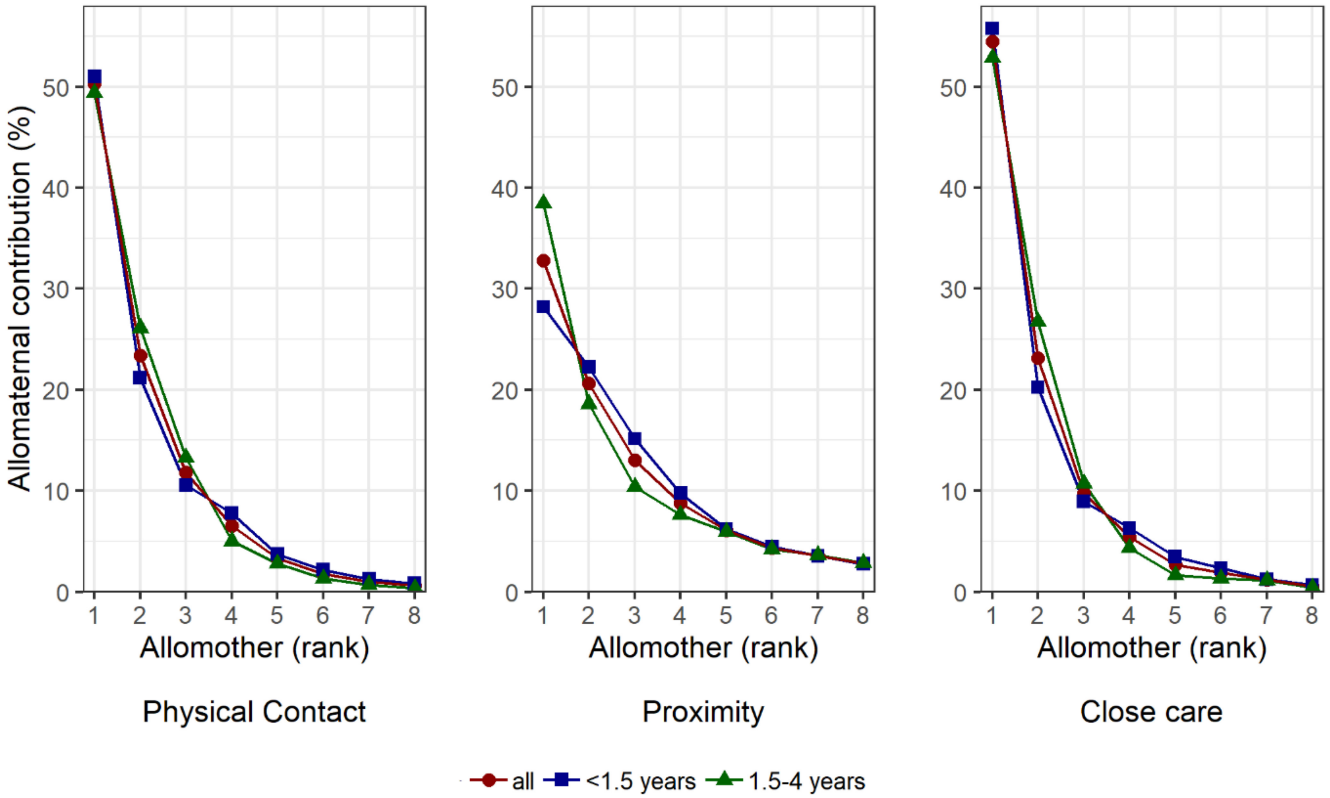
Note. The values presented represent children's mean (*SD*) number of allomothers of each relatedness status/life stage group/sex. The values in square brackets represent the median coefficient of relatedness between recipients of care and allomothers of a given life stage. There were no postreproductive responders to crying, thus no medican coefficient of relatedness could be calculated as indiciated by the NA.

childcare practices observed among contemporary hunter-gatherers, as opposed to non-hunter-gatherer societies, may be more typical of those practiced during our evolutionary history. This is more likely in cases where we observe notable similarities between hunter-gatherer populations living in vastly different ecologies, as this implies it may be something about a hunting and gathering way of life that produces these similar practices. However, we must not lose sight of the fact that we are observing modern populations, not relics of the past (Kelly, 2013).

Levels of Responsiveness to Crying

How parents should respond to crying has been debated for decades, and studies into the effects of different strategies have

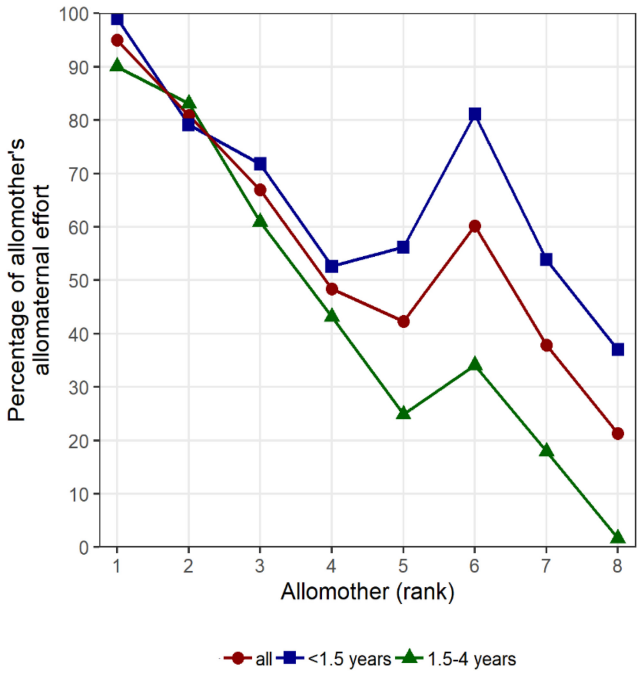
Figure 6
Concentration of Caregiving Networks



Note. The relative allomaternal contribution of a child's first to eighth most involved allomothers across different domains of care. See the online article for the color version of this figure.

Figure 7

Caregiver Sharing



Note. The proportion of an allomother's total allomaternal close care provision that is received by a child. This is calculated for a child's first to eighth most involved allomothers. For clarity, we first rank children's allomothers according to their relative contribution to his/her close allocare. For example, on average, a child receives ~80% of the allomaternal effort of their second most involved allomother, where involvement is ranked by how much of the child's care comes from that allomother, and allomaternal effort refers to the total allocare that caregiver provides to all children in the network. See the online article for the color version of this figure.

produced conflicting results (Bell & Ainsworth, 1972; Bilgin & Wolke, 2020; Gradisar et al., 2016; Middlemiss et al., 2012). Critics argue that the Western bias in attachment research has led to an oversimplistic conclusion that high responsiveness is always optimal (Keller et al., 2018). Additionally, parents are often concerned that too much responsiveness may spoil the child and interfere with the development of independence and self-reliance (M. A. Barnett et al., 2010; Burchinal et al., 2010).

Our findings offer an additional lens through which these debates can be considered, and suggest children may be evolutionarily primed to expect high responsiveness. We found 99% of Mbendjele infant and toddlers' crying bouts were responded to, usually within 25 s. Studies of the !Kung, Aka, and Efe hint that this exceptionally high responsiveness is normative among hunter-gatherers (Kruger & Konner, 2010; Meehan & Hawks, 2013; Tronick et al., 1987). Conversely, levels of responsiveness in many WEIRD societies are much lower; for example, in a recent English study, more than 60% of mothers did not always respond to their 3-month-old infants' cries (Bilgin & Wolke, 2020).

Substantial experimental and naturalistic research indicates that a key function of infant crying is to alert caregivers that they are currently experiencing distress, for example, hunger, pain, or fear, and to elicit care that can resolve this distress, hence crying holds important survival value (Zeifman, 2001). In hunter-gatherer societies, 30%–50% of children die before the age of 15 (Apicella & Crittenden, 2015), thus crying may be a crucial adaptation by which they signal distress and improve their survival prospects. Although children living in WEIRD populations are usually safe—for instance, in Europe, less than 1% of children die before the age of 15 (WHO, 2022)—the relatively lower level of responsiveness many children encounter may have been associated with danger or neglect in ancestral populations, and in turn misinterpreted as such (Chaudhary & Swanepoel, 2023). Infants may be evolutionarily primed with a high benchmark for the level of responsiveness required for confidence in caregiver availability. The responsiveness experienced by many WEIRD children may fall short of this benchmark, perhaps contributing to the high rates of insecure attachment, which are often estimated as between 30% and 40% (Ainsworth et al., 1978; The Sutton Trust, 2014). Importantly, several studies suggest that caregiver-sensitive responsiveness can be effectively enhanced via behavioral interventions (Bakermans-Kranenburg et al., 2003; Dunst & Kassow, 2014).

The very high responsiveness experience by Mbendjele children certainly does not prevent their development of independence. Mbendjele children freely explore their environment and acquire skills and competencies at very young ages. For example, many of them were already experimenting with machetes soon after they could walk; by the age of 2 they are comfortable spending substantial time in "playgroups" away from their parents and other adults; they begin to contribute by foraging for fruits and mushrooms well before adolescence, and are also capable of cooking and managing fires by themselves. This is very consistent with the attachment perspective whereby sensitive responsiveness from caregivers provides children with the confidence to explore, and does not hinder the development of independence and self-reliance.

Levels of Closeness

We found that Mbendjele children are virtually never alone; this result is mirrored in studies of the Efe and Aka (Hewlett et al., 1998; Ivey, 2000). This continuous proximity is facilitated by the communal living that is normative among hunter-gatherers (K. R. Hill et al., 2011). The trust that caregivers will be available if required is crucial to the formation of secure attachments (Bowlby, 1969; Mesman et al., 2018). If contemporary hunter-gatherer patterns match those of ancestral populations, then spending substantial amounts of time without cues of caregiver presence is likely an evolutionarily novel situation; this may explain why infants can find separation so distressing (Zeifman, 2001). Some psychologists have stressed that we should eliminate culturally constructed notions that crying when alone is abnormal or a pathology to be rectified (Blunden et al., 2011).

Levels of contact among the Mbendjele are also very high—children are carried on the carer's hip or back using a sling, or held on the carer's front. Infants and toddlers are in physical contact with a carer for nine and seven of the daylight hours, respectively. Given the attire, the majority of this time includes some skin-skin contact. Contact is even more frequent among the Aka, but less so among the !Kung; nonetheless, !Kung infants are still in contact with someone for more than 5 hr (Konner, 2005; Meehan & Hawks, 2013). While the variation across these societies is notable, levels of contact in WEIRD populations fall far outside this range. For example, during their first weeks, infants in control groups of intervention studies in Canada and Holland received less than half an hour of skin–skin

contact per day (Bigelow & Power, 2012; Cooijmans et al., 2022). Hence WEIRD children are likely receiving substantially less contact than has been typical throughout human prehistory.

Reducing this large discrepancy may offer numerous psychological benefits. In WEIRD studies, increased contact has been shown to increase maternal sensitivity; promote secure attachment; enhance brain development and learning abilities; and reduce depressive symptoms in mothers, in turn providing indirect benefits for their babies (W. Barnett et al., 2022; Little et al., 2018; Norholt, 2020). The extensiveness of contact found here implies that the psychological returns on increased contact may follow a dose–response relationship that extends far beyond the range of WEIRD contact levels, and even beyond intervention studies of the benefits of contact. Fully bridging this gap may be impractical; however, there are feasible interventions. Babywearing—the use of pouchlike devices to carry infants—resembles the sling-type carrying employed by hunter-gatherers and is increasingly used an alternative to prams in WEIRD societies (Little et al., 2019; Williams & Turner, 2020). Infant massage is another intervention that has been used to increase skin–skin contact levels (O'Higgins et al., 2008; Porreca et al., 2016). Future research should investigate whether the physiological effects that occur during infants massage—which takes place in a concentrated period of time—mirror those resulting from the extensive physical contact received by hunter-gatherer children via caregiving behaviors over the course of a typical day.

A Sensitive, Responsive, and Proximal Strategy

Some cross-cultural psychologists argue that the Western bias in developmental research has produced a narrow conception of optimal caregiving as sensitive and responsive, which largely ignores the importance of cultural context and socialization goals (Keller et al., 2018; Vicedo, 2017). The distinction between proximal versus distal strategies has also been highlighted as relevant to cultural intentions. We have already discussed the exceptionally high levels of responsiveness and physical closeness; here we discuss the nature of responsiveness and care to further highlight that Mbendjele caregiving is sensitive and proximal.

Mbendjele caregivers comforted crying children via soothing and holding, and nursed or fed them; these methods were far more frequent than stimulation. More striking is that across almost 300 crying bouts, there was not a single instance of scolding or attempts to force a child to stop crying. This pattern of responsiveness is well categorized as sensitive since the focus is on meeting the child's needs, and as proximal since tactile responses were much more frequent than distal stimulation. Among the !Kung, controlling responses were not completely absent, but they were rare and approximately 25 times less frequent than comforting ones (Kruger & Konner, 2010). The extensiveness of close care further highlights the sensitive and proximal nature of caregiving, since these behaviors are child-centered and usually require contact, or at least close proximity. Infants under 18 months received a striking 9 hr of close care per day.

Different approaches to responsiveness, and the provision of proximal versus distal care, are thought of by some psychologists as socialization strategies (Keller et al., 2009, 2018). For instance, in some societies scolding children for crying, which is inconsistent with the notion of sensitivity, is considered a means of cultivating obedience. Proximal styles of caregiving are also thought to occur in cultures that value obedience, hierarchy, and relatedness; whereas distal strategies are considered to emphasize autonomy (Keller et al., 2009). Preparing children to effectively function within their cultural environment is undoubtedly important for their well-being in and of itself. However, if highly sensitive, responsive, and proximal caregiving was normative for most of our species' evolutionary history, and children are psycho-biologically adapted to it, the socialization benefits of alternative strategies may come at a cost. Findings described in the previous sections, such as the benefits of skin–skin contact, indicate that this may well be the case. Therefore, in certain contexts, there may be tradeoffs between optimizing biological versus cultural aspects of psychological development, which then have independent effects on later life well-being.

It is noteworthy that the Mbendjele do not entirely conform to some expectations regarding the relationship between cultural values and caregiving styles, specifically the suggestion that cultures emphasizing autonomy follow distal caregiving strategies. Like many hunter-gatherers, the Mbendjele are politically egalitarian, and hierarchies are completely absent (Dyble et al., 2015; Woodburn, 1982). Expectations of obedience are rejected, authoritative behavior is met with ridicule or hostility, and autonomy is at the heart of the Mbendjele ethos (Bombjaková, 2018; Lewis, 2002). Children themselves have a great deal of autonomy, spending their days exploring without adult supervision, and parental instruction is minimal even within the context of learning (Salali et al., 2019). This further reinforces our argument that indulgent (highly proximal, sensitive, and responsive) caregiving does not interfere with the development of independence or autonomy.

Allomaternal Support

Across all the domains of caregiving examined here, allomothers provided a striking 40%–50% of the total caregiving. This is not anomalous among hunter-gatherers (Konner, 2005). For instance, at 4 months of age, 60% of Efe infants' physical contact is with allomothers (Tronick et al., 1987). These trends are very much at odds with (the common interpretation of) Bowlby's monotropic concept, which emphasizes the role of just one primary caretaker and attachment figure, usually the mother (Bowlby, 1969). It is allomothering that facilitates the exceptionally high responsiveness and closeness (and likely associated benefits) discussed above. It can also provide indirect benefits to children. For instance, maternal support in childcare has been shown to enhance children's socio-emotional adjustment and behavior via its effects on maternal well-being and parenting style (Morita et al., 2021). The extensiveness of allomothering observed among the Mbendjele highlights just how substantial childcare support may have been over our evolutionary past. WEIRD parents are faced with the challenge of childrearing outside the cooperative childcare systems that have been so a key in our species' evolution (Emmott et al., 2021). From this perspective, the high prevalence of parental exhaustion, which often adversely affects children's well-being, is to be expected.

As discussed above, crying can hold survival value; however, the relationship between crying and caregiver response is not fixed, and under certain circumstances crying has the opposite effect, eliciting harmful rather than caring behaviors. Excessive crying can be particularly stressful for mothers and increases the risk of child maltreatment and neglect (Esposito et al., 2017; Hiraoka & Nomura, 2017; Wren et al., 2021; Zeifman & St James-Roberts, 2017). Firk et al. (2018) note that maternal emotion regulation in response to infant distress is crucial and some mothers can become

overwhelmed resulting in intense negative emotions that increase the risk of child abuse. We found Mbendjele allomothers' involvement in responding to crying is roughly equivalent to that of the mother; the same is true among the !Kung (Kruger & Konner, 2010). In WEIRD societies, parents rarely have support in responding to crying; and after short periods of paternity leave, mothers have to manage infant crying alone. Again, this lack of support may represent an evolutionarily novel scenario that mothers may not be well adapted to cope with; hence it is unsurprising that they can find infant crying so profoundly distressing.

Multiple Caregiving Network Structure

The narrow focus on mothers in attachment research has limited our understanding of the role of multiple caregiving networks (Thompson, 2021). We found in both age groups children were typically in proximity with 14 caregivers per day, of whom 7–8 were sources of physical contact and close care; infants under 1.5 years old had 3–4 allomothers who responded to crying and 1.5- to 4-year-olds had 1–2. Multiple caregiving is normative in hunter-gatherers—young Efe infants are physical contact with 14 caregivers per day, and Aka children receive "high investment" care from over 10 caregivers and are in proximity with more than 20 (Meehan & Hawks, 2013, 2015; Tronick et al., 1987). These large caregiving networks facilitate the exceptionally high levels of closeness and responsiveness discussed above. They also act as an insurance when key caregivers temporarily have a reduced capacity to provide care. For example, one mother in Camp 3 was very unwell, so her infant spent most of his time with other caregivers retaining access to attentive care and allonursing too. Another plausible benefit is that interaction with many caregivers in early life enhances socio-emotional development and theory of mind since children have to adjust to different interactive styles and are exposed to different forms of emotional expression.

Despite these benefits, the relationship between number of caregivers and well-being is more complex. Children in institutional care are at risk of many adverse outcomes ranging from delays in brain development to atypical attachment (van IJzendoorn et al., 2020). Exposure to too many caregivers and instability of caregiving networks have been proposed as contributory factors (Bakermans-Kranenburg, 2021; van IJzendoorn et al., 2020). However, even in our small sample, there were several children who were in physical contact and receiving close care from more than 10 allomothers, and one child with 19 caregivers. Furthermore, the Mbendjele are highly mobile, individual families move between camps such that camp composition is fluid. The family of one of the infants in this study moved to another camp where we happened to be working a couple of months later. No other members of the first camp had moved there, so the composition of that infant's caregiving network must have changed drastically. The social structure of the Mbendjele is typical across mobile hunter-gatherers (Dyble et al., 2015; K. R. Hill et al., 2011), so large and fairly unstable caregiver networks were probably common over human evolutionary history. Therefore, children are likely psychologically equipped to deal with them, and they may not be harmful in and of themselves. However, within these large networks, Mbendjele children still have access to (a) a smaller set of core caregivers and (b) high caregiver:child network ratios and personal attention.

The close care and physical contact networks are large but also very concentrated, and the responding to crying networks are much smaller. Thus, the provision of a child's care isn't thinly distributed across their many allomothers, but highly skewed. This likely facilitates the formation of strong attachments since a child still has a few specific caregivers from whom they receive regular care, contact, and responsiveness. It also increases the predictability of interaction, which may prevent distress arising from the larger network instability.

The lowest caregiver:child ratio across the proximity networks was 6:1 in Camp 3. This is vastly different to institutional care and nursery settings where each caregiver is responsible for multiple children simultaneously; or even nuclear family homes where there are rarely more than two caregivers. Mbendjele children do share allomothers to some extent. However, they still usually have exclusive access to one allomother, and access to a majority of the allomaternal effort of three to four other caregivers. Hence the amount of personal attention available to them is much greater than across most WEIRD settings. There is some evidence from day care centers that high caregiver:child ratios enhance mother–infant attachment (Sagi et al., 2002).

In summary, Mbendjele children enjoy the insurance benefits and supplementary care derived from large allomothering networks without incurring costs that may arise from a lack of identifiable key caregivers who provide personal attention. We also offer a speculation here—in spite of their large allomothering networks, the number of attachments Mbendjele children form may not be so distinct from their WEIRD counterparts. This is because many of a child's allomothers make minimal contributions—which may be insufficient for attachment formation—and the vast majority of allocare is provided by three to four caregivers. Correspondingly, in WEIRD societies it is not uncommon for a child to form attachments with both parents and a childcare provider.

Network Composition

The composition of caregiving networks is similar across the two age groups in terms of the proportional representation of allomothers of different characteristics. Notably, children tend to have more related than unrelated allomothers, and fewer postreproductive than subadult and adult allomothers. Nevertheless, there is substantial breadth of sources of allocare—networks still include allomothers of both sexes, all life stages, and both related and unrelated caregivers. There is notable variation in the degree of relatedness between children and their allomothers. Our results indicate that related allomothers are not just fathers, siblings, and grandparents, but more distant relatives ($r < .25$) also frequently play a role. Additionally, despite some persisting misconceptions, cooperation between unrelated individuals is very common among hunter-gatherers, and likely has been throughout our evolutionary history (K. R. Hill et al., 2011); this is also reflected in our results.

Relative to WEIRD children one of the most pronounced differences in caregiver network composition is the prevalence of subadult Mbendjele allomothers. The composition of allomaternal networks varies substantially across hunter-gatherer groups (Page et al., 2022). For instance, we found that fathers only provided 5.5% of close care received by children under 1.5 years old, and 3.5% for 1.5- to 4-year-olds; whereas, the level of paternal care among Aka hunter-gatherers from the neighboring Central African Republic is the highest reported in any human society (Hewlett, 1992). However, the occurrence of subadult caregiving has been described

consistently in numerous hunter-gatherer societies residing on different continents (Kramer, 2010), such as the Hadza from Tanzania and the Agta from the Philippines (Crittenden & Marlowe, 2008; Page et al., 2021). As infants and toddlers begin to rely less on their mother's milk, they spend increasing portions of the day in mixed-age playgroups and are frequently supervised by older children rather than adults (Lew-Levy et al., 2017; Major-Smith et al., 2023).

Subadult allomothering is key to explaining the high caregiver: child ratios among the Mbendjele described above. We found infants and toddlers had more subadult than adult allomothers in their close care networks showing that older children are being entrusted with a lot more than basic supervision. It is not uncommon to see a prepubescent girl cleaning a young child's body or offering her nipple to pacify a crying baby; and children as young as 4 years of age are capable of sensitive caregiving (Mesman et al., 2018). In WEIRD societies, there is a very different perspective on the age up to which children require supervision and the age at which they are capable of providing it. Siblings are often not entrusted as responsible carers, reducing infants' and toddlers' access to additional caregivers, and mothers' access to support. Moreover, it prevents siblings from gaining caregiving experience and confidence, which may offer some protection against the anxiety, and associated postnatal depression, experienced by many first-time mothers. If hunter-gatherer children take on caregiving roles in environments that are substantially more dangerous than those inhabited by WEIRD societies, we should explore the possibility that WEIRD children can safely contribute to caregiving in a meaningful way.

In WEIRD societies rather than only relying on their personal networks, that is, informal childcare—in which grandparents are frequently the preferred helpers—parents have access to formal childcare services (Wheelock & Jones, 2002). However, parental concerns over the quality of formal childcare and whether to trust "strangers" with their children are common; these are often more pronounced among low-income families who are more constrained in their choice of provider because of affordability issues (Roberts, 2011). Importantly, while evidence from childcare research is mixed, numerous studies indicate high-quality childcare is associated with positive socio-emotional and cognitive developmental outcomes, particularly for children exposed to family adversity or economic hardship (Berry et al., 2016).

Hunter-gatherer allomothering networks differ from formal WEIRD childcare since parents have well-established personal relationships with allomothers, such relationships are evidently not restricted to grandparents or other relatives (note that the availability of postreproductive helpers is restricted by high mortality rates, and that average genetic relatedness among coresidents in hunter-gatherer camps tends to be low; Dyble et al., 2015; K. Hill & Hurtado, 2009; K. R. Hill et al., 2011). Thus, greater familiarity and the development of relationships between WEIRD parents and daycare staff may alleviate parental concerns regarding the quality of formal childcare. A study of English parents found informal interaction and frequent communication between parents and staff to be the most important for building parental trust (Roberts, 2011). Importantly, positive relationships between parents and childcare staff are associated with positive socio-emotional and cognitive outcomes for children; and transforming parental and formal childcare into "cocaring relationships" rather than two distinct components of a child's caregiving network may enhance child development (Halgunseth et al., 2009; Lang et al., 2016).

Limitations and Future Directions

There are several limitations of the present study. Firstly, we only examined caregiving itself, from which we made inferences about the type of caregiving children may be adapted to. As mentioned in the introduction, mapping out hunter-gatherer caregiving is just a first step; relevant components of child psychology may be phenotypically plastic, so discordance effects cannot be assumed. Future work should directly examine the psychological development and well-being of hunter-gatherer children. This would permit stronger conclusions regarding whether their caregiving styles provide psychological benefits, and if so, could direct subsequent WEIRD intervention studies. Our discussion does suggest there are benefits of hunter-gatherer caregiving by extrapolating findings from studies of maternal caregiving. However, it is necessary to investigate whether responsiveness and closeness produce the same benefits when provided by allomothers, and to explore the possible interactive effects of different attachment relationships.

Due to the time-intensive nature of focal follow observations, our sample size was limited to 18. Larger samples would strengthen the reliability of the findings and also permit more fine-grained analyses of how caregiving patterns vary with age. Our data cover 12 hr of observation per child. Following children for longer periods of time, particularly as they move between camps, would elucidate the total size and stability of their caregiving networks. Finally, this is a study of only one hunter-gatherer population, where possible we have included comparable data from other hunter-gatherers. More data, particularly on caregiving network structure, are required to confirm whether our findings reflect a "pan-forager" pattern, and to make stronger inferences about caregiving in ancestral societies.

Conclusion

Mbendjele children receive highly sensitive, responsive, and proximal caregiving. As highlighted above, we must exercise caution when making inferences about ancestral populations based on contemporary hunter-gatherers since the latter are not living fossils. Nevertheless, studies of other hunter-gatherers, who live in very different ecologies, find several similarities with the caregiving styles observed here. This indicates that these approaches to childcare may be tied to a subsistence relying on hunting and gathering, and therefore may be more similar to the caregiving experienced by children during our species' evolutionary history. In turn, children may be adapted to expect such forms of caregiving (Chaudhary & Swanepoel, 2023).

Parenting manuals that expect babies to spend extended periods of time playing alone or devoid of physical contact may be at odds with children's psycho-biological expectations. However, parenting styles also play an important role in socialization, thus in some cultures, there may be tradeoffs between biological and cultural development. Bridging the gap in levels of sensitive responsiveness and closeness between hunter-gatherer and WEIRD caregiving may be impractical. However, babywearing, sensitive caregiving behavioral interventions, and potentially infant massage, represent examples of how WEIRD parenting can better accommodate evolved child (and maternal) psychological needs, and highlight the potential for us to learn from hunter-gatherer caregiving. However, such behaviors/interventions may be difficult to implement for many caregivers. For instance, frequent babywearing may be impractical for mothers

who do not have the option of working from home or bringing their babies to work. Parents looking after many children with little support, or working long hours, have less time available to engage in behaviors like infant massage. Importantly, information about the potential benefits of such practices may be difficult to access. As a society, from policy-makers to employers to healthcare services, it is essential that we make caregiving education widely accessible, and aim to provide conditions that do not limit caregivers' ability to provide the kinds of care they wish to.

While our findings are very consistent with the attachment parenting style, the continuous closeness and sensitive responsiveness received by Mbendjele children is only possible because mothers receive substantial allomaternal support. It is essential not to place caring responsibilities solely on the mother (which is a common misinterpretation of the attachment approach), this is very much at odds with the highly collaborative childrearing systems which have been so crucial in our species' evolution (Chaudhary & Salali, 2022). It can lead to maternal exhaustion and depression with deleterious effects for children. Policies surrounding the provision of childcare support must account for the reduced risk of abuse and neglect, and enhancement of maternal condition and caregiving.

Given the size of Mbendjele caregiving networks, we infer that children are equipped to cope with exposure to large numbers of caregivers. However, within these large networks, they may still require a small stable set of core caregivers who provide personal attentive care. Caregiver:child ratios in institutional care facilities and nurseries are much smaller than those observed in the Mbendjele networks. Policy-makers and funders must recognize that caregiving in these contexts should go beyond effective supervision. It should also include access to responsive care and physical contact, and some consistency in key caregivers; these are resources that have likely been available to children for the vast majority of our species' evolutionary history.

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