UNIVERSITY OF CALIFORNIA, SAN DIEGO

# Culture, Carrying, and Communication:
# The Role of Mother-Infant Physical Contact in Maternal Responsiveness

A dissertation submitted in partial satisfaction of the
requirements for the degree Doctor of Philosophy

in

Psychology with a Specialization in Anthropogeny

by

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The Dissertation of Emily E. Little is approved, and it is acceptable in quality and form for publication on microfilm and electronically:

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# DEDICATION

This dissertation is dedicated to my parents. I am eternally grateful to have been raised by these two wonderful humans in an environment of unconditional support, encouragement, and love.

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ABSTRACT OF THE DISSERTATION

Culture, Carrying, and Communication:
The Role of Mother-Infant Physical Contact in Maternal Responsiveness

by

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Doctor of Philosophy in Psychology with a Specialization in Anthropogeny

University of California, San Diego, 2017

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This dissertation tests the proposal that mother-infant physical contact facilitates increased maternal responsiveness to infants' cues during both breastfeeding and non-feeding interaction, taking into account the potential contribution of underlying beliefs about responsiveness. These studies demonstrate for the first time that immediate mother-

infant physical contact predicts breastfeeding in response to early hunger cues and causes mothers to respond more contingently to infants' vocalizations.

In Chapter 1, responses to an at-home feeding log demonstrate that mother-infant physical contact predicts increased responsiveness to infant hunger cues when initiating feeding and that maternal beliefs predict ending feeding in response to infants' satiation cues. Measures of maternal behavior during an in-lab breastfeeding session show that maternal beliefs about responsiveness predict individual variation in responsiveness to infants' cues during feeding.

In Chapter 2, in-lab measures of maternal responsiveness during a non-feeding dyadic play interaction show that experience with physical contact predicts increased responsiveness to infants' facial cues and questionnaire data shows that experience with physical contact is associated with a particular set of beliefs about responsiveness. Comparisons of maternal behavior during a within-subject manipulation of physical contact show that responsiveness to infant vocalizations increases during mother-infant physical contact, demonstrating experimentally that physical contact has an immediate effect on maternal responsiveness.

These data make a novel contribution to our understanding of maternal responsiveness and challenge the current models of how responsiveness is tested, as responsiveness during feeding has been neglected as a central component of the infant's early learning environment. Given the established importance of maternal responsiveness for social learning, understanding what drives maternal responsiveness is vital to the broader goal of understanding how infant outcomes are shaped by the early social environment.

# INTRODUCTION

## Culture, Carrying, and Communication:

## The Role of Mother-Infant Physical Contact in Maternal Responsiveness

Human infants are born in a state of immaturity and dependence that is unique among primates, making how mothers (and others) respond to infant signals critical for neonatal survival. Maternal responsiveness is important for both infant health outcomes (i.e., by facilitating a successful breastfeeding interaction) and for early learning processes (i.e., by fostering the development of communication), yet the mechanisms underlying maternal responsiveness are not well understood. Ethnographic accounts of infant care show that mother-infant physical contact – shaped by culturally-mediated infant carrying practices – is consistently associated with high levels of maternal responsiveness, yet it is unclear whether this responsiveness is facilitated by the act of physical contact or by underlying beliefs about responsiveness. Motivated by fieldwork with mothers in Guatemala, Bolivia, and Vanuatu, this dissertation tests the hypothesis that physical contact with infants drives increased maternal responsiveness to infants' cues, both in the context of breastfeeding and in the context of non-feeding interactions.

With systematic measurement of naturally-occurring variation in maternal behavior during breastfeeding, I first demonstrate that U.S. mothers are more responsive to early hunger cues when in physical contact with infants, and that this increased responsiveness is not attributed to differences in maternal beliefs (Chapter 1). To demonstrate causality, I manipulated mother-infant physical contact in the lab, showing that physical contact increases mothers' contingent responses to infants' non-feeding cues (Chapter 2). This is the first investigation to demonstrate an immediate effect of mother-infant physical contact

on maternal responsiveness, confirming for the first time that physical contact increases maternal responsiveness above and beyond maternal beliefs and other confounding factors. Given the established importance of responsiveness – both for breastfeeding success and as a central component of the infant's early learning environment – these studies make an important contribution to our knowledge of the cultural and psychological factors that shape the infant's early environment.

## Background

To motivate the importance of investigating whether mother-infant physical contact facilitates increased responsiveness, I first introduce and explain the developmental implications of two types of maternal responsiveness: 1) responsiveness to feeding cues in the context of breastfeeding, and 2) contingent responsiveness to infants' social cues in the context of play interactions. Next, I evaluate existing support for the hypothesis that physical contact drives maternal responsiveness by critiquing relevant work from experimental studies of physical contact (including randomized controlled trials of postpartum skin-to-skin contact and carrying intervention studies). Finally, I highlight ethnographic work on physical contact and maternal responsiveness and discuss the importance of understanding these processes from within the broader cultural context of proximal care.

### What is responsiveness and why is it important?

Maternal responsiveness is broadly defined as prompt, appropriate responses to infants' cues (Ainsworth, 1979; Bornstein et al., 1992; Broesch, Rochat, Olah, Broesch, & Henrich, 2016; Wolff & Van Ijzendoorn, 1997). An infant's first experience of responsiveness is generally in the context of breastfeeding in the moments after birth.

Breastfeeding is embedded within culturally-meaningful beliefs and practices (Dettwyler, 1988; Fouts, Hewlett, & Lamb, 2012) and provides rich opportunities for the transfer of both social and biological information from mother to offspring (e.g., Gottlieb, 2004; Hinde et al., 2014; Lavelli & Poli, 1998). Responsive feeding is recommended internationally as a component of successful breastfeeding (WHO, 1998) and requires heightened awareness of very subtle forms of communication that are variable across individuals and change across development (McNally et al., 2015). These cues include indications of hunger – behaviors such as mouthing, finger sucking, hand-to-face, and hand-to-mouth – that occur before the onset of crying (Gill, White, & Anderson, 1984; Gross et al., 2010), as well as indications of fullness including falling asleep and looking disinterested (Crow, 1977; Hodges, Wasser, Colgan, & Bentley, 2016).

**Implications for breastfeeding success**

The importance of feeding in response to infant cues for breastfeeding success (i.e., initial and continued breastfeeding) was first experimentally demonstrated with a randomized controlled trial where mothers were assigned to feed newborn infants in response to their cues or on a schedule of feeding at four-hour intervals. This study found that infants in the responsive breastfeeding group were more likely to be breastfeeding at the one-month follow-up than infants in the scheduled group (Illingworth & Stone, 1952). This effect of responsiveness may be due to a decreased risk of common breastfeeding challenges, as mothers in the responsive group in this study reported significantly decreased incidence of sore nipples (Illingworth & Stone, 1952). Responsive feeding may also decrease the risk of perceived insufficient milk supply – a psychological phenomenon where mothers cease breastfeeding because they mistakenly think they are not producing

enough milk (Teich, Barnett, & Bonuck, 2014) – given that allowing infants to lead the supply and demand process of lactation optimizes maternal milk production (Jones & Spencer, 2007; Kent, 2007). Another study randomly assigned premature infants to be fed in response to cues versus on a schedule, finding that infants in the responsive feeding group developed independent feeding abilities earlier than infants in the scheduled group, resulting in earlier hospital discharge (Collinge, Bradley, Perks, Rezny, & Topping, 1982). This study and others (Kirk, Alder, & King, 2007) suggest that responsive feeding increases infants' display of hunger cues and fosters the development of non-cry communication (Papousek & Papousek, 1990).

**Implications for communication**

In addition to potentially facilitating increased display of hunger cues, responsiveness during breastfeeding – specifically, the way that mothers respond to infants' pauses in feeding – potentially lays the foundation for learning about the contingent nature of dyadic communication (Kaye & Wells, 1980). Outside of the context of breastfeeding, maternal responsiveness when studied in the lab is often operationalized as contingent responses: changes in maternal interaction behavior occurring within 1-2 seconds of an infant cue (Broesch et al., 2016). The temporal contingency of responsiveness supports the mapping of words to their referents, facilitating word comprehension (Tamis-LeMonda, Kuchirko, & Song, 2014), which is demonstrated by longitudinal associations between maternal responsiveness and achievement of language milestones (Tamis-Lemonda, Bornstein, & Baumwell, 2001). Experimental manipulations of maternal responsiveness in the lab show that infants produce more sophisticated pre-linguistic sounds when mothers are more responsive to their

vocalizations (Goldstein, Schwade, & Bornstein, 2009; Goldstein & Schwade, 2008; Gros-Louis, West, & King, 2016) and the way parents respond to infant attention during object play is related to word production (Stevens, Blake, Vitale, & MacDonald, 1998). For example, in one study, contingent reactions (i.e., smiling, approaching, touching) to 8-month-olds' babbling facilitated higher quantity and quality (phonologically complex) vocalizations during a mother-infant play session (Goldstein, King, & West, 2003).

**Implications for self-regulation**

Beyond the implications for breastfeeding success and the development of communication, maternal responsiveness is proposed to foster the development of self-regulation. How does responsiveness during feeding facilitate self-regulation? All infants demonstrate the ability to self-regulate their milk intake according to their specific needs and the dynamic composition of the breastmilk, which changes across days, development and even within each individual feeding (Woolridge, 1995; Wright, Fawcett, & Crow, 1980). However, this capacity for self-regulation is shaped by the responsiveness of the feeding environment. One study assessed the relationship between bottle-feeding – known to provide a less responsive interaction – and infant self-regulation (measured with an in-lab measurement of infant milk intake), finding a clear dose-response relationship between amount of bottle use (regardless of whether the bottle was being used to feed breastmilk or formula) and likelihood of the infant emptying a full bottle, indicating a lack of ability to self-regulate consumption (Li, Fein, & Grummer-Strawn, 2010). However, this study did not directly manipulate responsiveness, making it hard to draw strong conclusions. Another study experimentally tested feeding responsiveness using a within-subject manipulation of responsiveness during formula feeding, finding immediate effects of

responsiveness on infant propensity to self-regulate their intake. Specifically, in the responsive feeding condition (where mothers were instructed and monitored on how to initiate and terminate feeding in response to infant cues), infants consumed half as much formula in comparison with infants in the non-responsive feeding condition (Ventura & Mennella, 2016). This suggests that during a more mother-led feeding, infants are less able to regulate their intake and potentially end up consuming more than needed.

Given that self-regulation is an important predictor of academic achievement (e.g., Evans & Rosenbaum, 2008), these implications of responsiveness for self-regulation may be underlying the associations between both breastfeeding and maternal responsiveness on cognitive outcomes later in development (e.g., Bornstein & Tamis-Lemonda, 1989; Milgrom, Westley, & Gemmill, 2004; Stevens, Blake, Vitale, & MacDonald, 1998). This proposed explanation is supported by an infant feeding study demonstrating that among over 10,000 infants, infants fed on-demand (regardless of feeding content) had higher IQ and cognitive test scores than infants fed on a schedule, after controlling for all known potential confounds (Iacovou & Sevilla, 2012). Though this study was observational, the results are supported by an experimental study of breastfeeding that randomly assigned some mothers – out of a group who had already expressed intention to breastfeed – to receive breastfeeding support and encouragement. The infants of the mothers in the experimental group (who had been breastfed for longer than infants in the control group) had higher IQ scores, better results on cognitive tests, and higher-rated academic performance (Kramer et al., 2008). Potentially, the results of this study could have been at least partly attributed to the responsiveness of the breastfeeding interaction, rather than the breastmilk itself.

## Why might physical contact increase responsiveness?

Given the many benefits of responsiveness for both breastfeeding success and early learning, the question is, what drives responsiveness? And specifically, out of the many biological, cultural, and psychological factors that shape maternal (and infant) behavior, why might physical contact facilitate responsiveness, as I propose here?

### *Experimental literature*

Randomized controlled trials of postpartum contact show that skin-to-skin contact with infants immediately after birth facilitates initial breastfeeding success and increased duration of breastfeeding (Moore, Anderson, Bergman, & Dowswell, 2012). Though responsiveness to infants' cues was not measured directly in these studies, it is likely that increased breastfeeding success was at least partly attributed to an increase in responsiveness to infants' feeding cues, given what other studies have shown about the importance of responsiveness to feeding cues for breastfeeding success (e.g., Illingworth & Stone, 1952). Other studies of postpartum contact have measured responsiveness directly, showing that mothers who have skin-to-skin contact with their infant immediately after birth display higher levels of maternal responsiveness (Bigelow, Littlejohn, Bergman, & McDonald, 2010; Bystrova et al., 2009; Feldman, Eidelman, Sirota, & Weller, 2002). For example, one study compared the effect of standard incubator care versus skin-to-skin care (with a sample of 73 preterm infants matched on relevant demographic and medical measures) and found that when mother-infant interaction behavior was measured at three and six months postpartum, mothers in the experimental skin-to-skin group were more responsive to infant cues than mothers in the control group (Feldman et al., 2002). Another study randomly assigned 176 mother-infant dyads to one

of four groups: skin-to-skin, physical contact, rooming-in, and separate room while in the maternity ward (Bystrova et al., 2009). Skin-to-skin contact in the first two hours after birth caused mothers to be more responsive to their infants' cues when measured in a videotaped interaction at 12 months postpartum. Given that these studies tested a very specific type of physical contact (i.e., direct skin-to-skin) at a very sensitive period for development and bonding (i.e., immediately after birth), it is unclear whether these results apply to more general forms of mother-infant physical contact (e.g., during infant carrying). For example, in the study by Bystrova and colleagues (2009), mothers in the physical contact group (where infant was held by the mother, but dressed and swaddled) scored lower on measures of responsiveness than mothers in the skin-to-skin group, suggesting that in this sensitive postpartum context, the effects on maternal responsiveness may be specific to direct skin-to-skin contact.

However, a few studies have addressed the implications of infant carrying outside of the specific context of postpartum skin-to-skin. Hunziker and Barr (1986) conducted a randomized controlled trial of increased infant carrying, showing that infants in the experimental group cried significantly less than infants in the control group. Though responsiveness was not directly measured in this study, feeding frequency increased in the experimental group, suggesting an increase in maternal responsiveness to infants' hunger cues. In perhaps the most compelling demonstration of an effect of mother-infant physical contact on maternal responsiveness, Anisfeld and colleagues (1990) randomized mothers to receive cloth infant carriers (facilitating increased physical contact) or plastic seat carriers (facilitating decreased physical contact). After three months of this intervention, mothers in the increased physical contact group were more likely to respond to their

infants' vocalizations when measured in a play session (Anisfeld et al1990). Though it is possible that the increase in maternal responsiveness applies to all infant care practices and not just to vocalizations in the context of playing, this study did not measure other forms of responsiveness.

These carrying intervention studies address limitations of the medical literature by measuring effects of physical contact (without direct skin-to-skin contact) outside of the maternity ward. However, one critical limitation of even these carrying studies is that the length of the intervention period makes it difficult to understand whether physical contact itself drives the increase in maternal responsiveness. Specifically, experience with mother-infant physical contact may cause increased responsiveness because it facilitates increased *attention* to very subtle cues that would otherwise go unnoticed. Alternatively, experience with physical contact may lead to changes in infant behavior (e.g., decreased crying, calmer disposition), which then changes maternal perceptions of the infant and attitudes about infant care, and it is this *change in beliefs* that facilitates increased maternal responsiveness. Thus, the long-term interventions – though they show experimentally that physical contact does have an effect on responsiveness – do not clarify whether they physical contact has a direct, immediate effect or whether responsiveness increases because of a long-term change in maternal beliefs.

***Ethnographic literature***

Ethnographic accounts of infant care show that high levels of maternal responsiveness are often accompanied by high levels of mother-infant physical contact. From decades of ethnographic observations of the !Kung San of Northwestern Botswana, Konner and colleagues have noted that infants are in near-constant physical contact with

caregivers and that caregivers respond quickly to infants' needs (e.g., Konner, Stern, Konner, Herman, & Reichlin, 1986; Konner, 2005). Hewlett and colleagues have noted similar practices among the Aka foragers of Central Africa, who also keep infants close throughout the majority of the day and respond promptly to signs of distress (Hewlett, Lamb, Shannon, Leyendecker, & Schölmerich, 1998; Hewlett & Lamb, 2002). Responsiveness in this context of physical closeness often manifests in the form of offering the breast for nursing (e.g., among Gusii mothers in Kenya, Richman, Miller, & LeVine, 1992; mothers in Mali, True, Pisani, & Oumar, 2001; and Mayan mothers in Guatemala, Morelli, Rogoff, Oppenhein, & Goldsmith, 1992). Breastfeeding promptly in response to infants' subtle signs of discomfort precludes the need for overt displays of distress (Kärtner et al., 2010; Keller, 2002; LeVine et al., 1996; Richman, Miller, & LeVine, 1992).

Observers of mother-infant interaction in these cultures have proposed that when in sustained body contact, mothers can sense infants' needs via subtle physical movements as opposed to having to wait to see or hear an infant's elicitation for care (Caudill & Schooler, 1973; Kärtner et al., 2008). Though this subtle exchange of physical and tactile mother-infant communication is difficult to measure or even observe, overt behaviors can be used to infer the high level of maternal awareness of infants' needs, specifically: 1) mothers breastfeed very frequently (e.g., several times per hour in observations of mothers in !Kung communities of Botswana, Barr, Konner, Bakeman & Adamson, 1991; and mothers in Mali, Dettwyler, 1988), 2) mothers show acute awareness of subtle elimination signals, demonstrated by moving infants into a position to empty their bowels (e.g., among

mothers in Sri Lanka, Chapin, 2013), and 3) infants cry less, indicating that their needs are being met (e.g., Hewlett et al., 1998).

These ethnographic observations are supported by fieldwork conducted with mothers in Guatemala (Little & Shakya, in prep). In a survey of 279 mothers aged 13 to 53 years ($M$ = 29.86 years, $SD$ = 8.40 years) in the Western highlands of Guatemala, the majority of the mothers reported high levels of physical contact with infants through the use of babywearing (97.27%) and reported agreement with this physical contact being an important component of infant care (98.37%). Out of the mothers who expressed agreement with the importance of babywearing, 51.77% of mothers were motivated by knowledge-based reasons, such that they understood the benefits of physical contact for infant health, development, and mother-infant bonding. Mothers also reported physical contact during the night with the practice of co-sleeping (97.32%). Given that the high levels of physical contact were associated with high levels of breastfeeding (99.32% of mothers had breastfed, or were currently breastfeeding, their child), one possibility is that the increased physical contact facilitates increased responsiveness to feeding cues, leading to higher frequency of breastfeeding, decreased breastfeeding difficulties, and increased breastfeeding success. This is supported by the high frequency of breastfeeding reported by mothers in Guatemala (59.38% reported breastfeeding between 10 and 30 times per day) and continued breastfeeding until 12 (48.93% of mothers) or 24 (31.95% of mothers) months. However, another possibility is that increased breastfeeding responsiveness is driven by maternal beliefs about the importance of responsiveness, rather than facilitated by the actual act of physical contact itself. For example, 83.25% of mothers expressed that

it was important to breastfeed whenever the infant wants, and almost all mothers (98.25%) expressed that it was important to respond immediately to infant cues.

This fieldwork – in combination with the ethnographic literature on infant care practices – suggests that high levels of maternal responsiveness may be attributed to infants being kept in close physical contact with mothers (and others). However, drawing conclusions about physical contact from these studies is problematic because of the many other factors that characterize the infant care environment that may also be influencing maternal responsiveness behavior. For example, many ethnographers (e.g., Dettwyler, 1988; Fouts et al., 2012; Sellen & Smay, 2001) have discussed the influence of maternal work demands in shaping mothers' propensity to breastfeed frequently in response to infant cues. Maternal education, observed by Richman, Miller, and LeVine (1992) also predicts intracultural variation in maternal responsiveness.

Another contributing factor is community risk of infant mortality, which may motivate mothers to respond quickly and breastfeed often because signs of distress may be an indication of a health issue or malnutrition. This was reflected in fieldwork with Guatemalan mothers (Little & Shakya, in prep), given that among only 279 mothers, 11.19% of those mothers reported having lost an infant. However, one study described variation in maternal responsiveness in two communities with similar mortality and fertility levels, the same natural environment, and shared social, economic, and religious interactions (i.e., among the Aka and Ngandu in Central Africa, Hewlett et al., 1998). The authors proposed that one explanation for the increased responsiveness observed among Aka mothers (and others) may be attributed to the fact that Ngandu mothers hold infants

half as much as the Aka, though the authors did not evaluate differences in beliefs about maternal responsiveness, which may be another contributing factor.

A main limitation of the ethnographic literature – beyond the broader differences in societal and environmental factors – is that the connection between high levels of physical contact and high levels of maternal responsiveness is embedded within the broader parenting profile of proximal care, comprising a distinct set of parenting beliefs that may also be driving increased responsiveness. Systematic measurement of maternal beliefs about infant care across many cultural contexts shows that high levels of physical contact are associated with a set of beliefs about infancy that emphasize not only the importance of maternal proximity, but also the need for immediate responses to infant cues and breastfeeding as a strategy to minimize infant distress (e.g., Keller, 2002; Otto et al., 2016). These beliefs are referred to as parental ethnotheories, or cultural models used by parents to define their role as parents and their goals for their children and families (Harkness & Super, 2006). Parental ethnotheories predict variation in parenting behavior both within and across cultures (e.g., Harwood, Schoelmerich, Schulze, & Gonzalez, 1999; Keller et al., 2004), including specific variation in maternal responsiveness (Bornstein et al., 1992; Broesch et al., 2016; Kärtner et al., 2008; Kärtner, Keller, & Yovsi, 2010).

Proximal care has been primarily used to describe the parenting behavior of small-scale, indigenous communities. However, a movement within many Western countries has led some parents to choose to adopt a proximal care parenting style, despite infant care in Western cultures having historically been characterized as distal care (i.e., face-to-face interaction and object stimulation, Keller et al., 2009). One study showed that parents in

London who adopted a proximal care style of infant care had over 50% more physical contact with their infant than parents practicing distal care. This resulted in the infants of proximal care parents crying 50% less and having a longer duration of breastfeeding (St James-Roberts et al., 2006). Therefore, the aim of the current study was to measure the effect of mother-infant physical contact on maternal responsiveness among mothers in the U.S., taking into account degree of alignment with the maternal beliefs characteristic of proximal care culture.

## Current Investigation

Though ethnographic and experimental evidence supports the proposal that mother-infant physical contact increases responsiveness to infant cues, the details of this process are unclear. Specifically, past studies only show long-term effects of physical contact, and therefore, there are at least two potential explanations for the change in maternal responsiveness. For example, mother-infant physical contact may – over time – alter infant behavior (i.e., through physiological mechanisms), potentially leading to a change in maternal beliefs and an increase in motivation to care for her infant. Alternatively, mother-infant physical contact may have an immediate effect on maternal responsiveness by increasing maternal ability to attend to very subtle infant cues that would otherwise go unnoticed. Because immediate physical contact has not been measured in previous studies, we cannot determine whether physical contact has an immediate effect on responsiveness. In addition, because neither the immediate nor long-term effects of physical contact on responsiveness have been directly measured in the context of breastfeeding, it is unclear whether the established connection between skin-to-skin contact and increased duration of breastfeeding is caused by an immediate increase

in responsiveness to hunger cues (i.e., by facilitating attention to subtle cues), or whether it is explained by a long-term change in maternal beliefs. Along the same lines, ethnographic descriptions of mother-infant physical contact are embedded within the broader context of proximal care culture, making it unclear whether the increased responsiveness observed in these cultures is caused by the act of physical contact or by culturally-mediated beliefs about responsiveness.

To this end, there are several questions that have not been adequately addressed across these different literatures, reflecting gaps in the current knowledge of how mother-infant physical contact relates to maternal responsiveness. The aim of this dissertation was to test whether mother-infant physical contact facilitates increased responsiveness to infant cues, addressing three specific questions: 1) does mother-infant physical contact have an immediate, direct effect on maternal responsiveness to infants' cues? 2) are the long-term effects of physical contact attributed to variation in maternal beliefs about the importance of responsiveness? and 3) are different forms of responsiveness (e.g., to feeding cues during breastfeeding versus to social cues during non-feeding interactions) both predicted by physical contact (via infant carrying method and infant sleeping arrangements)?

In Chapter 1, we used two novel methods (i.e., breastfeeding behavior log and in-lab measurement of breastfeeding behavior) to show that immediate mother-infant physical contact predicts responsiveness to infant feeding cues during breastfeeding. We accounted for variation in maternal beliefs, showing that immediate physical contact is more important than maternal beliefs in predicting responsiveness. However, when immediate physical contact was held constant (i.e., when responsiveness was measured

*during* breastfeeding), then variation in proximal care beliefs was predictive of individual variation in responsiveness. In Chapter 2, we manipulated mother-infant physical contact in the lab, demonstrating experimentally that mother-infant physical contact has an immediate effect on maternal responsiveness. Given the established importance of maternal responsiveness for infant health outcomes and early learning processes, understanding what drives maternal responsiveness is vital to our theoretical understanding of how infant outcomes are shaped by their early social environment.

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# CHAPTER 1

## Implications of mother-infant physical contact for maternal responsiveness to infant cues during breastfeeding

## Abstract

Though the benefits of breastfeeding are well-established, new research suggests that a responsive feeding environment – where caregivers initiate and terminate feeding in response to infant feeding cues – facilitates positive developmental outcomes above and beyond the effect of the breastmilk itself. Based on observations of high levels of breastfeeding responsiveness in proximal care cultures – where mothers practice near-constant physical contact with infants and have distinct socialization goals – two hypotheses emerge: 1) physical contact facilitates responsiveness to infant feeding cues, and 2) beliefs about infant care drive increased responsiveness to infant feeding cues. To test these hypotheses, we had breastfeeding mothers fill out a feeding log for three days where they indicated the location of the infant before feeding onset and the reason for initiating feeding (Study 1) and terminating feeding (Study 2). In Study 1, we found that mother-infant physical contact preceding a feeding session was predictive of initiating a feeding because of early hunger cues (e.g., mouthing, squirming) in comparison with late cues (e.g., crying), which was not explained by variation in maternal beliefs. In Study 2, we found that beliefs about responsiveness were predictive of reason for terminating feeding. During an in-lab breastfeeding session in Study 3, maternal attitudes were predictive of increased responsiveness during the breastfeeding session. These data show that both mother-infant physical contact as well as maternal beliefs may shape the early feeding environment.


*Keywords: breastfeeding, mother-infant interaction, feeding cues, responsiveness, parenting beliefs, proximal care culture*

Responsive breastfeeding is recommended as best practice and is defined as unrestricted feeding for as often and as long as the infant wants (WHO, 1998). Responsive feeding involves initiating feeding in response to infants' cues for hunger (e.g., smacking lips, bodily movement) as well as allowing infants to feed until they show indications of fullness, including slowing of eating pace, becoming sleepy, looking around, refusing nipple/food, spitting, decreasing muscle tone, decreasing activity level, and increasing interest in surroundings (Crow, 1977; Hodges, Wasser, Colgan, & Bentley, 2016). Because infants have an extraordinary ability to self-regulate their milk intake (Dewey & Lönnerdal, 1986; Wright, Fawcett, & Crow, 1980), responsiveness to infant cues contributes to breastfeeding success by supporting the supply and demand physiology of lactation (i.e., optimizing maternal milk supply, Jones & Spencer, 2007; Kent, 2007). Responsiveness during breastfeeding also contributes to the infant's early learning environment by supporting the development of communication (Kaye & Wells, 1980) and self-regulation (Dewey & Lönnerdal, 1986; Li, Fein, & Grummer-Strawn, 2010), and is associated with a range of positive health and psychological outcomes above and beyond the benefits of breastmilk itself (Barr & Elias, 1988; Black & Aboud, 2011; Engle, Bently, & Pelto, 2000; Hurley, Cross, & Hughes, 2011; Renfrew, Lang, Martin, & Woolridge, 1999).

Though several studies have investigated predictors of responsiveness to infant hunger cues – finding that feeding method (breast versus bottle) is a strong predictor of degree of responsiveness to infants' cues (Hodges et al., 2013; Li et al., 2010; Wright et al., 1980) – very few studies have measured variation in responsiveness to hunger cues within the context of breastfeeding. Looking outside of Western culture for insight into this topic, differences in breastfeeding behavior between U.S. mothers and mothers from

proximal care communities – where infants are in near-constant physical contact with their infant – suggest two potential factors that may be driving differences in breastfeeding responsiveness: 1) mother-infant physical contact, and 2) beliefs about infant care. The aim of these studies was to test whether mother-infant physical contact was predictive of variation in breastfeeding responsiveness above and beyond the effect of maternal beliefs about responsiveness.

**Responsiveness and breastfeeding success**

Crying is the most commonly reported reason for initiating feeding among U.S. mothers (e.g., Hodges et al., 2008; Gross et al., 2010). However, crying is not a cue, but rather a distress signal (WIC, 2016), and waiting to feed until the onset of crying is can lead to breastfeeding difficulties. The importance of responsiveness for breastfeeding success has been demonstrated experimentally, such that infants randomly assigned to a responsive breastfeeding group were more likely to be breastfeeding at the one-month follow-up than infants randomly assigned to a scheduled breastfeeding group (Illingworth & Stone, 1952). This effect of responsiveness may be due to a decreased risk of common breastfeeding challenges, as mothers in the responsive group in this study reported significantly decreased incidence of sore nipples (Illingworth & Stone, 1952). Responsive feeding may also decrease the risk of perceived insufficient milk supply – a psychological phenomenon where mothers cease breastfeeding because they mistakenly think they are not producing enough milk (Teich, Barnett, & Bonuck, 2014) – given that allowing infants to lead the supply and demand process of lactation optimizes maternal milk production (Jones & Spencer, 2007; Kent, 2007). Given these benefits, an important – and

understudied – question is what drives maternal responsiveness to infant feeding cues during breastfeeding?

**What factors contribute to breastfeeding responsiveness?**

Many of the primary barriers to responsive breastfeeding among U.S. mothers have been identified at the societal level, including mother-infant separation due to lack of co-sleeping, maternal work demands, and lack of public acceptance of breastfeeding. Abysmal maternity leave policies in the U.S. make it difficult – if not impossible – for many U.S. mothers to exclusively practice responsive breastfeeding. This is reflected in the variation in responsive feeding with regard to socioeconomic status (Hodges et al., 2013) and ethnicity (Taveras, Gillman, Kleinman, Rich-Edwards, & Rifas-Shiman, 2010) such that mothers of a certain social class in the U.S. are more likely to have the resources to take time off work to be with their child and feed more frequently. In addition, taboos about breastfeeding in public further prevent mothers from comfortably feeding the infant in response to hunger cues, potentially being forced to wait to feed the infant until a private area is accessible. These societal factors dictate both the amount of time mothers can spend with infants and the likelihood that they will feed in response to cues – given the situation and location they are in. However, very few studies have looked at behavioral predictors of responsiveness during breastfeeding.

In order to understand why breastfeeding responsiveness is so low among mothers in the U.S., one place to look is outside of this cultural context, where breastfeeding responsiveness is much higher than the U.S. Specifically, mothers are more responsive to infant cues during breastfeeding in proximal care cultures, where infant care is characterized by near-constant night and day mother-infant physical contact (Keller, 2002;

Keller, et al., 2009). In contrast to this proximal care pattern of infant care that is most commonly practiced in rural, small-scale societies that value interdependence, distal care is characterized by face-to-face interaction and object stimulation, and is most widely practiced in Western, educated, industrialized, rich, and democratic ("WEIRD") societies (Henrich, Heine, & Norenzayan, 2010). These two profiles for infant-caregiver interaction have been identified from naturalistic observation of communities around the world, and are consistently negatively associated with one another, such that parenting characterized by more physical contact is usually lower in visual interaction, and vice versa, though substantial intercultural and intracultural variation has been observed (Lamm & Keller, 2007).

***Mother-infant physical contact***

Because of the increased breastfeeding responsiveness in proximal care cultures, one potential mechanism underlying cultural and individual differences in responsive feeding is amount of direct physical contact with infants. Specifically, in proximal care cultures where responsive breastfeeding is the norm, interactions with infants are characterized by near-constant physical contact (e.g., Barr, Konner, Bakeman & Adamson, 1991; Hewlett, Lamb, Shannon, Leyendecker, & Schölmerich, 1998; Konner, Stern, Konner, Herman, & Reichlin, 1976; Little, Carver, & Legare, 2016; Lozoff & Brittenham, 1979).

The hypothesis that *mother-infant physical contact facilitates maternal responsiveness to infant hunger cues* is consistent with a large body of work testing the effect of mother-infant skin-to-skin contact immediately after birth (Moore, Anderson, & Bergman, 2007). These studies show that mother-infant skin-to-skin contact immediately

after birth facilitates initial breastfeeding success (Furman, Minich, & Hack, 2002; Redshaw, Hennegan, & Kruske, 2014), suggesting that mothers were better able to recognize and respond to infant feeding cues. More generally, just a few hours of postnatal skin-to-skin contact leads parents to be more responsive (Feldman, Eidelman, Sirota, & Weller, 2002) and interactive (Moore et al., 2007) when measured months later during non-feeding interactions. Outside of the very specific context of postpartum skin-to-skin contact, one study measured the effect of parents adopting a proximal care strategy for infant care within a Western, industrialized society (by increasing physical contact) and found this to be associated with increased continued breastfeeding in comparison with parents using conventional infant care methods with less physical contact (St James-Roberts et al., 2006), though the design of this study makes it impossible to identify whether the physical contact specifically increased responsiveness to feeding cues.

Carrying intervention studies have shown that increased physical contact is predictive of breastfeeding responsiveness. Hunziker and Barr (1986) conducted a randomized controlled trial of increased infant carrying, showing that infants in the experimental group cried significantly less than infants in the control group. Though responsiveness was not directly measured in this study, feeding frequency increased in the experimental group, which – in combination with the decreased crying – suggests increased responsiveness to early hunger cues. Another carrying intervention study demonstrated that long-term mother-infant physical contact increased maternal responsiveness during play interactions (Anisfeld, Casper, Nozyce, & Cunningham, 1990), though this study did not measure responsiveness in the context of feeding.

***Parenting beliefs***

Proximal care is characterized by near-constant mother-infant physical contact, but this system of infant care is also associated with a distinct set of parenting beliefs, based on unique goals for socialization (Keller, 2002). To this end, one alternate hypothesis is that maternal beliefs drive variation in responsive breastfeeding, rather than the act of mother-infant physical contact itself.

Cultural beliefs about the "right" way to breastfeed have a long history of guiding breastfeeding behavior in Western society (Hodges et al., 2008). In the 18th century, wealthy English society women kept to a strict schedule of breastfeeding infants only four to six times per day (Fildes, 1995). In the 20th century, adult-led – scheduled, or interval – feeding was advocated for by American and European psychologists and pediatricians (e.g., John Watson and Luther Holt, Manz, Manz, & Lennert, 1997) due to the erroneous theory that rampant diarrheal diseases affecting infants and children in those days were caused by irregular patterns of feeding.

In contrast, proximal care culture is characterized by a set of beliefs about infant care that emphasize the importance of responding immediately to infant cues and maintaining mother-infant contact (Keller, 2002). Keller and colleagues have developed and validated an instrument to assess these parental ethnotheories, which has been used to assess degree of alignment with proximal versus distal parenting practices and beliefs in communities around the world (Keller et al., 2009; Lamm & Keller, 2007). Given the importance of understanding the cultural context of mother-infant interaction, we used this parental ethnotheory questionnaire to assess degree of alignment with proximal care beliefs in the current investigation (see Table 1.1).

## Current Investigation

In three studies, we used an at-home feeding log (Study 1, Study 2) and an in-lab breastfeeding observation (Study 3) to test the hypothesis that mother-infant physical contact predicts responsiveness to infant feeding cues in the context of breastfeeding. We tested the immediate effect of mother-infant physical contact on responsiveness to hunger cues (Study 1) and the effect of long-term experience with physical contact on responsiveness to cues during breastfeeding (Study 2, Study 3). Given that mother-infant physical contact is – in some cultures – associated with a specific set of parenting beliefs, we used Keller's (2002) parental ethnotheory questionnaire (in Study 1, 2, and 3) to assess mothers' degree of alignment with the values of proximal care culture (see Table 1.1).

There are different ways that physical contact may affect maternal responsiveness. Specifically, immediate physical contact may increase mothers' ability to perceive very subtle forms of communication that otherwise would be missed, allowing her to recognize and respond to infant cues much earlier than if she had not been in physical contact. Alternatively, long-term physical contact may facilitate other changes leading to an indirect effect of physical contact on responsiveness over time. For example, the calming effect of the physical contact on the infant (e.g., improved sleep and decreased crying) may facilitate a change in maternal perceptions of the infant and/or her role as a mother. To this end, this investigation tested both immediate physical contact (Study 1) and long-term effects of physical contact (Study 2, Study 3).

In Study 1, we used an at-home feeding log to test whether immediate differences in mother-infant physical contact were predictive of increased responsiveness to infant hunger cues during breastfeeding. In Study 2, we also used an at-home feeding log to test whether mothers with more experience with long-term physical contact were more likely

to end breastfeeding sessions in response to infant satiation cues. In Study 3, we measured breastfeeding behavior in the lab to assess whether long-term experience with physical contact was predictive of responsiveness to infant cues *during* breastfeeding. All three studies accounted for the cultural context of parenting practices by assessing degree of alignment with proximal care beliefs. Together, these studies used two novel methods to test the degree to which mother-infant physical contact and maternal beliefs predict individual variation in responsiveness during breastfeeding. Given the implications of responsiveness for breastfeeding success and early social learning, understanding the individual-level predictors of responsiveness during breastfeeding is an important and understudied topic.

## Study 1

The current study aimed to test whether mother-infant physical contact predicted: 1) feeding in response to early indications of hunger (i.e., cues) versus late indications of hunger (i.e., crying, distress), and 2) feeding for infant-motivated (i.e., to comfort, to help sleep) versus adult-motivated (i.e., logistics, schedules) non-hunger reasons. To test this, we had mothers fill out at-home feeding logs for three days. For each feeding, mothers documented the method they used to feed their baby: bottle-feeding, breastfeeding, or solids. To assess variation within breastfeeding mothers, only breastfeeding sessions were included in the final analyses. Mothers also documented the following information for each breastfeeding occurrence: 1) location of the infant (i.e., mother-infant contact) preceding feed onset, and 2) reason for feeding.

### Mother-infant contact

To isolate physical contact from general proximity to the infant (i.e., visual contact with no physical contact), we categorized responses as physical contact, visual contact, or no contact. Specifically, experimental studies show a connection between physical contact and maternal responsiveness, but if this is driven by the increased attention to infant communication facilitated by physical contact, then mothers who are visually attentive to infants in close proximity (without direct physical contact) should show the same increased responsiveness. We therefore tested the association between mother-infant visual contact and reason for feeding.

**Responsiveness to feeding cues**

Our first research aim was to test whether physical contact predicted feeding in response to early hunger cues rather than waiting for hunger-induced distress (i.e., crying). Motivated by the proposal that mother-infant physical contact may facilitate increased attention to the subtle indications of infant hunger, we predicted that mother-infant physical contact preceding a feeding session would be predictive of initiating a feeding because of early hunger cues (e.g., mouthing, squirming) rather than distress (i.e., crying, fussiness).

However, hunger is not the only reason that mothers initiate breastfeeding. Frequent offering of the breast for nursing is also used as a strategy for comforting infants and decreasing crying (True, Pisano, & Oumar, 2001) as sucking is one of the most efficient soothing mechanisms for infants (Woolridge, 1995). In contrast, mothers – in Western culture especially – may feed infants (by choice or by necessity from constraints of employment or other logistical factors) based on schedules. To this end, our second objective was to test whether mother-infant physical contact predicted feeding in response to infant-motivated non-hunger reasons (i.e., infant comfort) in comparison with adult-

motivated non-hunger reasons (i.e., maternal comfort, logistical factors). Based on the proposal that mother-infant physical contact facilitates mother-infant bonding – potentially attributed to physiological mechanisms (e.g., oxytocin release) or an increase in positive perceptions of the infant (Tessier et al., 1998) – we predicted that mother-infant physical contact would predict increased feeding in response to infant-led versus adult-led non-hunger reasons.

**Other factors of interest**

Though mother-infant physical contact was our main factor of interest, we wanted to test whether mother-infant physical contact was predictive of reason for feeding above and beyond other individual and societal level factors, so we tested – and controlled for – additional societal and behavioral factors in our analyses. In a questionnaire, we solicited demographic information from each mother, including infant age, maternal age, maternal education, household income, and parity. Given that these societal factors are some of the primary differences between proximal care and distal care cultures, we predicted they might be important in determining responsiveness to feeding cues. Also, because amount of time a mother spends with her infant may be important in determining interaction and feeding behavior, we solicited information about employment (currently working outside of the home versus not) and infant hours in daycare. We also asked mothers about feeding-related behaviors and beliefs, including any supplementation with formula, motivation for breastfeeding, and involvement with a breastfeeding community. To assess parenting beliefs, mothers were asked about their agreement or disagreement with general parenting regarding different components of maternal behavior toward a 3-month-old infant, using a

10-item questionnaire that been used globally to assess the degree of alignment with proximal care versus distal care parenting goals (Keller, 2002, see Table 1.1).

**Method**

All procedures and recruitment methods were approved by the Institutional Review Board of University of California, San Diego.

**Participants.** Participants were recruited from social media postings within U.S.-based parenting groups associated with breastfeeding (e.g., "Badass Breastfeeders"). To be eligible to be included in the study, mothers had to be currently breastfeeding a 1- to 12-month-old infant. Only mothers who completed the feeding log were included in the study, which we operationalized as having logged at least 12 breastfeeding sessions over a period of three consecutive days.

Ninety-nine breastfeeding mothers completed the feeding log and were included in the final analyses. Infants were 0- to 12-month-olds (51 female, $M$ = 5.66 months, $SD$ = 3.25). Mothers were 21 to 42 years old ($M$ = 30.97 years, $SD$ = 4.64) and had completed high school (30.61%), college (38.78%), or a graduate program (30.61%). The average household income of the sample was $78,703 ($SD$ = $50,064). Mothers were multiparous (had more than one child, 75.26%) and were exclusively breastfeeding (65.66%). Many of the mothers were not currently working (60.20%) and infant hours in daycare ranged from zero to 55 hours per week ($M$ = 4.41 hours, $SD$ = 11.52).

**Materials.** ***Maternal questionnaire.*** In an online questionnaire, we solicited demographic information from each mother, including infant age, maternal age, maternal education, household income, parity, maternal employment (currently working outside of the home versus not) and average hours per week that the infant spends in daycare.

Maternal beliefs were assessed with Keller's (2002) 10-question parental ethnotheory questionnaire that solicits degree of agreement with parenting statements regarding the care of a three-month-old infant (see Table 1.1). Responses to each item were on a scale from one (completely disagree) to five (completely agree). Responses from each participant were compiled to form a proximal care belief score, calculated by summing responses from all questions aimed to measure alignment with goals of proximal care parenting culture then subtracting the sum of responses to all questions designed to test alignment with goals of distal care parenting culture. The range of possible scores was negative 20 to positive 20. Any positive score indicated that mothers leaned more toward the values of proximal care culture than distal care culture, and a higher score indicated a greater agreement with the parenting goals characteristic of proximal care culture.

***Feeding log.*** The feeding log consisted of three questions: 1) feed method, 2) location of the infant before feeding onset, and 3) reason for feeding. The date and time of the feeding session was automatically recorded by the Google Form. For each of these questions, a list of options was provided, or mothers could use the "other" option to write in their own response. Only one response could be chosen for each question. However, after the first subset of participants had filled out the log ($N$ = 61), the feeding log was revised to not include the "other" option because too many mothers had used this category to provide long, unnecessary explanations of exactly where the infant was and what he/she was doing. We revised the questionnaire by providing more specific options for the mother to choose from, and also eliminated the response option of "other." With the new questionnaire, mothers could only choose one of the response options provided to them.

**Measures**. ***Mother-infant contact.*** For the question: "Where was your baby when you decided to fee him/her?", there were three pre-determined mutually exclusive categories of responses with regard to mother-infant contact: 1) physical contact (mother was in direct physical contact with the infant), 2) visual contact (the mother was near enough to see the infant, but not in physical contact), and 3) no contact (the infant was out of sight or with another caregiver).

***Reason for feeding.*** For the question: "Why did you decide to start feeding your baby?", there were four pre-determined mutually exclusive categories of responses: 1) hunger: early cues, 2) hunger: late cues, 3) non-hunger: infant-led, and 4) non-hunger: mother-led.

*Hunger: Early cues.* Feedings were coded as being in response to cues if the mother had indicated that the feeding was initiated because the infant had shown either visual communication (e.g., facial expression), vocal communication (e.g., lip smacking), or physical communication (e.g., breast nuzzling, squirming) that indicated hunger (but not to the point of distress or crying).

*Hunger: Late cues.* Feedings were coded as being in response to crying if the mother indicated she had decided to feed because the infant was crying or showing clear distress.

*Non-hunger: Infant-led.* Non-hunger feedings were coded as infant-led if the mother initiated feeding for a reason other than hunger that was centered around the well-being of the baby (e.g., wanted to comfort the baby, wanted to calm the baby before getting shots).

*Non-hunger: Mother-led.* Non-hunger feedings were coded as mother-led if the mother initiated feeding for a reason other than hunger that was centered around adult-dictated logistical reasons such as schedules (e.g., needing to leave for work) or other maternally-motivated reasons (e.g., breasts feeling engorged).

**Procedure.** After indicating interest in the study, mothers were contacted electronically by a research assistant to give the mother details about the feeding log procedure and obtain informed consent. Mothers were instructed to fill out the maternal questionnaire first, then fill out the feeding log during a consecutive three-day period of their choice. Both the questionnaire and the feeding log were administered via the Google Forms platform that can be accessed online from a web browser or smartphone app.

## Results

Mothers logged from 12-47 breastfeeding sessions over the course of three days ($M$ = 23.34, $SD$ = 7.95). Out of those logged breastfeeding sessions, an average of 55.17% were initiated when the infant was in physical contact with the mother ($SD$ = 18.83%, 16.67%- 100%) and an average of 32.84% were initiated when the infant was in visual contact with the mother ($SD$ = 17.10%, 0%- 78.57%). The most common reason for feeding was early hunger cues ($M$ = 29.72%, $SD$ = 17.87%), followed by late cues ($M$ = 29.50%, $SD$ = 21.63%), infant-led non-hunger reasons ($M$ = 22.83%, $SD$ = 17.48%), and mother-led non-hunger reasons ($M$ = 18.12%, $SD$ = 14.53%). With regard to maternal beliefs, mothers had a proximal care belief score of negative eight to positive 17 ($M$ = 6.51, $SD$ = 5.69) out of a possible range of negative 20 to positive 20.

These descriptions of the feeding beliefs and behavior of the sample reflect the particular population from which these mothers were sampled, and very clearly do not represent U.S. mothers at large. First, many other studies have reported that crying is the most commonly reported indication of hunger used by U.S. mothers to initiate feeding (Gross et al., 2010). The fact that this sample initiated feeding more often due to early hunger cues than late cues (i.e., crying) demonstrates the already high levels of responsiveness.

**Analyses**. We first used bivariate logistic regression analyses to assess any contributing effects of demographic factors on the outcome measure (reason for feeding). We next conducted generalized mixed-effects logistic regression models to test whether maternal beliefs (proximal care belief score) and immediate mother-infant physical contact (versus visual contact or no contact) were predictive of reason for feeding. We analyzed hunger-related reasons for feeding (early cues versus late cues) separately from non-hunger reasons for feeding (infant-led versus adult-led). In these models, we controlled for infant age, maternal education, maternal employment, and infant hours in daycare by including these as fixed effects. We included random intercepts for subject as well as random slopes to account for the multiple responses for each participant (Pinheiro & Bates, 2000). These analyses were conducted using the lme4 package within R Studio software, Version 1.0.44 (Bates, Maechler, & Bolker, 2011).

***Infant and mother characteristics***. Infant age was not predictive of feeding for early hunger cues versus late hunger cues, $\beta$ = -.003, *SE* = 0.039, $z$ = -0.082, $p$ = .935. Infant age was predictive of feeding for non-hunger infant-led reasons in comparison with non-hunger mother-led reasons, $\beta$ = .089, *SE* = 0.039, $z$ = 2.299, $p$ = .022. Maternal

education, and maternal employment were not predictive of hunger-related reasons for feeding (all *p*s > .3). Infant hours in daycare was predictive of feeding in response to cues in contrast to crying, $\beta$ = .040, *SE* = .013, *z* = 3.142 *p* = .002.

Hours in daycare was not predictive of non-hunger reasons for feeding (all *p*s > .3). Having a higher education (graduate degree) was negatively associated with feeding for infant-led non-hunger reasons in contrast to mother-led non-hunger reasons, $\beta$ = -.67, *SE* = 0.34, *z* = -1.968, *p* = .049. Mothers with a graduate degree had a higher average percent of feeds initiated for mother-led reasons (*M* = 21.60%, *SE* = .56), in comparison with having a high school degree (*M* = 12.53%, *SE* = .51) or a college degree (*M* = 19.56%, *SE* = .46). Maternal employment (working versus staying at home) was negatively associated with feeding for infant comfort, $\beta$ = -.815, *SE* = 0.261, *z* = -3.124, *p* = .002. Mothers who were employed currently had a lower percent of comfort-related logged feeds (*M* = 16.59%, *SE* = .565) than mothers who were currently staying at home (*M* = 26.03%, *SE* = .450).

***Maternal beliefs.*** Maternal beliefs (i.e., proximal care belief score) were not predictive of feeding for cues versus crying, but having a higher proximal care belief score was predictive of feeding for infant-led non-hunger reasons, $\beta$ = .074, *SE* = 0.021, *z* = 3.546, *p* = .0004. Mothers with higher alignment with the beliefs of proximal care culture (median split at 8 or higher) were more likely to have a greater percent of feeds initiated for infant-led reasons (*M* = 26.45%, *SE* = .498) than mothers with a lower (7 or less) proximal care belief score (*M* = 17.88%, *SE* = .519).

***Mother-infant physical contact.*** In the bivariate logistic regression, mother-infant physical contact preceding a feeding session was predictive of initiating the session in response to early cues in contrast to late cues, $\beta$ = .834, *SE* = 0.321, *z* = 2.593, *p* = .009,

though mother-infant visual contact was not significant in comparison with no contact, $\beta$ = -0.154, *SE* = 0.301, *z* = -.513, *p* = .608. In the multivariate model controlling for infant age, maternal education, maternal employment, and infant hours in daycare by including these factors as fixed effects, and controlling for multiple responses (i.e., feeding log entries) nested within participant by including random slopes for participant by mother-infant contact, we found that mother-infant physical contact was predictive of feeding in response to early hunger cues in comparison with late cues, $\beta$ = .991, *SE* = 0.315, *z* = 3.149, *p* = .002, see Table 1.2. Mothers with more feedings initiated in physical contact (i.e., the median 53% or more) had a higher percent of feeds initiated in response to early cues (*M* = 33.24%, *SE* = 2.41) than mothers with less feedings (less than 53%) initiated in physical contact (*M* = 25.67%, *SE* = 2.59), see Figure 1.1. In contrast, mother-infant visual contact was not predictive of feeding for early cues versus late cues, $\beta$ = 0.002, *SE* = .200, *z* = 0.007, *p* = .994.

With regard to non-hunger reason for feeding (infant-led versus mother-led), in the bivariate regression analysis, mother-infant physical contact was predictive of feeding for infant-led versus adult-led reasons, $\beta$ = 1.271, *SE* = 0.261, *z* = 4.868, *p* < .0001. In the multivariate mixed-effects model controlling for infant age, maternal education, maternal employment, and infant hours in daycare by including these factors as fixed effects, and controlling for multiple responses (i.e., feeding log entries) nested within participant by including random slopes for participant by mother-infant contact, we found that mother-infant physical contact was predictive of feeding for infant-led versus mother-led reasons, $\beta$ = 1.246, *SE* = 0.304, *z* = 4.095, *p* < .0001, see Table 1.3. Mothers with more feedings initiated in physical contact (i.e., the median 53% or more) had a lower percent of feeds

initiated for mother-led reasons ($M$ = 14.54%, $SE$ = 1.94) than mothers with less feedings (less than 53%) initiated in physical contact ($M$ = 22.22%, $SE$ = 2.08), see Figure 1.2. In contrast, mother-infant visual contact was not predictive of feeding for infant-led versus mother-led reasons, $\beta$ = 0.397, $SE$ = .288, $z$ = 1.379, $p$ = .168.

**Discussion**

This was the first known investigation of how immediate mother-infant physical contact relates to breastfeeding behavior. Our primary research aims were to: 1) test whether mother-infant physical contact predicts feeding in response to early hunger cues (versus in response to late hunger cues), and 2) test whether mother-infant physical contact predicts feeding for infant-led non-hunger reasons (rather than mother-led non-hunger reasons). Our data support the proposal that mother-infant physical contact predicts increased maternal responsiveness to infant needs both in the context of responding to infant hunger cues as well as in the context of responding to infants' need for comfort outside of the context of hunger.

Consistent with our predictions, mothers were more likely to be responsive to their infant's early hunger cues when feeding was preceded by physical contact with their infant. Importantly, mother-infant visual contact did not predict reason for feeding, suggesting that it is something special about physical contact specifically that facilitates increased responsiveness. Our data also show that increased responsiveness to hunger cues was not simply attributed to increased feeding frequency overall. We were also able to rule out the possibility that maternal beliefs were driving the association between physical contact and increased responsiveness to hunger cues.

Our second research aim was to test whether mother-infant physical contact was predictive of infant-led non-hunger reasons for feeding. When feeding for contextual reasons rather than hunger-based reasons, mothers in this study were more likely to feed for infant-led reasons (i.e., to comfort the infant) rather than adult-motivated reasons when the feeding was preceded by mother-infant physical contact. Again, mother-infant visual contact was not associated with feeding for non-hunger reasons, suggesting that there is something special about direct physical contact that facilitates infant-led motivations for feeding above and beyond just having the infant in proximity. However, in this non-hunger context, maternal beliefs were predictive of reason for feeding, such that mothers with greater alignment with the beliefs of proximal care culture were more likely to feed for infant-led versus mother-led non-hunger reasons.

Given that this was the first study to use this type of feeding log, there are several limitations that should be improved upon in future work. The specific response options to the feeding log questions should be more specific and more standardized in future studies. Specifically, we made improvements to the feeding log halfway through data collection in response to difficulties arising from including the option for participants to write in their own response (with the "other" option). Though this is not an ideal methodological decision, we analyzed the two samples separately (i.e., participants who filled out the first feeding log versus those who filled out the second feeding log) and found no differences in the results, allowing us to collapse across the two groups. In addition, another limitation of the study was the large age range. As infants develop increasingly sophisticated communication skills over the first year of life, it may become easier for caregivers to recognize signals for hunger. However, we did not see systematic age differences with

regard for feeding in response to early hunger cues versus late hunger cues, showing that this is less of a critical issue.

This study contributes a novel measure of maternal responsiveness to the field. In the psychological literature, maternal responsiveness – or the ability to respond to infants' signals promptly and appropriately – is associated with social learning (Bigelow & Birch, 1999; Johnson, Slaughter, & Carey, 1998), language development (Nicely, Tamis-LeMonda, & Bornstein, 1999; Tamis-LeMonda, Kuchirko, & Song, 2014), and secure attachment (Anisfeld et al., 1990; Dunst & Kassow, 2008). However, these studies have only measured maternal responsiveness in the context of mother-infant play paradigms (e.g., measuring contingent vocalizations during playtime), which is an irrelevant measure for many mothers in communities where adult play and vocal interaction with infants is not a priority. In contrast, measuring responsiveness in the context of feeding provides a much more globally and biologically relevant measure of responsiveness. Using this novel approach, these data show that culturally-mediated contact with caregivers shapes one of the most foundational experiences of infancy: feeding.

## Study 2

Study 1 showed that mother-infant physical contact before a feeding session was predictive of initiating feeding because of early hunger cues (e.g., mouthing) and infant-led non-hunger reasons (e.g., as a comforting technique) in contrast to late hunger cues (e.g., crying) and mother-led non-hunger reasons (e.g., schedules). However, responsiveness to hunger cues – as the reason for initiating feeding – is just one component of responsive breastfeeding. The duration of the breastfeeding session depends on whether mothers allow infants to feed as long as they want or if they decide to end the session after

a predetermined duration. Once infants are already in physical contact with the mother (i.e., during breastfeeding) physical contact before the feeding session should no longer matter with regard to reasons for terminating feeding. Two alternate possibilities are: 1) responsiveness to satiation cues will be determined by maternal beliefs about responsiveness, or 2) responsiveness to satiation cues will be predicted by experience with mother-infant physical contact. Specifically, long-term experience with physical contact may facilitate increased bonding between mother and infant, potentially motivating the mother to be more responsive to subtle cues. To this end, Study 2 used an at-home feeding log to assess whether breastfeeding sessions ended due to satiation cues (i.e., infant-led termination) or because of mother-led reasons (e.g., duration, logistics, maternal comfort). The primary aim of Study 2 was to test whether maternal responsiveness to infant cues for satiation (e.g., appearing "milk drunk," falling asleep, turning away) was driven by maternal beliefs about responsiveness or by long-term experience with mother-infant physical contact.

Breastfeeding mothers filled out a feeding log for three days during which they documented the reason for terminating each breastfeeding session. Mothers also filled out a questionnaire about parenting practices – including use of practices that facilitated mother-infant physical contact (e.g., babywearing) – and maternal beliefs, specifically their degree of alignment with the values of proximal care parenting culture. Given the profound implications of responsive feeding for infant health and psychological development, understanding how mother-infant interaction shapes feeding behavior is a crucial and often overlooked component of infant nutrition.

## Method

All procedures and recruitment methods were approved by the Institutional Review Board of University of California, San Diego.

**Participants.** Mothers were recruited from social media postings within U.S.-based breastfeeding groups. To be eligible to participate in the study, mothers had to be currently breastfeeding, had to complete all three days of the feeding log, and had to log at least 12 breastfeeding sessions.

Thirty-one mothers (*M* = 31.16 years, *SD* = 4.80, 21-42 years) and their infants (16 female, *M* = 6.82 months, *SD* = 3.05, 1.54-12.52 months) participated in the study. Infants were normally distributed across the age groups, with seven 2- to 3-month-olds, five 4- to 5-month-olds, five 6- to 7-month-olds, ten 8- to 9-month-olds, and four 10- to 12-month-olds. Mothers had obtained either a high school diploma (35.48%), a college degree (29.03%), or a graduate degree (35.48%). The average annual household income was $79,333 (*SD* = $54,120, $20,000 - $275,000). Twenty of the mothers were multiparous (had more than one child, 64.52%) or primiparous (had only one child, 35.48%). Eighteen of the mothers were currently not working (58.06%) and the rest were working outside of the home (41.94%). Infants spent an average of 12.26 hours per week in daycare (*SD* = 16.10, 0-55).

**Materials.** ***Maternal questionnaire.*** In the same online questionnaire used in Study 1, we solicited demographic information from each mother, including infant age, maternal age, maternal education, household income, parity, maternal employment (currently working outside of the home versus not) and average hours per week that the infant spends in daycare. Maternal beliefs were assessed in the same way as Study 1 (i.e., using the 10-

question parental ethnotheory questionnaire soliciting degree of agreement with parenting statements regarding the care of a three-month-old infant, see Table 1.1).

*Mother-infant physical contact.* We measured long-term experience with mother-infant physical contact by asking mothers about their infant transport method (babywearing versus strollers or other). Mothers were categorized as having more physical contact with their infant if they practiced babywearing and were characterized as having less physical contact if they reported anything other than babywearing.

***Feeding log.*** The feeding log consisted of two questions: 1) feed method, 2) reason for terminating feeding. The date and time of the feeding session was automatically recorded by the Google Form. For each of these questions, a list of options was provided and only one response could be chosen for each question.

*Responsiveness to satiation cues.* For each feeding that was logged over the three-day period, mothers were instructed to indicate the primary reason they decided to terminate each feeding session. There were two categories of responses: infant-led (satiation cues) and mother-led (logistical, maternal comfort, or duration/quantity). Any feedings that were terminated in response to the infant communicating fullness were coded as infant-led (i.e., indicating the mother had ended the session in response to satiation cues). Any feedings that were terminated for maternal reasons (e.g., maternal comfort, time since last feed, quantity consumed) or because of duration of the feed (e.g., timing, perceived quantity consumed) were coded as mother-led.

**Procedure.** After indicating interest in the study, mothers were contacted electronically by a research assistant to give the mother details about the feeding log procedure and obtain informed consent. Mothers were instructed to fill out the maternal

questionnaire first, then fill out the feeding log during a consecutive three-day period of their choice. Both the questionnaire and the feeding log were administered via the Google Forms platform that can be accessed online from a web browser or smartphone app.

**Results**

During the three days of the feeding log, mothers recorded between 13 and 39 breastfeeding sessions ($M$ = 22.77, $SD$ = 6.76). Out of the total logged feeds per participant, a high percent of those were terminated for infant-led reasons ($M$ = 81.6%, $SD$ = 13.9%, 35% – 100%). Mothers (83.87%) reported using babywearing as their primary transport method with their infant. Mothers in this sample were also quite aligned with the practices and beliefs of proximal care culture. Out of the possible range from negative 20 to positive 20 (with positive scores indicating a higher degree of alignment with proximal care culture than distal care culture), the average proximal care belief score was 6.52 ($SD$ = 6.91, -6 to 17).

**Analyses.** We first used bivariate logistic regression to predict reason for terminating feeding by infant and maternal characteristics. We then used generalized mixed-effects logistic regression models to predict reason for terminating feeding (infant-led versus mother-led) by experience with physical contact (babywearing), and degree of alignment with proximal care (proximal care belief score). In these models, we included random slopes for the multiple responses of each participant (Pinheiro & Bates, 2000). These analyses were conducted using the lme4 package within R Studio software, Version 1.0.44 (Bates, Maechler, & Bolker, 2011).

***Maternal and infant characteristics.*** Infant age was not predictive of reason for terminating feeding ($p$ > .2). None of the maternal demographic variables (education,

employment, or hours in daycare were predictive of reason for terminating feeding (all *p*s > .2).

***Mother-infant physical contact.*** Experience with babywearing was not predictive of reason for terminating the feeding session ($p > .9$).

***Maternal beliefs.*** Degree of alignment with proximal care beliefs was predictive of ending the session in response to cues, $\beta = .079$, $SE = .038$, $z = 2.090$, $p = .037$. Mothers who had a high proximal care belief score (> 8), had a higher percentage of breastfeeding sessions terminated in response to cues ($M = 87.02\%$, $SE = 3.63\%$) in comparison with mothers who had low (7 or less) proximal care belief scores ($M = 77.62\%$, $SE = 3.51\%$), see Figure 1.4.

In the multivariate model controlling for infant age, maternal education, maternal employment, infant hours in daycare, and breastfeeding motivation by including these factors as fixed effects, and controlling for multiple responses (i.e., feeding log entries) nested within participant by including random slopes for participant, we found that maternal beliefs were predictive of ending the feeding in response to cues versus other maternal reasons, $\beta = .092$, $SE = 0.031$, $z = 2.929$, $p = .0003$, see Table 1.4.

**Post-hoc analyses.** ***Feeding frequency.*** One possible interpretation of these results is that mothers with certain beliefs about responsiveness (i.e., higher alignment with the values of proximal care culture) or certain motivations for breastfeeding are more likely to breastfeed more often, thus allowing the mother to develop increased recognition of her infant's cues for satiation. With bivariate linear regressions, we tested whether proximal care belief score or breastfeeding motivation were predictive of total number of logged breastfeeding sessions and found no relationship in either case (*p*s > .4).

**Discussion**

The primary aim of this study was to assess whether experience with mother-infant physical contact (i.e., participation in practices that facilitate increased physical contact, such as babywearing) or maternal beliefs about responsiveness were predictive of ending breastfeeding sessions in response to infant satiation cues in contrast to mother-led reasons. Long-term mother-infant physical contact (i.e., babywearing) was not associated with variation in responsiveness to infant satiation cues. However, in our sample, the majority of mothers (83.87%) reported babywearing as their primary transport method. This lack of variation may have hindered our ability to assess the relationship between long-term physical contact and responsiveness to satiation cues. To more effectively assess the effect of experience with physical contact, future work should have a sample that is more representative of both mothers with more experience with physical contact as well as mothers with less experience with physical contact, which we address in Study 3.

Our findings do support the alternate hypothesis: maternal beliefs related to proximal care were associated with responsiveness to satiation cues, such that mothers who expressed a higher level of agreement with proximal care beliefs were more likely to be responsive to their infant's cues for satiation. Past studies have shown a significant effect of feed method on responsiveness to satiation cues (Crow, Fawcett, & Wright, 1908), yet very few studies have looked at feeding responsiveness within the context of breastfeeding only and no study has looked specifically at responsiveness to satiation cues within the context of breastfeeding. This study used a novel methodology to explore the reasons breastfeeding mothers decide to end feeding sessions, finding that maternal beliefs –

alignment with the values of proximal care culture – were predictive of ending breastfeeding sessions due to infant cues for satiation.

One alternate interpretation of these results is that mothers with increased desire to be responsive to infant cues would be more likely to report responsiveness – regardless of the actual reason for initiating or terminating a feeding session – creating the potential for response bias. Study 3 aimed to assess the validity of this result by testing the association between maternal beliefs and responsiveness to infant cues during breastfeeding by objectively measuring maternal-infant interaction with an in-lab breastfeeding session.

## Study 3

Study 3 used an in-lab observation of mother-infant interaction during breastfeeding to assess the predictors of maternal responsiveness to infant cues during breastfeeding. The first research aim was to test whether maternal beliefs (i.e., alignment with the values of proximal care culture) were predictive of responsiveness to infant cues during breastfeeding, as suggested by the self-report data of Study 2. First, we tested whether alignment with beliefs of proximal care culture were predictive of maternal responsiveness during breastfeeding, with regard to letting the infant lead the breastfeeding session rather than having an adult-led session. We predicted that – in line with results from the at-home feeding log of Study 2 – mothers who expressed increased agreement with the parenting goals of proximal care culture (i.e., increased responsiveness and mother-infant physical contact) would be more likely to show responsiveness to their infant cues during the breastfeeding session. Because experience with mother-infant physical contact was not predictive of responsiveness to satiation cues (as demonstrated by the results of Study 2), we did not predict that experience with mother-infant physical contact

(i.e., babywearing) would be predictive of increased maternal responsiveness during breastfeeding.

The second research aim was to describe individual differences in multi-modal mother-infant communication (vocalization and touch) during breastfeeding. Mother-infant interaction during feeding is influenced by feed method, such that breastfeeding mothers have been observed to be more interactive during feeding (via touch, gaze) than bottle-feeding mothers (Lavelli & Poli, 1998). The interaction behavior that infants experience during breastfeeding is thought to lay the foundation for learning about patterns of communication (Kaye & Wells, 1980), yet no study has described the individual variation in patterns of interaction among breastfeeding mothers.

**Method**

All procedures and recruitment methods were approved by the Institutional Review Board of University of California, San Diego.

**Participants.** Mothers were recruited from a lab database of parents and from social media postings from local parenting groups. A total of 30 mother-infant dyads participated in this study (17 female, infants, *M* = 6.56 months, *SD* = .507, 1.82-13.9). Infants were normally distributed across the age range, with five 2- to 3-month-olds, six 4- to 5-month-olds, eleven 6- to 7-month-olds, five 8- to 9-month-olds, and three 10- to 13-month-olds. Mothers were an average of 33.13 years old (26-44 years, *SD* = 3.59) and had completed an average of 16.96 years of schooling (12-18 years, *SD* = 1.70). Mothers had an average household income of $119,551 annually ($32,000- $250,000, *SD* = $51,813). Most (73.33%) of the mothers were on temporary leave from work or were stay-at-home

mothers, while the rest were employed outside of the home. Fifteen mothers were primiparous (having only one child, 53.57%).

**Materials.** ***Maternal questionnaire***. In a written questionnaire, we solicited demographic information from each mother and assessed maternal beliefs.

*Maternal beliefs.* Maternal beliefs were assessed with Keller's (2002) 10-question parental ethnotheory questionnaire that solicits degree of agreement with parenting statements regarding the care of a three-month-old infant (see Table 1.1). Responses to each item were on a scale from one (completely disagree) to five (completely agree). Responses from each participant were compiled to form a proximal care belief score, calculated by summing responses from all questions aimed to measure alignment with goals of proximal care parenting culture then subtracting the sum of responses to all questions designed to test alignment with goals of distal care parenting culture. The range of possible scores was negative 20 to positive 20. Any positive score indicated that mothers leaned more toward the values of proximal care culture than distal care culture, and a higher score indicated a greater agreement with the parenting goals characteristic of proximal care culture.

*Mother-infant physical contact.* We measured long-term experience with mother-infant physical contact by asking mothers about their infant transport method (babywearing versus strollers or other). Mothers were categorized as having more physical contact with their infant if they practiced babywearing and were categorized as having less physical contact with their infant if they did not report babywearing as their primary method of transporting the infant.

***Experimental setup.*** The experimental setup consisted of a private room with a large armchair available for the mother to breastfeed her infant. Two FlipCam video cameras were used for the video recording. One was positioned across from the mother, and the second was positioned above the mother's head, to get a better view of the infant's face and unlatching behavior.

**Procedure.** Mothers came into the lab where they were greeted by a research assistant who explained the study details and obtained written, informed consent to participate. Mothers were instructed to schedule the session at a good time to feed the infant (in case their infant had a routine feeding schedule). The research assistant showed the mother to a private room and instructed her to feed her child however she normally does. Participants were not time restricted, and were told to feed for as long as they would like and to open the door when they were finished. The research assistant pressed record on the two video cameras before leaving the room.

**Video coding.** We measured maternal responsiveness (i.e., percent of infant-led unlatches, see below), maternal vocalizations, and maternal touch. For the behavioral outcome measures (maternal responsiveness and maternal vocalizations and touch), coding was completed by two coders – blind to the hypotheses of the study – through the use of ELAN, video annotation software developed by the Max Planck Institute for Psycholinguistics (Lausberg & Sloetjes, 2009). The coders overlapped on the first 20% of the participant videos and any discrepancies were discussed until coders arrived at complete (100%) agreement.

***Infant-led unlatches.*** During breastfeeding, it is common for infants to unlatch themselves from the mother's breast, after which they can either re-approach the breast to

continue feeding or not re-approach, indicating satiation by turning away, looking disinterested, or falling asleep. Each time the infant unlatched, the subsequent behavior was coded as infant-led versus mother-led. The instance of unlatching was coded as infant-led if the mother allowed the infant to initiate the approach to the breast. In contrast, the instance of unlatching was coded as mother-led if the mother: a) encouraged continued feeding (e.g., approaching the infant, moving the infant's head/body toward the breast, or positioning the breast in/near the infant's mouth before the infant had initiated the re-approach or started opening their mouth, or b) terminated the feeding by removing access to the breast before giving the infant the chance to either re-approach or indicate satiation. The percent of infant-led unlatches (out of total instances of unlatching) was calculated for each dyad.

***Maternal behavior.*** *Vocalization.* We calculated frequency of maternal vocalizations (as rate of vocalizations per minute) as a measure of non-feeding social engagement during the breastfeeding session.

*Tactile interaction.* The frequency of maternal touches was calculated as the rate of tactile contact per minute, including any voluntary touch initiated by the mother outside of the inevitable physical contact of breastfeeding (e.g., stroking the infant's cheek, wiggling the infant's toes). Tactile interaction was used as a measure of non-feeding social engagement during the breastfeeding session.

**Results**

The average breastfeeding session was 11.14 minutes (4.60- 25.65 minutes, *SD* = 5.75 minutes) and infants had an average of 6.27 unlatch occurrences (1-18 unlatches, *SD* = 4.43 unlatches). Fifteen of the mothers self-identified as babywearers and reported

babywearing as the primary method of transporting their baby. With regard to parenting beliefs, mothers had an average proximal care belief score from negative eight to positive 13 (out of a possible range of negative 20 to positive 20, $M = 3.86$, $SD = 5.58$). Thirteen mothers were exclusively breastfeeding (43.33%), five were supplementing with formula (16.67%), and the rest were providing complementary solid food in addition to breastmilk (40%).

**Analyses.** We conducted bivariate regression analyses to measure whether our independent measures (maternal and infant characteristics, mother-infant physical contact, and maternal beliefs) were predictive of the behavioral outcome measures (percent of infant-led unlatches, maternal and infant rate of vocalization, maternal and infant rate of touch).

***Maternal and infant characteristics.*** Infant age was not associated with percent of infant-led unlatches or maternal behavior (all *p*s > .1). Maternal age, maternal education, income, and parity were not associated with infant-led unlatches, rate of maternal touch per minute, or rate of maternal vocalization per minute (all *p*s > .1).

***Maternal beliefs.*** Bivariate tests showed that having a higher proximal care belief score (indicating increased alignment with the infant care values characteristic of proximal care) was predictive of higher infant-led unlatches, $\beta = 2.76$, $SE = 1.14$, $t = 2.43$, $p = .02$. Specifically, mothers who had a higher proximal care belief score (median split at a score of 5 or greater) had a higher percent of infant-led unlatches ($M = 83.35\%$, $SE = 8.71\%$) than mothers with a lower (median split at a score of 4 or lower) proximal care belief score ($M = 48.38\%$, $SE = 8.41\%$, see Figure 1.4). Proximal care belief score was not associated with maternal vocalization or maternal touch (all *p*s > .1).

***Long-term physical contact.*** Infant carrying method was not predictive of percent infant-led unlatches, $\beta$ = 11.41, *SE* = 6.30, *t* = 1.81, *p* = .08. With regard to maternal interaction behavior, babywearing was significantly associated with rate of maternal vocalizations per minute, $\beta$ = 1.36, *SE* = .23, *t* = 5.96, *p* < .0001, such that babywearing mothers had a higher rate of vocalization per minute (*M* = 3.81, *SD* = .31) than non-babywearing mothers (*M* = 1.09, *SD* = .34). Experience with mother-infant physical contact was also predictive of rate of maternal touches per minute, $\beta$ = .54, *SE* = .25, *t* = 2.17, *p* = .04. Babywearing mothers had a higher rate of touches per minute (*M* = 2.41, *SE* = .33) than non-babywearing mothers (*M* = 1.32, *SE* = .37).

**Post-hoc analyses: Infant behavior.** Given the importance of infant behavior in shaping mother-infant interaction, we wanted to test whether infant behavior was predictive of maternal responsiveness. We conducted bivariate linear regressions to test the relationship between infant behavior and maternal responsiveness (i.e., percent of infant-led unlatches). Overall rate of infant unlatching was not predictive of infant-led unlatches, $\beta$ = 10.89, *SE* = 14.53, *t* = .75, *p* = .46. Rate of infant vocalization was not predictive of infant-led unlatches, $\beta$ = 6.77, *SE* = .88, *t* = .88, *p* = .39. Length of the breastfeeding session was not associated with infant-led unlatches, $\beta$ = -.82, *SE* = 1.45, *t* = -.56, *p* = .58. Maternal rate of vocalization was not predicted by infant rate of unlatch, $\beta$ = .97, *SE* = .66, *t* = 1.46, *p* = .16, but was predicted by infant rate of vocalization, $\beta$ = .74, *SE* = .33, *t* = 2.28, *p* = .04. Infant rate of vocalization was predicted by rate of unlatch, $\beta$ = 1.45, *SE* = .28, *t* = 5.04, *p* < .0001.

## Discussion

The objective of this study was to assess whether maternal behavior (i.e., experience with mother-infant physical contact) and beliefs (i.e., degree of alignment with proximal care culture) were predictive of: 1) maternal responsiveness (i.e., percent infant-led unlatches), and 2) maternal interaction behavior (rate of vocalization, touch) during breastfeeding. Consistent with our predictions, we found that mothers with higher proximal care belief scores (indicative of increased agreement with proximal care parenting goals) had more infant-led – versus adult-led – unlatches. Consistent with the results of Study 2, we did not find a significant effect of long-term experience with physical contact.

Experience with physical contact predicted increased interaction behavior during breastfeeding, including a higher rate of maternal vocalization and maternal touch. Others have proposed that the communication that occurs during breastfeeding lays the foundations for understanding the back-and-forth contingent nature of communication patterns (e.g., Kaye & Wells, 1980). These data show that – consistent with the proposal that mother-infant physical contact shapes interaction behavior – mothers with more experience with physical contact (via babywearing) were more interactive to their infants during the breastfeeding process.

This was the first study to test maternal responsiveness to infant satiation cues during an in-lab breastfeeding session and used a novel observational measure (i.e., percent infant-led unlatches) as a proxy for maternal responsiveness in the context of breastfeeding. Though observation may be more valid than self-report on many levels, more studies should be conducted to further assess the internal validity of this measure. For example, though a period of unlatch and relatch may appear to be mother-led or infant-led to an outside observer, only the mother knows whether the infant was engaged in nutritive (i.e.,

extracting milk) versus non-nutritive sucking (i.e., for comfort), potentially leading to a mismatch in observed versus actual behavior. Given that these data are consistent with the self-report findings of Study 2 (i.e., maternal beliefs predicted increased responsiveness to infant satiation cues), providing support for the validity of the measures and providing motivation to continue developing this measure as an effective and consistent measure.

## General Discussion

In three studies, we tested whether mother-infant physical contact and maternal beliefs predicted increased responsiveness to infant cues in the context of breastfeeding. We were able to confirm our primary hypothesis – that mother-infant physical contact predicted increased responsiveness to infant feeding cues – but only in one specific case: in response to infant cues for hunger. Specifically, in Study 1, immediate mother-infant physical contact preceding a feeding session was predictive of initiating the feeding session in response to early hunger cues versus late cues. Once in physical contact (via breastfeeding), we found in Study 2 that maternal beliefs were predictive of maternal responsiveness (i.e., to satiation cues), such that a higher proximal care belief score (i.e., indicating alignment with the value of responsiveness and physical contact) was predictive of ending breastfeeding sessions due to infant displays of satiation (rather than mother-determined reasons). However, long-term experience with mother-infant physical contact was not predictive of ending the feeding session due to infant-led versus mother-led reasons. In Study 3, we again confirmed that maternal beliefs were predictive of responsiveness during breastfeeding with an in-lab measurement of maternal responsiveness during a breastfeeding session, and again experience with long-term mother-infant physical contact was not predictive of responsiveness to infant cues during

breastfeeding. Together, these data demonstrate that mother-infant physical contact –as well as maternal beliefs – are important in shaping maternal responsiveness in the infant's early social environment.

In proximal care cultures where physical contact is the norm for infant-caregiver interaction, breastfeeding can occur several times per hour (Barr et al., 1991; Konner, 2005). The data from this study show that even in a "WEIRD" – Western, educated, industrialized, rich, and democratic – society (Henrich et al., 2010), increased physical contact is associated with increased responsiveness to hunger cues. However, infant-caregiver interaction is mediated by a complex combination of cultural and social factors (e.g., Bornstein, 2012; Broesch et al., 2016; Clegg & Legare, 2015; Legare & Nielsen, 2015; Legare, Wen, Herrmann, & Whitehouse, 2015; Mathew & Perreault, 2015) and shows a wide range of variation in both the modality and contingency of interaction behavior (e.g., Bornstein et al., 1992; Kärtner, Keller, & Yovsi, 2010; Kärtner et al., 2008; Lancy, Bock, & Gaskins, 2010). Unfortunately, current research in developmental psychology is biased toward work that features Western populations (Akhtar & Gernsbacher, 2008; Arnett, 2008), impeding a more comprehensive understanding of how maternal responsiveness to infant feeding cues relates to infant care practices.

Breastmilk is internationally recognized as the optimal nutrition for infant health and development. Despite high rates of breastfeeding initiation, most U.S. mothers do not meet the recommendations for exclusive and continued breastfeeding (CDC, 2016), causing increasing public health and societal concerns (Bartick et al., 2017). Neglecting to recognize and respond to infant feeding cues exacerbates both physiological and psychological breastfeeding challenges (Shloim, Vereijken, Blundell, & Hetherington,

2017; Woolridge, 1995), providing one explanation for U.S. mothers not meeting global breastfeeding duration goals despite strong positive intentions to breastfeed and encouragement from health professionals. Above and beyond the implications for breastfeeding success, feeding according to adult schedules rather than in response to infant cues may increase the risk for malnutrition and obesity (Black & Aboud, 2011; Engle et al., 2000), may impact the development of self-regulation (Wright, 1988; Wright et al., 1980) and non-cry communication (Kirk, Alder, & King, 2007; Saunders, Friedman, & Stramoski, 1991), and is associated with increased crying (Barr & Elias, 1988; Hewlett et al., 1998; Keller & Otto, 2009) and increased risk of insecure attachment (Tharner et al., 2012). Though most breastfeeding interventions target breastfeeding barriers on the societal level (e.g., rampant infant formula marketing, hospital birthing procedures, public breastfeeding taboos, work constraints, highly scheduled societal demands, sexualization of breasts, and breastfeeding myths perpetuated by the media, Jung, 2015; Sriraman & Kellams, 2016), the data presented here suggest that individual-level factors (i.e., maternal behavior and beliefs) facilitate increased responsiveness to infant feeding cues, thus providing a potential new avenue to support breastfeeding success.

These studies contributed novel measures (at-home feeding logs, responsiveness *during* observed breastfeeding interaction) and novel findings (mother-infant physical contact predicting responsiveness to hunger cues and individual differences in responsiveness to satiation cues predicted by degree of alignment with the goals of proximal care culture) to the literature on maternal responsiveness. Maternal responsiveness is an extensively studied topic in developmental psychology but is generally not tested in the context of breastfeeding. However, breastfeeding is one of the

earliest and most universal early contexts from which infants learn about the social world, so understanding the variation in breastfeeding behavior is critical for our knowledge of how infants develop communication, contingency preferences, and interaction behavior.

Chapter 1, in full, is currently being prepared for submission for publication of the material. Little, E. E., Carver, L.J., & Legare, C.H. Implications of mother-infant physical contact for maternal responsiveness. The dissertation author was the primary investigator and author of this material.

Table 1.1: Proximal Care Beliefs Questionnaire. To assess maternal beliefs about infant care, mothers responded to the following ten statements regarding the care of a 3-month-old infant on a scale from 1 (completely disagree) to 5 (completely agree). The proximal care beliefs score was calculated by summing responses to statements in the left column (i.e., proximal care) and subtracting the sum of responses to statements in the right column (i.e., distal care). This questionnaire was developed by Keller (2002) and has been used in diverse countries around the world to assess cultural models of parenting.

| | |
|---|---|
| It is important to rock a crying baby in the arms in order to console him/her<br><br>1----------2---------3----------4----------5<br>(completely disagree) (completely agree) | Sleeping through the night should be trained as early as possible<br><br>1----------2---------3----------4----------5<br>(completely disagree) (completely agree) |
| Gymnastics/motor stimulation makes a baby strong<br><br>1----------2---------3----------4----------5<br>(completely disagree) (completely agree) | You cannot start early enough to direct the infant's attention towards objects and toys<br><br>1----------2---------3----------4----------5<br>(completely disagree) (completely agree) |
| When a baby cries, he/she should be nursed immediately<br><br>1----------2---------3----------4----------5<br>(completely disagree) (completely agree) | It is not necessary to react immediately to a crying baby<br><br>1----------2---------3----------4----------5<br>(completely disagree) (completely agree) |
| If a baby is fussy, he/she should be immediately picked up<br><br>1----------2---------3----------4----------5<br>(completely disagree) (completely agree) | It is good for the baby to sleep alone<br><br>1----------2---------3----------4----------5<br>(completely disagree) (completely agree) |
| A baby should be always in close proximity with his/her mother, so that she can react immediately to his/her signals<br><br>1----------2---------3----------4----------5<br>(completely disagree) (completely agree)<br>(completely agree) | Babies should be left crying for a moment in order to see whether they console themselves<br><br>1----------2---------3----------4----------5<br>(completely disagree) (completely agree) |

Table 1.2: Model Predicting Responsiveness to Cues. Fixed effects for the mixed-effects model predicting initiating hunger-related feedings in response to early cues (in comparison with crying) in Study 1.

| | Effect Estimate | Standard Error | *z* value | *p* value |
|---|---|---|---|---|
| Variable | | | | |
| **Infant age** (in months) | -0.030 | 0.044 | -0.665 | .506 |
| **Maternal education** | | | | |
| High school degree | (Reference) | | | |
| College degree | -0.081 | 0.343 | -0.235 | .814 |
| Graduate degree | 0.740 | 0.390 | 1.898 | .058 |
| **Employment** | | | | |
| Not currently working | (Reference) | | | |
| Currently working | -0.604 | 0.326 | -1.853 | .064 |
| **Daycare** | | | | |
| Hours per week | 0.044 | 0.016 | 2.844 | .004** |
| **Maternal beliefs** | | | | |
| Proximal care belief score | 0.030 | 0.027 | 1.106 | .269 |
| **Mother-infant contact** | | | | |
| No contact | (Reference) | | | |
| Visual contact | 0.002 | 0.300 | 0.007 | .994 |
| Physical contact | 0.991 | 0.315 | 3.149 | .002** |

Table 1.3: Model Predicting Responsiveness to Cues. Fixed effects for the mixed-effects model predicting initiating non-hunger feedings in response to infant comfort (in comparison with adult-determined reasons) in Study 1.

| | Effect Estimate | Standard Error | *z* value | *p* value |
|---|---|---|---|---|
| Variable | | | | |
| **Infant age** (in months) | 0.067 | 0.044 | 1.514 | .130 |
| **Maternal education** | | | | |
| High school degree | (Reference) | | | |
| College degree | 0.027 | 0.345 | 0.079 | .937 |
| Graduate degree | 0.085 | 0.403 | 0.210 | .833 |
| **Employment** | | | | |
| Not currently working | (Reference) | | | |
| Currently working | -0.446 | 0.319 | -1.397 | .162 |
| **Daycare** | | | | |
| Hours per week | -0.013 | 0.015 | -0.897 | .369 |
| **Maternal beliefs** | | | | |
| Proximal care belief score | 0.057 | 0.022 | 2.665 | .008** |
| **Mother-infant contact** | | | | |
| No contact | (Reference) | | | |
| Visual contact | 0.397 | 0.288 | 1.379 | .168 |
| Physical contact | 1.246 | 0.304 | 4.095 | <.0001*** |

Table 1.4: Model Predicting Responsiveness to Satiation Cues. Fixed effects associated with ending the feeding in response to infant cues (in comparison with adult-determined reasons) in Study 2.

| | Effect Estimate | Standard Error | *z* value | *p* value |
|---|---|---|---|---|
| Variable | | | | |
| **Infant age** (in months) | -0.017 | 0.067 | -.258 | .797 |
| **Maternal education** | | | | |
| High school degree | (Reference) | | | |
| College degree | 0.574 | 0813 | 0.705 | .481 |
| Graduate degree | -1.116 | 0.556 | -2.007 | .045* |
| **Employment** | | | | |
| Not currently working | (Reference) | | | |
| Currently working | 0.956 | 0.653 | 1.464 | .143 |
| **Daycare** | | | | |
| Hours per week | 0.010 | 0.026 | 0.400 | .689 |
| **Maternal beliefs** | | | | |
| Proximal care belief score | 0.092 | 0.031 | 2.929 | .0003** |

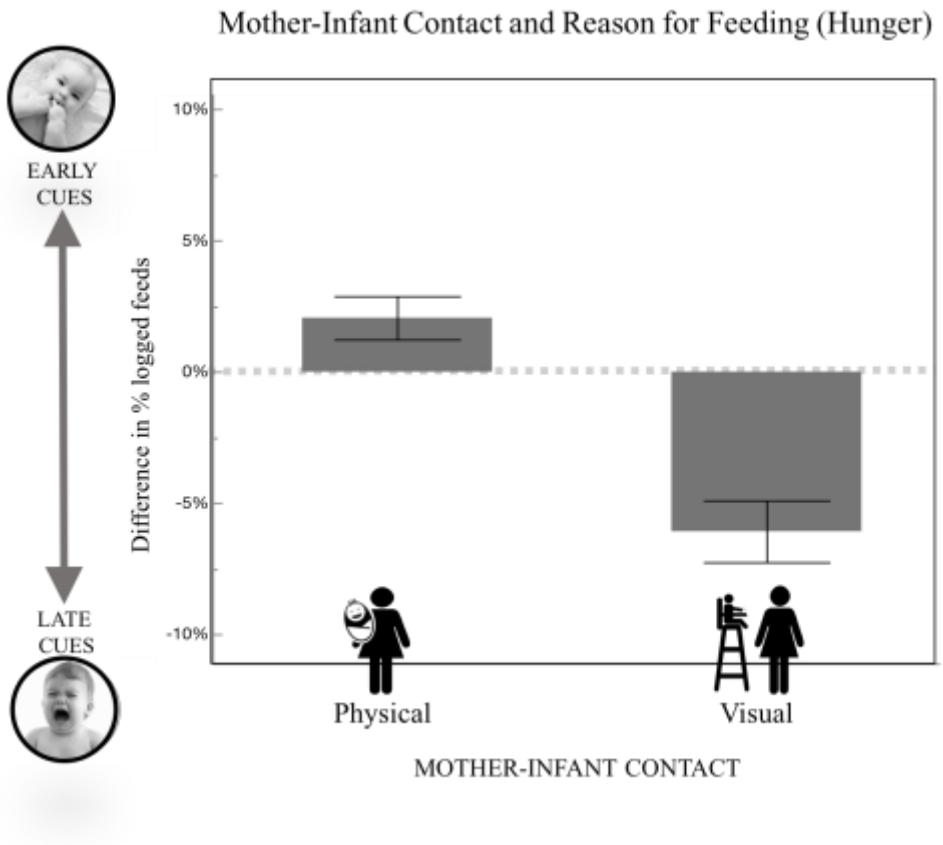


Figure 1.1: Difference between the mean percent of logged breastfeeding sessions initiated in response to cues versus crying plotted by the location of the infant before feeding onset (physical contact, visual contact) in Study 1. Error bars represent standard error of the mean.

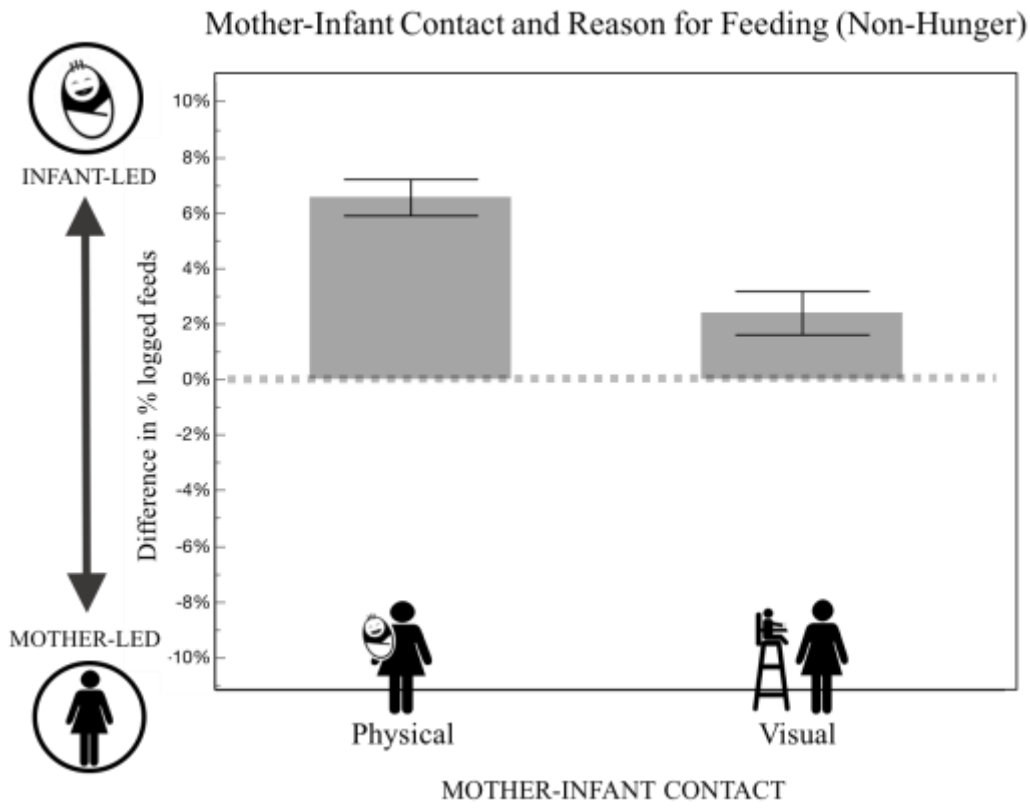


Figure 1.2: Difference between the mean percent of logged breastfeeding sessions initiated for comfort versus clocks plotted by the location of the infant before feeding onset (physical contact, visual contact) in Study 1. Error bars represent standard error of the mean.

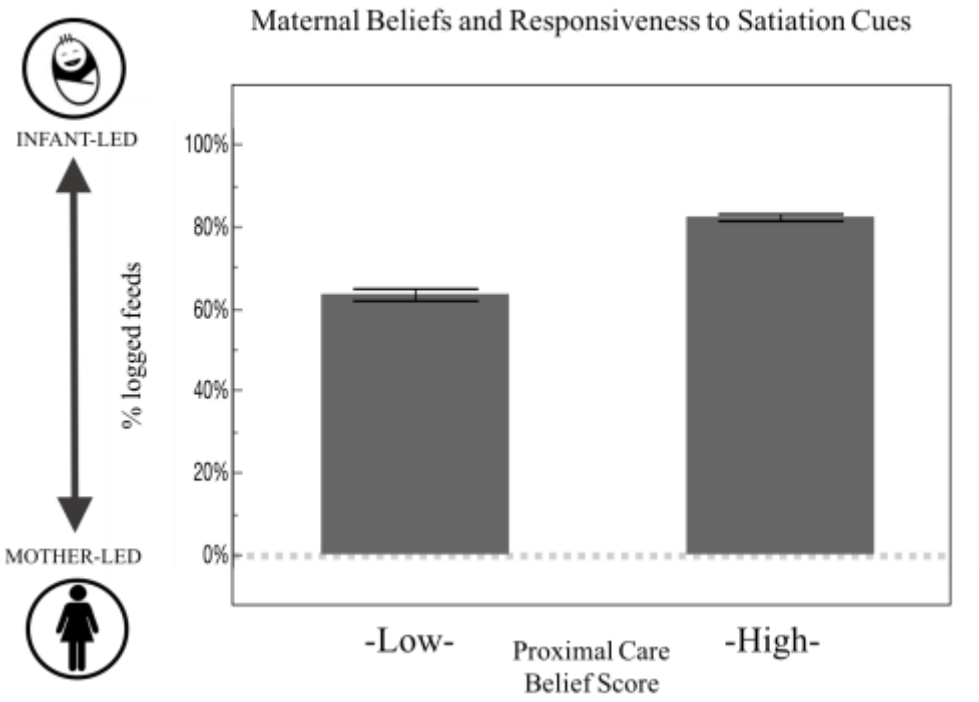


Figure 1.3: Difference between the mean percent of logged breastfeeding sessions that were ended in response to infant cues for satiation (versus among mothers with higher alignment with proximal care beliefs and lower proximal care beliefs in Study 2. Error bars represent standard error of the mean.

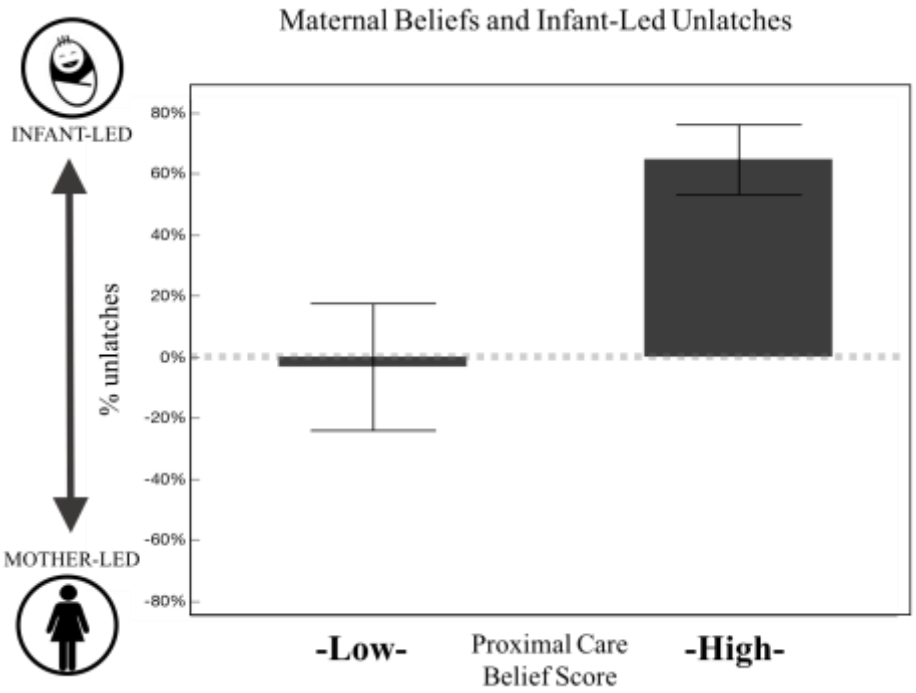


Figure 1.4: Difference between the mean percent of infant-led versus mother-led unlatches among mothers with low and high (median split) proximal care belief scores in Study 3. Error bars represent standard error of the mean.

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# Chapter 2

## The effect of physical contact on maternal responsiveness and mother-infant interaction

## Abstract

Increased maternal responsiveness is proposed to underlie some of the benefits of mother-infant physical contact, such as decreased crying and improved breastfeeding success. We tested the prediction that mother-infant physical contact facilitates increased maternal responsiveness to infant cues. In Study 1, mothers who had more long-term physical contact with their infant were more likely to interact contingently in response to infant cues than mothers with less long-term experience with physical contact during an in-lab play session. Study 2 demonstrated that the practice of babywearing was predictive of maternal beliefs that emphasize responsiveness to infants' cues, providing a potential explanation for the findings of Study 1. In Study 3, we manipulated mother-infant physical contact within-subjects in the lab and found that physical contact facilitated increased maternal tactile interaction, decreased maternal and infant object contact, and increased maternal responsiveness to infant vocalizations. These studies provide a novel explanation for the long-term effects of physical contact found in past work and demonstrate an immediate effect of physical contact on responsiveness that has not been found previously. These data are consistent with the proposal that the positive outcomes associated with physical contact may be at least partially attributed to increased maternal responsiveness.


*Keywords: mother-infant interaction, physical contact, babywearing, maternal responsiveness, proximal care culture*

Infants enter the world biologically prepared for physical contact with mothers. For altricial primates like humans, the necessity for close contact continues in the months after birth, as this contact ensures the warmth, security, and sustenance that is needed for infant survival (Bard, 2002). Medical research has documented the measurable outcomes of this close contact for physiological stabilization (Charpak, Ruiz-Peláez, & Charpak, 2002) and psychological development (Chwo et al., 2002; Feldman, Eidelman, Sirota, & Weller, 2002). Though effects on heart rate, respiration, and temperature regulation can be attributed to physiological processes (Esposito et al., 2013; Gabriel et al., 2010; Zeifman, 2001), explanations for physical contact on behavioral outcomes – such as decreased crying and improved breastfeeding – are less clear. One proposal is that it is the mother-infant interaction – and specifically, the increased maternal responsiveness – facilitated by being in close contact that leads to these positive behavioral outcomes. This hypothesis is supported by ethnographic observations of infant care practices in proximal care cultures, where mothers are in near-constant physical contact with infants and respond promptly to infant cues (Hewlett, Lamb, Shannon, Leyendecker, & Schölmerich, 1998; Richman, Miller, & LeVine, 1992; St James-Roberts et al., 2006), but it is impossible to infer causality from these observational studies. A few experimental studies show that mother-infant physical contact has a long-term effect on maternal responsiveness (e.g., Anisfeld, Casper, Nozyce, & Cunningham, 1990; Bystrova et al., 2009), yet it is unclear from these studies whether physical contact has an immediate effect on maternal responsiveness. This investigation sought to clarify the process through which physical contact has a long-term effect on responsiveness by examining the behavior (Study 1) and beliefs (Study 2) associated with practices that emphasize mother-infant physical contact (i.e.,

babywearing), as well as by experimentally testing the immediate effect of mother-infant physical contact on maternal responsiveness (Study 3).

Maternal responsiveness refers to the ability to respond to infant signals promptly and appropriately and is often operationalized in the literature as changes in maternal behavior that are temporally contingent (occurring within 1 to 2 seconds) of an infant cue (Broesch, Rochat, Olah, Broesch, & Henrich, 2016). Infants are very perceptive of the responsiveness of their mother or other social partner, showing sensitivity to the contingent patterns of back-and-forth communication from a young age (Adamson & Frick, 2003; Mesman, Ijzendoorn, & Bakermans-Kranenburg, 2009). Infants are attuned to contingency regardless of the familiarity (Stack & Muir, 1992) or humanity (Johnson, Slaughter, & Carey, 1998) of their social partner, or the modality of interaction (i.e., screen versus live, Gusella, Muir, & Tronick, 1988). Contingency is such a salient social cue that infants prefer social interactions that are contingent over those that are affective and positive, yet not contingent (Nadel, Carchon, Kervella, Marcelli, & Réserbat-Plantey, 1999). Contingent responses shape social learning (Bigelow & Birch, 1999), language acquisition (Nicely, Tamis-LeMonda, & Bornstein, 1999; Tamis-LeMonda, Kuchirko, & Song, 2014), and attachment formation (Ainsworth, Blehar, Waters, & Wall, 1978; Anisfeld et al.,1990; Dunst & Kassow, 2008). Many factors including infant temperament (Braungart-Rieker, Garwood, Powers, & Wang, 2001), maternal education level (Richman et al., 1992), and culture (Bornstein, Cote, & Venuti, 2001; Bornstein et al., 1992; Broesch et al., 2016; Kärtner, Keller, & Yovsi, 2010) predict variation in maternal responsiveness.

In cultures where adults practice near-constant physical contact with infants, caregivers are more likely to respond contingently – almost in an anticipatory fashion – to

infant cues (Barr, Konner, Bakeman & Adamson, 1991; Caudill & Schooler, 1973; Keller, 2002; Mesman et al., 2017). Though there are many potential explanations for these differences in maternal behavior at the societal level (e.g., maternal work demands, Sellen & Smay, 2001), experimental studies also support the hypothesis that mother-infant physical contact facilitates increased responsiveness.

Randomized controlled trials of post-partum contact show that mothers who have skin-to-skin contact with their infant are more responsive when measured months later (Bystrova et al., 2009; Feldman et al., 2002). However, it is unclear whether these results apply to physical contact more generally, given that these studies measured effects of a very specific type of physical contact (i.e., skin-to-skin contact) during a potentially sensitive period (i.e., immediately after birth) and sometimes with specific populations (i.e., preterm infants, Feldman et al., 2002). In a study more applicable to physical contact outside of the maternity ward, Anisfeld and colleagues (1990) randomly assigned parents to an infant carrying intervention aimed to increase physical contact (via babywearing). After three months of the intervention, parents in the physical contact group were more vocally responsive to their infants during a play session, and at 12 months the infants were more likely to be securely attached to their caregivers (Anisfeld et al., 1990).

However, given the length of the intervention period, it is difficult to understand the process through which physical contact affects responsiveness. Specifically, physical contact may have an immediate, direct effect on responsiveness, such that mothers are better able to attend to subtle cues when in physical contact. This immediate effect of physical contact on maternal responsiveness would therefore improve mother-infant communication and synchrony over time. Alternatively, physical contact may indirectly

affect maternal responsiveness by increasing mother-infant bonding over time, thus promoting a shift in maternal beliefs about infant care and increasing her desire to be responsive to her infants' cues.

## Current Investigation

There are three main issues with the literature on physical contact and maternal responsiveness: 1) ethnographic work examines physical contact within the context of proximal care culture, making it equally likely that physical contact or culturally-mediated beliefs about infant care drive the high levels of maternal responsiveness, 2) medical research measures effects of a very specific type of physical contact (i.e., skin-to-skin) at a very specific time (i.e., immediately after birth), making it unclear whether these results translate to more day-to-day forms of physical contact, and 3) carrying intervention studies measure the effect of physical contact over time, making it unclear whether this contact has direct, immediate effects on maternal responsiveness. Therefore, the aim of this investigation was to test the hypothesis that mother-infant physical contact facilitates increased responsiveness to infants' cues, testing a more common and generalizable form of day-to-day physical contact (Study 1), measuring the degree to which practices that facilitate physical contact may be attributed to underlying parenting beliefs (Study 2), and assessing not only long-term changes in maternal responsiveness associated with mother-infant physical contact but also immediate effects of physical contact (Study 3).

There are many different types of physical contact to study. Medical studies have focused on direct skin-to-skin contact and ethnographic studies have described the effects of both babywearing (i.e., near-constant infant carrying facilitated by the use of a cloth sling or wrap) and co-sleeping (i.e., maintaining physical contact throughout the night by

bed-sharing). Other forms of contact that have been addressed in the literature are infant massage – as a clinical practice – and stimulating touch – during psychological studies of dyadic interaction (e.g., the still-face paradigm, Gusella et al.,1988).

For the purposes of generalizability and applicability to the ethnographic work that motivated this hypothesis, we measured physical contact in the context of infant carrying practices, specifically, the practice of babywearing. Though arm carrying also facilitates both movement and physical contact, babywearing is more efficient and less strenuous than arm carrying, and allows adults to travel longer and faster (Wall-Scheffler, Geiger, & Steudel-Numbers, 2007). Babywearing also has roots in our evolutionary history. Though newborn offspring of chimpanzees and other primates are able to cling to their mothers to maintain mother-infant contact, changes in body hair, foot anatomy, upright posture, and post-natal maturity are all associated with the loss of the infant grasping ability (Tanner & Zihlman, 1976). It is proposed that early hominids developed tools to maintain close contact (i.e., cloth slings) to compensate for the high energetic cost of using the arms to carry infants long distances during upright bipedal transit (Wall-Scheffler et al., 2007). Babywearing also is relevant from the perspective of human culture, as babywearing is still the primary method of transporting infants in the majority of indigenous or non-industrialized societies around the world (e.g., Dettwyler, 1988).

In the U.S and other Western, industrialized societies, the practice of babywearing was largely abandoned with the advent of strollers and other plastic carrying gear and baby-containment apparatuses like playpens, bouncers, and swings (Maudlin, Sandlin, & Thaller, 2012). However, there is a growing movements of parents in Western society that are choosing to adopt a style of parenting more aligned with the practices of proximal care

(St James-Roberts et al., 2006). Though this new culture of proximal care within Western society is modeled off the proximal care that is practiced in Guatemala and other many areas of the world, the subculture of U.S. proximal care is in no way identical. For example, Guatemalan mothers almost exclusively carry infants on the back, while U.S. mothers report carrying in the front facing in (72.19%), on the back (23.67%), and in the front facing out (4.14%) (Little & Shakya, in prep). While many ethnographic descriptions of infant care show that proximal care – and babywearing practices – are tied to a distinct set of parenting beliefs that emphasize the importance of maternal responsiveness, mother-infant closeness, and minimizing infant distress (e.g., Keller et al., 2009; Lamm & Keller, 2007), no study has yet tested the degree to which U.S. babywearing mothers subscribe to the values of proximal care parenting culture.

In Study 1, mothers and their infants participated in a face-to-face play session in the lab, where babywearing and non-babywearing mothers were compared on contingent responsiveness to their infant's positive and negative facial cues. In Study 2, we examined whether practicing babywearing was predictive of embracing a set of maternal beliefs more aligned with the values of proximal care. In Study 3, we manipulated mother-infant contact in the lab by positioning infants in physical contact with the mother (via the use of a soft structured infant carrier) and in face-to-face contact (by putting the infant across from the mother in a seat), measuring the immediate effect of physical contact on maternal responsiveness to infant vocalizations.

## Study 1

Past work suggests that mother-infant physical contact may increase maternal responsiveness, but this work has tested a very specific type of physical contact at a very

specific time, has not taken into account differences in infant behavior, and has not investigated the valence of cues to which mothers choose to respond. We had three main objectives in Study 1. First, we examined whether increased long-term mother-infant physical contact (i.e., facilitated by the practice of babywearing) was predictive of differences in the overall contingency of maternal responses to infants' cues. Two groups of mothers (those who practiced babywearing and those who did not) participated in a face-to-face play session in the lab where we measured overall contingent responsiveness to infant cues. In line with past work (e.g., Anisfeld et al., 1990), we predicted that mothers with more long-term experience with mother-infant physical contact would be more likely to respond contingently to their infant's cues.

Second, we tested whether experience with long-term physical contact was associated with a difference in the specific type of responsiveness, with regard to the valence of cues to which mothers respond. Specifically, we measured the proportion of infants' positive cues versus negative cues to which the mother responded. Mothers in many proximal care cultures (e.g., Gussii mothers in Kenya, Richman et al., 1992; !Kung San mothers in Botswana, Barr et al., 1991; Nso mothers in Camaroon, Kärtner et al., 2010) commonly respond to indications of discomfort – rather than positive signals – as a way to prevent overt displays of distress. However, typical mother-infant interaction in the U.S. (i.e., distal care culture) is characterized by encouragement of positive emotionality. If mothers in the U.S. who practice babywearing are more similar to mothers in proximal care cultures outside of the U.S. than they are to U.S. mothers who do not practice babywearing, we would expect these mothers to be more likely to respond to infants' negative cues than positive cues.

Lastly, we measured differences in infant behavior between infants of babywearing and non-babywearing mothers. Given the bi-directionality of mother-infant interaction, it is impossible to make conclusions about the connection between physical contact and maternal responsiveness without taking into account differences in infant behavior that may be indirectly influencing maternal behavior.

**Method**

All procedures and recruitment methods were approved by the Institutional Review Board of University of California, San Diego.

**Participants.** Twenty-three mothers and their infants ($M$ = 9.25 months, $SD$ = 2.16 months, 4.4- 11.93 months) participated in this study. Mothers were characterized as having more experience with long-term physical contact if they identified babywearing as the primary means of transporting their infant and were characterized as having less experience with long-term physical contact if they reported using strollers or other methods of transporting their infant. These dyads were recruited both from a subject list compiled from the San Diego County Records Office and from social media recruitment within parenting groups.

**Materials.** Two FlipCam video cameras were setup with flexible GorillaPod tripods in the experimental room to record the mother-infant interaction. One camera was positioned across from the infant, to record the infant's facial expressions, while the second camera was positioned across from the mother's face. The infant was positioned in a plastic play chair with a plastic tray. There was a rubber play mat on the floor, and mothers were instructed to sit on the floor across from the infant.

**Procedure.** Mothers came into the lab with their infant where the study was explained to them and written consent was obtained. For the play session, mothers were positioned face-to-face across from their infant, who was sitting in a play chair with a tray. Mothers were told to play with their infant however they wanted for two minutes. No toys were provided. The experimenter pressed record on the two video cameras than left the room during the play session while mother and infant were videotaped.

**Coding.** The videotaped interaction was coded for infant displays of positive and negative affect, infant gaze, and maternal contingent responses to infants' positive and negative cues. Mothers were measured on the overall proportion of infant cues to which they responded contingently, as well as the valence of infant cues to which they responded (i.e., proportion of the infant's positive cues to which they responded, proportion of the infant's negative cues to which they responded). For the behavioral outcome measures, coding was completed by two coders – blind to the hypotheses of the study – through the use of ELAN, video annotation software developed by the Max Planck Institute for Psycholinguistics (Lausberg & Sloetjes, 2009). The coders completed the first 20% of the participant videos together and any discrepancies were discussed until coders arrived at complete (100%) agreement.

***Infant positive affect.*** Positive affect was coded whenever the infant smiled or laughed. A smile was defined as the corners of the infant's mouth being turned upward, with the mouth being either open or closed. For each infant, we calculated the total number of occurrences and total duration (in seconds) during which the baby displayed positive affect.

***Infant negative affect.*** Negative affect was coded whenever the infant frowned, grimaced, or cried. A frown was defined as the corners of the infant's mouth being turned downward, with the mouth being either open or closed. For each infant, we calculated the total number of occurrences and total duration (in seconds) during which the baby displayed negative affect.

***Infant gaze.*** To assess the level of social engagement across the two groups, we measured infant gaze as anytime the infant was looking at the mother's face (irrespective of whether the mother was currently looking at the infant). For each infant, we calculated the total number of occurrences and total duration (in seconds) during which the baby gazed at the mother.

***Overall maternal responsiveness***. Contingent responsiveness was coded whenever the mother's infant-directed behavior changed within the one-second window after an infant display of positive or negative affect (e.g., baby smiled and mom smiled, baby frowned and mom vocalized). This temporal window is consistent (e.g., Broesch et al., 2016) or even more conservative (e.g., Anisfeld et al., 1990) than past work in the literature on maternal responsiveness. For each participant, we calculated total proportion of cues to which the mother responded (total maternal responses divided by total occurrences of infant positive or negative affect). Proportion of instances of responsiveness was chosen over number of occurrences of responsiveness for these measures to account for the fact that some infants did not display any negative affect.

***Maternal responsiveness to positive cues.*** We calculated the number of positive cues to which the mother responded within a one-second window. For each mother, we calculated the proportion of the infant's positive cues to which she responded (total

maternal responses to infant positive affect divided by total occurrences infant positive affect).

***Maternal responsiveness to negative cues.*** We also calculated the specific proportion of negative cues to which the mother responded within a one-second window. For each mother, we calculated the proportion of the infant's negative cues to which she responded (total maternal responses to infant negative affect divided by total occurrences infant negative affect).

**Results**

Fourteen of the mothers were characterized as having more experience with long-term physical contact and nine of the mothers were characterized as having less experience with long-term physical contact. There was no difference between the high physical contact group ($M$ = 9.14 months, $SE$ = .59 months) and the low physical contact group ($M$ = 9.47, $SE$ = .74) with regard to infant age, $F$ (1, 22) = .15, $p$ = .70.

**Analyses.** To test the prediction that more experience with long-term physical contact would be predictive of increased responsiveness to infant cues, we conducted Analysis of Variance (ANOVA) tests for each of the dependent measures of infant behavior and maternal responsiveness, with group (high physical contact versus low physical contact) as the predictor variable.

Collapsing across the two physical contact groups, infant age was not predictive of infant positive affect, infant negative affect, infant gaze, maternal responsiveness to positive cues, maternal responsiveness to negative cues, or overall maternal responsiveness (all $p$s $> .1$).

***Infant positive affect.*** There was no significant difference between the high physical contact group (*M* = 24.14 seconds, *SE* = 3.42) and the low physical contact group (*M* = 19.40 seconds, *SE* = 4.27) with regard to duration of infant positive affect, *F* (1, 22) = .75, *p* = .40, $\eta^2$ = .03.

***Infant negative affect.*** There was no difference between the high physical contact group (*M* = 11.27 seconds, *SE* = 5.87) and the low physical contact group (*M* = 8.05 seconds, *SE* = 5.87) with regard to duration of infant negative affect, *F* (1, 22) = .18, *p* = .67, $\eta^2$ = .008.

***Infant gaze.*** There was no difference between the high physical contact group (*M* = 39.41 seconds, *SE* = 7.19) and the low physical contact group (*M* = 26.72 seconds, *SE* = 8.96) with regard to duration of infant gaze at their mother, *F* (1, 22) = 1.22, *p* = .28, $\eta^2$ = .05.

***Overall maternal responsiveness.*** There was a significant difference between the high physical contact group (*M* = .84, *SE* = .05) and the low physical contact group (*M* = .62, *SE* = .07) with regard to overall proportion of the infant's cues to which the mother responded, *F* (1, 21) = 5.48, *p* = .03, $\eta^2$= .22, see Figure 2.1.

***Maternal responsiveness to positive cues.*** There was a significant difference between the high physical contact group (*M* = .82, *SE* = .07) and the low physical contact group (*M* = .57, *SE* = .08) with regard to proportion of the infant's positive cues to which the mother responded, *F* (1, 21) = 5.13, *p* = .03, $\eta^2$ = .20.

***Maternal responsiveness to negative cues.*** There was no difference between the high physical contact group (*M* = .83, *SE* = .12) and the low physical contact group (*M* =

.59, *SE* = .15) with regard to proportion of the infant's negative cues to which the mother responded, $F$ (1, 12) = 1.56, $p$ = .24, $\eta^2$ = .12.

**Discussion**

This study examined whether long-term experience with physical contact (via babywearing) was predictive of differences in maternal responsiveness in the context of a face-to-face mother-infant play paradigm, testing three specific questions: 1) Is experience with long-term mother-infant physical contact predictive of differences in overall maternal responsiveness to infants' cues?, 2) Does experience with long-term mother-infant physical contact promote responsiveness to a certain valence of infant cue (positive versus negative)?, and 3) Is experience with long-term mother-infant physical contact associated with differences in infant behavior?

Our first finding was in line with our predictions, such that mothers with more long-term experience with physical contact were more contingently responsive to infants' cues than mothers with less long-term experience with physical contact. This result is consistent with past results showing mothers were more responsive to their infants' vocalizations after participating in a long-term physical contact intervention (Anisfeld et al., 1990).

Mothers with more long-term experience with physical contact were more likely to respond to positive cues than mothers without long-term experience with physical contact. Given that responsiveness in proximal care cultures is characterized by responding to indications of discomfort as a way to mitigate infant distress (Keller et al., 2009; Richman, Miller, & LeVine, 1992), we predicted that increased physical contact might make mothers in the U.S. more likely to respond to negative cues. However, it is difficult to draw

conclusions about responsiveness to negative affect in this sample, given that very few infants actually displayed negative affect.

Lastly, our data showed no differences in infant behavior across the two groups. Given that mother-infant interaction is a reciprocal and bidirectional process, one possibility is that experience with long-term physical contact influences maternal interaction behavior because by first causing a change in the infant. In this study, there were no differences in infant behavior across the two groups, suggesting that long-term experience with mother-infant physical contact may be affecting maternal responsiveness directly, rather than via a change in infant communication.

The primary limitation of the study was that mothers were not randomly assigned to groups. Therefore, it is possible that the increased responsiveness could be attributed to the experience with physical contact, but it is just as likely that the increased responsiveness could be explained by differences in maternal beliefs associated with the practice of babywearing. For example, mothers may be more likely to practice babywearing if they support a certain (i.e., responsive) approach to infant care. Ethnographic studies conducted in small-scale societies outside of the U.S. demonstrate that the practice of babywearing is closely tied to a distinct set of maternal beliefs about infant care and maternal responsiveness, yet no study has evaluated the degree to which U.S. babywearing mothers subscribe to these beliefs. To evaluate whether mothers who practice babywearing in the U.S. espouse a parenting ideology that emphasizes responsiveness – potentially providing an explanation for the results of Study 1 – we used a maternal questionnaire (Keller, 2002, see Table 2.1) to assess whether babywearing predicts increased alignment with the values of proximal care culture in Study 2.

## Study 2

Globally, ethnographic studies demonstrate that beliefs about infant care are culturally-variable (e.g., Bornstein et al., 2001; Shwalb, Shwalb, & Shoji, 1996) and consistent with both parenting behavior (Broesch et al., 2016; Hewlett & Lamb, 2002; Keller, 2002; Lamm & Keller, 2007) and infant outcomes (Keller et al., 2004). Practices in the U.S. that facilitate increased mother-infant physical contact (e.g., babywearing, co-sleeping) are encouraged by certain parenting communities that emphasize an infant-led, responsive approach to infant care (e.g., Attachment Parenting, Granju & Kennedy, 1999; Sears & Sears, 2001). However, many mothers practice babywearing simply for the convenience and don't necessarily belong to such communities or subscribe to these beliefs. No study has yet systematically measured the degree to which the practice of babywearing predicts increased emphasis on maternal responsiveness as a parenting priority.

### Method

All procedures and recruitment methods were approved by the Institutional Review Board of University of California, San Diego.

**Participants.** We recruited mothers ($N$ = 492) of newborn to 12-month-old infants to fill out an online questionnaire. These dyads were recruited from social media postings within U.S.-based parenting groups. Mothers were 20-45 years of age ($M$= 30.85, $SD$ = 4.49) and infants ranged from .23 months to 12.98 months ($M$ = 6.43, $SD$ = 3.47). Mothers had completed an average of 16.09 years of schooling ($SD$ = 2.61, 10-25 years). A little over half of the mothers were currently not working (55.19%) and were multiparous (i.e.,

had more than one child, 68.11%). About half of the mothers were exclusively breastfeeding (51.53%).

**Materials.** ***Maternal questionnaire.*** Mothers filled out an online questionnaire (administered through the Google Forms platform) which assessed demographic factors, babywearing practices, and infant feeding practices.

*Demographics.* Demographic information was solicited from each mother, including maternal age, maternal education, employment, and number of children.

*Breastfeeding status.* Given that breastfeeding is closely tied to the beliefs and practices of proximal care culture, we asked mothers about their current feeding method (exclusive breastfeeding, some breastfeeding, no breastfeeding).

*Mother-infant physical contact.* To assess long-term mother-infant physical contact, we asked about general use of babywearing (in comparison with arm carrying or stroller use), as well as variation in the intensity of babywearing (e.g., hours per day spend babywearing, age of babywearing initiation). Given that the likelihood of babywearing predicting maternal beliefs is probably more likely among parents who practice babywearing for health, development, and bonding, in comparison with convenience, we also measured motivation for babywearing.

*Maternal beliefs.* To assess parenting beliefs, mothers were asked about their agreement or disagreement with general parenting statements – or "ethnotheories" – regarding different components of maternal behavior toward a 3-month-old infant. This instrument has been used globally to assess the degree of alignment with proximal care versus distal care parenting goals (Keller, 2002, see Table 2.1). Responses to each question were on a scale from one (completely disagree) to five (completely agree). Responses from

each participant were compiled to form a proximal care belief score, calculated by summing responses from all questions aimed to measure alignment with goals of proximal care parenting culture then subtracting the sum of responses to all questions designed to test alignment with goals of distal care parenting culture. The range of possible scores was negative 20 to positive 20. Any positive score indicated that mothers leaned more toward the values of proximal care culture than distal care culture, and a higher score indicated a greater agreement with the parenting goals characteristic of proximal care culture.

**Procedure.** After mothers expressed interest in participating in the study, they were contacted electronically by a research assistant who explained the study and obtained consent. Participants filled out the online questionnaire from their home, administered through the Google Forms platform.

## Results

Many mothers reported babywearing as their primary infant transport method (72.82%) with the other mothers choosing arm carrying (15.92%) and strollers/seats (11.25%). Mothers reported initiating babywearing at age zero to six months ($M$ = .41, $SD$ = 1.01) and reported babywearing for an average of 2.61 hours per day ($SD$ = 2.44, 0-15 hours).

**Analyses.** We first conducted a bivariate linear regression to predict maternal beliefs (i.e., degree of alignment with proximal care culture) from babywearing (versus arms carrying and stroller use), babywearing intensity (hours per week and age of initiation), and babywearing motivation. We next tested these effects while controlling for potential confounds by including fixed effects for infant age, maternal age, maternal education, employment, parity, and breastfeeding status.

Babywearing (in comparison with strollers) was predictive of a higher overall proximal care belief score, $\beta = 1.643$, $SE = .399$, $t = 4.11$, $p < .0001$, and arm carrying was not, $\beta = 0.371$, $SE = .519$, $t = 0.71$, $p = .475$. Mothers who practiced babywearing had a higher proximal care belief score ($M = 6.637$, $SE = .309$) than mothers who reported carrying in arms ($M = 5.36$, $SE = .651$) or mothers who used a stroller or seat ($M = 2.980$, $SE = .793$), see Figure 2.2.

There was also an effect of babywearing intensity. Age of initiation of babywearing (in months) was negatively associated with proximal care belief score, $\beta = -0.659$, $SE = .276$, $t = -2.39$, $p = .017$, such that mothers who had started wearing their infant later in development had a lower proximal care belief score. Hours per day spent babywearing was predictive of a higher proximal care belief score, $\beta = 0.314$, $SE = .111$, $t = 2.83$, $p = .005$.

Reason for babywearing was predictive of proximal care belief score, $F(4, 433) = 3.705$, $p = .006$. Specifically, being motivated to babywear because of convenience was negatively associated with proximal care belief score, $\beta = 3.258$, $SE = 1.623$, $t = -2.01$, $p = .045$. Mothers who reported babywearing for convenience had a lower proximal care belief score ($M = 5.234$, $SE = .348$) than mothers who practiced babywearing for social or cultural reasons ($M = 16$, $SE = 5.621$), for bonding ($M = 6.6.21$, $SE = .554$), or for health and development ($M = 7.603$, $SE = .681$).

In the multivariate model controlling for infant age, maternal age, maternal education, employment, parity, and breastfeeding status, babywearing (versus strollers) was still significantly predictive of a higher proximal care belief score, $\beta = 1.098$, $SE =$

0.433, $t$ = 2.54, $p$ = .012, while arm carrying was not, $\beta$ = 1.098, $SE$ = .433, $t$ = 1.22, $p$ = .222.

**Discussion**

The aim of this study was to assess the degree to which babywearing in the U.S. predicts certain parenting beliefs, specifically, those that have been identified as characteristic of proximal care culture. Proximal care beliefs that have thus far only been used to describe parenting beliefs and practices outside of the U.S., but measuring intracultural variation is just as important as intercultural (Bornstein et al., 1992). These data suggest that underlying beliefs about responsiveness may be at least partially driving the differences in responsiveness between babywearers and non-babywearers observed in Study 1. However, another possibility is that the act of physical contact itself directly facilitates increased responsiveness to infants' cues, regardless of maternal beliefs. To test this possibility, Study 3 manipulated mother-infant physical contact in the lab to measure immediate effects of physical contact on maternal responsiveness.

## Study 3

Study 3 used a within-subject manipulation of mother-infant contact to experimentally test whether immediate physical contact facilitated increased maternal responsiveness. Mothers were asked to play naturally with their infant in two conditions that were designed to manipulate amount of mother-infant physical contact. In one condition, the infant was positioned in an infant carrier strapped to the mother face-in (physical contact condition) and in the other condition the infant was positioned face-to-face sitting in a high chair (no physical contact condition). As mothers and infants were in face-to-face contact for both conditions, amount of visual contact was held constant to

isolate the potential effect of physical contact on mother-infant interaction. In contrast to Study 1, we included basic play objects for mothers to use if desired (no instructions were given about object use). There were two main objectives for this study: 1) test the effect of immediate mother-infant physical contact on maternal responsiveness, and 2) measure whether being in physical contact led to other changes in maternal or infant behavior.

Our first aim was to test the effect of immediate physical contact on maternal responsiveness to infants' cues. We measured maternal responsiveness as maternal vocalizations occurring within 1 second of an infant's vocalization. Because infants being strapped to the mother's chest in a carrier made it difficult to measure facial expressions in the physical contact condition, vocalization was a more viable measure of responsiveness in this study. As demonstrated in Study 2, infant care practices that facilitate long-term physical contact are associated with parenting goals that emphasize maternal responsiveness, making it unclear whether physical contact has an immediate effect on responsiveness. We predicted that – above and beyond differences in parenting beliefs – mothers would be more responsive to their infant when in immediate physical contact in comparison to when not in physical contact.

Our second aim was to measure changes in maternal behavior and infant behavior caused by the difference in physical contact. We tested for changes in the duration of maternal vocalizations, touch, and object contact from the physical contact condition to the non-physical contact condition. Most previous work suggesting a connection between mother-infant physical contact and specific modalities of communication has been done across cultures, consistently showing that mother-infant physical contact is associated with increased interaction in the tactile modality (e.g., Little, Carver & Legare, 2016) and

decreased vocal and object-based interaction (e.g., Keller et al., 2004). We therefore predicted that mothers would be more likely to interact with infants using touch (tactile interaction) in the physical contact condition and would be more likely to interact using vocal communication and object stimulation in the non-physical contact condition. To ensure that any differences in maternal responsiveness were not driven by differences in infant behavior, we also measured infant vocalizations, touch, and object contact.

**Method**

All procedures and recruitment methods were approved by the Institutional Review Board of University of California, San Diego.

**Participants.** Twenty mothers and their 3- to 8-month-old infants participated in this study (*M* = 5.62 months; 2.6-8.6 months, 11 female). Mothers had completed an average of 17.25 years of education (*SD* = 1.39 years, 15- 20 years). Mothers were White (84.21%) or Hispanic/Latina (15.79%). Mothers were recruited from online social media postings to U.S. parenting groups. During this single session study, mothers interacted with their infants in two different conditions (physical contact, no physical contact) the order of which was counterbalanced across participants. None of the dyads from Study 1 or Study 2 participated in Study 3. After obtaining their consent, the procedure was explained and mothers were asked to provide information about the demographics of their household and infant feeding practices.

**Materials.** Two FlipCam video cameras were setup with flexible GorillaPod tripods in the experimental room to record the mother-infant interaction. One camera was positioned across from the infant, to record the infant's facial expressions, while the second camera was positioned across from the mother's face. For the physical contact condition,

infants were strapped to their mother's chest with a soft structured infant carrier. Mothers who had their own babywearing carrier were permitted to use their own if they wanted (for comfort) as long as the carrier kept the infant in a face-to-face, tummy-to-tummy position. For the no physical contact condition, the infant was positioned in a plastic play chair with a plastic tray. There was a rubber play mat on the floor, and mothers were instructed to sit on the floor across from the infant. For both conditions, there were simple toys available to use in the room (squishy ball and stacking cups).

**Procedure.** For both of the two within-subject conditions (physical contact and no physical contact) mothers were told to play with their infant however they normally do while they were videotaped for two minutes in a playroom alone. The mother was not given specific instructions as to whether or not she should use the toys.

**Coding.** Mothers were measured on their degree of responsiveness to infants' vocalizations. Mothers and infants were also measured on their interaction behavior, scored for the duration of vocalization, touch, and object contact during the play session. Coding was completed by two independent coders – blind to the hypotheses of the study – through the use of ELAN video annotation software developed by the Max Planck Institute for Psycholinguistics (Lausberg & Sloetjes, 2009). The coders completed the first 20% of the participant videos together and any discrepancies were discussed until coders arrived at complete (100%) agreement, after which coding was completed independently.

***Maternal and infant characteristics.*** We solicited information about infant age, maternal age, maternal education, and ethnicity from all mothers to examine any associations with maternal or infant behavior. We also asked mothers about current

breastfeeding status to assess whether the potential physiological bonding facilitated by breastfeeding may have been underlying any differences in maternal or infant behavior.

***Infant vocalization.*** Infant vocalization was coded whenever the infant vocalized. All voluntary utterances were counted as vocalizations, while all sneezes, burps, or other involuntary noises were not coded as vocalization. Each infant was scored on the duration of time spent vocalizing during the play session of each condition.

***Infant touch.*** Infant touch was coded whenever the infant touched the mother (coding separately for mother-initiated versus infant-initiated, depending on who initiated the touch). All voluntary physical contact initiated by the infant and directed toward the mother was counted as infant touch, while all passive physical contact (i.e., the inevitable physical contact of having the infant strapped to the mother in the physical contact condition) were not coded as touch. Each infant was scored on duration of time touching the mother during each condition.

***Infant object contact.*** Infant object contact was coded as any contact with the object initiated by the infant. Each infant was scored separately for duration of time in object contact during each condition.

***Maternal vocalization.*** Vocalization was coded whenever the mother vocalized – either verbal or non-verbal. All voluntary utterances were counted as vocalizations, while all sneezes, burps, or other involuntary noises were not coded as vocalization. Each mother was scored on the duration of time of vocalization during the play session of each condition.

***Maternal touch.*** Maternal touch was coded whenever the mother touched the infant. All voluntary physical contact was counted as tactile interaction, while all passive physical contact (i.e., the inevitable physical contact of having the infant strapped to the

mother in the physical contact condition) were not coded as touch. Each mother was scored for duration of time touching the infant during each condition.

***Maternal object contact.*** Any contact by the caregiver with one of the play objects – in the context of the mother-infant interaction – was coded as object contact. Any contact by the mother with an object that was out of sight of the infant (or unable to be felt by the infant) was not included. Each mother was scored for duration of time in object contact during each condition.

***Maternal responsiveness.*** Maternal responsiveness was coded as the number of occurrences of the mother vocalizing in response to an infant vocalization (i.e., within a one-second window). This temporal window is consistent (e.g., Broesch et al., 2016) or even more conservative (e.g., Anisfeld et al., 1990) than past work in the literature on maternal responsiveness.

**Results**

Out of the twenty mothers that participated, twelve of the mothers were exclusively breastfeeding, two were formula feeding and breastfeeding, five were breastfeeding and complementary feeding (solids), and one was feeding with only formula. Though all mothers had been recruited from a babywearing-specific social media group, five of the mothers reported that they no longer used babywearing as their primary means of transporting their infant despite having done so in the past.

**Analyses.** We first ran bivariate regressions within each condition to test whether infant age, maternal demographics, and feeding practices were predictive of maternal or infant behavior. To test whether mother-infant physical contact had an effect on differences in maternal responsiveness and maternal and infant interaction behavior, we performed

repeated measures ANOVAs for each maternal and infant behavior of interest with condition (physical contact versus no physical contact) as the independent predictor variable.

***Maternal and infant characteristics.*** In the no physical contact condition, infant age was negatively associated with duration of infant touch, $\beta$ = -.49, $t$ = -2.36, $p$ = .03, and positively associated with duration of object contact, $\beta$ = 15.51, $t$ = 5.91, $p$ = .02. Infant age was not predictive of duration of infant vocalization in the no physical contact condition, $\beta$ = .72, $t$ = 2.06, $p$ = .05. Infant age was not associated with infant or maternal behavior in the physical contact condition (all $p$s > .1).

In the physical contact condition, maternal age was negatively associated with duration of object contact, $\beta$ = -3.34, $t$ = -2.55, $p$ = .02. Maternal age, maternal education, and ethnicity were not associated with any other maternal or infant behaviors in the physical contact condition or the no physical contact condition (all $p$s > .1).

Breastfeeding status was not associated with any maternal or infant behaviors in the physical contact condition or the non-physical contact condition (all $p$s > .1).

***Infant vocalization.*** There was no difference between duration of infant vocalization in the physical contact condition ($M$ = 3.62 seconds, $SE$ = .73) in comparison with the non-physical contact condition ($M$ = 2.32 seconds, $SE$ = .73), $F$ (1, 19) = 2.29, $p$ = .15, $\eta^2$ = .49.

***Infant touch.*** There was no difference in duration of infant touch in the physical contact condition ($M$ = .63 seconds, $SE$ = .41) in comparison with the no physical contact condition ($M$ = .57 seconds, $SE$ = .41), $F$ (1, 19) = .009, $p$ = .93, $\eta^2$ = .04.

***Infant object contact.*** There was a significant difference in duration of infant object contact, $F$ (1, 19) = 9.68, $p$ = .006, $\eta^2$ = .56, such that infants were in contact with objects for less time in the physical contact condition ($M$ = 25.44 seconds, $SE$ = 9.28) than in the no physical contact condition ($M$ = 59.20 seconds, $SE$ = 9.28).

***Maternal vocalization.*** There was no difference in duration of maternal vocalization in the physical contact condition ($M$ = 38.24 seconds, $SE$ = 3.89) in comparison with the no physical contact condition ($M$ = 38.81 seconds, $SE$ = 3.90), $F$ (1, 19) = 0.01, $p$ = .92, $\eta^2$ = -0.07.

***Maternal touch.*** There was a difference between conditions in duration of maternal touch, $F$ (1, 19) = 11.06, $p$ = .004, $\eta^2$ = .52, such that mothers touched their infants for longer in the physical contact condition ($M$ = 31.71 seconds, $SE$ = 6.31) than in the no physical contact condition ($M$ = 6.24 seconds, $SE$ = 6.31).

***Maternal object contact.*** There was not a significant difference between the physical contact condition ($M$ = 24.39 seconds, $SE$ = 6.69) and the no physical contact condition ($M$ = 41.98 seconds, $SE$ = 6.69) with regard to duration of maternal object contact, $F$ (1, 19) = 3.74, $p$ = .068, $\eta^2$ = .21.

***Maternal responsiveness.*** There was a significant difference between conditions in maternal responsiveness, $F$ (1, 19) = 5.37, $p$ = .03, $\eta^2$ = .67, such that mothers were more responsive to infants' vocalizations in the physical contact condition ($M$ = 3.95 contingent vocalizations, $SE$ = .76 vocalizations) than in the no physical contact condition contact ($M$ = 2.15 contingent vocalizations, $SE$ = .76), see Figure 2.3.

**Post-hoc analyses.** ***Type of chair.*** To make sure the effect of increased maternal and infant object contact in the no physical contact condition could not be attributed to the

specific type of infant chair that was used (which had an attached tray that may have facilitated infant contact with objects), we ran a subset of participants ($N$ = 5) with a different type of chair (a leaned back hammock seat that still facilitated mother-infant face-to-face contact but did not have a tray for objects). We found that type of chair was not related to differences in amount of infant object contact, $p$ = .604.

***Object contact.*** One alternate explanation of these results is that the difference in maternal responsiveness could be attributed to differences in object contact across the two conditions. Specifically, a triadic interaction between mother, infant, and object may facilitate a different type of communication pattern than dyadic mother-infant interaction, potentially influencing maternal responsiveness. To test this, we coded the videos for a subset of participants who had participated in an additional within-subject play condition (physical contact + no objects) to test differences in maternal responsiveness when dyads were interacting with objects versus no objects. We coded maternal responsiveness to infants' vocalizations in the same way as they had been coded for the full sample of participants and we also coded for duration of infant vocalization and infant touch. To test whether infant object contact predicted differences in the contingency of maternal responsiveness, we performed a repeated-measures Analysis of Variance (ANOVA) with the within-subject condition (objects versus no objects) as the predictor variable and each behavior of interest (maternal responsiveness, infant vocalization, and infant touch) as the dependent measures.

The subset consisted of ten mothers and their infants ($M$ = 5.99 months; 4.03-8.6 months, 5 female). Within this sample – in the object condition – infants interacted with

the objects an average of 36.92 seconds out of the total play session (*SE* = 13.02) and mothers interacted with objects an average of 34.97 seconds (*SE* = 9.50).

*Infant vocalization.* There was a difference between conditions with regard to infant vocalization, $F$ (1, 9) = 10.25 $p$ = .01, $\eta^2$ = .46, such that infants spent more time vocalizing in the no object condition (*M* = 17.99, *SE* = 3.20) than in the object condition (*M* = 4.27, occurrences, *SE* = 3.19).

*Infant touch.* There was a difference between conditions with regard to infant touch, $F$ (1, 9) = 11.10, $p$ = .009, $\eta^2$ = .44, such that infants spent more time in tactile contact with their mother in the no object condition (*M* = 11.24 seconds, *SE* = 2.38) than in the object condition (*M* = .41, seconds, *SE* = 2.38).

*Maternal responsiveness.* There was no difference between conditions with regard to maternal responsiveness, $F$ (1, 9) = 2.70, $p$ = .13, $\eta^2$ = .57, such that there were no more instances of the mother responding contingently to the infant's vocalizations in the no object condition (*M* = 7.40 occurrences, *SE* = 1.51) than in the object condition (*M* = 4.60, occurrences, *SE* = 1.60).

**Discussion**

This was the first experimental study to use a within-subject test of the immediate effect of mother-infant physical contact on maternal responsiveness. In this study, we aimed to measure 1) the effect of physical contact on maternal responses to infant vocalizations, and 2) the effect of physical contact on the duration of maternal and infant vocalization, touch, and object contact. Consistent with our predictions, maternal responsiveness increased when mothers and infants were in physical contact in comparison when they were sitting across from each other.

As expected, mothers engaged in more touch when in physical contact with their infant. There was no effect of physical contact on overall duration of maternal or infant vocalizations, confirming that the increase in responsive maternal vocalizations in the physical contact condition was specific to responsiveness rather than reflective of an overall increase in vocalizations. This result is aligned with past work comparing triadic mother-infant interactions with objects in proximal care versus distal care communities that found that differences in mother-infant physical contact were not associated with variation in vocalization (e.g., Little, Carver, & Legare, 2016).

Because we found that infants were more likely to engage in object contact when not in physical contact, we wanted to rule out an alternate explanation of the results, which was that differences in maternal responsiveness were attributed to differences in object contact instead of differences in physical contact. To clarify the effect of object contact on maternal responsiveness, we coded the videos for a subset of participants who had participated in another condition of the play paradigm where they did not have access to objects. In this post-hoc analysis, we compared maternal responsiveness when mothers and infants were interacting with objects versus no objects (with physical contact held constant by having the infant in the carrier for both conditions) and found no difference in maternal responsiveness across these two within-subject conditions. We did find a difference in infant behavior, such that infants spent more time in tactile interaction with their mothers when objects were *not* included in the interaction. When infants' hands are occupied with an object, it makes sense that they would be less likely to engage in tactile interaction with their mother. Interestingly, infants were also more likely to vocalize in the no object condition, which was not predicted. These data suggest that overall engagement with a

social partner increases when the interaction is dyadic, rather than triadic. However, this may be due to the age of our sample, given that it is difficult for infants to coordinate attention between objects and social partners until toward the end of the first year of life. In addition, the small sample size of these post-hoc analyses makes it difficult to draw strong conclusions.

Importantly, these results also confirm that the differences in maternal responsiveness were explained by differences in physical contact rather than the associated variation in mother-infant object contact. This is an important consideration for the broader research aim of understanding the mechanisms underlying differences in responsiveness between proximal care cultures and distal care cultures, given that these two models of parenting differ with regard to relative emphasis on object play and triadic interaction (e.g., Little, Carver, & Legare, 2016).

## General Discussion

Physical contact with mothers (and others) is the natural post-natal condition for primates (Bard, 2002) and is associated with a range of benefits for both mother and offspring (e.g., Charpak et al., 2001; Ferber et al., 2002), though the mechanisms underlying these benefits are not well understood. The aim of this investigation was to test the proposal that mother-infant physical contact facilitates increased maternal responsiveness. Because of the many benefits of responsiveness for early development, support for this proposal would provide a social explanation for the effects of physical contact. In examining long-term effects of physical contact, mothers who reported more experience with mother-infant physical contact (i.e., through babywearing experience) were more likely to interact contingently in response to their infant's cues than mothers

with less experience with long-term physical contact during a face-to-face in-lab play paradigm (Study 1) and were more likely to report agreement with parenting beliefs characteristic of proximal care culture (Study 2). To test the immediate effect of mother-infant physical contact, we manipulated physical contact within-subjects during an in-lab play paradigm and found that increased mother-infant physical contact caused increased maternal tactile interaction, decreased maternal and infant object contact, and increased contingently responsive vocalizations. Importantly, with post-hoc analyses, we were also able to rule out the alternate explanation that these results had been caused by amount of contact with objects. Together, these findings support the proposal that physical contact shapes the modality and contingency of mother-infant communication and maternal responsiveness.

There are several explanations as to why physical contact increases responsiveness. One explanation is that the long-term experience with physical contact promotes mother-infant bonding over time, increasing maternal motivation to attend to and respond to their infant's cues. This explanation is supported by the findings of Study1 showing that mothers with more long term experience with physical contact were more likely to be responsive to infants' cues even when not in direct physical contact. This is also supported by the results of Study 2 showing that mothers who practice babywearing are more likely to prioritize maternal responsiveness and other goals of proximal care culture. One limitation of these two studies is that because of their observational nature, we are unable to conclude whether physical contact changes maternal beliefs or whether maternal beliefs motivate mothers to practice increased physical contact with their infants. Regardless, we were able to experimentally demonstrate an immediate, within-subject change in responsiveness in

Study 3 caused by amount of mother-infant physical contact. This study suggests that in addition to increasing maternal motivation to respond to infants, physical contact also has a direct, immediate effect on responsiveness, potentially explained by the closeness of the infants' body allowing the mother to attend to cues that normally would have been missed (e.g., subtle movements or instances of tactile contact).

**WEIRD responsiveness**

This work brings up a broader critique of the maternal responsiveness literature. Because developmental research favors work from "WEIRD" populations (Henrich, Heine, & Norenzayan, 2010) this field has a bias toward privileging the vocal and visual communication characteristic of Western distal patterns of interaction (Akhtar & Gernsbacher, 2008). Thus far, touch and physical contact have not been adequately incorporated into experimental methodology as viable components of responsiveness and social contingency, except within a deficit model framework. For example, maternal touch has been studied in the social contingency literature as a compensatory strategy for mothers suffering from post-partum depression who lack the typical levels of visual and vocal maternal responsiveness (e.g., Peláez-Nogueras, Field, Hossain, and Pickens, 1996). But the mother-infant physical contact facilitated by babywearing is more than just a transport method; rather it is a socialization tool with an equally important role as the visual cues (i.e., gaze) and auditory cues (i.e., vocalizations) that are emphasized to a much greater degree in the developmental literature (Akhtar & Gernsbacher, 2008; Arnett, 2008). Controlled studies outside of Western culture show that mothers (and others) in many places of the world not only use physical contact as a necessary means of transporting their infant (e.g., because strollers and other products are unavailable and impractical) or

keeping their infant safe (e.g., from the hazards of the environment), but that physical contact plays a central role in both play-based and pedagogical interactions. For example, in a controlled object manipulation paradigm, mothers in Vanuatu – a remote island archipelago – were more likely to use physical contact and tactile interaction to teach their infant about a novel toy, in comparison with U.S. mothers who used visual shared attention to interact with and teach their infant about the object (Little, Carver, & Legare, 2016). This finding suggests that physical contact is implicated in developmental processes – such as early social learning – to a degree that had previously not been recognized in the developmental psychology literature. Understanding the differences in the modality of social interaction is crucial to understanding early social development, given that the modality of interaction can have an influence on developmental trajectories. When comparing German and Cameroonian mother-infant interaction, the increased face-to-face contact among the German dyads facilitated increased propensity of 6- to 8-week-old infants to gaze at their mothers (Kärtner, Keller, & Yovsi, 2010). Similarly, cultural differences in physical versus face-to-face contact among 12-week-old infants and their mothers were associated with differences in the emergence of social smiling (Wörmann, Holodynski, Kärtner, & Keller, 2012). These studies suggest that the development of different forms of early communication is not fixed and universal, but rather shaped by the modality and contingency of interactions experienced by the infant within their early social and cultural context.

In an investigation of an important and understudied topic, these studies showed that long-term physical contact with infants is associated with increased maternal responsiveness and that immediate physical contact causes direct changes in

responsiveness. We were also able to document the beliefs associated with physical contact, providing a potential explanation for some of the long-term effects of physical contact. In combination, the results of these studies support the proposal that culturally-mediated carrying methods – that either facilitate or impede mother-infant physical contact – have profound implications for shaping the early learning environment.

Chapter 2, in full, is currently being prepared for submission for publication of the material. Little, E.E., Legare, C.H., & Carver, L.J. The effect of physical contact on maternal responsiveness and mother-infant interaction. The dissertation author was the primary investigator and author of this material.

Table 2.1: Proximal Care Beliefs Questionnaire. To assess maternal beliefs about infant care, mothers responded to the following ten statements regarding the care of a 3-month-old infant on a scale from 1 (completely disagree) to 5 (completely agree). The proximal care beliefs score was calculated by summing responses to statements in the left column (i.e., proximal care) and subtracting the sum of responses to statements in the right column (i.e., distal care). This questionnaire was developed by Keller (2002) and has been used in diverse countries around the world to assess cultural models of parenting.

| | |
|---|---|
| It is important to rock a crying baby in the arms in order to console him/her<br><br>1----------2---------3----------4----------5<br>(completely disagree) (completely agree) | Sleeping through the night should be trained as early as possible<br><br>1----------2---------3----------4----------5<br>(completely disagree) (completely agree) |
| Gymnastics/motor stimulation makes a baby strong<br><br>1----------2---------3----------4----------5<br>(completely disagree) (completely agree) | You cannot start early enough to direct the infant's attention towards objects and toys<br><br>1----------2---------3----------4----------5<br>(completely disagree) (completely agree) |
| When a baby cries, he/she should be nursed immediately<br><br>1----------2---------3----------4----------5<br>(completely disagree) (completely agree) | It is not necessary to react immediately to a crying baby<br><br>1----------2---------3----------4----------5<br>(completely disagree) (completely agree) |
| If a baby is fussy, he/she should be immediately picked up<br><br>1----------2---------3----------4----------5<br>(completely disagree) (completely agree) | It is good for the baby to sleep alone<br><br>1----------2---------3----------4----------5<br>(completely disagree) (completely agree) |
| A baby should be always in close proximity with his/her mother, so that she can react immediately to his/her signals<br><br>1----------2---------3----------4----------5<br>(completely disagree) (completely agree)<br>(completely agree) | Babies should be left crying for a moment in order to see whether they console themselves<br><br>1----------2---------3----------4----------5<br>(completely disagree) (completely agree) |

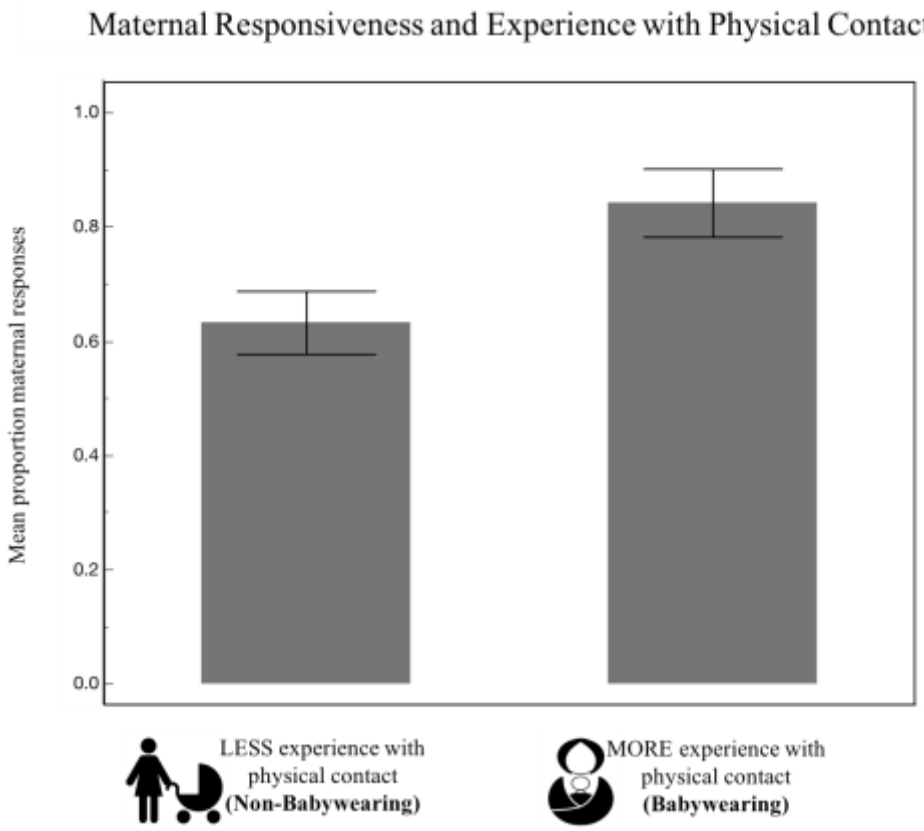


Figure 2.1: Difference in overall maternal responsiveness between mothers with less experience with physical contact and more experience with physical contact in Study 1. Error bars represent standard error of the mean.

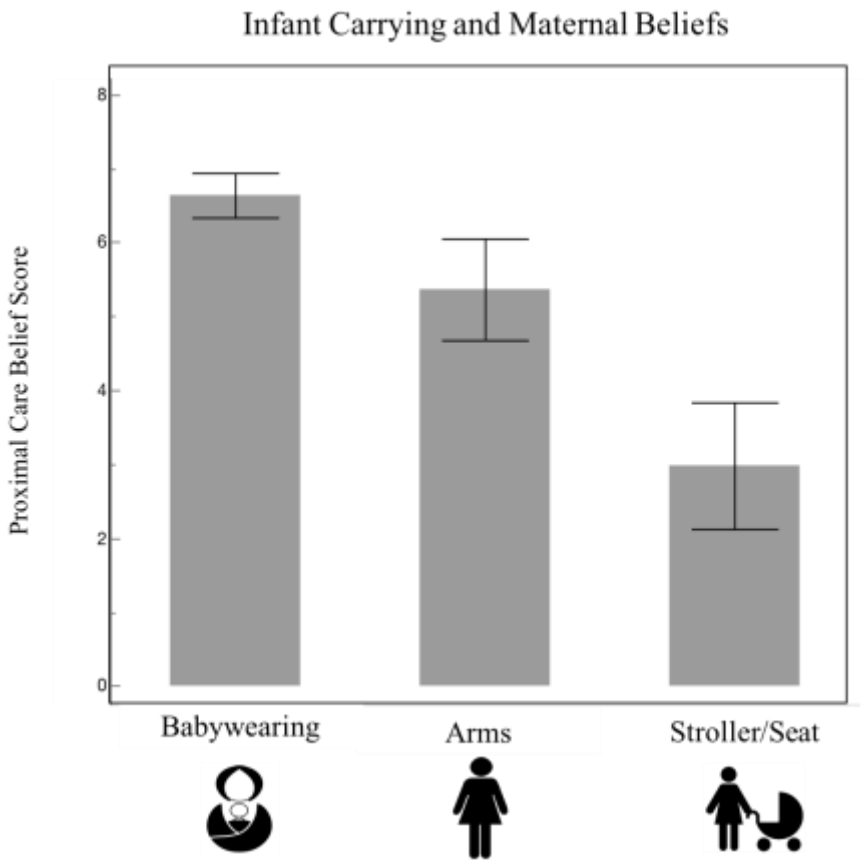


Figure 2.2: Difference in proximal care belief score associated with infant transport method in Study 2. Error bars represent standard error of the mean.

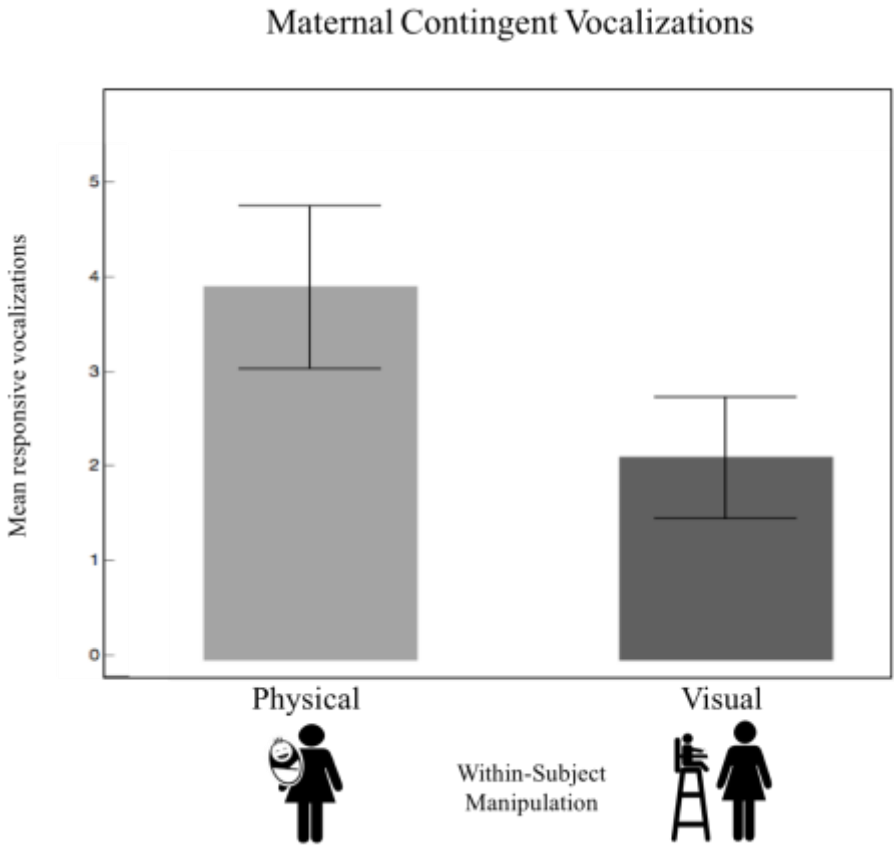


Figure 2.3: Difference in maternal responses to infants' vocalizations when not in physical contact with their infant and when in physical contact (within-subjects) in Study 3. Error bars represent standard error of the mean.

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# GENERAL DISCUSSION

Infant survival, health, and learning are shaped by whether and how caregivers respond to infant cues. Globally, this responsiveness takes many forms, yet previous research has not identified whether variation in responsiveness is attributed to a particular set of beliefs about responsiveness or behavioral differences in mother-infant interaction (i.e., amount of physical contact with infants). This dissertation tested the proposal that mother-infant physical contact facilitates increased maternal responsiveness during both breastfeeding and non-feeding interaction, demonstrating for the first time that immediate mother-infant physical contact predicts breastfeeding in response to early hunger cues (Chapter 1) and causes mothers to be more contingently responsive to infants' vocalizations (Chapter 2). Specifically, the data presented here addressed three questions not answered by past studies: 1) does mother-infant physical contact have an immediate, direct effect on responsiveness to infants' cues? 2) are the long-term effects of physical contact attributed to variation in maternal beliefs about responsiveness? and 3) are different forms of responsiveness (e.g., to infants' feeding cues during breastfeeding versus to infants' social cues during non-feeding interaction) both predicted by physical contact?

First, though past work has demonstrated a long-term effect of physical contact on responsiveness, no study has tested whether physical contact has an immediate effect on maternal responsiveness to infants' cues. In Chapter 1, individual variation in mother-infant physical contact predicted breastfeeding in response to early hunger cues rather than waiting for the onset of infant distress, even when controlling for maternal beliefs about responsiveness. In Chapter 2, maternal responsiveness increased when mothers were in physical contact with their infant in comparison with not in physical contact. Both of these

findings support the proposal that physical contact has immediate effects on maternal responsiveness.

Second, past studies have found that long-term experience with physical contact has an effect – over time – on maternal responsiveness, though it is unclear whether these effects are potentially attributed to changes in maternal beliefs about responsiveness. To address this, we showed that maternal beliefs (i.e., degree of alignment with proximal care culture) were predictive of individual differences in maternal responsiveness during breastfeeding (measured through self-report behavior logs and in-lab observations in Chapter 1). In Chapter 2, we used questionnaire data to demonstrate that mothers with increased long-term experience with practices that facilitate physical contact (i.e., babywearing) were more likely to subscribe to maternal beliefs characteristic of proximal care culture. Together, these data provide support for the proposal that long-term effects of physical contact on maternal responsiveness may be at least partly attributed to maternal beliefs about responsiveness.

Finally, both Chapter 1 and Chapter 2 demonstrate that maternal beliefs characteristic of proximal care culture, long-term experience with physical contact (i.e., through babywearing), and immediate physical contact (both natural variation and experimentally-manipulated changes) all predict increased maternal responsiveness. Importantly, this was the first investigation to show that responsiveness to vocalizations and facial expressions during non-feeding play-based interactions is driven by the same processes as responsiveness to infant hunger cues during breastfeeding. These data make a novel contribution to our understanding of maternal responsiveness and challenge the current models of how responsiveness is tested, given that responsiveness during feeding

is only investigated from the context of attachment research and social learning and language acquisition is only attributed to responsiveness during non-feeding play based interactions. Given that breastfeeding is the form that maternal responsiveness takes in many communities outside of Western, industrialized culture, these findings confirm the importance of looking outside of the WEIRDly biased research context of Western, educated, industrialized, rich, and democratic samples (Henrich, Heine, & Norenzayan, 2010) to develop a more comprehensive understanding of developmental processes and cultural influences on human development.

**Why might physical contact increase responsiveness?**

Infants' subtle movements or physiological changes that cannot be observed but can be felt may facilitate increased maternal awareness of her infant's emotional state and communicative intentions, thus increasing responsiveness. In Chapter 1, naturally-occurring within-subject variation in immediate mother-infant physical contact was predictive of increased responsiveness to infants' hunger cues, above and beyond effects of long-term experience with physical contact or underlying beliefs about responsiveness. When manipulating physical contact in the lab in Chapter 2, maternal responsiveness increased when mothers were in physical contact with their infants in comparison with when not in physical contact, showing that *even if* mothers had had more long-term experience learning their infants' cues (e.g., via more experience babywearing) they were still more responsive when in direct physical contact. These are the first studies to show an immediate, direct effect of physical contact, and the first to test this both in the context of non-feeding and feeding interactions.

These data also provide support for the proposal that physical contact has long-term effects on maternal responsiveness, which is consistent with past work (e.g., Anisfeld, Casper, Nozyce, & Cunningham, 1990). In Chapter 1, past experience with physical contact was associated with increased maternal responsiveness during breastfeeding (i.e., increased percent of infant-led unlatches) when measured during the in-lab breastfeeding session, though this was not significant when controlling for maternal beliefs. This suggests that long-term physical contact may cause (or be caused by, given that we are unable to determine the direction of the relationship from this observational study) mothers to be more aligned with the values of proximal care culture, including an increased emphasis on maternal responsiveness. Similarly, Chapter 2 demonstrated that mothers with more experience with physical contact were more likely to respond to their infant's cues, and were more likely to subscribe to the beliefs of proximal care culture.

***Physiological bonding***

An additional explanation is that the release of oxytocin – a neuropeptide involved in mammalian social bonds – during mother-infant physical contact underlies the effect of physical contact on maternal responsiveness. Oxytocin is associated with maternal affection (Feldman et al., 2009; Uvnäs-Moberg, 1998) and at least some aspects of responsiveness (e.g., to infant crying, Bakermans-Kranenburg, Ijzendoorn, Riem, Tops, & Alink, 2012; and infant laughing, Riem et al., 2012). Because of the surge in oxytocin during and immediately after childbirth, it is likely that oxytocin drives many of the effects of postpartum skin-to-skin contact cited in the medical literature (see Nagasawa, Okabe, Magi, & Kikusui, 2012 for a review). After the postpartum period, oxytocin release is caused by nipple stimulation through suckling – but not pumping! – (Neumann et al.,

1993), providing an explanation for differences between breastfeeding and bottle-feeding mothers found in past work (Hodges et al., 2013; Li, Fein, & Grummer-Strawn, 2010). However, oxytocin is also released during skin-to-skin contact (Uvnäs-Moberg, 1998), infant holding (without direct skin-to-skin, Light et al., 2000), and even in response to infant vocalizations (Seltzer et al., 2010), making it a viable explanation for the effect of mother-infant physical contact on maternal responsiveness demonstrated in these studies. Though measuring oxytocin was outside of the scope of the current project, future research should measure the effect of mother-infant contact on maternal responsiveness while accounting for potential changes in oxytocin levels.

**Remaining questions**

In all studies, and especially evident in the studies of Chapter 1, mothers were from a very selective sample of the population, specifically, most were breastfeeding (and many were babywearing) mothers. In some ways, this was a strength of these studies. By minimizing differences in breastfeeding and long-term physical contact, we were able to show that immediate physical contact does have a direct effect on maternal responsiveness above and beyond the other beliefs and practices generally associated with proximal care culture. However, this also raises the question of whether the effect of physical contact is applicable to mothers in the general U.S. population who may not be breastfeeding or babywearing. In one study, breastfeeding mothers – in comparison with bottle-feeding mothers – were more likely to show an increase in oxytocin levels after holding their infant (Light et al., 2000), suggesting that some effects of mother-infant physical contact may be specific to breastfeeding mothers.

**WEIRD measures**

Again, this example speaks to a broader issue in psychological research, such that the majority of our knowledge about maternal responsiveness – and human development – is based on studies conducted in "WEIRD" (Western, educated, industrialized, rich, and democratic, Henrich, Heine, & Norenzayan, 2010) populations. There are two main problems resulting from this bias: 1) maternal responsiveness is measured in the context of playing with objects, defining responsiveness as a social exchange rather than a response to infants' biological needs, and 2) maternal responsiveness is generally measured in the visual and vocal modalities, neglecting other potentially important modalities of mother-infant communication (e.g., touch, smell, movement).

Fieldwork with mothers outside of the U.S. makes it clear that what psychologists operationalize as a "cue" or communicative intent on the part of the infant is entirely mediated by cultural norms for communication. Back-and-forth vocalizations and mirroring of facial affect in the context of a play interaction is largely absent from the socialization experience of infants in many cultures (Barr, Konner, Bakeman, & Adamson, 1991; Lancy, Bock, & Gaskins, 2010; Rogoff, 2003) and the amount of vocalizing, smiling and mutual gaze encouraged by caregivers is mediated by cultural norms for communication (Carra, Lavelli, & Keller, 2014; Kärtner, Keller, & Yovsi, 2010; Whaley, Sigman, Beckwith, Cohen, & Espinosa, 2002) and by variation in infant carrying position (Feldman, Masalha, & Alony, 2006; Fogel, Messinger, Dickson, & Hsu, 1999). Crying and showing negative emotions in infancy is less common outside of the WEIRD cultural context – and is often actively discouraged by caregivers to promote calmness (Keller & Otto, 2009). Regulating infant distress and discouraging negative emotion expression – especially crying – is achieved among parents in these communities through carrying

(Kärtner et al., 2008), breastfeeding on demand (Keller & Otto, 2009), and verbal prompts to suppress emotionality (Demuth, Keller, & Yovsi, 2011). For example, in a comparison of social contingencies with Cameroonian Nso mothers and German mothers, mothers in Cameroon were more likely to respond to negative displays of emotion rather than positive and were less likely to smile or mirror their infant's positive affect (Kärtner et al., 2010). Similarly, Gussii mothers in Kenya discourage displays of positive emotion in their infants (LeVine et al., 1996).

Given this documented cultural variation in what caregivers consider to be cues that warrant responses (and the ways in which mothers choose to respond), the tendency of Western developmental researchers to privilege the forms of communication to which we are most accustomed (i.e., visual and vocal cues, Akhtar & Gernsbacher, 2008) leads to a cultural bias in our ability to objectively measure how caregivers respond to infants. Specifically, because these physical and tactile cues and responses that are exchanged between mother and infant are fairly imperceptible to the outside observer, researchers attempting to measure "responsiveness" from a Western perspective (i.e., contingent vocal responses) may make the mistake of assuming mothers are less responsive. Though the exchange of information that occurs between mother and infant when they are in direct physical contact can be inferred from overt behavior (e.g., high frequency of breastfeeding, decreased infant crying), directly measuring this subtle exchange of sensory information is possible yet much more difficult (McKenna, Mosko, Dungy, & McAninch, 1990), presenting a challenge that should be taken on with future investigations of this topic.

One strength of the current work is that we used breastfeeding behavior as a context from which to measure responsiveness. Though most developmental studies measure

maternal responsiveness in the context of a play paradigm, this is just one social environment to which U.S. infants are exposed and it is not shared by infants in many other places of the world (Rogoff, 2003). A potentially more important environment is the feeding environment, which not only provides the sustenance and nutrition critical for development, but also provides a wealth of social learning opportunities (Gottlieb, 2004; Lavelli & Poli, 1998). In an effort to have a more globally-relevant investigation of maternal responsiveness, Chapter 1 of this dissertation measured responsiveness in the context of responding to infants' cues for hunger and satiation. The importance of measuring responsiveness in the context of feeding is consistent with ethnographic descriptions of maternal responsiveness, such that in proximal care cultures, breastfeeding is one of the most common forms of responding to infants' cues, hunger-related or not.

However, there are even more subtle forms of cues and responses that should be considered in future investigations of maternal responsiveness. For example, rodent studies have found the olfactory cues of both mother and infant to be integral in the initiation and maintenance of bonding behaviors (Hofer, Shair, & Singh, 1976; Nagasawa et al., 2012). Even in human studies, mothers possess the skills to discriminate the odor of their own infant from that of other infants (Porter, Cernoch, & McLaughlin, 1983). The olfactory sense is one of the first to develop in early infancy, with the evolutionary purpose of directing the immature infant to the food source (i.e., the mother's breast). Neonatal recognition of the scent of mother's milk is an important factor in determining breastfeeding duration (Mizuno, Mizuno, Shinohara, & Noda, 2004), and is facilitated by postpartum skin-to-skin contact.

***Mothers and others***

Though these studies have focused on mother-infant interaction, other studies have found that the effects of physical contact are not necessarily specific to mothers or to medical professionals (Ferber et al., 2002). For most of human history – and still in many of the proximal care cultures discussed here – the model of parenting was "mothers and others" (Hrdy, 2011). In Guatemala, for example, sibling caregiving is the norm and older siblings practice physical contact with infants (i.e., through the use of babywearing slings) in the same way that adults do (Little & Shakya, in prep). Maternal support and shared caregiving responsibilities is an important determinant of breastfeeding behavior (Sellen & Smay, 2001) and in some communities, the degree of social support extends to breastfeeding itself, as for example, Aka and Bofi mothers in Central Africa, still practice allomaternal (i.e., shared across non-biological mothers) breastfeeding with young infants (Fouts, Hewlett, & Lamb, 2012) as do mothers in Mali (Dettwyler, 1988) and many other communities around the world. In Western industrialized infant care culture, there are less examples of shared caregiving, but rather there exists a different type of exception to the model of biological mothers being the primary caregiver. The most common example is fathers taking on primary caregiving roles. Other examples include adoption and increasingly more prevalent reproductive technologies that have challenged the definition of biological motherhood. Biological mothers have certain qualities that are unique from other types of caregivers – and the implications of breastfeeding, birth, and other biological bonding processes shared between an infant and their biological mother represent an important determinant of social and developmental processes, including maternal responsiveness. Understanding and accounting for these biological processes is therefore a critical component of our understanding of infant development. However, an important

challenge for developmental scientists – as proposed in recent work (e.g., Mesman, Minter, & Angnged, 2016) – will be to broaden definitions of psychological constructs – like responsiveness – to incorporate and account for culturally-variable models of infant care, including sibling caregiving, same-sex parenting, and allomaternal care.

**Conclusion**

Human infants are like all other primates in their need to maintain close contact with mothers for warmth, security, and sustenance (Bard, 2002). However, the amount of physical contact with infants in modern Western society – that comprises the majority of developmental research (Henrich et al., 2010) – is substantially lower than in many other human societies (Green et al., 2004; Moore, Anderson, Bergman, & Dowswell, 2012). Infant care in Western, industrialized societies is increasingly dominated by products that limit physical contact between infants and caregivers (e.g., cribs, strollers, playpens, bouncers) that have come to define "good" motherhood in today's society (Prothero, 2002). This societal obsession with baby gear continues to grow despite the potentially deleterious effects of such decreased amounts of physical contact with infants. Academic research should continue to look beyond Western culture to inform future studies addressing how culturally-mediated infant care practices and baby gear shape early psychological development and mother-infant communication.

Though the importance of early physical contact has been well established for decades, past work has focused primarily on physiological mechanisms underlying the effects of physical contact. This dissertation demonstrated that mother-infant physical contact facilitates maternal responsiveness in the context of breastfeeding (Chapter 1) and in the context of non-feeding interaction (Chapter 2), making three important novel

contributions to our understanding of responsiveness by showing that: 1) physical contact has an immediate effect on responsiveness, 2) long-term physical contact is associated with a particular set of parenting beliefs that may contribute to effects on responsiveness, and 3) both responsiveness during breastfeeding and responsiveness during non-feeding play-based interactions are driven – at least in part – by the same underlying mechanism (i.e., differences in mother-infant physical contact), motivating the need to incorporate infant feeding practices into the developmental literature on cognitive implications of responsiveness in the infant's early learning environment.

Human infants are born more dependent on adults and experience a longer infancy period than any other species. Mother-infant physical contact is a central component of infant care, yet the processes through which physical contact shapes development are not well understood. This dissertation investigated one such process, though the role of physical contact in human caregiving will not be fully understood until more research addresses the physiological, psychological, and cultural mechanisms involved in mother-infant interaction. Mothers (and others) have played an integral role in shaping not only infant development, but the trajectory of human behavior, culture, and evolution, so understanding what drives variation in how mothers care for and communicate with offspring is a key component of understanding human nature.

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