

NEURAL RESPONSES TO UNFAMILIAR INFANT FACES IN MOTHERS RAISING
YOUNG CHILDREN UNDER CONDITIONS OF ECONOMIC ADVERSITY:
AN EVENT-RELATED POTENTIAL STUDY

by

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A DISSERTATION

Presented to the Department of Psychology
and the Graduate School of the University of Oregon
in partial fulfillment of the requirements
for the degree of
Doctor of Philosophy

September 2018

DISSERTATION APPROVAL PAGE

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Title: Neural Responses to Unfamiliar Infant Faces in Mothers Raising Young Children Under Conditions of Economic Adversity: An Event-Related Potential Study

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DISSERTATION ABSTRACT

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Doctor of Philosophy

Department of Psychology

September 2018

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Infant faces represent highly salient visual stimuli that have been shown to elicit intuitive caregiving behaviors in healthy adults. However, the temporal dynamics of infant face processing in parents of young children remain poorly understood and the mechanism of action for the release of intuitive caregiving has not been elucidated. Although substantial advances have been made mapping the parental brain with fMRI, further work is needed to characterize the temporal dynamics of infant visual cue processing—particularly in populations at risk for disruptions in caregiving, such as families raising young children under conditions of economic adversity. Therefore, the purpose of this investigation was to examine the temporal dynamics of caregivers' neural responses to unfamiliar infant faces in a sample of mothers raising young children with limited financial resources.

To achieve this goal, this study utilized an event-related potential (ERP) paradigm—in combination with self-report and observational measures—to (1) examine the temporal dynamics of mothers' infant face processing across different phases of perceptual processing; (2) test the relationship between mothers' neural responses to unfamiliar infant faces and to other aspects of parental function; and (3) examine whether

mothers' neural responses to unfamiliar infant faces are sensitive to change with intervention. Three ERP components examined in prior work with caregivers (i.e., the P100, N170, and P300) were utilized to index the temporal dynamics of infant cue processing and two separate sets of analyses (Study 1 and Study 2) were conducted. Broadly speaking, the data collected in this investigation suggest that, for mothers raising young children under conditions of economic adversity, the parental brain begins differentiating between infant emotional expressions very early in the temporal course of stimulus perception and that mothers' ERPs for unfamiliar infant faces are associated with other aspects of parental function, including self-reported experience and observable caregiving behavior. Preliminary analyses suggest that ERPs for unfamiliar infant faces are sensitive to change via a strength-based parenting program designed to reinforce caregivers' attention to infant cues. These results are discussed with an emphasis on directions for future research and study limitations.

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ACKNOWLEDGMENTS

First and foremost, I wish to express my gratitude to my advisor Phil Fisher, whose vision for population-level change gives me hope for a better future and inspires me to be part of the solution. Your steadfast support and encouragement during my time in graduate school have been invaluable and I am so grateful for the opportunity to work with you. Thank you to my committee—Jennifer Freyd, Maureen Zalewski, and Nicole Giuliani—for your guidance, insight, and mentorship during my time at the UO. I could not have asked for a more grounding and brilliant group of female role models and I have learned so much from each of you. I extend my gratitude to our outside project collaborators who provided key input during this study’s conceptualization, design, and data collection: Tahl Frenkel at IDC Herzliya; Hyoun Kim at Oregon Social Learning Center; and Linda Mayes and Helena Rutherford at the Yale Child Study Center. Likewise, I would like to thank Jennifer Lewis for her help early on with E-Prime; Tyson Barker for his technical expertise; and Elliot Berkman for his statistics consultation. I couldn’t have done this work without close collaboration from Melissa Marquardt, Kristen Greenley, Kyndal Howell, Melanie Berry, and Alex Wagnon—a thousand times thank you each for countless hours of team-based work. I am proud of our work together!

I would like to acknowledge members of the PANDA Project and FIND Community Research Teams who consistently went above and beyond with countless contributions to this work: Ashley Albin, Julie Bartlett, Sarah Beercroft-Haffner, Rachele Bedsole, Christian Carrillo, Adriana Conn, Bryna Cooper, Madeline Cresswell, Patrick Drossel, Kaliq Fulton-Mathia, Chase Geddes, Kyle Harrif, Alexander Heinz, Christian Jordan, Jordan Lofton, Madison Long, Stephanie Mayer, Oliver Medak, Andrea

Myovich, Sarah Nachbar, Layla Nasr, Anna Oliver-Steinberg, Rachel Polsky, Katie Remmers, Samantha Scherer, Lisa Shimonada, Amber Stocker, Cody Thomas, Bao Tran Tieu, and Alexander Wagon. Equally, I wish to thank the FIND Community Clinical Team, whose hard work coaching and editing film from the mothers in the FIND Community study remind me why this kind of work matters: Yasaman Ahmadi-Kashani, Brigitte Amidon, Melanie Berry, Kate Beauchamp, Grace Binion, Alex Darling, Jessica Flannery, Sarah Horn, Kyndal Howell, Madison Long, Tim Matthews, Celeste Mena, Ellisa Nam, Kelcie Rodriguez, Sylvia Shaykis, Sandra Stegenga, Sally Steinman, Katie Trageser, Jillian Tusso, Margie Watkins, and Zoe Wong.

A very special thanks goes to members of the UO Stress Neurobiology and Prevention Lab, the 2011 UO doctoral cohort, and my fellow interns at Penn Medicine—without whom I would have lost my mind long ago. My heart is full of gratitude for my inner circle of empowering women (that’s you Kate Ritley Blazar, Brianna Delker, Laura Schulte, and Charlotte Vaughn), loving friends—who I am fortunate to say are too many to name here, and members of the Noll and Allen families, whose support has seen me through the past decade of higher education. And to my partner, Ira Allen: thank you for believing in me. Your unwavering confidence in my capacities as a scholar has been a guiding light over the past decade together.

This investigation was supported by a student support grant from the UO Center for the Study of Women in Society to myself and my co-Investigator Melissa Marquardt; research funds from the UO to Phil Fisher; and seed funding from OSLC’s Translational Drug Abuse Center (1 P50 DA035763) and the University of Minnesota Early Experiences, Stress, and Neurobehavioral Development Center (5 P50 MH078105-02).

For Ira
My Lighthouse

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CHAPTER I

INTRODUCTION

Purpose

How caregivers attend to and encode their infant's preverbal communication is believed to impact their ability to respond sensitively and contingently to their child's needs (Maupin, Hayes, Mayes, & Rutherford, 2015; Noll, Mayes, & Rutherford, 2012). However, the temporal dynamics of infant cue processing in parents of young children remain poorly understood. Although substantial advances have been made mapping the parental brain (for reviews see Feldman, 2015; Pechtel, Murray, Brumariu, & Lyon's-Ruth, 2013; and Young et al., 2016), further work is needed to elucidate the temporal dynamics of infant visual cue processing—particularly in populations at increased risk for disruptions in caregiving, such as families raising young children under conditions of economic adversity. Therefore, the overarching aim of this dissertation study is to delineate neural responses to unfamiliar infant faces using a neuroimaging method with high temporal resolution and to examine associations between this infant visual cue processing at different stages of perceptual processing and parental function in mothers raising young children with limited financial resources.

Organization

First, in Chapter One, literatures from evolutionary theories of parental function, observational studies of parenting behavior, and the neuroscience of intuitive parenting are reviewed with an emphasis on the implications for interventions designed to support families at increased risk for disruptions in parental function. Second, mothers' ($N = 70$)

neural responses to unfamiliar infant faces and the relationship of these responses to other domains of maternal function are examined in Chapter Two, using event-related potential (ERP) data from a passive viewing paradigm, self-report measures, and observational data from a free play parent-child interaction task (Study 1). Third, Chapter Three explores the sensitivity of mothers' ($N = 30$) neural reactions to unfamiliar infant faces to change with intervention using data from the Filming Interactions to Nurture Development (FIND) Community Pilot Project (Study 2). Finally, results from Studies 1 and 2 are integrated and discussed in Chapter Four, with an emphasis on study limitations and directions for future research.

Study Assumptions

Research with at-risk families that neglects the social and institutional determinants of inequality runs the risk of localizing the burden of change harmfully within individuals who are already marginalized. Therefore, the following assumptions regarding at-risk families and economic inequality inform this work:

1. Mothers raising young children under conditions of economic adversity are doing the best they can with the resources available to them.
2. Problems of economic inequality that adversely impact mothers raising young children cannot be solved by family-based interventions alone.
3. In the face of intractable economic inequality, clinical scientists must work to ameliorate the negative impact of such adversity on families by identifying intervention targets that maximally bolster parents' intuitive caregiving capacities, while advocating for systemic change.

Background

Evolutionary Theories of Intuitive Parenting: A Theoretical Framework for Understanding Caregivers' Behavioral Responses to Infant Faces

Building on Darwin's (1872) study of emotional expression across species, Lorenz (1943, 1971) was among the first to formally observe that humans respond to *Kindchenschema* or baby schema (i.e., facial features common to newborns across mammalian species) with positive emotions and increased attention. These features include large low-set eyes, small chins, short and narrow noses, and rounded cheeks (Young et al., 2016) and have been associated with the perception of cuteness and motivation for caregiving in adults (Alley, 1981; Glocker et al., 2009). Lorenz (1943, 1971) proposed that infant facial features facilitate parental care—and by extension reproductive success for the species—by way of an evolutionarily conserved *innate releasing mechanism*.

Over the past 60 years, Lorenz's theory has received considerable support from observational studies of parent-infant interaction in laboratory settings. Perhaps most notably, second-by-second coding of caregiver-infant interactions suggests that baby schema trigger the release of the developmentally supportive parenting behaviors that operate outside of the caregiver's conscious control¹ (e.g. Papoušek & Papoušek, 1975, 1977, 1982, 1983, 1987, & 2007), leading developmental psychologists to term this phenomenon *intuitive parenting* (Papoušek & Papoušek, 2000). These behaviors include modifying speech and establishing eye contact while staying within in the center of the

¹ In fact, some evidence suggests that a parent's conscious reflection about parenting during face-to-face interactions with their child may actually disrupt the release of intuitive parenting behavior (Lohaus, Keller, Volker, Cappenberg, & Chasiotis, 1997).

infant's visual field at the infant's exact focal distance (Papoušek & Papoušek, 1987), exhibiting an automatic 'greeting response' immediately after establishing eye contact (Lohaus, Keller, Volker, Cappenberg, & Chasiotis, 1997), and mirroring the neonate's facial expressions and posture (Stern, 1985)—all within time scales that suggest these responses are slower than reflexes but faster than conscious responses. Specifically, Papoušek & Papoušek (1987) observed that intuitive parenting behaviors operate over temporal intervals ranging from 200-800ms, suggesting that preconscious responses to infant stimuli underlie intuitive parenting behaviors. As such, parents' rapid neural discrimination of infant visual cues (e.g., facial expressions) is thought to be crucial for the release of intuitive parenting behaviors (Parsons, Young, Stein, & Kringelbach, 2017) and now represents an important site of empirical investigation.

Importance of Infant Facial Expressions for Release of Intuitive Parenting Behavior

Before human infants acquire language, they rely on facial expressions and preverbal vocalizations to communicate with their caregivers. These preverbal expressions are believed to serve two key functions (Young et al., 2016). First, preverbal infant communication facilitates infant survival by providing caregivers with important information about the infant's physiological and emotional state (Soltis, 2004), thus enabling caregivers to modify their caregiving behavior according to the infant's needs and rapidly evolving developmental trajectory. Second, back-and-forth exchanges between infants and their caregivers are believed to form the foundation for complex attachment relationships that emerge as the infant develops increasingly complex social-emotional capacities. In a series of influential experiments, Melzoff and Moore (1977, 1983) documented the capacity for human neonates to mirror adult facial gestures soon

after birth and theorized that each neonate possesses a representational system that allows them to generate behavior on the basis of intermodal matching between their perception of the environment and their perception of their body. More recent longitudinal work failed to find evidence for neonatal imitation of facial gestures (Oostenbroek et al., 2016), suggesting the capacity for mirroring emerges later during the perinatal period and is a learned behavior. Regardless of origin or exact timing of onset for neonate mirroring, substantial evidence indicates that caregivers' contingent responses to infant preverbal communication plays an important role in dyadic learning—allowing the infant to perceive causal relationships between their preverbal communication and caregiving responses (Beeghly, Fuertes, Liu, Delonis, & Tronick, 2010), while simultaneously enabling the caregiver to regulate the amount of stimulation they direct towards the infant according to the child's communicated needs (Beebe et al., 2008, 2010). Importantly, this complex mirroring and the scaffolding of the dyad's social learning is highly contingent upon the caregiver's ability to perceive and discriminate infants' preverbal expressions of pleasure and distress (Ainsworth, Bell, & Stayton, 1974; Ainsworth, Blehar, Waters, & Wall, 1978; Parsons, Young, Stein, & Kringelbach, 2017). Furthermore, this sensitivity lays the foundation for infant attachment (de Wolff & van IJzendoorn, 1997) and is supported by biological changes that occur with reproductive and caregiving experiences.

The Biological Underpinnings of Intuitive Parenting

Before discussing the neural underpinnings of caregivers' ability to perceive and discriminate infants' preverbal communication specifically, it is important to note the large body of literature documenting the biological underpinnings of intuitive caregiving behavior more generally. Specifically, preclinical studies with non-human animals and

human participants document dramatic biological changes in the parental body and brain that occur during reproduction and caregiving (Kinsley & Lambert, 2008). Such changes are commonly regarded as adaptations that help individuals meet the numerous demands of reproduction and caregiving and ensure species survival during this critical period of development for both neonate and caregiver—including but not limited to detecting and responding to infant preverbal cues. Some of the earliest empirical work in this area focused on the maternal neuroendocrine system, which proved critical for understanding the complex relationship between changes in the parental brain and body. In two seminal experiments, Terkel and Rosenblatt (1968, 1972) demonstrated that a blood transfusion between a parturient female rat and a virgin female rat could induce maternal behaviors in the latter, suggesting that something in the blood plays a key role in activating intuitive parenting. A decade later, Bridges (1984) documented associations between the hormone profiles of oestrogen and progesterone in pregnant rats and the rapid onset of maternal behavior. Today, maternal hormonal fluctuations are thought to induce the onset of maternal behavior, at least in part, by modifying the genomic expression of proteins implicated in both neuronal activity (McEwen, 1991) and structural changes to brain architecture (Cohen & Pfaff, 1981), such as dendritic remodeling (Parrish, Emoto, Kim, & Jan, 2007). As such, recent work in this area has focused on unpacking complex relationships between the parents' neuroendocrine system, brain activity, and caregiving behavior (for review see Feldman, 2015). Although beyond the scope of the current investigation, this rapidly growing literature forms the foundation for the current study and, thus, informs both the interpretation of results and directions for future research.

The Parental Brain and Neural Correlates Infant Face Processing in Adults

Although scientific interest in the biological underpinning of parenting behavior and parent-infant bonding is more than a hundred years old (Feldman, 2015), the application of neuroimaging to examine the neural correlates of parenting behavior is relatively new. Within this field of inquiry, numerous techniques exist, each occupying a “distinct problem space” (Stewart & Walsh, 2006, p. 3) that generates qualitatively different types of knowledge regarding the detection and higher-order processing of preverbal infant communication. Accordingly, the suitability of each technique is contingent upon the research question(s) of interest. Due to their high spatial resolution and relatively non-invasive nature, functional magnetic resonance imaging (fMRI) and magnetoencephalography (MEG) have been used to map the parental brain and examine patterns of infant cue processing that support caregiving behavior in human subjects (for recent reviews see Feldman, 2015; Pechtel, Murray, Brumariu, & Lyons-Ruth, 2013; Young et al., 2016). Such neuroimaging investigations frequently elicit parents’ and (occasionally non-parents’) brain response to infant stimuli (cries, faces) across auditory and/or visual modalities and examine the relation of such brain activation to other aspects of parental experience, including observed parenting behavior (Atzil, Hendler, & Feldman, 2011; Kim et al., 2011; Kuo, Carp, Light, & Grewen, 2012; Musser, Kaiser-Laurent, & Ablow, 2012); attachment, feelings of maternal love, and positive perceptions of their own infant (Barrett et al., 2012; Bartels & Zeki, 2003; Kim et al., 2010a; Strathearn, Li, Fonagy, & Montague, 2008); behavioral inhabitation and activation (Montoya et al., 2012); psychiatric symptomatology such as PTSD, depression, and substance abuse (Landi et al., 2011; Laurent & Ablow, 2011; Musser, Kaiser-Laurent, &

Ablow, 2012; Schechter et al., 2011); mood (Nitschke et al., 2004); hormone levels (Atzil, Hendler, & Feldman, 2011; Kuo, Carp, Light, & Grewen, 2012; Laurent, Stevens, & Ablow, 2011; Riem et al., 2011; Riem et al., 2012); and childhood experiences (Kim et al. 2010b).

These fMRI experiments suggest that infant face stimuli—like adult face stimuli in earlier work (e.g., Kanwisher, McDermott, & Chun, 1997)—activate the visual cortex and fusiform face areas of the brain (Parsons, Young, Stein, & Kringelbach, 2010). However, consistent with behavioral dot-probe experiments demonstrating that infant faces stimuli capture attention faster than other human and non-human faces (e.g., Brosch et al., 2007), this growing literature also suggests that—unlike adult faces—infant face stimuli elicit activation in additional brain regions, such as those implicated in reward processing, motivation, emotional regulation, and pre-motor activity (Caria et al., 2012; Strathearn, Li, Fonagy, & Montague, 2008). For example, in one study Kingelbach and colleagues (2008) demonstrated that in adult participants the medial orbitofrontal cortex (mOFC) was differentially activated in response to unfamiliar infant faces compared to unfamiliar adult faces, peaking at 130 ms post-stimulus in the 10-15 Hz band. Differential activity for infant face stimuli over adult face stimuli was also observed at around 165 ms, in a different band (20–25 Hz) in the right fusiform face area (FFA), suggesting a feedback effect from mOFC. In a similar study, Nitschke and colleagues (2004) found that OFC activity was correlated with the positive mood of mothers while viewing pictures of their own infant versus unfamiliar infants, suggesting that differential OFC activation may be an indicator of the emotional salience of infant face stimuli.

Thus far, the identified networks of the parental brain include reactivity to infant cues in cortical regions within the temporal lobe (middle temporal gyrus, superior temporal gyrus/sulcus, and inferior temporal gyrus/sulcus) and frontal lobe (orbital frontal cortex, anterior cingulate, prefrontal cortex, insula); subcortical activation within the basal ganglia, amygdala, and periaqueductal grey; and motor regions (motor cortex, premotor cortex, supplementary cortex) (Feldman, 2015; Young et al., 2016). Although many of these regions overlap with neural networks that are sensitive to social stimuli in general, Young and colleagues (2016) recently proposed that neural networks of the ‘parental brain’ and more general ‘social brain’ differ insofar as the former preferentially recruits ‘survival circuitry’ (e.g., subcortical and brainstem areas that support reflexive responses) and that such recruitment has been evolutionarily conserved across species. This is consistent with evolutionary theories of hardwired intuitive parenting behaviors that are released in survival contexts (e.g., when providing crucial caregiving for a neonate who cannot survive on his or her own). With regard to the processing of infant facial expressions specifically, projections between brain regions involved in processing of visual sensory information (i.e., occipital and temporal regions such as the fusiform gyrus) and frontal regions such as the orbital frontal cortex and inferior frontal gyrus are theorized to facilitate rapid salience evaluation and higher-order processing (Kingelbach et al., 2008; Nitschke et al., 2004; Strathearn, Li, Fonagy, & Montague, 2008; Young et al., 2016) that are needed to coordinate complex behavior responses to infants’ pre-verbal visual communications.

Taken together, over the past two decades fMRI and MEG studies have advanced our understanding of the parental brain considerably. However, comparatively less is

known about the temporal dynamics of infant face processing in parents of young children. Given the developmental significance of timing for intuitive caregiving behavior, elucidating the temporal dynamics of infant face processing is a crucial for understanding (a) to what extent aberrations in infant cue processing predict disruptions in caregiving behavior; and (b) what stage in infant cue processing represents the most efficacious target for interventions designed to support at-risk parents.

Importance of Understanding Infant Face Processing and Intuitive Parenting Processes in Mothers Raising Young Children Under Conditions of Economic Adversity

Much work has documented the deleterious impact of economic adversity on child outcomes (Bradshaw, 2002; Brooks-Gunn & Duncan, 1997; Duncan & Brooks-Gunn, 2000; Parker, Greer, & Zuckerman, 1988), however comparatively less is known about parental function in this context. Mothers raising young children under conditions of economic adversity represent an important target population for elucidating the temporal dynamics of infant cue processing, as they are at elevated risk for disruptions in caregiving. At the extreme end of the caregiving continuum, disruptions in caregiving may rise to level of early childhood maltreatment, which remains a pervasive and understudied public health problem in the United States, with serious long-term effects on children's health and development (Allen & Oliver, 1982; Cecil, Viding, Fearon, Glaser, & McCrory, 2017; Cicchetti & Carlon, 1989; Dubowitz, 1999; Engeland, Sroufe, & Erickson, 1983; Fox, Long, & Langlois, 1988; Gaudin, 1999; Hildyard & Wolfe, 2002; Johnson et al., 2017; Kotch et al., 2008; Manly, Kim, Rogosch, & Cicchetti, 2001; Mills et al., 2010; Trickett & McBride-Chang, 1995; Widom, 2013). Studies have shown that caregivers who abuse or neglect their infants are more likely to have a history of

childhood maltreatment (Dukewich, Borkowski, & Whitman, 1996; Ertem, Leventhal, & Dobbs, 2000; Lounds, Borkowski, & Whitman, 2006), live in poverty (Sedlak et al., 2010; Slack, Holl, McDaniel, Yoo, & Colger, 2004), and struggle with mental health problems (Bartlett, Raskin, Kotake, Nearing, & Easterbrooks, 2014). However, despite the robust relationship between these risk factors and maltreatment perpetration, marked heterogeneity exists in such populations and many caregivers raising young children under conditions of economic disadvantage do not abuse or neglect their children. Importantly, comparatively little is known about the precise mechanisms by which caregiving is disrupted in at-risk families (Strathearn, 2011). This gap must be bridged in order to identify appropriate intervention targets that directly address the underlying proximate cause(s) of behavioral maltreatment in caregivers of young children and best support caregivers raising children in the context of poverty. Since the neural encoding and downstream processing of infant visual cues represent important antecedents of developmentally supportive caregiving behavior, it is crucial to examine the temporal dynamics of infant face processing in caregivers raising children under conditions of economic adversity.

The Challenges of Responding to Infant Cues Under Conditions of Economic Adversity

A moderately large literature documents robust associations between socioeconomic status (SES) and parenting behavior (Roubinov & Boyce, 2017). However, the variability in parenting quality observed across low- and high-SES families (e.g., Luthar & Latendresse, 2005) suggests additional factors likely mediate and/or moderate these associations. For example, using data from the Early Childhood Longitudinal Study ($N=21,255$), Gershoff and colleagues (2007) identified a unique

pathway predicting child social-emotional competence from material hardship via parent stress and parenting behavior, suggesting that these mediating variables may help account for such variability and, by extension, also represent important targets for intervention. However, interventions that aim to reduce parenting stress and increase parenting quality may be most efficacious if the neurocognitive mechanisms underlying links between increased stress and reductions in developmentally supportive caregiving are first identified. Therefore, the current investigation aims to examine one potential mechanism: mothers' neural responses to nonverbal infant communication, which may co-vary with other domains of parental function and subjective experience which have been documented to (a) co-vary with experiences of psychosocial and economic adversity; and (b) exert a causal impact on caregiving quality. These include: maternal mental health symptoms, emotion regulation difficulties, parental reflective function, and parents' subjective experience of parenting (stress, self-efficacy, and reward).

Under conditions of economic adversity, both the neural encoding of infant cues and subsequent behavioral responsivity may be disrupted. Importantly, such impairment may be most pronounced and deleterious in the context of infant distress, which poses a significant challenge to the emotional and behavioral regulatory abilities of even low-risk caregivers. Although to date no studies have examined disruptions in infant cue encoding in low-income families, extant empirical work indicates that low SES is associated with 'risky' family characteristics such as higher levels of conflict, reduced support, and exposure to violence within the family (Repetti, Taylor, & Seeman, 2012). Specifically, in contrast to high-SES families, parents living under low-SES conditions are more likely to experience income-related distress (McLoyd, 1998) and, thus, more likely to be harsh

and punitive (Hoffman, 2003), less sensitive (Mistry, Biesanz, Chien, Howes, & Benner, 2008); less supportive of child autonomy (Richman & Mandara, 2013); less able to carry out and sustain daily routine over time (Evans, 2004; Fiese, Rhodes, & Beardslee, 2013; Jensen, James, Boyce, & Hartnett, 1983); and more chaotic (Evans, Gonnella, Marcynyszyn, Gentile, & Salpekar, 2005).

Taken together, these studies suggest that low-income families are at increased risk for disruptions in caregiving and that more work is needed to identify the exact mechanisms by which caregiving is disrupted. Specifically, since many of the environmental factors associated with disruptions in caregiving may be intractable for clinicians aiming to support parents raising children under conditions of economic adversity, work that identifies candidate mechanisms to bolster developmentally supportive parenting (and the neurobiological mechanisms that release such intuitive caregiving behavior) are crucial. This is not to say that interventions that are focused on mitigating the impact of socioeconomic inequality on parental function via two-generation programs are sufficient or should take the place of larger sociocultural interventions. Rather, given the current realities of unrelenting and even worsening socioeconomic inequality, identifying the most powerful levers for affecting individual-level change within the context of intractable environmental constraints represents one important source of empowerment for families raising young children under conditions of economic adversity. Drawing on extant studies of intuitive parenting behavior, I propose that caregivers' neural processing of non-verbal communication may represent one such lever. The conceptual model for neural processing of infant cues as one hypothesized

mechanism linking caregivers' adversity-related characteristics to variations in caregiving behavior are shown below in Figure 1.

Figure 1. Conceptual Model Linking Adversity-Related Maternal Characteristics to Parenting Quality through Neural Responses to Visual Infant Cues

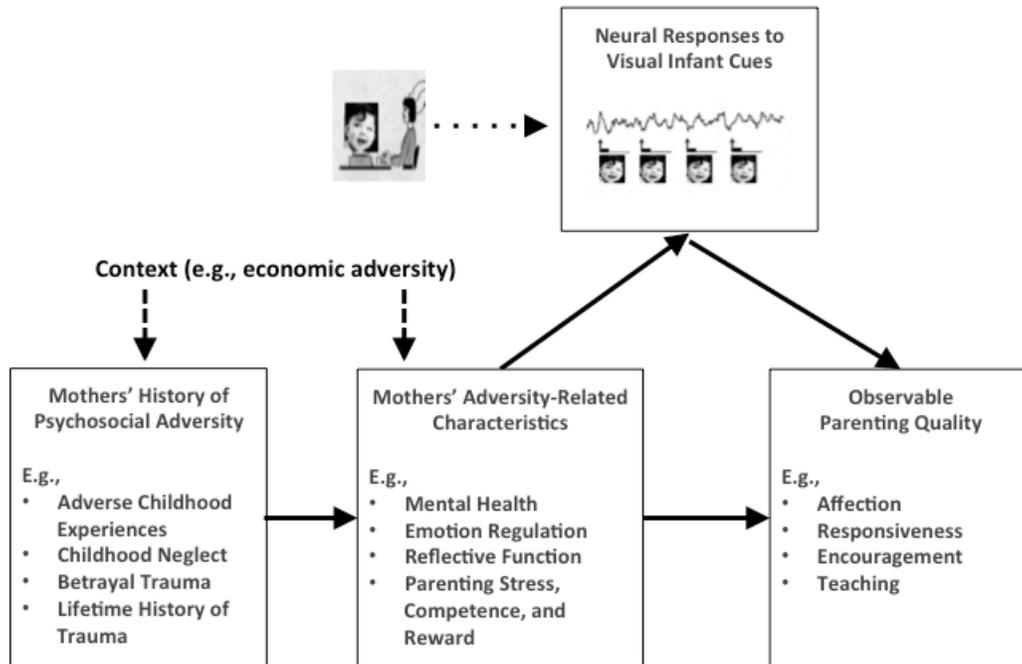


Figure 1. Conceptual model linking known predictors of parenting quality through and independent of mothers' neural responses to infant cues.

Interventions to Enhance Infant Visual Cue Processing in At-Risk Caregivers

Reviews and meta-analyses document the positive impact of video feedback on parenting behaviors, caregiver attitudes, and child development (e.g., Balldin, Fisher, & Wirtberg, 2016; Fukkink, 2008; Fukkink, Trienekens, & Kramer, 2011; Hitchcock, Dowrisk, & Prater, 2003), however, comparatively little is known about the mechanisms underlying improvements in parental function. One possibility is that that by asking caregivers to attend to visual stimuli within the context of a supportive relationship with a therapist or coach, their child's visual cues (i.e., facial expressions) capture attention

more effectively, become more salient, and initiate increased neural resource allocation—all of which combines to improve caregiving quality. Consistent with this hypothesis, Bernard and colleagues (2015) found that mothers involved with Child Protective Services (CPS) who participated in the Attachment and Biobehavioral Catchup (ABC) intervention and low-risk comparison mothers exhibited greater event-related potential (ERP) enhancement for emotional children's faces relative to neutral faces, compared to CPS mothers who had not received the intervention. Additionally, the magnitude of ERP responses in this study was associated with observed maternal sensitivity, providing preliminary evidence that ERP markers of face processing may represent useful biomarkers for intervention-related changes in maternal sensitivity. However, since the authors only measured ERPs post-intervention and this was the first published study of its kind, further work should control for between-group differences at baseline in order to make stronger inferences about the sensitivity of the ERPs of interest to change with video-feedback interventions.

The current study examines mothers' neural responses to infant cues in the context of the Filming Interactions to Nurture Development (FIND) intervention, a brief video-coaching program for caregivers of young children, developed by Dr. Phil Fisher and colleagues at Oregon Social Learning Center and the University of Oregon (Fisher, Frenkel, Noll, Berry, & Yockelson, 2016). Although it shares many similarities with other two-generation video-feedback programs and was adapted from another family-based video-feedback program called *Marte Meo* (Aarts, 2000; Nese et al., 2016), FIND has a number of distinguishing features that make it particularly well suited to the study of infant cue sensitivity across time. These features include: descriptive frame-by-frame

analyses of serve-and-return elements that utilize precise language and techniques that were developed to maximize the salience of children’s bids for caregiver attention; and highly operationalized materials that reduce reliance on professional and paraprofessional expertise and, hence, facilitate fidelity of consistent implementation in research contexts. Caregivers’ neural processing of preverbal child communication as a underlying neurocognitive caregiver capacity in the FIND theory-of-change is shown in Figure 2 and a detailed description of the program’s development, components, and theory-of-change may be found in previously published work (see Nese et al., 2016; Fisher et al., 2016).

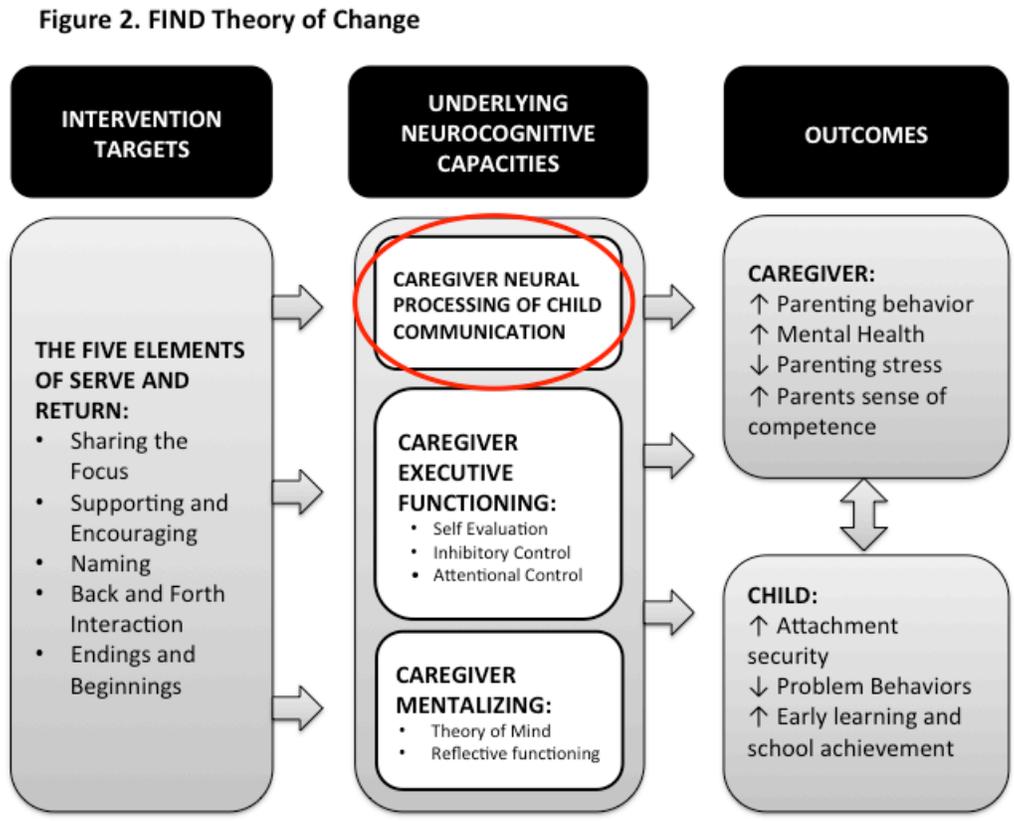


Figure 2. The Filming Interactions to Nurture Development (FIND) Theory of Change, adapted from Fisher et al. (2016) to include caregiver processing of non-verbal child communication as a hypothesized neurocognitive mechanism linking the intervention targets to improvements in caregiver function.

Neuroimaging Approach

Use of ERP Paradigms to Study the Temporal Dynamics of Infant Face Processing

Electroencephalography (EEG) and event-related potential (ERP) paradigms provide non-invasive and relatively inexpensive means of investigating the functional course of visual processing (i.e., encoding) at the neural level, with high temporal resolution in the millisecond range (Luck, 2014). Accordingly, this neuroimaging technique is particularly well-suited to the study of the early sensory processing of infant visual cues (e.g., facial expressions), which occur within time frames too narrow to be captured by self-report measures, behavioral observation, or other neuroimaging technologies (i.e., fMRI) alone (Noll, Mayes, & Rutherford, 2012). As such, the ERP modality may help further our understanding of differences in caregiving responses by allowing us to differentiate between aberrations in early stimulus perception (i.e., encoding) and later “down-stream” neural reactivity, such as those underpinning attention allocation and the coordination of caregivers’ developmentally supportive behavior. Such delineation may be particularly useful in the clinical domain, where the processes by which psychopathologies disrupt caregiving remain poorly understood (Maupin, Hayes, Mayes, & Rutherford, 2015) and low-cost, highly efficacious programs are lacking.

ERP Components that Index Neural Processing of Infant Faces across Time

Although precise definitions vary, “an ERP component can be operationally defined as a set of voltage changes that are consistent with a single neural generator site and that systematically vary in amplitude across conditions, time, individuals, and so forth. That is, an ERP component is a source of systematic and reliable variability in an ERP data set” (Luck, 2014, p. 68). The EEG waveforms that form the raw data for an

ERP dataset are generated by postsynaptic potentials of cortical pyramidal neurons, which are measured at the scalp via electrodes. In ERP experiments, EEG waveforms are time-locked to stimuli (i.e., events) and the ERP components associated with those events are subsequently extracted and analyzed with respect to their latency and amplitude, both of which may vary with experimental conditions.² Where other neuroimaging techniques (e.g., fMRI) help researchers delineate neural responses to infant cues in space (i.e., brain regions), ERP designs are optimally suited for delineating neural responses to infant cues across time.

Early stimulus detection: the N/P100.

In visual processing EEG tasks, early visual stimulus detection is indexed by the N/P100 (sometimes called the N/P1 as a shorthand) ERP component, which is usually observed between 80 to 130 ms after stimulus onset (Mangun, 1995; Spehlmann, 1965). Structural MRI studies and source density maps place the putative neuronal source of the N/P100 somewhere over the primary and association cortices of Brodmann's Area 18, which is located in the occipital lobe (Di Russo, Martinez, & Hillyard, 1990; Young et al., 2016). The N/P100 is frequently observed in visual ERP tasks and is modulated by selective attention, such that N/P100 amplitudes are larger when the target stimulus is attended to than when it is not (e.g., Van Voorhis & Hilyard, 1977), a phenomenon termed the P100 or P1 'effect' for selective attention (Bornstein, Arterberry, & Mash, 2013).

² Following the recommendation of Luck (2014) and others, in this study I have elected to plot ERP waveforms with positive voltages upward and negative voltages downward. However, in the field it remains common convention to plot ERP waveforms in the opposite direction. As Luck (2014) notes, this is likely a historical artifact of the early neurophysiologists who plotted the action potentials of neurons as upward-going spikes.

N/P100 Modulation. Although the N/P100 is widely regarded as a reliable index of early visual processing and rapid cortical sensitivity in human processing of infant facial expressions (Young et al., 2016), it remains unclear to what extent the amplitude and latency of the N/P100 for infant face stimuli are modulated by their emotional valance, intensity of expression, and/or characteristics of the participant (e.g., parental status). Some evidence suggests that lateral occipital N/P100 responses to unfamiliar infant faces are larger in women than in men and, furthermore, that lateralization at the N/P100 (i.e., right hemisphere amplitudes > left hemisphere amplitudes) is modulated by parental status (Proverbio, Brignone, Matarazzo, Del Zotto, & Zani, 2006), such that mothers were the only group (compared to non-parent women and men) for whom P100 responses for unfamiliar infant faces were bilateral. At least one study has documented modulation effects of N/P100 latency by the intensity of infant emotional expression. Specifically, during an infant face-processing task that manipulated participants' attentional focus, Peltola and colleagues (2014) found that mothers' N1 latency was shorter for infant faces expressing strong intensities of emotion in the right hemisphere, compared to infant faces expressing comparatively mild emotional expressions. Furthermore, across both mothers and non-mothers, peak latency of the N1 response to strong versus mild intensity infant faces predicted the speed of correctly classifying infant faces as positive or negative in a separate task, perhaps indicating a functional relationship between early visual detection speed and downstream speed of stimulus categorization. However, other studies—including both active and passive paradigms—have observed no modulation of P100 characteristics by infant face valence (e.g., Proverbio et al., 2006; Noll et al., 2012).

Regardless of whether the N/P100 is modulated by infant emotional expression, emerging evidence suggests it may provide a useful index of early preparation for downstream parental functions. In one recent study, although P100 amplitude remained uncorrelated with observed caregiving behavior, a significant association was observed between P100 amplitude and parents' self-reported activation of the parental care system (Endendijk, Spencer, van Baar, & Bos, 2018), perhaps indicating that the magnitude of P100 response to unfamiliar infant faces indexes brain activation that is necessary but not sufficient for the coordination of developmentally supportive parenting behavior. Taken together, these studies suggest that modulation of N/P100 latency and amplitude may be more likely in visual tasks that specifically manipulate selective attention, that the N/P100 is more sensitive to the intensity of affective expression than categorical valance, and that this neural index of parental function is associated with some but not aspects of parental function. However, further work is needed to clarify the determinants of N/P100 modulation for infant faces processing in adults and the relationship between early stimulus detection of infant faces and downstream aberrations in caregivers' neural response to infant faces and/or caregiver function.

Early perceptual processing and pre-attentive face recognition: the N170.

Once visual stimuli have been detected (as indexed by the N/P100), they must be further processed to allow for salience detection, categorization, and higher-order processing. In ERP experiments, after eliciting an initial deflection at the N/P100, face stimuli reliably generate a large negative potential at lateral occipital-temporal electrode sites in the low alpha range (7-8 Hz) (Allison, 1994; Bentin, McCarthy, Perez, Puce, & Allison, 1996; Bötzel, Schulze, & Stodieck, 1995; Rossion & Jacques, 2012). This

negative deflection typically peaks between 130-200 ms post-stimulus and has been termed the N170, as the average peak for this component is approximately 170 ms after stimulus onset (Bentin et al., 1996). Source localization and MRI studies have identified the fusiform and inferior temporal gyri as the most likely neuronal source for the N170 (Young et al., 2016).

Consistent with distributed models of face processing (e.g., Bruce & Young, 1986; Haxby, Hoffman, & Gobbini, 2000), many visual processing researchers regard the N170 ERP component to be a face-specific marker of visual processing that reflects the structural encoding of facial stimuli preceding higher-order processing (e.g., Eimer 2000a, b; Eimer & Holmes, 2007). However, the functional significance of this component remains a matter of on-going controversy and the determinants of N170 modulation continue to be a subject of debate among visual processing experts. Although the N170 is widely described as a ‘face specific’ ERP component because face stimuli have been observed to elicit larger N170 deflections compared to other visual objects (see review by Rossion & Jacques, 2012), some argue that it is more accurate to regard the N170 as ‘face sensitive’ (Eimer, 2011).

One possibility is that the N170 component may be best understood as a marker of structural encoding for general visual expertise, rather than face processing per say—something that was perhaps obscured by the fact that humans have been hardwired by evolution to be experts in face processing. Consistent with this, a seminal study by Diamond and Carey (1985) demonstrated that the ‘inversion effect’ observed in visual recognition experiments is not unique to faces and is also observed for other types of visual stimuli (e.g., dogs); and more recent studies have demonstrated that bird experts

exhibit enhanced N170 responses to birds, dog experts to dogs, fingerprint experts to fingerprints (Tanaka & Curran, 2001; Busey & Vanderkolk, 2005) suggesting that the N170 itself is more “face sensitive” than “face specific.” Further supporting this notion, Rossion and colleagues (2002) recorded N170 responses to upright and inverted faces and novel visual objects (Greebles) before and after two weeks of training with Greebles. They found that expertise training with Greebles led to left-lateralized facelike electrophysiological responses, such that an inversion effect was observed only for experts and primarily in the left hemisphere. These results indicate that the neurobiological mechanisms underpinning human face processing may extend to non-face objects when visual expertise is recruited. Of particular relevance to the current investigation, although human infants appear to be predisposed to orient toward face stimuli, human expertise for face-specific processing appears to become faster and more complex over the course of development (Coch & Gullick, 2012) and is likely to be modulated by experience. As such, the N170 represents a useful index of early visual processing for infant faces (Bornstein, Arterberry, & Mash, 2013) and a potential candidate marker for changes that occur in the parental brain with caregiving-related experience and expertise.

N170 modulation. With regard to the determinants of N170 modulation, early theories suggested that the structural encoding of face stimuli (as indexed by the N170) should not be modulated by emotional expression, familiarity, or non-structural factors. However, a recent meta-analysis conducted by Hinojosa and colleagues (2015) concluded by that, in healthy adult participants, the N170 is modulated by facial expression, such that adult faces expressing fear, anger, and happiness elicit the greatest N170 responses.

Although the neural processing of infant visual cues may be similarly impacted by such modulation, since N170 investigations of infant faces are comparatively new and fMRI experiments indicate infant faces recruit additional neural networks (Feldman, 2015; Kringelbach et al., 2008; Strathearn, Li, Fonagy, & Montague, 2008), it remains largely unknown to what extent and under what conditions N170 modulation differs for infant faces of varying emotional expressions.

In a seminal study, Proverbio and colleagues (2006) used a low-density EEG array to record ERPs during an emotion recognition task to investigate the impact of gender and parental status on neural responses to unfamiliar infant faces, which varied in emotional valence and intensity of expression. In this experiment, N170 amplitude varied significantly by infant facial expression, with distressed (versus content or happy) faces provoking the largest response. While no difference in N170 amplitude was found between non-parents of both genders, N170 amplitude in mothers was significantly larger than N170 amplitude in fathers, suggesting that parental status (and by extension caregiving experience) may modulate the early perceptual encoding of infant faces more strongly in women than in men. Similar results of N170 modulation by infant facial expression have been found in other infant face experiments that utilize emotion categorization paradigms. Perhaps most notably, Rodrigo and colleagues (2011) investigated the neural correlates of infant face processing during an emotion recognition task in a small sample of mothers with substantiated neglect of a child under five years old and compared their responses to control mothers who did not have a documented history of neglecting their child. Compared to the control group, neglectful mothers did not exhibit increased N170 amplitude at temporal recording sites in response to viewing

crying versus laughing and neutral infant facial expressions. These finding suggests that a lack of neural differentiation between emotional conditions at the N170 may index maternal insensitivity to infant facial expressions of distress and that this aberration is associated with infant neglect.

Findings for N170 modulation by infant facial expression in passive viewing paradigms have been more mixed, with some studies finding no differences in N170 amplitude by emotional expression (e.g., Grasso, Moser, Dozier, & Simons, 2009; Noll, Rutherford, & Mayes, 2012). However, where significant differences have been observed, they have been consistent with those of the emotional categorization experiments (i.e., with infant visual expressions of distress elicit the largest N170 amplitude). For example, using a paradigm where mothers observed crying or smiling photos of their own or unfamiliar infant's faces, Doi and Shinohara (2012b) found that the amplitude of the N170 was largest for crying faces irrespective of infant face familiarity. It remains unclear why N170 amplitude varies by infant emotional facial expression in some passive viewing experiments but not others and, moreover, whether such variations are a function of within-subjects variables (e.g., markers of demographic risk).

Taken together, this small but rapidly growing literature suggests that the N170 for infant face stimuli may be modulated by parental status (Proverbio et al., 2006), infant facial expression (Doi & Shinohara, 2012b; Proverbio et al., 2006; Peltoa et al., 2014; Rodrigo et al., 2011; but see Grasso, Moser, Dozier, & Simons, 2009; and Noll et al., 2012), and maternal characteristics such as psychiatric symptomatology (Noll et al., 2012; but see Rutherford et al., 2017), attachment style (Fraedrich, Lakatos, & Spangler,

2010; Leyh, Heinisch, Behringer, Reiner, & Spangler, 2016), and reflective functioning (Rutherford, Maupin, Landi, Potenza, & Mayes, 2017). However, these findings remained mixed and await replication in diverse samples. To date, no such studies have been conducted with caregivers who are at increased risk for disruptions in infant visual cue processing because they are parenting under conditions of economic adversity.

Late salience detection and resource allocation: the P300.

The amplitude of parietally-maximal P300 ERP components (sometimes referred to as P300b or P3b components to differentiate them from their frontally maximal P300a or P3a counterparts) are often used as an index of attention allocation and their latency to peak is often interpreted as the amount of time it takes the brain to accomplish this allocation.

P300 modulation. Despite thousands of P300 experiments that have been published to date, there is still no clear consensus in the field regarding the functional significance of the ‘P3 family’ of ERP components (Luck, 2014). However, the sensitivity of the P300 to changes in task-relevant target probability is well documented (see Polich, 2012 for review). As such, P300 responses are often examined in face processing experiments where some stimuli are shown more frequently than others. For example, in one sample of 16 mothers who were assessed with an odd-ball paradigm, mothers with a secure attachment classification exhibited greater magnitude of the P300 response to unfamiliar infant faces than mothers with an insecure attachment classification (Fraedrich, Lakatos, & Spangler, 2010). In early theoretical work on the P300, Donchin (1981) referred to the processes underpinning P300 modulation as ‘context updating,’ something that is sometimes interpreted to index strategic ‘working

memory updating' (Luck, 2014). In addition to target stimulus probability, the amplitude of the P300 component is modulated by task difficulty and uncertainty—leading some researchers to regard it as a marker of resource allocation (Isreal, Chesney, Wickens, & Conchin, 1980). Notably, Johnson (1984, 1986) postulated that these variables may be used to calculate P300 amplitude according to the formula: $P300 \text{ amplitude} = \text{uncertainty} \times (\text{probability} + \text{resource allocation})$. If this equation is correct, one implication is that if probability and uncertainty are held constant (e.g., in an infant cue processing experiment with no performance demands where all infant face stimuli are presented at the same frequency), the P300 could therefore be utilized as an index of neural resource allocation for processing infant face stimuli.

Consistent with this, emerging evidence suggests that P300 amplitude for infant faces may be modulated by parity. In one recent study, Maupin and colleagues (2018) found that primiparous mothers exhibited larger P300 amplitude for unfamiliar neutral infant faces compared to multiparous mothers. A similar difference by parity was observed for happy faces, however this association did not reach statistical significance. One interpretation of these findings is that first-time mothers need to allocate more neural resources when processing infant visual cues than mothers who have previous caregiving experience. Although the functional significance of such increased allocation remains largely unknown, it is possible that increased resource allocation is associated with neuroendocrine responses that help facilitate mother-infant bonding. Consistent with this hypothesis, Bick and colleagues (2013) found that average P300 amplitude in response to children's faces was associated with foster mothers' oxytocin production in response to a cuddle interaction with their foster child. The P300 may also be modulated by maternal

characteristics documented to co-vary with experiences of adversity, such as mental health symptoms. Like the N170, significant differences between emotional infant faces at the P300 have been associated with individual differences in maternal characteristics during the perinatal period. For example, in one study higher depression symptoms were associated with P300 amplitude for distressed infant faces during pregnancy but not happy or neutral infant faces (Rutherford, Graber, & Mayes, 2016). Taken together, these studies suggest that although the P300 is often used in odd-ball experiments, it may have utility as a neural index of resources allocation for infant cues in face processing paradigms. However, no such studies have been conducted in populations at risk for disruptions in caregiving due to economic adversity and it remains unknown whether the patterns of neural activity for infant faces at the P300 are similar or different in mothers' raising young children under conditions of economic disadvantage.

Literature Review Summary

Taken together, these literatures suggest that mothers' neural responses to unfamiliar infant faces may have utility as biomarkers of caregiving function and may be particularly useful for research that aims to document the neural underpinnings of intuitive parenting behavior and prevention science work that aims to identify intervention targets that will maximally bolster caregivers' intuitive caregiving responses. However, more work is needed to explore the significance of these markers for parental function under conditions of increased risk for disrupted caregiving, such as parenting under conditions of economic adversity. Specifically, both basic science work delineating caregivers' responses to unfamiliar infant faces in this population and translational science work exploring the utility of these biomarkers for prevention programs are

needed. Although research with infant cues of different sensory modalities (visual, auditory) and levels of familiarity (unfamiliar, familiar) are needed, this study focuses on mothers' neural responses to unfamiliar infant faces. This is the first study of its kind with caregivers raising young children under conditions of economic adversity and, as such, this focus allows for the greatest number of comparisons to the extant literature, which is currently largest for unfamiliar infant faces.

The Current Study

Study Aims and Hypotheses

The overarching goal of this study is to characterize the temporal dynamics of low-income mothers' neural responses to unfamiliar infant faces and to assess whether these responses are sensitive to change with a brief video-coaching intervention that reinforces caregiver's attention to infant visual cues. To achieve these goals, data from two phases of research conducted by my collaborators and I in the UO Stress Neurobiology and Prevention Laboratory were utilized (see Figure 3). The specific aims and hypotheses of this project are as follows:

Aim 1: The first aim of this study is to delineate low-income mothers' neural responses to unfamiliar infant faces in three conditions (happy, neutral, and distressed facial expressions) under passive viewing conditions. Specifically, I aim to characterize three ERP components known to have significance for maternal function: the P100, N170, and P300. A combined sample from Study 1 and Study 2 will be utilized to test the following hypotheses:

Hypothesis 1a: P100 amplitude and latency. Consistent with the results of previous active and passive viewing experiments utilizing emotional infant faces (e.g.,

Proverbio et al., 2006; Noll et al., 2012) in other low-risk adults, I predict that P100 amplitude and latency will not vary by infant emotional expression. Although previous work documents strong lateralization for unfamiliar faces in heterogeneous samples of adult women, bilateral activation at the P100 has been observed in mothers (Proverbio et al., 2006). As such, I hypothesize that no main within-subjects effect for hemisphere will be observed in this sample of mothers.

Hypothesis 1b: N170 amplitude and latency. Given the importance of rapid detection of infant distress for survival and previous work documenting significant differences in N170 response to infant faces by emotional condition (e.g., Doi & Shinohara, 2012b; Colasante, Mossad, Dudek, & Haley, 2017), I predict N170 amplitudes will be largest and N170 latencies will be fastest for distressed infant faces (compared to neutral and happy infant faces) in low-income mothers of young children. Additionally, since neural responses to emotional infant faces in right-handed participants are significantly larger in the right versus left hemisphere (Colasante, Mossad, Dudek, & Haley, 2017; Proverbio et al., 2006; Noll et al., 2012), I also predict that this main effect for hemisphere will replicate in low-income mothers.

Hypothesis 1c: P300 amplitude and latency. Since no consensus yet exists about the functional significance of the P300 ERP component (Luck, 2014) and the infant face passive viewing paradigm used in this project was designed to hold the probability of each infant emotional expression (happy, neutral, distressed) constant, I predict that the amplitude of the P300 will differ significantly by condition in a manner that reflects the differential neural resources allocated to process each type of facial expression. Specifically, since neutral faces are theoretically the most difficult to decode and

arguably require additional neural resources to categorize, I predict neutral infant facial expressions will elicit significantly greater P300 amplitudes than distressed or happy facial expressions.

Aim 2: The second aim of this study is to examine the relationship between low-income mothers' neural response to unfamiliar infant faces, aspects of maternal experience known to co-vary with caregiving quality, and observed caregiving behavior. As in Aim 1, a combined sample from Study 1 and Study 2 will be utilized to test the following hypotheses:

Hypothesis 2a: Distal risk factors. Although exposure to childhood maltreatment and adversity has been identified as a risk factor for poor caregiving quality via its impact on adversity-related maternal characteristics (reduced mental health, difficulties with emotion regulation, low parental reflective functioning, greater parenting stress, reduced parenting self-efficacy, and reduced parenting reward), marked heterogeneity exists and, hence, I do not expect mothers' history of childhood adversity itself will be directly associated with neural responses to infant cues at any stage of infant face processing.

Hypothesis 2b: Maternal Characteristics. Previous work has documented associations between mothers' adversity-related individual characteristics and ERPs for unfamiliar infant faces. However, no research has examined such associations in mothers raising young children under conditions of economic adversity. As such, I do not have strong a priori predictions about which maternal self-report variables will be most strongly associated with ERPs for unfamiliar infant faces in this population. Since this is the first ERP study of its kind to examine these associations in low-income mothers, this work is exploratory in nature and results will be interpreted with caution.

Hypothesis 2c: Observed behavior. Little work has examined direct associations between the temporal dynamics of neural reactivity to unfamiliar infant faces and observed caregiving behavior and no work has examined these relationships in mothers raising young children under conditions of economic adversity. However, since allocating attention for infant stimuli is theoretically necessary for the coordination of complex caregiving behavior, I predict that the magnitude of neural responses to emotional infant faces at the P300 will be associated with the quality of caregiving behavior, whereas early perceptual processing components (P100 and N170 responses) will not.

Hypothesis 2d: Mediation by ERPs. Since mothers' neural responses to infant faces are theorized to be a mediating mechanism by which individual differences in mothers' adversity-related characteristics are linked to observable parenting behavior, I predict that any ERPs that are correlated with mothers' parenting (in Hypothesis 2c) will demonstrate mediating (indirect) effects on the relationship between self-reported maternal characteristics and behavior, after controlling for any demographic variables and distal risk factors (i.e., history of early childhood abuse or neglect, life-time exposure to potentially traumatic events, and experiences of betrayal trauma) that are themselves associated with parenting quality.

Aim 3: The third aim of this study is to assess whether low-income mothers' neural responses to unfamiliar infant faces are sensitive to change via the Filming Interactions to Nurture Development (FIND) video-coaching program. To accomplish this aim, I will use data collected from the FIND Community pilot study (Study 2), a small randomized-controlled trial designed to assess the impact of FIND on

low-income mothers and identify underlying neurocognitive mechanisms that mediate intervention-related change.

Hypothesis 3: Change with Intervention. Consistent with preliminary evidence documenting changes in neural reactivity to children's faces after participating in a strength-based video-feedback program (Bernard et al., 2015) and the FIND 'theory of change' (Fisher et al., 2016), which emphasizes both the strength-based nature of FIND and its behavioral reinforcement of mothers' attention to infant facial expressions, I hypothesize that FIND will increase both the magnitude and speed of mothers' neural responses to unfamiliar infant faces. Specifically, I predict that FIND will increase mothers' selective attention for infant faces across conditions and that both the magnitude and speed of mothers' neural responses at the P100 (when averaged across conditions since no differentiation by emotion is expected) will increase in FIND intervention group. Since attenuation effects due to the repeated administration of the same paradigm with the same stimuli are expected, it is not unlikely that this will look like a smaller reduction in amplitude between the pre- and post-assessment waves in the FIND group compared to the Waitlist Control group. Likewise, I predict that FIND will increase the magnitude of the face-sensitive N170 and later P300 ERP components for all three infant emotional expressions (happy, neutral, distressed) and that these effects will be largest and fastest for distressed infant faces at the N170 (due to an increase in top-down feedback that increases reward value of infant faces that active both approach and withdrawal circuitry) and largest and fastest for happy infant faces at the P300 (since FIND behaviorally reinforces attention allocation for child serves, which are often paired with expressions of happiness).

Figure 3. Data Collection Timeline and Analytic Strategy

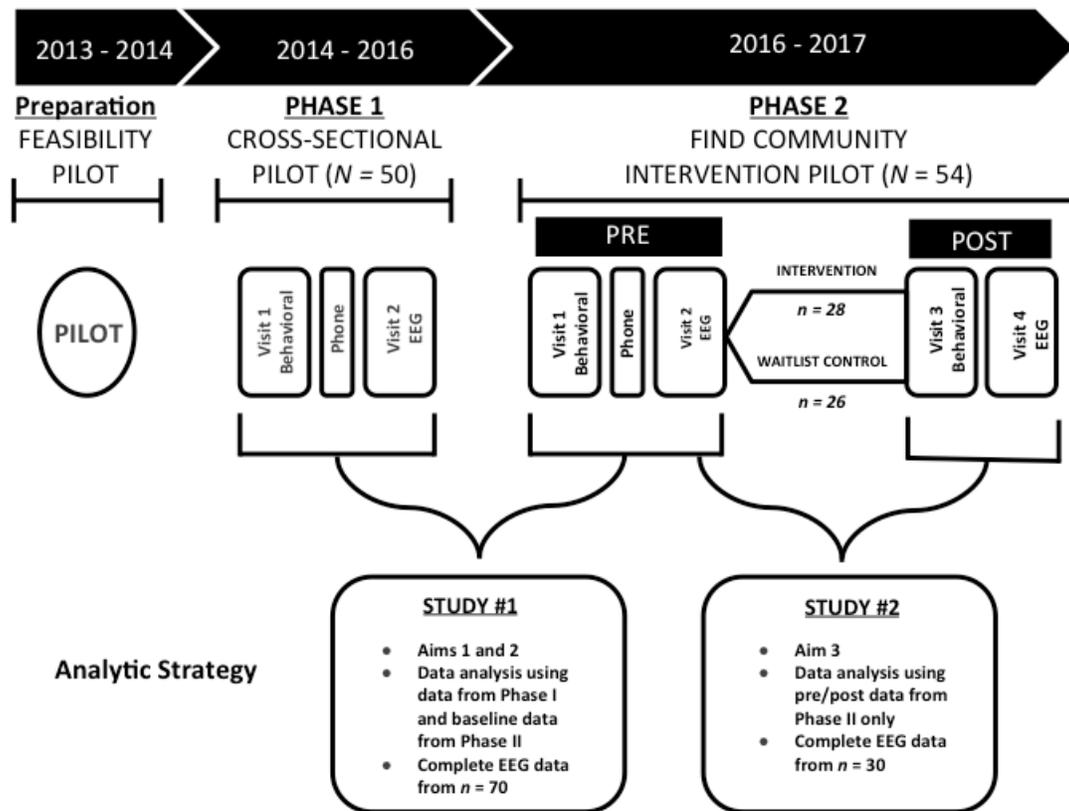


Figure 3. Data collection timeline and analytic strategy for dissertation Studies 1 and 2. Data for Study 1 represents a combined sample drawn from the Promoting Actions to Nurture Developmental Advancement (PANDA) cross-sectional pilot and baseline data from the FIND Community Intervention Pilot. Data for Study 2 was drawn from the FIND Community Intervention Pilot only.

Chapter One Summary

In this chapter, literatures from evolutionary theories of parental function, observational studies of parenting behavior, and the neuroscience of intuitive parenting were reviewed with an emphasis on the implications for interventions designed to support families at increased risk for disruptions in parental function. The rationale for this dissertation study, specific aims, and hypotheses were presented alongside an overview of the analytic strategy for utilizing data collected over two phases of research with the

population of interest (mothers' raising young children under conditions of economic adversity). In the next Chapter, the method and results of Study 1 are presented. The purpose of this study is to delineate low-income mothers' neural responses to unfamiliar infant faces in three conditions (happy, neutral, and distressed facial expressions) under passive viewing conditions (Aim 1); and to examine the relationship between low-income mothers' neural responses to unfamiliar infant faces, aspects of maternal experience known to co-vary with caregiving quality, and observed caregiving behavior (Aim 2).

CHAPTER II

STUDY 1

Method

Participants

Mothers ($N = 70$) with young children (ages 0-4 years old) were recruited to participate in research aiming to characterize the correlates of parental function in mothers raising young children under conditions of economic adversity. The current sample represents data drawn from The Promoting Actions that Nurture Developmental Advancement (PANDA) correlational study and baseline data from the FIND Community Pilot Project, a small randomized controlled trial (see Figure 3 for analytic strategy). All participants were recruited from the Eugene / Springfield area via fliers posted on public notice boards, community organizations that serve low-income families (e.g., Women, Infants, and Children (WIC); relief nurseries, and mental health service providers); free electronic notice boards (e.g., Craigslist); and targeted advertising on social media (Facebook, Instagram). Mothers were eligible to participate if they were 18 years old or older, English speaking at an eighth grade reading level, reported a household income that would qualify them for low-income community services (i.e., free or reduced school lunch)³, and had at least one biological child within the target age range. Women were excluded from participating if they were left-handed, had a history

³ The income cut-off for the two samples differed slightly. The cut-off for the PANDA study was calculated by the Federal Poverty Guidelines (see Appendix A), whereas the cut-off for the FIND Community study was raised partway through data collection to the income cut-off for free and reduced school lunch in Lane County. As such, income was examined as a demographic variable of interest in subsequent analyses.

of epilepsy or seizures, had an open head wound or head lice, reported current involvement with child protective services (CPS), had previously participated in a parenting program funded by the study sponsor, were uncomfortable being separated from their child for 15 minutes, reported a history of drug or alcohol addiction, or reported that they or their child had a physical or medical condition that would make it uncomfortable to complete the research visits.

At the time of their first research visit, participating mothers ranged in age from 19 to 47 years ($M = 29.37$, $SD = 6.37$). These women were ethnically representative of the urban area in which they resided (82.9% Euro-American/White/Caucasian; 2.9% Hispanic or Latino; 2.9% Asian American; and 10.0% Mixed Race). One participant did not report her ethnicity. Approximately a quarter of the sample (25.7%) reported an annual household income of < \$10,000, 10.0% \$10,000 - 14,999; 11.4% \$15,000 - 19,999; 20.0% \$20,000 – 24,999; 14.3% \$25,000 – 29,000; 8.6% \$30,000 – 39,000; 5.7% \$40,000 – 49,000; and 2.9% \$50,000 – 59,000. Approximately one-third of mothers (31.5%) had a bachelor's degree or higher, while 27.1% attended some college or had an associate's degree, 34.3% had a high school diploma or GED, and 7.1% did not graduate from high school. Most reported that they were either married (42.9%) or not married but currently living together with a partner (25.7%). Of the remaining women, 8.6% were divorced, 7.1% separated, and 15.7% reported that they were never married. Just over half of participants in this sample were first-time mothers (54.3%), whereas 28.6% had two children, 11.4% had three children, and 5.7% had four children. For this study, the mother's youngest biological child was regarded as the target study child. Target study

children in this sample were 50% female and ranged in age between 1.75 and 42.00 months ($M = 22.88$, $SD = 10.34$).

Procedure

All procedures used in this study were approved and monitored by the university's Office for the Protection of Human Subjects and written informed consent was obtained from all participants at the beginning of their first study visit (see Appendices A and B for consent documents from the PANDA and FIND studies, respectively). Prior to enrollment, interested women were screened by phone to determine their eligibility for the study, after which they were scheduled for an initial visit to the laboratory. Assessment activities in this study were divided between three time points, which were scheduled over the course of approximately one week: the mother and target child's initial visit to the lab (Visit 1), a phone interview, and an EEG visit with the mother only (Visit 2). Participants were compensated a total of \$100 for completing all study activities, which included money to offset the cost of childcare during study activities where the target child could not be present. Study children were also given a small stuffed animal toy during Visit 1.

Visit 1: Behavioral data collection (mother and target child).

During their first visit to the lab, mothers completed informed consent and were briefly oriented to the lab space before beginning assessment activities with the target study child. Assessment activities for this visit included self-report questionnaires administered on a desktop computer via Qualtrics (a web-based survey program) and a filmed parent-child interaction task. Additional measures relevant to other study aims

were also collected during this visit and are not reported here. This visit was approximately two hours in length.

Phone interview (mother only).

Within one week of completing Visit 1, mothers completed a phone interview approximately 30-60 minutes in length. During this interview mothers were asked about their experiences of lifetime history of psychosocial adversity, daily parenting stress, and handedness. Only data obtained from selected phone interview measures relevant to the study aims are presented here.

Visit 2: EEG data collection (mother only).

During their second visit to the lab, mothers were oriented to the EEG equipment and fitted for the dense-array EEG net. A research assistant explained the experimental procedures and seated each of 256 electrodes and checked electrode impedances. Mothers then completed six tasks in a set order that did not vary across participants: a resting state task, a passive viewing task with infant faces, an active viewing task with infant and adult faces, a go/no-go task, a flanker task, and a dimensional card sort task. Only procedures and analyses from the passive viewing task with infant faces are reported here. The length of this visit ranged from 1-2 hours, varying with the length of electrode seating. Participants completed a brief study debriefing at the end of their EEG visit.

Self-Report Measures

Handedness. Mothers' handedness was evaluated with the Edinburgh Handedness Inventory (Oldfield, 1971), a 10-item self-report measure that asks respondents to indicate their hand preference for a series of common tasks (e.g., writing, opening a box lid, and using utensils) by placing one or two check marks next to the

activity under “right” or “left” depending on the strength of their preference. Respondents who do not have a preference or whose hand preference for the activity is equal for the activity are instructed to place one check mark in both columns. Where an activity requires two hands (e.g., using a broom), the part of the task or object for which hand preference is wanted is indicated in parentheses. The total number of check marks in each column is summed and both a cumulative total and difference score between right and left hand preference are calculated. A handedness score is computed by dividing the difference score by the cumulative total such that resultant scores < -40 indicate the individual is left-handed, scores between -40 and $+40$ indicate they are ambidextrous, and scores $> +40$ indicate they are right handed. In this sample, resultant scores ranged from 63.64 - 100.00 ($M = 95.40$, $SD = 9.32$), indicating that 100% of individuals were right-handed.

Distal risk factors: Mothers’ lifetime history of psychosocial adversity.

Adverse childhood experiences. Mothers’ experiences of adversity before the age of 18 were measured with a 10-item version of the Adverse Childhood Experiences Survey (ACES; Felitti et al., 1998). This survey consists of 10 yes or no questions regarding adverse events during childhood including parental separation, parental substance use, experiences of abuse and neglect, and exposure to violence. Scores in this sample ranged from 0 to 10 ($M = 3.83$, $SD = 2.76$). Scores on this measure were normally distributed.

Childhood neglect. Mothers’ childhood experiences of neglect were assessed with the 25-item Dubowitz Neglect Scale (DNS; Dubowitz et al., 2011), which asks participants to indicate what it was like when they were living with their primary

caregivers in elementary school. For each question, respondents are asked to indicate how often their caregivers engaged in various caregiving behaviors (e.g., “Made sure you bathed regularly,” “Gave you enough to eat,” “Comforted you if you were upset”) on a 4-point scale ranging from “0” (never) to “3” (a lot). All items (except two reverse-keyed items) were reverse scored; total scores on this measure range can range from 0 to 75, with higher scores indicating more frequent neglect. Scores in this sample ranged from 0 to 48 ($M = 11.46$, $SD = 11.21$). The DNS’s internal reliability in this sample was excellent ($\alpha = .94$) and scores on this measure were normally distributed.

Betrayal trauma. Experiences of betrayal trauma were assessed with the Brief Betrayal Trauma Survey (BBTS; Goldberg & Freyd, 2006), a 14-item self-report survey of potentially traumatic childhood and adult experiences that range from low to high in betrayal. Betrayal increases as the relational closeness of the victim’s relationship with the perpetrator increases; for example, physical assault perpetrated by a domestic partner would be a higher-betrayal event than physical assault perpetrated by a neighbor or stranger. Medium and high betrayal events endorsed were summed to create a betrayal trauma count, which did not take into account the total frequency of events within type. Betrayal trauma count scores in this sample ranged from 0 to 10 ($M = 2.54$, $SD = 2.29$). Internal reliability of betrayal trauma count in this sample was good ($\alpha = .89$) and scores for betrayal trauma count were normally distributed.

Lifetime exposure to potentially traumatic events. Mothers’ lifetime exposure to traumatic events was assessed with the 17-item Life Events Checklist for the DSM-5 (LEC-5; Weathers et al., 2013a), a self-report measure designed to assess exposure to 16 types of events (e.g., sexual assault, combat or exposure to a war-zone) that can result in

PTSD or extraordinary stress and any other very stressful event or experience they may have experienced. For each type of event, respondents are asked to indicate whether: (a) it happened to you personally; (b) you witnessed it happen to someone else; (c) you learned about it happening to a close family member or close friend; (d) you were exposed to it as part of your job (for example, paramedic, police, military, or other first responder); (e) you're not sure if it fits; or (f) it doesn't apply to you. This measure was administered during the phone interview and at the end, mothers were asked to indicate which event was the most traumatic for them. In this study, items were summed to create three subscale scores: number of events witnessed (range = 1 - 9, $M = 2.76$, $SD = 1.83$); number of events directly experienced (range = 1 - 9, $M = 3.03$, $SD = 2.01$); and number of events learned about (range = 1 - 14, $M = 5.19$, $SD = 3.27$). Internal reliability of items on the LEC in this sample was acceptable ($\alpha = .71$) and scores on each subscale were normally distributed.

Adversity-related maternal characteristics shown in previous research to predict parenting quality.

Mentalization. The 38-item Parental Reflective Function Questionnaire, Version 1 (PRFQ-1; Luyten et al. 2009) was used to assess mothers' current ability to mentalize (i.e., hold their child's mind in mind) in the context of parenting. Mothers indicated their agreement for each item (e.g., "My child can react to a situation very differently than I think he or she will") on a scale of "1" (strongly disagree) to "7" (strongly agree). In this study, two of the PRFQ-1 subscales were utilized: (1) the High-Low scale, with higher scores on these items reflecting higher levels of parental mentalization; and (2) the Low-High scale, with lower scores on these items reflecting higher levels of parental mentalization. Subscale scores on the High-Low scale in the current sample ranged 4.18

– 6.41 ($M = 5.49$, $SD = .57$); and scores on the Low-High scale ranged 1.00 – 3.29 ($M = 2.09$, $SD = .50$). Internal reliability on these subscales was acceptable ($\alpha = .70 - .71$) and data on both subscales were normally distributed.

Emotion regulation difficulties. The 36-item Difficulties in Emotion Regulation Scale (DERS; Gratz & Roemer, 2004) was used to assess the frequency of mothers' current symptoms of emotional dysregulation (e.g., "When I'm upset, I have difficulty controlling my behaviors"), ranging from "1" (almost never / 0-10% of the time) to "5" (almost always / 91-100% of the time). Total scores on this measure can range from 36-180, with higher scores indicating higher levels of emotional dysregulation. Total scores in the current sample ranged 36 - 130 ($M = 69.61$, $SD = 22.77$), indicating that on average participants did not endorse clinical levels of emotion dysregulation.

Participants endorsed difficulties on all 6 subscales, which include non-acceptance of emotional responses (range 6 - 28, $M = 11.74$, $SD = 5.60$), difficulty engaging in goal-directed behavior (range 5 - 24, $M = 12.19$, $SD = 5.02$), impulse control difficulties (range 6 - 20, $M = 9.11$, $SD = 3.53$), lack of emotional awareness (range 6 - 28, $M = 12.91$, $SD = 5.35$), limited access to emotional regulation strategies (range 8 - 31, $M = 14.06$, $SD = 5.67$), and lack of emotional clarity (range 5 - 22, $M = 9.60$, $SD = 3.57$). The DERS' internal reliability in this sample for the total score was excellent ($\alpha = .93$) and subscale scores ranged from acceptable to good ($\alpha = .74 - .89$). DERS data in this sample were normally distributed.

Post-traumatic stress disorder (PTSD) symptoms. Mothers' symptoms of PTSD were assessed with the 20-item PTSD checklist for the DSM-5 (PCL-5; Weathers et al., 2013b). The PCL has been used in previous research with mothers' of young children

(Brand, Engel, Canfield, & Yehuda, 2006). For each PTSD symptom, respondents are asked to indicate how much they have been bothered in the last month ranging from “0” (not at all) to “4” (extremely). Total symptom severity scores on the PCL-5 can range from 0 to 80, with higher scores indicating greater symptom severity. Total scores in this sample ranged from 0 to 47 ($M = 13.58$, $SD = 11.98$). According to scoring guidelines from the National Center for PTSD website (www.ptsd.va.gov), a provisional PTSD diagnosis can be made by counting each item rated as moderately (2) or higher as a symptom endorsed, then following the DSM-5 diagnostic rule which requires the following number of items endorsed per criteria domain: 1 B item (questions 1-5), 1 C item (questions 6-7), 2 D items (questions 8-14), 2 E items (questions 15-20). According to these guidelines, of the 64 mothers’ who completed the PCL-5 in this sample, 9 (12.9%) met criteria for a PTSD diagnosis. The PCL-5’s internal reliability in this sample was excellent ($\alpha = .91$) and data were normally distributed.

Depression symptoms. The 21-item Beck Depression Inventory, Second Edition (BDI-II; Beck, Steer, & Brown, 1996) was used to assess how much various symptoms of depression bothered mothers’ during the past two weeks, ranging from “0” (an absence of the symptom) to “3” (symptom present in a severe form). Scores in the current sample ranged from 0 – 34 ($M = 11.20$, $SD = 8.39$), with the majority of mothers (84.3%) reporting minimal (scores 0 - 13) to mild (scores 14 - 19) levels of depression and a minority (15.7%) reporting moderate (scores 20 - 28) to severe (scores > 29) depression symptoms. The BDI-II’s internal reliability in this sample was good ($\alpha = .89$) and data were normally distributed.

Anxiety symptoms. The 21-item Beck Anxiety Inventory (BAI; Beck, Epstein,

Brown, & Steer, 1988) was used to assess how much various experiences of anxiety bothered mothers during the past week, ranging from “1” (mildly, it did not bother me much) to “3” (severely, I could barely stand it). Scores in the current sample ranged from 0 - 38 ($M = 12.79$, $SD = 9.04$), with the majority of mothers (84.3%) reporting low levels of anxiety (scores 0 - 21), 12.8% reporting moderate levels (scores 22 - 35), and 2.9% reporting severe levels (scores > 36). The BAI’s internal reliability in this sample was excellent ($\alpha = .91$) and data were normally distributed.

Parenting stress. Mothers’ experience of parenting stress was assessed using the 36-item Parenting Stress Index, Fourth Edition Short Form (PSI-IV-SF; Abidin, 1990). Sample items on this measure include “I feel trapped by my responsibilities as a parent” and “My child rarely does things for me that make me feel good,” each of which respondents evaluate on a 5-point agreement scale ranging from “1” (strongly agree) to “5” (strongly disagree), which are recoded and summed to calculate scores on three subscales (parental distress, parent-child dysfunctional interaction, and difficult child) and a total score, with higher scores indicating greater levels of parenting stress. Parental distress subscale scores in this sample ranged 12 - 49 ($M = 29.13$, $SD = 8.16$); parent-child dysfunctional interaction subscale scores ranged 14 - 30 ($M = 21.17$, $SD = 4.57$); and difficult child subscale scores ranged 16 - 47 ($M = 28.46$, $SD = 7.10$). Total PSI-IV-SF scores in this sample ranged 46 - 116 ($M = 79.76$, $SD = 16.25$). The PSI-IV-SF’s internal reliability for total scores in this sample was good ($\alpha = .89$) and data were normally distributed.

Parenting self-efficacy. Mothers’ parenting self-efficacy was assessed using a modified 18-item version of the Parenting Sense of Competence self-report

questionnaire (PSOC; Johnston & Mash, 1989). Total PSOC scores in this sample ranged 38 - 72 ($M = 53.67$, $SD = 7.64$). The PSOC's internal reliability in this sample was good ($\alpha = .89$) and data were normally distributed.

Parenting reward. Mothers' experience of parenting reward was assessed using the 14-item Parenting Reward Questionnaire (PRQ; Delker, 2017). Items were selected to index the *liking*, *wanting*, and *learning* components of parenting reward and include items such as "I am delighted by my child" and "I want to be with my child when we are apart," each of which are assessed on a 5-point responses scale ranging from "0" (never) to "4" (always). Items are summed to create a total parenting reward score, ranging from 0 - 56, with higher scores indicating greater parenting reward. Scores in this sample ranged 31 - 56 ($M = 51.40$, $SD = 4.78$), indicated on average mothers in this study endorsed high levels of parenting reward. The PRQ's internal reliability in this sample was good ($\alpha = .89$) and data were normally distributed.

Parenting quality.

Observed supportive parenting behaviors were coded from videotaped parent-child interaction during a 10-minute free play task that included a three-minute clean up period. During this task, mothers were provided with a standardized selection of age-appropriate toys and were instructed to play with the child as they normally would. To quantify the presence of developmentally supportive caregiving behavior in this sample, videotapes were rated by a team of non-expert student raters who were trained to the research team. Ten videotapes (14.28%) were unable to be rated due to problems with the video recording (no sound, corrupted file, or child out of frame).

Developmentally supportive parenting behavior. The Parenting Interactions with

Children: Checklist of Observations Linked to Outcomes (PICCOLO; Roggman, Cook, Innocenti, Norman & Christiansen, 2013) coding system was used to quantify the presence of affection, responsiveness, encouragement, and teaching exhibited by caregivers during mother-child free play interaction. The PICCOLO system was developed and validated using film from the Early Head Start Research and Evaluation Project and is both psychometrically sound and practical for use with caregivers of very young children (Roggman et al., 2013). For each domain, 7-8 parenting behaviors are rated on a 3-point scale ranging from “0” (*absent*) to “2” (*clearly present*). Items were summed to create subscale scores: affection (range = 7 – 14, $M = 10.83$, $SD = 1.99$); responsiveness (range = 5 – 14, $M = 10.75$, $SD = 2.64$); encouragement (range = 4 – 14, $M = 10.68$, $SD = 2.39$); and teaching (range = 0 – 14, $M = 7.61$, $SD = 3.46$). All items were summed to create a total score: range = 19 – 56, $M = 39.86$, $SD = 7.69$. In this sample, this measure has adequate internal reliability ($\alpha = .77$) and all subscales were normally distributed. Thirty-five percent of films were doubled coded and interrater reliability was assessed using a two-way mixed, consistency, average-measures interclass correlation (McGraw & Wong, 1996; Hallgren, 2012) to quantify the degree to which coders provided consistency in their ratings across participants. The resulting ICC for each subscale were in the good to excellent range, $ICCs = .60 - .92$, and the ICC for PICCOLO scores across all items was excellent, $ICC = .82$ (Cicchetti, 1994).

High Dense Array EEG Apparatus

A HydroCel GSN 256.10 dense array EEG net (Electrical Geodesics, Inc.; Eugene, OR) was placed on the participant’s head and fitted according to manufacturer specifications. All electrodes were spaced evenly and symmetrically to cover the scalp

from nasion toinion and from left to right ear. Impedances were kept below 40 k Ω .

Continuous EEG were amplified (1000x) using EGI's Net Amp 300 and recorded with a sampling rate of 500 Hz, using NetStation 5.2.1 (Electrical Geodesics, Inc., 2013-2014).

Electrodes were referenced to Cz during EEG recording.

Unfamiliar Infant Face Stimuli

Infant face stimuli were provided by Drs. Linda Mayes and Helena Rutherford at the Yale Child Study Center (NIH grant # R01 DA026437) and were presented to participants on an Intel Core I3 Dell Optiplex 7010 computer controlling a 50 x 30 cm color monitor (60 Hz, 1920 x 1080 resolution) and running E-Prime 2.0.8.90 software (Psychology Software Tools, Pittsburgh, PA). Images were viewed at a distance of 63.5 cm in a sound-attenuated room with low ambient illumination. Infant face stimuli consisted of 75 high-resolution, grayscale digital images sized 15.9 cm (14.27 degrees) wide and 11.2 cm (10.08 degrees) tall of 25 unique infant faces, each expressing one of three emotions: happiness, neutrality (comfort), or distress (25 for each emotion). All images were cropped with a standardized oval shaped matt (such that only the infant's face was visible), equiluminant, and displayed on a black background. Representative examples of these images are shown in Figure 4. Each face was clearly in the foreground of its image, and rotated no more than 45 degrees from the frontal or inclined position. All images were evaluated by a panel of experts and standardized for facial expression. The measured visual offset of the stimuli was 13 ms.

Figure 4. Examples of Infant Face Stimuli

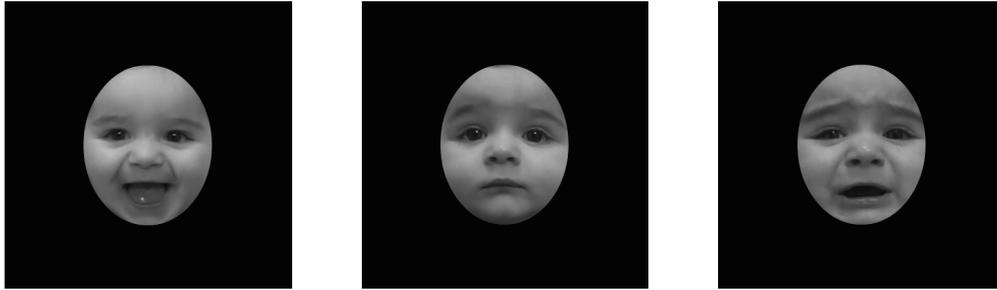


Figure 4. Example infant face stimuli from each of three conditions: happy (left), neutral (middle), and distressed (right). All infant face stimuli were cropped using a standardized oval and presented in greyscale on a black background. Proportions of infant face to background shown here are to scale as they were presented to participants.

Passive Viewing Paradigm for Unfamiliar Infant Faces

EEG data were recorded continuously throughout each trial. At the beginning of each trial, a central fixation cross was presented for 2000 ms followed by a 500 ms solid black screen. A randomly selected infant face was then presented for 240 ms, followed by another solid black screen inter-trial interval (ITI), which randomly varied 1260-1460 ms in duration. This paradigm is illustrated in Figure 5. The presentation time for infant face stimuli was chosen to be long enough to allow conscious awareness of visual face stimuli to emerge (Genetti, Khateb, Heinzer, Michel, & Penga, 2008) but short enough to prevent participants from scanning the faces for additional information via eye saccades. There were 75 trials in total and the procedure took approximately 5 minutes to complete.

Figure 5. Infant Face Passive Viewing Paradigm

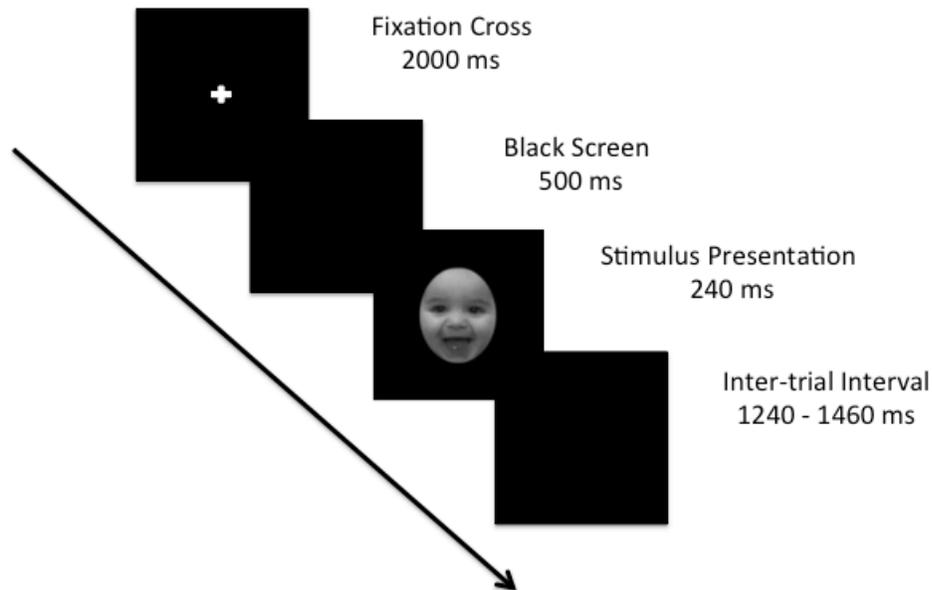


Figure 5. Passive viewing ERP paradigm for unfamiliar infant faces.

EEG Data Pre-processing

EEG data were pre-processed and prepared for statistical analysis using NetStation Version 5.1.2. Files were individually corrected to account for an additional 18 ms offset using a digital anti-alias filter alignment tool provided by EGI. Prior to segmentation, each file was digitally filtered with a .1 - 30 Hz band pass filter to reduce environmental noise artifacts. EEG signal was segmented into epochs of one second, beginning 100 ms before and ending 900 ms after each stimulus onset. NetStation artifact detection was set to 200 μ V for bad channels, 140 μ V for eye blinks, and 55 μ V for eye movements.

Channels with more than 20% of bad segments were marked as bad channels and replaced through spline interpolation. Segments that contained eye blinks or eye movements and those with more than 10 bad channels were marked as bad and excluded from analyses. Following artifact detection and bad channel replacement, data were transformed to correct for baseline shifts and re-referenced to the average reference of all electrodes. All participants included in this study had at least 40% artifact-free trials ($M = 75.85\%$, $SD = 17.30$, equating to an average of 18.96 trials per condition).

ERP Electrode Selection

Electrodes of interest for the P100/N170 were selected by maximal observed N170 amplitude for unfamiliar infant faces. These conformed to those used in previous high-dense array EEG parenting research (Malak et al., 2015; Noll et al., 2012; Rutherford et al., 2017) and the scalp regions characteristically eliciting the N170 (Bentin et al., 1996; Eimer, 2000). These overlapped with the 10/20 electrode sites T5 and T6 used in low-dense array face processing studies. ERP data for the P100 and N170 components were averaged across eight electrodes over the left lateral posterior scalp (96, 97, 106, 107, 114, 115, 122, 123) and eight electrodes over the right lateral posterior scalp (158, 159, 160, 161, 167, 168, 169, 170). Consistent with previous parenting research (Grasso et al., 2009; Proverbio et al., 2006; Rutherford et al., 2017), the eight electrodes selected for the parietally-maximal P300 (100, 101, 110, 118, 119, 127, 128, 129) were clustered around Pz. The positions of the electrode montages for the P100/N170 and P300 are shown in Figure 6.

Figure 6. EEG Sensor Layout for the HydroCel GSN 256.10 Dense Array Net

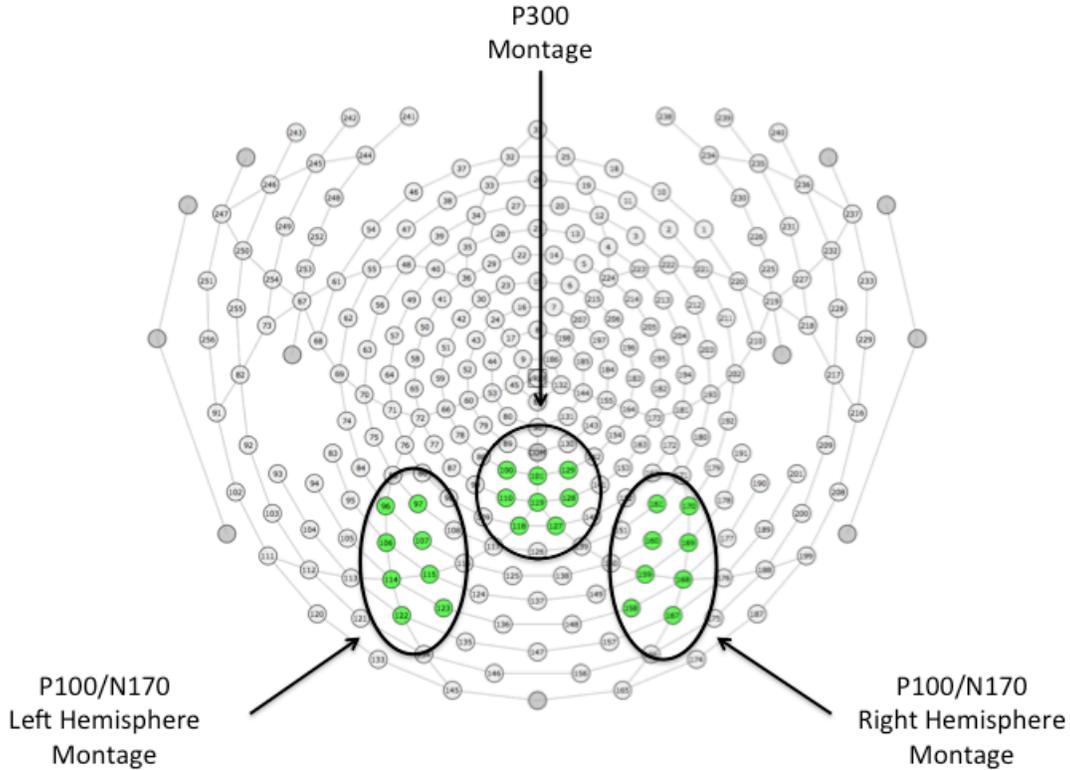


Figure 6. Sensor layout for the HydroCel GSN 256.10 dense array EEG net (Electrical Geodesics, Inc.; Eugene, OR). Electrodes used in the analysis of P100, N170, and P300 ERP components are highlighted in green.

Statistical Extraction of ERP Components

The time windows for analysis of the P100, N170, and P300 components were chosen by visual inspection of the grand averaged data and with reference to the extant ERP parenting literature. The resultant time windows for the P100 (67 - 123 ms post-stimulus onset), N170 (125 - 183 ms post-stimulus onset), and P300 (200 - 600 ms post-stimulus onset) were examined for each participant to confirm that the components of interest were captured at each electrode for each subject and overlapped with the time windows utilized in previous parenting research. Mean peak amplitude and latency-to-

peak measures were averaged across each electrode group within the specified time window and were statistically extracted for each participant. Following statistical extraction, ERP amplitude and latency measures were exported to SPSS (Version 24.0) for further analysis and to ERP PCA Toolkit (Version 2.66) for waveform visualization.

Analytic Plan

All variables of interest were examined for normality and outliers greater than three standard deviations above or below the mean for all participants were identified and excluded from parametric tests. To address Aim 1, separate repeated-measures analysis of variance (ANOVAs) were utilized to assess modulation of the P100, N170, and P300 by infant emotional expression. For the P100 and N170, the within-subjects factors were infant emotional expression (happy, neutral, distressed) and hemisphere (left, right). For the P300, the within-subjects factor was infant emotional expression (happy, neutral, distressed). Where indicated, post-hoc tests were conducted to further delineate maternal neural responses to unfamiliar infant facial expressions. Mothers' age (years) and the target child age (months) were entered into each model as covariates, as these demographic variables were correlated with some ERP measures in this sample; and parity (primiparous, multiparous) was entered as a between-subjects factor. No other demographic variables were associated with the ERP variables of interest and, as such, were not included in the ANOVAs. Although subsample (PANDA, FIND Community) was not hypothesized to impact the variables of interest, all models were re-run with project group as a between-subjects factor to confirm that any between group differences were not driving observed within-subjects ERP effects. Alpha levels were set at $p < .05$ and effect sizes are presented as partial eta-squared (η^2_{partial}), where .01 represents a small

effect size, .06 represents a medium effect size, and .14 represents a large effect size (Cohen, 1988). Where sphericity assumptions were violated, Greenhouse-Geisser (epsilon, $\epsilon < .75$) and Huynh-Feld corrections (epsilon, $\epsilon > .75$) were utilized. Bonferroni corrections were used to adjust for multiple comparisons in post-hoc tests.

To address Aim 2, exploratory partial correlations between the amplitudes and latencies of each ERP component (P100, N170, and P300), mothers' history of psychosocial adversity, variables shown in previous research to predict parenting quality (i.e., mental health symptoms, difficulties with emotion regulation, parental reflective function, and experience of parenting), and observed parenting behavior during free play were all examined with demographic variables identified as correlating with ERP measures in Aim 1 included as covariates. ERP variables with robust associations with both maternal characteristics and observed parenting were selected for further examination. Where indicated, mediation analyses were conducted via SPSS PROCESS (Version 3.0; Hayes, 2018), a macro for SPSS designed to test direct and indirect pathways in mediation, moderation, and conditional process analyses (Hayes, 2018). Instead of relying on the assumption that variables and combinations of variables are normally distributed in the population (as in more traditional mediation analyses, e.g., Baron and Kenny's four-step multiple regression), SPSS PROCESS utilizes bootstrapping (i.e., repeatedly sampling the data with replacement to create an empirical distribution) to estimate the standard error, which is then used to compute regression coefficients and 95% confidence intervals to test inferential hypotheses. The number of bootstrapped samples selected for percentile bootstrap confidence intervals in the current sample was 10,000. As in parametric tests for Aim 1, demographic variables observed to

correlate significantly with the variables of interest (ERPS, maternal characteristics, observed parenting behavior) were included as covariates in all models. Where no indirect effects for the ERP variable of interest were found, the best fit direct effects regression model was examined to determine the contributions of each model variable to the variance in observed maternal parenting behavior.

Results

Demographics

Although mothers from the two samples (PANDA, FIND Community) did not differ with respect to their mean age, $t(68) = .560, p = .577$, education, $t(68) = .535, p = .595$, age of target child, $t(68) = .677, p = .677$, or number of children $t(68) = .801, p = .426$, mothers in the PANDA sample reported significantly lower gross household income than mothers in the FIND Community sample, $t(67) = .2670, p = .010^4$. Means and standard deviations of these demographic covariates by group are shown in Table 1.

Table 1

Means and Standard Deviations for Demographic Covariates by Subsample

	Group					
	PANDA (<i>n</i> = 35)		FIND (<i>n</i> = 35)		Full Sample (<i>N</i> = 70)	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Age	28.94	6.88	29.80	5.88	29.37	6.37
Income	3.74	2.06	5.09	2.12	4.41	2.19
Education	2.86	1.17	2.97	1.04	2.91	1.10
Age of TC	22.21	11.68	23.54	8.94	22.88	10.34
# of children	1.60	.81	1.77	.97	1.69	.89

Note. Age = maternal age (years); Income = annual household gross income reported on a continuous scale where 1 = < \$4,999, 2 = \$5,000 – 9,999, 3 = \$10,000 – 14,999, 4 = \$15,000 – 19,999, 5 = \$20,000 – 24,999, 6 = \$25,000 – 29,999, 7 = \$30,000 – 39,999, 8 = \$40,000 – 49,999, 9 = \$50,000 – 59,000; Education = highest level of education achieved reported on a continuous scale where 1 = did not graduate from high school, 2 = earned a high school diploma or GED, 3 = completed some college or an associate’s degree, 4 = earned a bachelor’s degree, 5 = graduate education or beyond; Age of TC = age of target child (months); and # of children = total number of biological children.

⁴ The difference in household income between groups was expected, as the income cutoff for the PANDA project was lower than that of the FIND Community project differed.

Relationship between Sample Demographics and ERP Measures

The relationship between each demographic variable and each ERP measure was examined to ensure appropriate controls were included in parametric tests. Maternal education and gross household income were unassociated with ERP amplitudes and latencies ($ps > .05$). However, significant positive associations were observed between target child age and mean P100 latency-to-peak for happy infant faces in the left hemisphere, Pearson's $r(66) = .287, p = .019$, as well as between target child age and mean P100 latency-to-peak for distressed infant faces in the left hemisphere, Pearson's $r(66) = .257, p = .037$. A significant negative association was also observed between maternal age and mean P100 latency-to-peak for distressed infant faces in the right hemisphere, Pearson's $r(66) = -.257, p = .037$. With respect to the N170 ERP measures, although target child age and maternal age remained uncorrelated with N170 amplitudes, significant associations were observed between target child age and mean N170 latency-to-peak for neutral infant faces in the left hemisphere, Pearson's $r(68) = .268, p = .027$, and between target child age and mean N170 latency-to-peak for distressed infant faces in the right hemisphere, Pearson's $r(68) = .347, p = .004$. As such, target child age and maternal age were included as covariates in subsequent analyses. No significant associations were observed between maternal age or target child age and P300 measures ($ps > .05$).

Aim 1: To delineate low-income mothers' neural responses to unfamiliar infant faces in three conditions (happy, neutral, and distressed facial expressions) under passive viewing conditions.

Grand averaged data for mothers' ($N = 70$) neural responses to unfamiliar infant faces are shown in Figures 7 and 8.

Figure 7. Grand averaged ERP waveform for the P100/N170 montage.

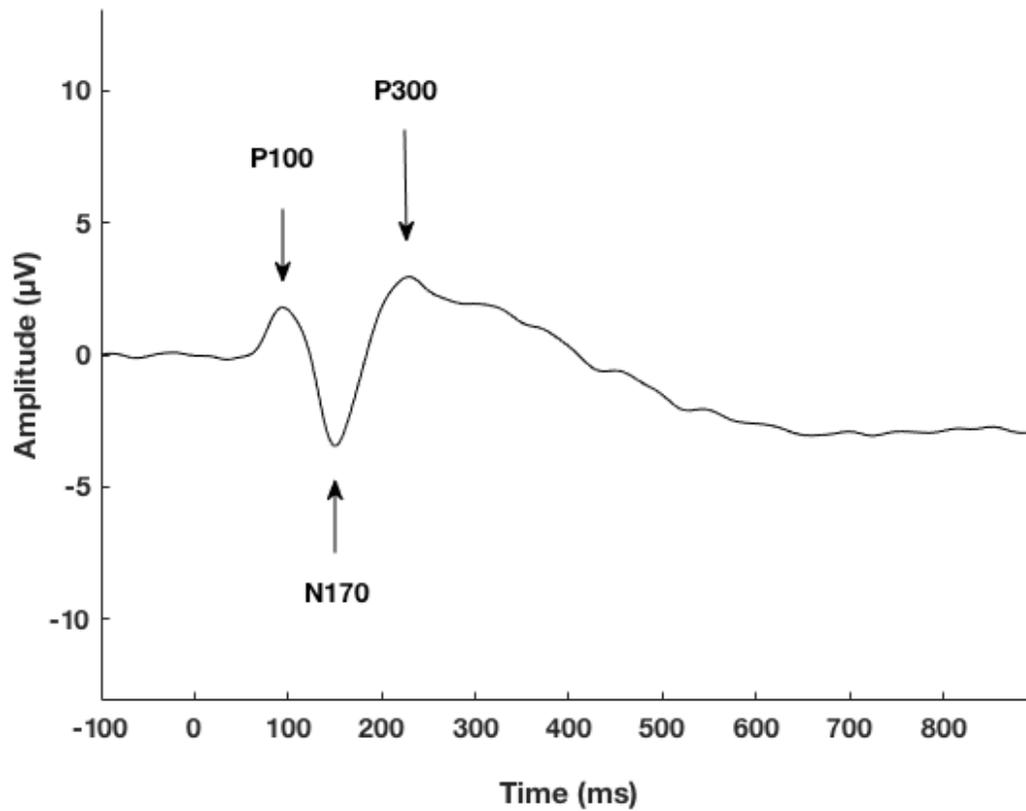


Figure 7. Grand averaged ERP waveform representing early neural response to unfamiliar infant faces in low-income mothers ($N = 70$). Data were extracted from P100/N170 electrodes and averaged across three infant emotional expressions (happy, neutral, distressed) and right and left hemisphere.

Figure 8. Grand averaged ERP waveform for the P300 montage.

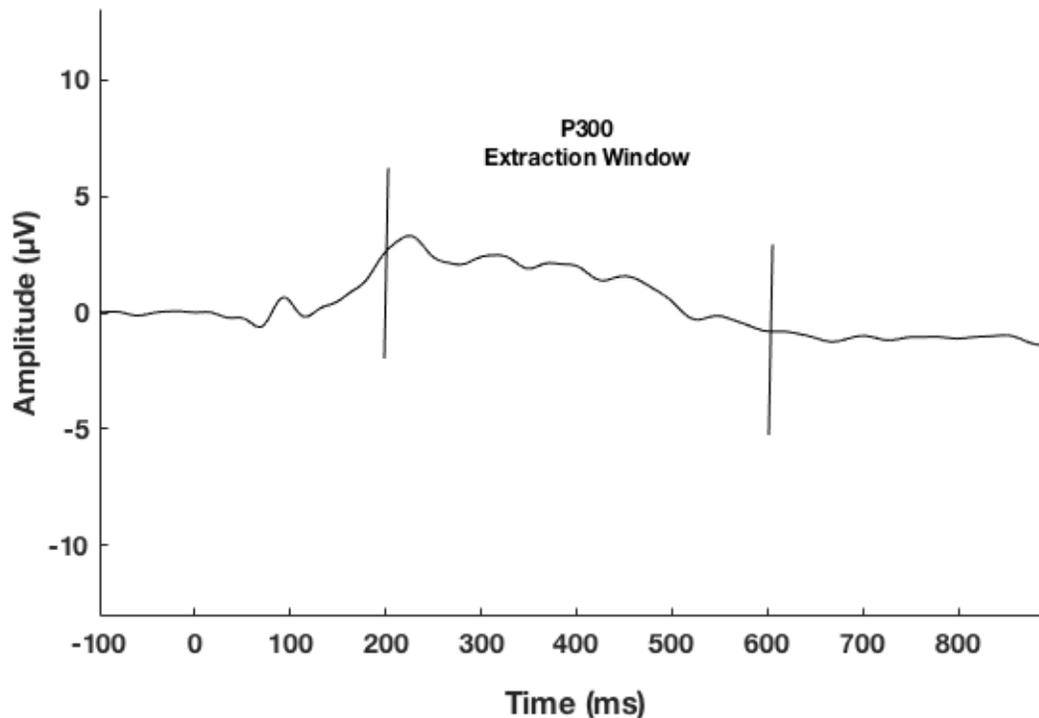


Figure 8. Grand averaged ERP waveform representing P300 neural response to unfamiliar infant faces in low-income mothers ($N = 70$). Data were extracted from the partially-maximal P300 electrode montage and averaged across three infant emotional expressions (happy, neutral, distressed). Neural response at the P300 is believed to index late salience detection and resource allocation for visual stimuli.

P100 Amplitude. Four participants were excluded from analysis of P100 amplitude because their neural responses to infant face stimuli were more than three standard deviations outside the mean (2 above, 2 below) for all participants in at least one condition.⁵ The means and standard deviations for P100 amplitude in this sample before and after outlier removal are shown in Tables 2 and 3, respectively. A 3 x 2 repeated measures ANOVA was conducted to examine the effect of infant emotional expression

⁵ P100 amplitude outliers for Study 1 were as follows: outlier 1 exhibited low mean amplitudes for happy and distressed infant faces (right hemisphere); outlier 2 exhibited low mean amplitude for happy, neutral, and distressed infant faces (right hemisphere); outlier 3 exhibited high mean amplitude for neutral infant faces (left hemisphere); and outlier 4 exhibited high mean amplitude for distressed infant faces (right hemisphere).

and hemisphere on P100 amplitude. Mauchly's test indicated that the assumption of sphericity for infant emotional expression had been violated, $X^2(2) = 12.32, p = .002$, therefore the degrees of freedom were adjusted using the Huynh-Feldt correction, epsilon (ϵ) = .91. After controlling for maternal age, $F(1,62) = .061, p = .806, \eta^2_{\text{partial}} = .001$, observed power = .057, and target child age, $F(1,62) = .264, p = .609, \eta^2_{\text{partial}} = .004$, observed power = .080, a significant within-subjects effect was observed for infant emotional expression, $F(1.817,4.417) = 3.529, p = .032, \eta^2_{\text{partial}} = .054$, observed power = .648. Post-hoc pairwise comparisons with Bonferroni adjustments for multiple comparisons indicated that this effect was driven by the difference between happy and distressed infant faces, such that happy infant facial expressions elicited significantly greater P100 amplitudes than distressed infant facial expressions, $p = .018$ (see Figure 9). Although no within-subjects effect was observed for hemisphere, $F(1,62) = .446, p = .506, \eta^2_{\text{partial}} = .077$, observed power = .101, a significant emotion by hemisphere cross-over interaction effect was found, $F(2,124) = 5.646, p = .005, \eta^2_{\text{partial}} = .083$, observed power = .853, such that the estimated marginal means for P100 amplitude differed: $R_{\text{hemisphere}} > L_{\text{hemisphere}}$ for happy infant faces, whereas P100 amplitude $R_{\text{hemisphere}} < L_{\text{hemisphere}}$ for distressed infant faces. The between-subjects effect of parity was not significant, $F(1,62) = .420, p = .519, \eta^2_{\text{partial}} = .007$, observed power = .098. Although P100 amplitude differed significantly by group (PANDA, FIND Community), $F(1,60) = 10.349, p = .002, \eta = .147$, observed power = .886, such that mothers in the FIND Community subsample exhibited larger P100 amplitudes across conditions ($M = 5.74, SD = 3.98$) than mothers in the PANDA subsample ($M = 3.22, SD = 2.01$), $t(43.15) = 3.192$,

$p = .003$, inclusion of group as an additional between-subjects factor in this model did not significantly change the results.

Figure 9. Grand averaged waveform by infant emotional expression.

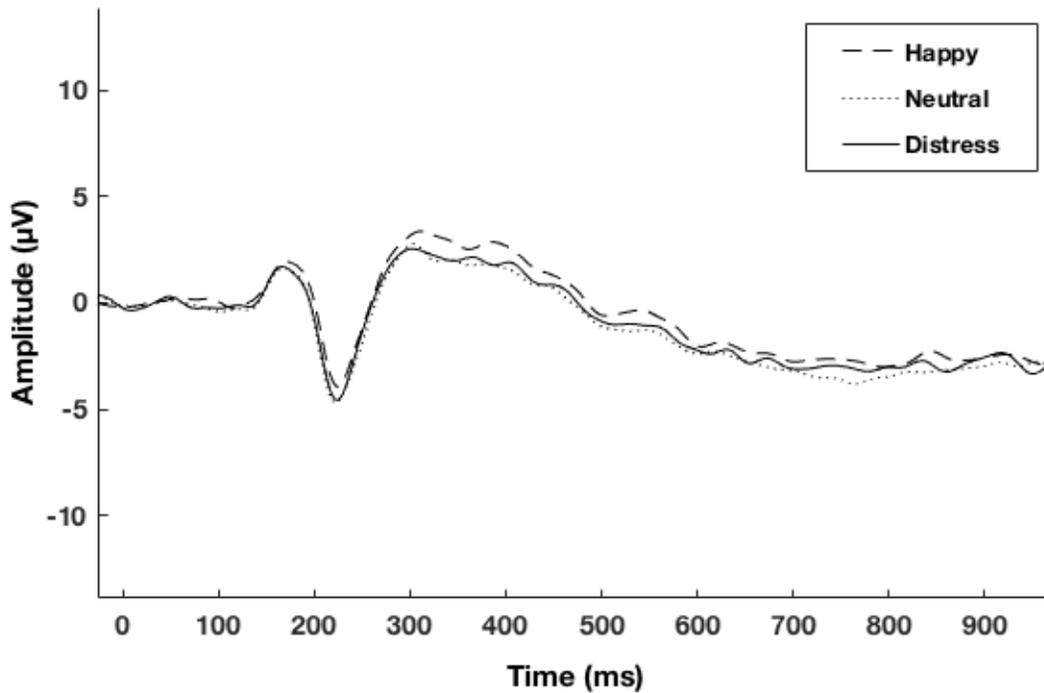


Figure 9. Grand averaged ERP waveform representing early neural response to unfamiliar infant faces in low-income mothers ($N = 70$) by infant emotional expression (happy, neutral, distress). Data were extracted from P100/N170 electrodes and averaged across hemispheres.

P100 Latency. No outliers for P100 latency were identified. A 3 x 2 repeated measures ANOVA was conducted to examine the effect of infant emotional expression and hemisphere on P100 latency-to-peak. The means and standard deviations for P100 latency in this sample before and after outlier removal are shown in Tables 2 and 3, respectively. After controlling for maternal age, $F(1,62) = 1.947$, $p = .168$, $\eta^2_{\text{partial}} = .030$, observed power = .279, and target child age, $F(1,62) = 2.656$, $p = .108$, $\eta^2_{\text{partial}} = .041$, observed power = .361, no within-subjects effects were observed for infant emotional

expression, $F(2,124) = 1.766, p = .175, \eta^2_{\text{partial}} = .028$, observed power = .364, or hemisphere, $F(1,62) = .597, p = .443, \eta^2_{\text{partial}} = .010$, observed power = .118. However, the within-subjects interaction effect between infant emotional expression and hemisphere was significant, $F(2,124) = 4.202, p = .017, \eta^2_{\text{partial}} = .063$, observed power = .729. Although pairwise tests with Bonferroni adjustments for multiple comparisons did not reach significance ($ps > .05$), post-hoc analyses indicated that this interaction was accounted for by a difference in estimated marginal means for P100 latency, such that $R_{\text{hemisphere}} > L_{\text{hemisphere}}$ for happy and neutral infant faces, whereas P100 latency $R_{\text{hemisphere}} < L_{\text{hemisphere}}$ for distressed infant faces. The between-subjects effect of parity was not significant, $F(1,62) = .065, p = .799, \eta^2_{\text{partial}} = .001$, observed power = .057. No between-subjects effect for group (PANDA, FIND Community) on P100 latency was observed when this variable was added to the model, $F(1,60) = .332, p = .567, \eta^2 = .006$, observed power = .088, nor did its inclusion change the results.

Table 2

Means and Standard Deviations for Mean Peak P100 Amplitude and Latency-to-Peak Measures by Condition before Outlier Removal

	Hemisphere					
	Left		Right		Average	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
<u>P100 Amplitude</u>						
Happy	4.61	4.51	4.08	6.92	4.35	5.72
Neutral	4.61	4.55	4.11	6.84	4.36	5.70
Distressed	4.45	4.38	3.65	6.75	4.05	5.57
Average	4.56	4.48	3.95	6.84	4.25	5.66
<u>P100 Latency</u>						
Happy	95.21	14.77	97.21	14.17	96.21	14.47
Neutral	96.57	14.68	98.04	13.44	97.31	14.06
Distressed	97.56	15.63	97.31	15.71	97.44	15.67
Average	96.45	15.03	97.52	14.44	96.98	14.73

Note. Descriptive statistics for mean peak P100 amplitude (microvolts, μV) and latency-to-peak (milliseconds, ms) represent those from the total sample ($N = 70$) prior to outlier removal. Data from the right hemisphere for all three conditions were significantly non-normal in distribution (skewedness statistics ranged -3.04 to -2.33).

Table 3

Means and Standard Deviations for Mean Peak P100 Amplitude and Latency-to-Peak Measures by Condition after Outlier Removal

	Hemisphere					
	Left		Right		Average	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
<u>P100 Amplitude</u>						
Happy	4.43	4.26	4.80	4.33	4.62	4.30
Neutral	4.37	4.03	4.62	4.70	4.50	4.37
Distressed	4.14	3.91	4.07	4.05	4.11	3.98
Average	4.31	4.07	4.50	4.36	4.41	4.21
<u>P100 Latency</u>						
Happy	94.56	14.73	96.86	14.15	95.71	14.44
Neutral	96.55	14.36	98.00	13.01	97.28	13.69
Distressed	97.12	15.59	96.62	16.63	96.87	16.11
Average	96.08	14.89	97.16	14.60	96.62	14.75

Note. Descriptive statistics for mean peak P100 amplitude (microvolts, μV) and latency-to-peak (milliseconds, *ms*) represent those from sample after four outliers were removed (resultant $n = 66$). After outlier removal, all P100 variables were normally distributed (skewness statistics between -1 and +1).

N170 Amplitude. Two participants were excluded from analysis of N170 amplitude because their neural response to infant faces was more than three standard deviations below the mean for all participants in at least one condition⁶. The means and standard deviations for N170 amplitude in this sample before and after outlier removal are shown in Tables 4 and 5, respectively. A 3 x 2 repeated measures ANOVA was conducted to examine the effect of infant emotional expression and hemisphere on N170 mean peak amplitude. After controlling for maternal age, $F(1,64) = .003, p = .957, \eta^2_{\text{partial}} = .000$, observed power = .050, and target child age, $F(1,64) = .318, p = .575, \eta^2_{\text{partial}} = .000$,

⁶ N170 amplitude outliers for Study 1 were identified as follows: outlier 1 exhibited low mean amplitude for happy and distressed infant faces (right hemisphere) and neutral infant faces (left hemisphere); outlier 2 exhibited low mean amplitude for distressed infant faces (right hemisphere).

$\eta^2_{\text{partial}} = .005$, observed power = .086, a significant within-subjects effect was observed for infant emotional expression, $F(2,128) = 3.768$, $p = .026$, $\eta^2_{\text{partial}} = .056$, observed power = .679. Post-hoc tests indicated that distressed infant facial expressions elicited the largest mean peak N170 amplitude, such that $N170_{\text{distressed}} > N170_{\text{neutral}} > N170_{\text{happy}}$ (see Figure 10). However, pairwise comparisons did not reach statistical significance after Bonferroni adjustments for multiple comparisons, $ps > .05$. No statistically significant within-subjects effect was observed for hemisphere, $F(1,64) = .013$, $p = .910$, $\eta^2_{\text{partial}} = .000$, observed power = .051. However, a small within-subjects interaction effect between infant emotional expression and hemisphere approached significance $F(2,128) = 2.638$, $p = .075$, $\eta^2_{\text{partial}} = .040$, observed power = .517. Post-hoc tests indicated that N170 amplitudes for unfamiliar faces in the right hemisphere were significantly greater (more negative) in the right hemisphere than the left hemisphere, $p = .029$ (see Figures 10 and 11). The between-subjects effect of parity was not significant, $F(1,64) = .565$, $p = .455$, $\eta^2_{\text{partial}} = .009$, observed power = .115. Although N170 amplitude differed significantly by group (PANDA, FIND Community), $F(1,62) = 8.685$, $p = .005$, $\eta = .123$, observed power = .827, such that mothers in the FIND Community subsample exhibited smaller (less negative) mean N170 peak amplitudes, ($M = -1.57$, $SD = 4.82$) than mothers in the PANDA subsample ($M = -4.60$, $SD = 3.31$), inclusion of project group as an additional between-subjects factor in this model did not significantly change the results.

Figure 10. N170 Voltage Maps

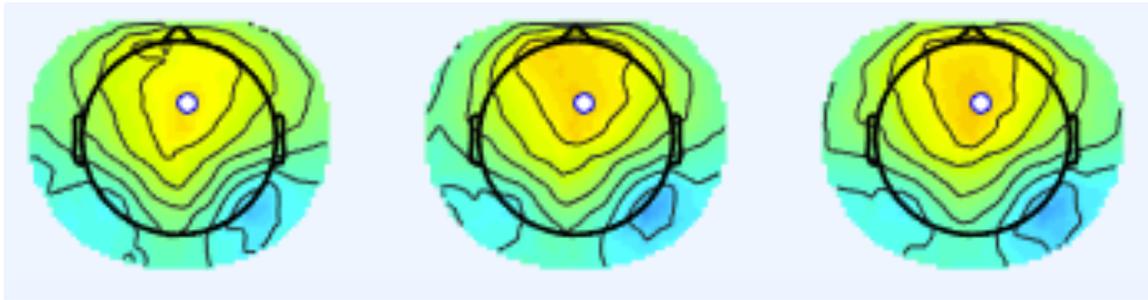


Figure 10. N170 voltage map for happy (left), neutral (middle) and distressed (right) infant facial expressions measured from E7, where the VPP-N170 dipole was maximal. Note: VPP = vertex positive potential. Darker colors indicate more negative voltage. As shown, distressed infant faces in the right hemisphere elicited the most negative voltage.

Figure 11. 3D N170 Voltage Map

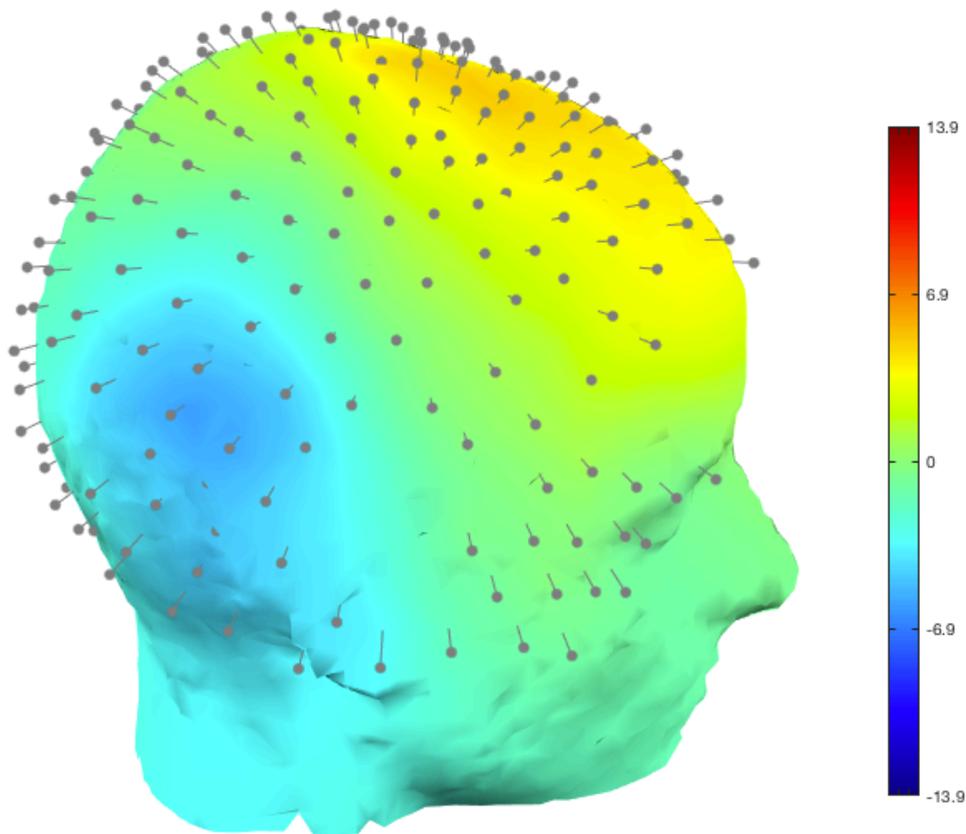


Figure 11. Three-dimensional N170 voltage map for unfamiliar infant facial expressions measured from E7, where the VPP-N170 dipole was maximal. Note: VPP = vertex positive potential. Darker colors indicate more negative voltage (microvolts, uV). As shown, right hemisphere elicited the most negative voltage.

N170 Latency. No outliers for N170 latency were identified. The means and standard deviations for N170 latency in this sample are shown in Tables 4 and 5. A 3 x 2 repeated measures ANOVA was conducted to examine the effects of infant emotional expression and hemisphere on N170 latency-to-peak. Mauchly's test indicated that the assumption of sphericity for infant emotional expression had been violated, $X^2(2) = 6.887, p = .032$, therefore the degrees of freedom were adjusted using the Huynh-Feldt correction, $\epsilon = .975$. After controlling for maternal age, $F(1,64) = .471, p = .495, \eta^2_{\text{partial}} = .007$, observed power = .104, and target child age, $F(1,64) = 2.978, p = .089, \eta^2_{\text{partial}} = .044$, observed power = .397, no within-subjects effect of infant emotional expression, $F(1.950,124.771) = .967, p = .383, \eta^2_{\text{partial}} = .015$, observed power = .215, or hemisphere, $F(1,64) = .711, p = .402, \eta^2_{\text{partial}} = .011$, observed power = .132, on mean N170 latency-to-peak was observed. The interaction effect between infant emotional expression and hemisphere was also not significant, $F(2,128) = .881, p = .417, \eta^2_{\text{partial}} = .014$, observed power = .199. The between-subjects effect of parity did approach significance, $F(1,64) = 3.737, p = .058, \eta^2_{\text{partial}} = .055$, observed power = .478. Post-hoc tests suggested that, across conditions, primiparous mothers exhibited faster N170 latency-to-peak than multiparous mothers, $t(66) = -2.299, p = .025$, and that this effect was strongest in the left hemisphere, $t(66) = -2.281, p = .026$, compared to the right hemisphere, $t(66) = -1.938, p = .057$. A crossover interaction was also observed for distressed infant facial expressions, such that for primiparous mothers, N170 latencies were slightly faster in the left hemisphere ($M = 148.31, SD = 11.60$) than the right hemisphere ($M = 148.90, SD = 11.06$), whereas for multiparous mothers, N170 latencies were fastest in the right hemisphere ($M = 152.02, SD = 11.58$) compared to the left

hemisphere ($M = 154.27$, $SD = 13.18$). No between-subjects effect for group (PANDA, FIND Community) on N170 latency was observed when this variable was added to the model, $F(1,62) = .209$, $p = .649$, $\eta^2_{\text{partial}} = .003$, observed power = .074, nor did its inclusion change the results.

Table 4

Means and Standard Deviations for Mean Peak N170 Amplitude and Latency-to-Peak Measures by Condition before Outlier Removal

	Hemisphere					
	Left		Right		Average	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
<u>N170 Amplitude</u>						
Happy	-2.38	4.48	-4.33	7.57	-3.36	6.03
Neutral	-2.45	4.66	-4.86	7.69	-3.66	6.18
Distressed	-2.50	4.67	-4.92	7.56	-3.71	6.12
Average	-2.44	4.60	-4.70	7.61	-3.57	6.11
<u>N170 Latency</u>						
Happy	151.22	12.73	150.22	11.79	150.72	12.26
Neutral	151.22	12.51	149.68	11.26	150.45	11.89
Distressed	151.26	12.50	150.15	11.44	150.71	11.97
Average	151.23	12.58	150.02	11.50	150.63	12.04

Note. Descriptive statistics for mean peak N170 amplitude (microvolts, μV) and latency-to-peak (milliseconds, ms) represent those from the total sample ($N = 70$) prior to outlier removal. All variables were normally distributed (skewedness statistics between -2 and +2).

Table 5

Means and Standard Deviations for Mean Peak N170 Amplitude and Latency-to-Peak Measures by Condition after Outlier Removal

	Hemisphere					
	Left		Right		Average	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
<u>N170 Amplitude</u>						
Happy	-2.27	4.48	-3.62	6.10	-2.95	5.29
Neutral	-2.30	4.56	-4.07	6.18	-3.19	5.37
Distressed	-2.45	4.66	-4.11	5.90	-3.28	5.28
Average	-2.34	4.57	-3.93	6.06	-3.14	5.31
<u>N170 Latency</u>						
Happy	150.96	12.80	150.52	11.60	150.74	12.20
Neutral	151.50	12.32	149.89	11.25	150.70	11.79
Distressed	151.12	12.64	150.37	11.33	150.75	11.99
Average	151.19	12.59	150.26	11.39	150.73	11.99

Note. Descriptive statistics for mean peak N170 amplitude (microvolts, μV) and latency-to-peak (milliseconds, *ms*) represent those from the sample after two outliers were removed (resultant sample $n = 68$). All variables were normally distributed (skewedness statistics between -1 and +1).

P300 Amplitude. Two participants were excluded from analysis of P300 amplitude because their neural response to infant faces was more than three standard deviations below the mean for all participants in at least one condition⁷. The means and standard deviations for P300 amplitude in this sample before and after outlier removal are shown in Tables 6 and 7, respectively. A repeated measures ANOVA was conducted to examine the effect of infant emotional expression and hemisphere on P300 mean peak amplitude. After controlling for maternal age, $F(1,64) = 1.156, p = .286, \eta^2_{\text{partial}} = .018$, observed power = .185, and target child age, $F(1,64) = .962, p = .330, \eta^2_{\text{partial}} = .015$,

⁷ P300 amplitude outliers for Study 1 were identified as follows: outlier 1 exhibited low mean amplitude for happy, neutral, and distressed infant faces; outlier 2 exhibited out mean amplitude for happy infant faces.

observed power = .162, no within-subjects effect of infant emotional expression on P300 mean peak amplitude was observed, $F(2,128) = .194, p = .824, \eta^2_{\text{partial}} = .003$, observed power = .080. The between-subjects effect of parity was also not significant, $F(1,64) = .159, p = .691, \eta^2_{\text{partial}} = .002$, observed power = .068. Although P300 amplitude differed significantly by group (PANDA, FIND Community), $F(1,62) = 12.985, p = .001, \eta^2 = .173$, observed power = .994, such that mothers in the FIND Community subsample exhibited larger P300 amplitudes ($M = 8.55, SD = 3.91$) across conditions than mothers in the PANDA subsample ($M = 5.66, SD = 2.60$), inclusion of group as an additional between-subjects factor in this model did not significantly change the results.

P300 Latency. No outliers for P300 latency were identified. The means and standard deviations for P300 latency in this sample are shown in Tables 6 and 7. After controlling for maternal age, $F(1,64) = 1.114, p = .295, \eta^2_{\text{partial}} = .017$, observed power = .180, and target child age, $F(1,64) = .567, p = .454, \eta^2_{\text{partial}} = .009$, observed power = .115, no within-subjects effect of infant emotional expression on P300 mean latency-to-peak was observed, $F(2,128) = .366, p = .694, \eta^2_{\text{partial}} = .006$, observed power = .108. The between-subjects effect of parity was also not significant, $F(1,64) = .159, p = .379, \eta^2_{\text{partial}} = .012$, observed power = .141. No between-subjects effect for group (PANDA, FIND Community) on N170 latency was observed when this variable was added to the model, $F(1,62) = .364, p = .548, \eta^2 = .006$, observed power = .091, nor did its inclusion change the results.

Table 6

Means and Standard Deviations for Mean Peak P300 Amplitude and Latency-to-Peak Measures by Condition before Outlier Removal

	<i>M</i>	<i>SD</i>
<u>P300 Amplitude</u>		
Happy	6.61	5.31
Neutral	6.32	5.08
Distressed	6.46	5.24
Average	6.46	5.21
<u>P300 Latency</u>		
Happy	306.13	75.77
Neutral	291.72	63.28
Distressed	308.61	76.42
Average	302.15	71.82

Note. Descriptive statistics for mean peak P300 amplitude (microvolts, μV) and latency-to-peak (milliseconds, ms) represent those from the total sample ($N = 70$) prior to outlier removal. All variables were normally distributed (skewedness statistics between -2 and +2).

Table 7

Means and Standard Deviations for Mean Peak P300 Amplitude and Latency-to-Peak Measures by Condition after Outlier Removal

	<i>M</i>	<i>SD</i>
<u>P300 Amplitude</u>		
Happy	7.26	3.68
Neutral	6.90	3.76
Distressed	7.04	3.93
Average	7.07	3.79
<u>P300 Latency</u>		
Happy	305.77	75.61
Neutral	293.49	63.34
Distressed	308.03	75.53
Average	302.43	71.49

Note. Descriptive statistics for mean peak P300 amplitude (microvolts, μV) and latency-to-peak (milliseconds, ms) represent those from the sample after two outliers were removed (resultant $n = 68$). All variables were normally distributed (skewedness statistics between -1 and +1).

Summary of Within-Subjects Effects for Aim 1

Significant within-subjects effects for infant emotional expression, hemisphere, and interactions between emotional expression and hemisphere across ERP measures are shown in Table 8. The between-subjects effect for parity was significant for N170 latency only. Although ERP measures across components differed significantly by group (PANDA, FIND Community), inclusion of this additional factor did not alter the results.

Table 8

Summary of Significant Within-Subjects Effects from Study 1

	Emotion	Hemisphere	Emotion x Hemisphere
P100 Amplitude	✓	–	✓
P100 Latency	–	–	✓
N170 Amplitude	✓	–	(trend)
N170 Latency	–	–	–
P300 Amplitude	–	N/A	N/A
P300 Latency	–	N/A	N/A

Note. ✓ = significant within-subjects effect ($p < .05$); trend = $p = .05 - .10$; – = effect not significant ($p > .05$); N/A = not applicable (effect not examined).

Aim 2: To examine the relationship between low-income mothers' neural response to unfamiliar infant faces, aspects of maternal experience known to co-vary with caregiving quality, and observed caregiving behavior.

Associations between ERPs and Mothers' History of Adversity

No direct associations were observed between ERP (P100, N170, P300) measures and mothers' self-reported history of adverse childhood experiences (ACES), lifetime exposure to potentially trauma events (LEC), childhood neglect (DNS), or betrayal trauma (BBTS), $ps > .05$.

Associations between ERPs and Maternal Characteristics

Exploratory partial correlations between ERPs and maternal characteristics shown in prior research to predict parenting quality were examined. Maternal age and target child age were included as covariates, as these variables were shown in Aim 1 to correlate with some ERP measures, and ERP outliers identified in previous analyses were excluded. Since P100 and N170 amplitudes were shown to differ by emotional condition and significant emotion by hemisphere interaction effects were observed, partial correlations for each condition (happy, neutral, distressed) in each hemisphere (left, right) as well as the average amplitude collapsed across conditions and hemispheres, were examined. By contrast, since no significant within-subjects effects for emotion or hemisphere were observed for the P100 latency or N170 latency, and no significant within-subjects effects for emotion were observed for P300 amplitude and latency, only the average ERP was considered for these variables.

P100 amplitude and maternal characteristics. A robust negative association between maternal anxiety and P100 amplitude was observed for all three infant emotional expressions (happy, neutral, distressed) in both the right and left hemisphere, such that greater anxiety predicted smaller P100 neural responses to infant faces. This relationship remained significant after averaging across conditions in the left hemisphere, $r(62) = -.248, p = .049$, across conditions in the right hemisphere, $r(62) = -.252, p = .045$, and across conditions and hemispheres, $r(62) = -.299, p = .016$. A negative association was also observed between P100 amplitude and the Parenting Stress Index, Dysfunctional Parent-Child Interactions (PSI-DI) subscale across conditions in the left hemisphere, $r(62) = -.232, p = .009$, such that smaller P100 responses to infant faces correlated with

greater self-reported dysfunctional interactions between mothers and their young children. Although these associations were not significant in the right hemisphere ($ps > .05$), the overall relationship between this PSI subscale and P100 amplitude remained significant, $r(62) = -.254, p = .043$. The relationship between other maternal characteristics and P100 amplitudes were not as robust, although some associations did approach significance ($ps = .05 - .10$).

P100 latency and maternal characteristics. Positive associations were observed between the Difficulty Engaging in Goal Directed Behavior subscale of the DERS and P100 latency-to-peak for happy infant facial expressions in the right hemisphere, $r(62) = .273, p = .029$, for neutral facial expressions in the right hemisphere, $r(62) = .255, p = .042$, and for overall P100 latency-to-peak for infant facial expressions in the right hemisphere averaged across conditions, $r(62) = .256, p = .041$, such that slower latency-to-peak for infant faces was associated with greater self-reported difficulties engaging in goal-directed behavior. A negative association between the P100 latency-to-peak for neutral infant facial expressions in the left hemisphere and the Impulse Control Difficulties subscale of the DERS, $r(62) = -.251, p = .046$, such that faster latency-to-peak for neutral infant faces was associated with greater self-reported difficulties with impulse control. No other significant associations for P100 latency were observed.

N170 amplitude and maternal characteristics. Significant negative associations were observed between maternal anxiety (BAI total scores) and N170 amplitudes for happy infant facial expressions in the left hemisphere, $r(64) = -.258, p = .037$, such that greater anxiety was associated with larger (more negative) N170 peaks. The relationship between BAI scores and N170 amplitudes in the left hemisphere and overall N170 neural

responses to infant faces in the left hemisphere approached significance ($ps = .05 - .10$). However, no relationship between maternal anxiety and N170 amplitudes in the right hemisphere, or overall N170 amplitude when averaged across conditions and hemispheres was observed. Several positive associations were observed between scores on the High-Low subscale of the PRFQ and N170 amplitude for happy infant faces in the left hemisphere, $r(64) = .277, p = .032$, distressed faces in the left hemisphere, $r(64) = .253, p = .051$, and N170 amplitude in the left hemisphere averaged across conditions, $r(64) = .264, p = .042$, such that smaller (less negative) N170 peaks were associated with higher parental reflective functioning / mentalization (i.e., ability to hold her child's mind in mind). No associations between N170 amplitudes in the right hemisphere or overall N170 neural response and parental reflective functioning / mentalization were observed. A positive association was observed between N170 amplitude for distressed infant faces in the right hemisphere and parenting reward (PRQ total scores), $r(64) = .274, p = .042$, such that smaller (less negative) deflections at the N170 were associated with greater parenting reward. No other significant associations between N170 amplitudes and maternal characteristics were observed ($ps > .05$).

N170 latency and maternal characteristics. Several significant associations were observed between mean N170 latency-to-peak and maternal characteristics. A significant positive relationship was observed between parenting reward (PRQ total scores) and N170 latencies for happy infant faces in the right hemisphere, $r(64) = .287, p = .032$, and neutral infant faces in the left hemisphere, $r(64) = .273, p = .042$, such that slower latency-to-peak was associated with greater parenting reward. However, this association did not remain significant when averaging across conditions or hemispheres

($ps > .05$). Negative associations between parenting self-efficacy (PSOC total scores) and N170 latency-to-peak for neutral infant faces in the right hemisphere, $r(64) = -.287$, $p = .032$, and distressed infant faces in the right hemisphere, $r(64) = -.303$, $p = .023$, were observed such that faster latency-to-peak for infant faces was associated with greater parenting self-efficacy. However, the relationship between N170 latency and parenting self-efficacy did not remain significant after averaging across conditions and hemispheres ($ps > .05$). With respect to mothers' self-reported difficulties with emotion regulation, several significant positive associations between DERS subscale scores and N170 latency-to-peak were observed. Mothers' difficulty pursuing goal-directed activities was positively associated with N170 latency for distressed infant faces in the right hemisphere, $r(64) = .257$, $p = .037$; and mothers' difficulty with impulse control was positively associated with N170 latency for distressed infant faces in the right hemisphere, $r(64) = .255$, $p = .039$, such that greater difficulties in these areas of emotion regulation were associated with slower N170 latency-to-peak for distressed infant faces. A positive association was also observed between mothers' self-reported lack of emotional awareness and N170 latencies for neutral infant faces in the right hemisphere, $r(64) = .267$, $p = .030$, such that greater difficulty with emotional awareness was associated with slower N170 latencies for neutral infant faces. Several other associations between N170 latencies and DERS subscale scores were observed, however none reached significance ($ps > .05$) and none remained significant after averaging across conditions and hemispheres.

P300 amplitude and maternal characteristics. No significant associations between mean P300 amplitude averaged across conditions and maternal characteristics were observed ($ps > .05$).

P300 latency and maternal characteristics. No significant associations between mean P300 latency-to-peak averaged across conditions and maternal characteristics were observed ($ps > .05$).

Summary of Associations between ERPs and Maternal Characteristics

Taken together, these exploratory analyses suggest that although several maternal characteristics were associated with mothers' ERP responses to unfamiliar infant faces in this sample (see Table 9 for summary), the most robust associations were observed between (1) P100 amplitude and maternal anxiety (BAI total scores); and (2) P100 amplitude and mothers' parenting stress related to parent-child dysfunctional interactions (PSI-DI subscale scores). As such, these variables were selected for further examination and mediation tests via SPSS PROCESS, after the associations between ERPs and observational measures were characterized.

Table 9*Summary of Significant Associations between Maternal Self-Report and ERP Measures*

	ERP Measures					
	P100		N170		P300	
	Amp	Lat	Amp	Lat	Amp	Lat
Psychosocial Adversity						
• ACES	–	–	–	–	–	–
• BBTS	–	–	–	–	–	–
• DNS	–	–	–	–	–	–
• LEC	–	–	–	–	–	–
Mental Health Symptoms						
• PTSD	–	–	–	–	–	–
• BDI	–	–	–	–	–	–
• BAI	✓	–	✓	–	–	–
Emotion Regulation Difficulties						
• DERS	–	✓	–	✓	–	–
Experiences of Parenting						
• PSI	✓	–	–	–	–	–
• PSOC	–	–	–	✓	–	–
• PRQ	–	–	✓	✓	–	–
Parental Reflective Functioning						
• PRFQ	–	–	✓	–	–	–

Note. ✓ = significant bivariate association in at least one condition or subscale after controlling for maternal age and target child age ($p < .05$); – = associations not significant ($p > .05$)

Associations between ERPs and Observed Parenting

One additional participant was excluded from all analyses of observed parenting because her PICCOLO scores were more than three standard deviations below the mean across observed parenting subscales.

ERP amplitudes and observed parenting. Robust positive associations between mean ERP peak amplitudes and observed parenting during free play were observed across conditions for all PICCOLO subscale scores except the Responsiveness subscale. As such, ERP amplitude measures were collapsed across conditions and hemispheres.

Partial correlations between average ERP amplitudes and scores on the PICCOLO, controlling for maternal age and target child age, are shown in Table 10.

ERP latencies and observed parenting. Three associations between mean ERP latency-to-peak measures and observed parenting approached significance ($ps = .05 - .10$). Specifically, a negative association between P100 latencies for happy infant faces in the right hemisphere and scores on the PICCOLO Encouragement subscale approached significance, $r(52) = -.249, p = .069$, such that faster latencies were associated with greater encouragement. By contrast, a positive association between N170 latency for distressed infant faces in the left hemisphere and scores on the PICCOLO Encouragement subscale also approached significance, $r(54) = .231, p = .086$, such that slower latencies for distressed infant faces were associated with greater encouragement. Likewise, a positive association between P300 latency for neutral infant faces and scores on the PICCOLO Responsiveness subscale approached significance, $r(54) = .242, p = .073$, such that slower latency-to-peak was associated with higher parenting quality. However, these associations were less robust than those observed for ERP amplitudes, and did not remain significant after averaging across conditions and (where relevant) hemispheres.

Table 10*Partial Correlations between Average ERPs and PICCOLO Scale Scores*

	Affection Subscale	Responsiveness Subscale	Encouragement Subscale	Teaching Subscale	Total Score
<u>Amplitude</u>					
P100	.312*	ns	.406**	.339*	.360**
N170	.351**	ns	.307*	.320*	.320*
P300	.354**	ns	.278*	.341*	.330*
<u>Latency</u>					
P100	ns	ns	ns	ns	ns
N170	ns	ns	ns	ns	ns
P300	ns	ns	ns	ns	ns

Note. Partial correlations for mean peak amplitudes and latencies for each ERP averaged across conditions and (where relevant) hemispheres, controlling for maternal age and target child age. * $p < .05$, ** $p < .01$, ns = not significant ($p > .05$). Since P100 and P300 amplitudes represent positive deflections, where N170 amplitudes represent negative deflections, it is important to note that the positive associations observed here indicate that larger peaks were associated with higher parenting quality for the former, whereas larger peaks were associated with lower parenting quality for the latter.

Associations between Maternal Characteristics and Observed Parenting

Maternal self-report variables with robust associations with ERP measures (i.e., BAI Total Score, PSI-DI subscale scores) were examined for their relationship to observed parenting. Partial correlations between these variables and PICCOLO scores are shown in Table 11.

Table 11

Partial Correlations between Maternal Characteristics with Observed Associations with ERP Measures and PICCOLO Scale Scores

	Affection Subscale	Responsiveness Subscale	Encouragement Subscale	Teaching Subscale	Total Score
BAI	ns	ns	ns	-.276 ⁺	ns
PSI-DI	ns	-.240 ⁺	-.332*	-.261*	-.284*

Note. Partial correlations between maternal self-report measures with robust associations with ERP measures (BAI = Beck Anxiety Inventory, Total Score; PSI-DI = Parenting Stress Index, Parent-Child Dysfunctional Interaction Subscale Score) and observed parenting on the PICCOLO, controlling for maternal age and target child age. * $p < .05$, ** $p < .01$, ⁺ $p = .05 - .08$; ns = not significant ($p > .05$).

Associations between Maternal History of Adversity and Observed Parenting

The relationship between mothers' self-reported history of psychosocial adversity and observed parenting was examined. Partial correlations between these variables and PICCOLO scores are shown in Table 12. As indicated, the only domain of mothers' history of adversity shown to have a negative relationship with observed parenting quality was mothers' history of childhood neglect, $r(54) = -.267, p = .047$. As such, maternal history of childhood neglect was selected for inclusion in exploratory mediation tests as a covariate. All other types of self-reported psychosocial adversity either had no relationship to observed parenting ($ps > .05$) or a positive association that did not reach statistical significance.

Table 12*Partial Correlations between Mothers' History of Adversity and PICCOLO Scale Scores*

	Affection Subscale	Responsiveness Subscale	Encouragement Subscale	Teaching Subscale	Total Score
ACES	ns	ns	ns	ns	ns
BT	ns	ns	ns	ns	ns
MNBS	-.282*	ns	ns	-.321*	-.267*
LEC-E	ns	ns	.285 ⁺	ns	ns
LEC-W	ns	ns	ns	ns	ns
LEC-L	ns	ns	ns	ns	ns

Note. Partial correlations between maternal history of adversity and observed parenting as measured by the PICCOLO, controlling for maternal age and target child age. ACES = Adverse Childhood Experiences, Total Score; BT = Betrayal Trauma, Total Count; MNBS = Dubowitz Neglect Scale, Total Score; LEC-E = Life Events Checklist – Potential Traumatic Events Experienced; LEC-W = Lifetime Events Checklist – Potentially Traumatic Events Witnessed; LEC-L = Lifetime Events Checklist – Potentially Traumatic Events Learned About. * $p < .05$, ** $p < .01$, ⁺ $p = .05 - .08$; ns = not significant ($p > .05$).

Exploratory Mediation Tests

Follow-up mediation analyses were conducted to test whether the ERP with the most robust relationships to maternal self-report characteristics and observed parenting behavior (i.e., mean P100 amplitude) mediated the relationship between maternal characteristics (i.e., anxiety, parenting stress) and parenting behavior during free-play. A total of five mediation tests were conducted in SPSS PROCESS: one for the relationship between maternal anxiety and maternal teaching behavior; and four for the relationships between maternal stress due to dysfunctional parent-child interactions and observed parenting quality. Test results are summarized below.

Do mothers' P100 amplitude responses to unfamiliar infant faces mediate the relationship between maternal anxiety (BAI total scores) and maternal teaching behavior (PICCOLO Teaching subscale scores), after controlling for maternal age, child age, and maternal history of childhood neglect?

P100 mediation test for maternal anxiety and maternal teaching. The direct effect of maternal anxiety (BAI total scores) and indirect effect of P100 amplitude for infant facial expressions on maternal teaching behavior (PICCOLO Teaching subscale scores) were examined using a SPSS PROCESS simple mediation test. Maternal age, target child age, and mothers' self-reported history of childhood neglect were included as covariates. No indirect effect of P100 amplitude on mothers' observed teaching behavior during the parent-child interaction task was observed (Table 13).

Table 13

Model Coefficients for the Mediation Test of P100 Amplitude for Unfamiliar Infant Faces on the Relationship between Maternal Anxiety and Mothers' Observed Use of Teaching Behavior During the Free Play Parent-Child Interaction Task

Antecedent		Consequent						
		M (P100 Amp)			Y (Teaching)			
		Coeff.	SE	p		Coeff.	SE	p
X (BAI)	<i>A</i>	-0.04	0.06	.46	<i>c'</i>	-.05	.10	.64
M (P100 Amp)		-	-	-	<i>b</i>	.49	.24	.04
Constant	<i>i_M</i>	5.48	2.38	.03	<i>i_Y</i>	8.22	4.17	.05
$R^2 = .044$				$R^2 = .233$				
$F(4,50) = .57, p = .69$				$F(5,49) = 2.98, p = .02$				

Note. $N = 55$; Maternal Anxiety = Beck Anxiety Inventory Total Scores; P100 Amp = mean P100 amplitude averaged across conditions (happy, neutral, distressed) and hemispheres (left, right) in microvolts (μV); Teaching = PICCOLO Teaching subscale scores. Maternal age, target child age, and mothers' history of childhood neglect were included as covariates.

Instead, the best fitting model was a direct effects regression model regressing each variable of interest on PICCOLO Teaching subscale scores, $F(5,49) = 2.98, p = .02$.

Coefficients for the variables of interest (maternal anxiety, P100 amplitude) and

covariates are shown in Table 14. As indicated, only P100 amplitude and target child age significantly predicted mothers' teaching behavior in this model.

Table 14

Direct Effects Regression Model Predicting Mothers' Teaching Behavior from Maternal Anxiety

	<i>B</i>	<i>SE</i>	<i>t</i>	<i>P</i>	<i>LLCI</i>	<i>ULCI</i>
PICCOLO Teaching Subscale Scores						
Hypothesized Predictors						
Maternal Anxiety	-.05	.10	-.48	.64	-.25	.15
P100 Amplitude	.49	.24	2.09	.04	.02	.97
Covariates						
Maternal Age	-.02	.11	-.18	.86	-.24	.20
Target Child Age	.16	.07	2.25	.02	.02	.30
Maternal History of Neglect	-.11	.07	-1.50	.14	-.26	.04

Note. $N = 55$; CI = 95% confidence interval; *LL* = lower limit; *UL* = upper limit.

Maternal Anxiety = Beck Anxiety Inventory Total Scores; P100 Amplitude = mean P100 amplitude averaged across conditions (happy, neutral, distressed) and hemispheres (left, right) in microvolts (μV); Maternal Age = mothers' self-reported age in years; Target Child Age = age of mothers' youngest biological child in months; Maternal History of Neglect = mothers' self-reported history of their own experience of early childhood neglect as indexed by the Dubowitz Neglect Scale total scores.

Do mothers' P100 amplitude responses to unfamiliar infant faces mediate the relationship between mothers' self-reported stress due to dysfunctional parenting-child interactions and observed parenting quality?

P100 mediation test for PSI-DI and maternal responsiveness. The direct effect of mothers' self-reported stress due to dysfunctional parent-child interactions (PDI-DI subscale scores) and indirect effect of P100 amplitude for infant facial expressions on maternal responsiveness (PICCOLO Responsiveness subscale scores) were examined using a SPSS PROCESS simple mediation test. As expected due to the lack of observed partial correlations with maternal responsiveness, no indirect effect of P100 amplitude on mothers' observed responsiveness during the parent-child interaction task was observed nor was the direct effects regression model significant, $F(5,49) = 1.17, p = .33$, after

controlling for mothers' age, target child age, and mothers' self-reported history of early childhood neglect, none of which were significant $ps > .05$. Model coefficients for the mediation test of P100 amplitude on the relationship between PSI-DI and maternal responsiveness are shown in Table 15.

Table 15

Model Coefficients for the Mediation Test of P100 amplitude for Unfamiliar Infant Faces on the Relationship between Maternal Stress due to Dysfunctional Parent-Child Interactions and Observed Maternal Responsiveness during the Free Play Parent-Child Interaction Task

		Consequent						
		M (P100 Amp)			Y (Responsiveness)			
Antecedent		Coeff.	SE	P		Coeff.	SE	p
X (PSI-DI)	A	-0.18	0.09	.05	c'	-0.12	0.09	.17
M (P100 Amp)		-	-	-	B	0.14	0.13	.29
Constant	i _M	7.12	2.46	.006	i _Y	13.30	2.39	<.001
R ² = .103				R ² = .107				
F(4,50) = 1.43, p = .24				F(5,49) = 1.17, p = .33				

Note. N = 55; PSI-DI = Parenting Stress Index, Parent-Child Dysfunctional Interaction subscale scores; P100 Amp = mean P100 amplitude averaged across conditions (happy, neutral, distressed) and hemispheres (left, right) in microvolts (μ V); Responsiveness = PICCOLO Responsiveness subscale scores. Maternal age, target child age, and mothers' history of neglect were included as covariates.

P100 mediation test for PSI-DI and maternal encouragement. The direct effect of mothers' self-reported stress due to dysfunctional parent-child interactions (PDI-DI subscale scores) and indirect effect of P100 amplitude for infant facial expressions on maternal encouragement (PICCOLO Encouragement subscale scores) were examined using a SPSS PROCESS simple mediation test. Both a direct effect of PSI-DI on maternal encouragement and an indirect effect of P100 amplitude on maternal encouragement were observed (see Figure 12). In the total effect model, the direct effect of mothers' self-reported stress due to dysfunctional parent-child interactions was significant, $t(50) = -2.68, p = .01$, such that increased stress was associated with lower

levels of observed encouragement. The indirect effect of P100 amplitude on maternal encouragement was statistically different from zero, as revealed by a 95% bootstrap confidence interval that was entirely below zero (-.162 to -.002). The completely standardized indirect effect indicated that for every 1 unit increase in maternal encouragement, the slope predicting the negative relationship between PSI-DI and encouragement decreased by a unit of -.09. In other words, as neural responses to unfamiliar infant faces at the P100 increased, the negative association between parenting stress due to dysfunctional parent-child interactions and maternal encouragement strengthened. Unstandardized model coefficients for this mediation test are shown in Table 16.

Table 16

Model Coefficients for the Mediation test of P100 amplitude for Unfamiliar Infant Faces on the Relationship between Maternal Stress due to Dysfunctional Parent-Child Interactions and Mothers' Observed use of Encouragement During the Free Play Parent-Child Interaction Task

Antecedent		Consequent						
		M (P100 Amp)			Y (Encouragement)			
		Coeff.	SE	P		Coeff.	SE	p
X (PSI-DI)	<i>a</i>	-0.18	0.09	.05	<i>c'</i>	-0.22	0.11	.04
M (P100 Amp)		-	-	-	<i>b</i>	0.36	0.16	.02
Constant	<i>i_M</i>	7.12	2.46	.006	<i>i_Y</i>	12.69	2.91	<.001
$R^2 = .103$				$R^2 = .257$				
$F(4,50) = 1.43, p = .23$				$F(5,49) = 3.39, p = .01$				

Note. $N = 55$; PSI-DI = Parenting Stress Index, Parent-Child Dysfunctional Interaction subscale; P100 Amp = mean P100 amplitude averaged across conditions (happy, neutral, distressed) and hemispheres (left, right) in microvolts (μV); Encouragement = PICCOLO Encouragement subscale scores. Maternal age, target child age, and mothers' history of neglect were included as covariates.

Figure 12. Mediation of PSI-DI and Encouragement by P100 Mean Peak Amplitude

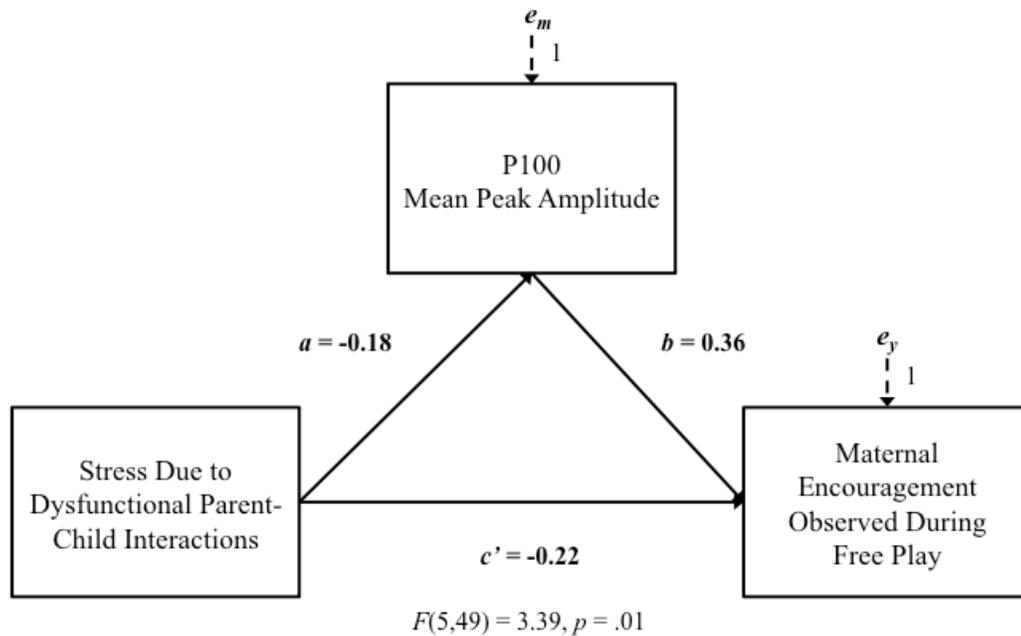


Figure 12. Simple mediation model for the effect of parenting stress due to dysfunctional parent-child interaction on maternal encouragement through and independent of early neural responses to visual infant cues. Note: $N = 55$; Stress Due to Dysfunctional Parent-Child Interactions = PSI-DI subscale Scores; P100 Mean Peak Amplitude represents the P100 amplitude averaged across conditions (happy, neutral, distressed) and hemispheres (left, right) in microvolts (μV); Maternal Encouragement Observed During Free Play = PICCOLO Encouragement subscale scores. Maternal age, target child age, and mothers' history of neglect were included as covariates.

P100 mediation test for PSI-DI and maternal teaching. The direct effect of mothers' self-report stress due to dysfunctional parent-child interactions (PSI-DI subscale scores) and indirect effect of P100 amplitude for infant facial expressions on maternal teaching behavior (PICCOLO Teaching subscale scores) were examined using a SPSS PROCESS simple mediation test. Maternal age, target child age, and mothers' self-reported history of childhood neglect were included as covariates. No indirect effect of

P100 amplitude on mothers' observed teaching during the parent-child interaction task was observed (Table 17).

Table 17

Model Coefficients for the Mediation Test of P100 Amplitude for Unfamiliar Infant Faces on the Relationship between Maternal Stress due to Dysfunctional Parent-Child Interactions and Mothers' Observed Use of Teaching Behavior During the Free Play Parent-Child Interaction Task

Antecedent		Consequent						
		M (P100 Amp)			Y (Teaching)			
		Coeff.	SE	P		Coeff.	SE	p
X (PSI-DI)	<i>a</i>	-.18	.09	.05	<i>c'</i>	-.23	.16	.17
M (P100 Amp)		-	-	-	<i>b</i>	.42	.24	.09
Constant	<i>i_y</i>	7.12	2.46	.005	<i>i_y</i>	10.70	4.50	.02
$R^2 = .103$				$R^2 = .258$				
$F(4,50) = 1.43, p = .23$				$F(5,49) = 3.42, p = .01$				

Note. $N = 55$; PSI-DI = Parenting Stress Index, Parent-Child Dysfunctional Interaction subscale scores; P100 Amp = mean P100 amplitude averaged across conditions (happy, neutral, distressed) and hemispheres (left, right) in microvolts (μV); Teaching = PICCOLO Teaching subscale scores. Maternal age, target child age, and mothers' history of neglect were included as covariates.

Instead, the best fitting model was a direct effects regression model regressing each variable of interest on PICCOLO teaching subscale scores, $F(5,49) = 3.42, p = .01$. Coefficients for the variables of interest (maternal stress due to dysfunctional parent-child interactions, P100 amplitude) and covariates are shown in Table 18. As indicated, only target child age significantly predicted mothers' teaching behavior in this model, such that as child age increased more maternal teaching behaviors were observed.

Table 18

Direct Effects Regression Model Predicting Mothers' Observed Teaching Behavior from Mothers' Self-Reported Stress Due to Dysfunctional Parent-Child Interactions

	<i>B</i>	<i>SE</i>	<i>t</i>	<i>p</i>	<i>LLCI</i>	<i>ULCI</i>
PICCOLO Teaching Subscale Scores						
Hypothesized Predictors						
PSI-DI	-.23	.16	-1.38	.17	-.55	.10
P100 Amplitude	.42	.24	1.73	.09	-.07	.90
Covariates						
Maternal Age	.04	.11	.33	.74	-.19	.26
Target Child Age	.18	.07	2.60	.01	.04	.32
Maternal History of Neglect	-.12	.06	-1.90	.06	-.24	.01

Note. *N* = 55; CI = 95% confidence interval; *LL* = lower limit; *UL* = upper limit. PSI-DI = Parenting Stress Index, Parent-Child Dysfunctional Interaction subscale Scores; P100 Amplitude = mean P100 amplitude averaged across conditions (happy, neutral, distressed) and hemispheres (left, right) in microvolts (μ V); Maternal Age = mothers' self-reported age in years; Target Child Age = age of mothers' youngest biological child in months; Maternal History of Neglect = mothers' self-reported history of their own experience of early childhood neglect as indexed by the Dubowitz Neglect Scale total scores.

P100 mediation test for PSI-DI and Overall Parenting Quality (PICCOLO total scores). Finally, the direct effect of mothers' self-report stress due to dysfunctional parent-child interactions (PSI-DI subscale scores) and indirect effect of P100 amplitude for infant facial expressions on mothers' observed use of developmentally supportive behaviors during the free play task (PICCOLO Total Scores) were examined using a SPSS PROCESS simple mediation test. Maternal age, target child age, and mothers' self-reported history of childhood neglect were included as covariates. As with the Responsiveness and Teaching subscales, no indirect effect of P100 amplitude on mothers' observed teaching behavior during the parent-child interaction task was observed (Table 19).

Table 19

Model Coefficients for the Mediation Test of P100 Amplitude for Unfamiliar Infant Faces on the Relationship between Maternal Stress Due to Dysfunctional Parent-Child Interactions and Mothers' Observed Use of Developmentally Supportive Behaviors During the Free Play Parent-Child Interaction Task

Antecedent		Consequent						
		M (P100 Amp)			Y (PICCOLO TOTAL)			
		Coeff.	SE	<i>p</i>		Coeff.	SE	<i>p</i>
X (PSI-DI)	<i>A</i>	-.18	.09	.05	<i>c'</i>	-.63	.40	.12
M (P100 Amp)		-	-	-	<i>b</i>	1.16	.59	.06
Constant	<i>i_M</i>	7.12	2.46	.005	<i>i_Y</i>	54.25	11.09	<.001
$R^2 = .103$				$R^2 = .214$				
$F(4,50) = 1.43, p = .24$				$F(5,49) = 2.67, p = .03$				

Note. $N = 55$; PSI-DI = Parenting Stress Index, Parent-Child Dysfunctional Interaction subscale scores; P100 Amp = mean P100 amplitude averaged across conditions (happy, neutral, distressed) and hemispheres (left, right) in microvolts (μV); PICCOLO TOTAL = PICCOLO Total Scores. Maternal age, target child age, and mothers' history of neglect were included as covariates.

Instead, the best fitting model was a direct effects regression model regressing each variable of interest on PICCOLO total scores, $F(5,49) = 2.67, p = .03$. Coefficients for the variables of interest (maternal stress due to dysfunctional parent-child interactions, P100 amplitude) and covariates are shown in Table 20. As indicated, only P100 amplitude approached significance in this model ($p = .06$), such that as P100 amplitudes increased, greater frequencies of developmentally supportive parenting behavior were observed.

Table 20

Direct Effects Regression Model Predicting Mothers' PICCOLO Total Scores from Mothers' Self-Reported Stress Due to Dysfunctional Parent-Child Interactions

	<i>B</i>	<i>SE</i>	<i>t</i>	<i>p</i>	<i>LLCI</i>	<i>ULCI</i>
PICCOLO Total Scores						
Hypothesized Predictors						
PSI-DI	-.63	.40	-1.58	.12	-1.44	.17
P100 Amplitude	1.16	.59	1.96	.06	-.03	2.34
Covariates						
Maternal Age	.14	.28	.52	.60	-.41	.70
Target Child Age	.25	.17	1.45	.15	-.10	.59
Maternal History of Neglect	-.21	.15	-1.34	.19	-.52	.10

Note. *N* = 55; CI = 95% confidence interval; *LL* = lower limit; *UL* = upper limit. PSI-DI = Parenting Stress Index, Dysfunctional Parent-Child Interaction subscale Scores; P100 Amplitude = mean P100 amplitude averaged across conditions (happy, neutral, distressed) and hemispheres (left, right) in microvolts (μ V); Maternal Age = mothers' self-reported age in years; Target Child Age = age of mothers' youngest biological child in months; Maternal History of Neglect = mothers' self-reported history of their own experience of early childhood neglect as indexed by the Dubowitz Neglect Scale total scores.

Chapter Two Summary

In this chapter, the method and results from Study 1 were presented. First, to address Aim 1, mothers' neural responses to unfamiliar infant faces in three conditions (happy, neutral, distressed) were delineated for three ERP components (P100, N170, and P300). Second, to address Aim 2, associations between ERP variables and other study variables of interest (mothers' history of psychosocial adversity, mothers' adversity-related characteristics, and observed maternal behavior) were examined and variables with robust relations with one another were selected for follow-up mediation tests. Exploratory mediation analyses were run to test whether ERPs indirectly accounted for observed relationships between maternal characteristics and observed maternal behavior during free play interaction. P100 amplitude was found to mediate the relationship between mothers' self-reported stress due to parent-child dysfunctional interaction and

observed maternal encouragement during free play. In the next chapter, the method and results from Study 2 are presented to address Aim 3. The purpose of this next investigation was to test whether mothers' neural responses to unfamiliar infant faces change as a function of a strength-based video coaching program that reinforces mothers' attention to visual infant cues.

CHAPTER III

STUDY 2

Method

Participants

The present investigation is part of the Filming Interactions to Nurture Development (FIND) Community Pilot—a small randomized-controlled trial designed to evaluate the impact of a strength-based video-coaching program on low-income mothers of young children living in the Eugene/Springfield area. In this study, mothers ($N = 54$) with young children (ages 12-48 months old) were recruited from the community via fliers posted on public notice boards, community organizations that serve low-income families (e.g., Women, Infants, and Children (WIC), relief nurseries, mental health services providers), free electronic notice boards (e.g., Craigslist), and targeted advertising on Facebook. Mothers were eligible to participate if they were 18 years old or older, English speaking at an eighth grade reading level, reported a household income that would qualify them for low-income community services (i.e., free or reduced school lunch), and had at least one biological child within the target age range. Women were excluded from participating if they were left-handed, had a history of epilepsy or seizures, had an open head wound or head lice, reported current involvement with child protective services (CPS), reported current substance abuse or a history of addiction, had previously participated in a parenting program funded by the study sponsor or were currently participating in a parenting program research study, were uncomfortable being separated from their child for 45 minutes, or reported that they or their child had a

physical or medical condition that would make it uncomfortable to complete the research visits. Of the 443 mothers who initially expressed interest in the study via email, phone, or the lab's website, 173 were not able to be contacted again for screening, 147 were deemed ineligible, 32 people were no longer interested after the study activities were explained, 20 were not able to be scheduled, and 17 did not show up for their initial visit.

At the time of their first research visit, participating mothers ranged in age from 19 to 45 years ($M = 29.57$, $SD = 5.53$). These women were ethnically representative of the urban area in which they resided (88.9% Euro-American/White/Caucasian; 3.7% Hispanic or Latino; 3.7% Asian American; 1.9% African American/Black; and 1.9% Mixed Race), with the exception that no Native Hawaiian or Pacific Islander mothers were recruited. Approximately three quarters of the sample (75.5%) reported a gross annual household income of < \$30,000 with 3.7% < \$5,000; 13.0% \$5,000 - 9,999; 14.8% \$10,000 - 14,999; 11.1% \$15,000 – 19,999; 16.7% \$20,000 – 24,999; 14.8% \$25,000 – 29,999; 9.3% \$30,000 – 39,999; and 14.9% > \$40,000. One participant did not report their household income. A quarter of the women (25.9%) had a bachelor's degree or higher, while 29.6% attended some college or had an associate's degree, 37.0% had a high school diploma or GED, and 7.4% did not graduate from high school. Most reported that they were either married (40.7%) or not married but currently living together with a partner (20.4%). Of the remaining women, 9.3% were divorced, 9.3% separated, and 20.4% reported that they were never married. Approximately half of participants in this sample were first-time mothers (46.3%), whereas 29.6% had two children, 13.0% had three children, 9.3% had four children; and 1.9% had 5 children. For this study, the mothers' youngest biological child was regarded as the target study child. Target study

children in this sample were 53.7% male and ranged in age between 12 and 36 months ($M = 23.65$, $SD = 8.88$).

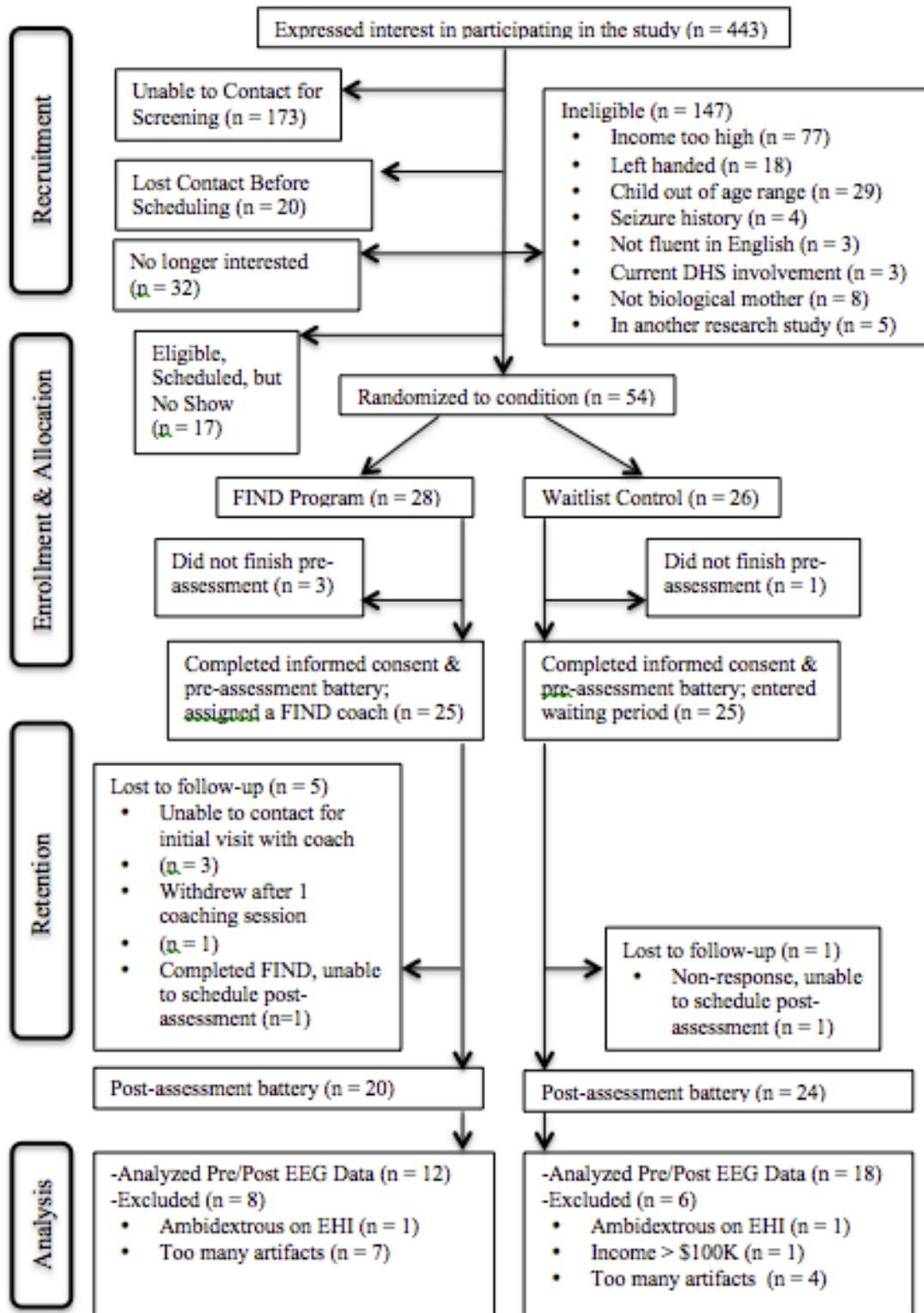
Procedure

All procedures used in this study were approved and monitored by the University of Oregon's Office for the Protection of Human Subjects and written informed consent was obtained from all participants at the beginning of their first study visit (see Appendix B). Prior to enrollment, interested women were screened by phone to determine their eligibility for the study, after which they were scheduled for an initial visit to the laboratory and randomized to condition.

Randomization.

Upon enrollment into the study, participating mothers were randomly assigned to one of two conditions using a random number generator: the FIND condition ($n = 28$) or the Waitlist Control condition ($n = 26$). See Figure 13 for recruitment flow and study retention by group.

Figure 13. FIND Community Pilot Project CONSORT Diagram



Assessment schedule and compensation.

Assessment activities in this study were divided between seven assessment points, which were scheduled over the course of approximately three months. The baseline assessment portion of the study consisted of four assessments: the mother and target child's initial visit to the lab (Visit 1), a phone interview, an in-home language assessment, and an EEG visit with mother only (Visit 2). The follow-up assessment portion of the study consisted of three assessments: the mother and target child's follow-up visit to the lab (Visit 3), a follow-up in-home language assessment, and a follow-up EEG visit with mother only (Visit 4). Participants were compensated a total of \$245 for completing all study activities, which included money to offset the cost of childcare during study activities where the target child could not be present. Participants who dropped out or who elected not to complete some study activities were compensated for the activities they completed according to a prorated payment scheme outlined during the initial informed consent process.

Baseline assessment.

Laboratory Visit 1: Behavioral data collection (mother and target child). During their first visit to the lab, mothers completed informed consent and were briefly oriented to the lab space before beginning assessment activities with the target study child. Assessment activities for this visit included self-report questionnaires administered on a desktop computer via Qualtrics, two filmed parent-child interaction tasks, an orientation to the in-home language acquisition device, and a brief service utilization interview. This visit was approximately two hours in length. Only selected data obtained from Visit 1 are presented here.

Phone interview (mother only). Within one week of completing Visit 1, mothers completed a phone interview approximately 30-60 minutes in length. During this interview, mothers were asked about their experiences of lifetime history of adversity, daily parenting stress, and handedness. Only data obtained from selected phone interview measures are presented here.

In-home language assessment (mother and target child). After completion of Visit 1, mothers were asked to collect 6-8 hours of audio recoding of themselves interacting with the target child during everyday activities in their home environment. These data are not relevant to this study's aims and are, thus, not reported here; the in-home language assessment should not impact other variables of interest.

Laboratory Visits 2: EEG data collection (mother only). During their second visit to the lab, mothers were oriented to the EEG equipment and fitted for the dense-array EEG net. A research assistant explained the experimental procedures and seated each of 256 electrodes and checked electrode impedances. Mothers then completed five EEG tasks in a set order that did not vary across participants: a resting state task, a passive viewing task with infant faces, an active viewing task with infant and adult faces, a go/no-go task, and a flanker task. Only procedures and analyses from the passive viewing task are reported here. The length of visit two ranged from 1-2 hours, varying with the length of electrode seating.

Conditions.

FIND condition. After completing all pre-assessment activities (Visit 1, Phone Interview, Visit 2, and in-home language assessment), participants randomly assigned to the FIND Condition ($n = 28$) were assigned to a FIND coach to meet with in their home

for the duration of the intervention. The FIND program is brief and designed to take place over 10 weekly sessions (approximately 30-45 minutes in duration), which alternate between video-recoding sessions and coaching sessions. Prior to each coaching session, raw film taken of the mother-infant dyad engaging in everyday activities was edited by a FIND editor to select brief examples of the mother engaging in developmentally supportive ‘serve and return’ interactions with her infant. The edited film was presented in a format designed and standardized to facilitate learning and optimize mothers’ engagement. Each edited film featured two still-frame photos at either end of three short video clips, which were each presented three times during each coaching session (once played through with the coach reading descriptive text, once played through with the coach providing frame-by-frame analysis, and then played through a third time to consolidate learning), alongside psychoeducational information about each of five ‘serve and return’ elements. These elements included: (1) sharing the focus; (2) supporting and encouraging; (3) naming; (4) back and forth interaction; and (5) endings and beginnings. More information about the five elements of ‘serve and return’ and the FIND program may be found in Fisher et al. (2016). During the study, participants in the FIND condition were asked to continue any other community services they were utilizing as usual, provided that they did not enroll in any other parenting program research studies.

Waitlist Control condition. Participants randomly assigned to the Waitlist Control condition ($n = 26$) were asked to continue their community service utilization as usual for the duration of the study. After completion of all study assessments, participants in the Waitlist Control condition were offered a group version of the FIND program with other mother-child dyads from Waitlist Control groups across FIND pilot studies being

conducted by the FIND team at the University of Oregon. Participation in group-based FIND after the study's completion was entirely voluntary and the information collected from mothers during group-based FIND was not used for research purposes (see Appendix C for additional information).

Follow-up assessment.

Laboratory Visit 3: Follow-up behavioral data collection (mother and target child). During their third visit to the lab, mothers reviewed informed consent information and were briefly re-oriented to the lab space before beginning assessment activities with the target study child. Assessment activities for this visit were the same as in Visit 1, with the exception that demographic and life-time history of adversity were not assessed again and an additional questionnaire designed by the investigators (Noll & Marquardt) was added to assess participants' experiences of the FIND program. This visit was approximately 1.5 hours in length. Only data obtained from selected self-report questionnaires and the filmed free play interaction task are reported here.

In-home language assessment (mother and target child). After completion of Visit 3, mothers were asked to collect 6-8 hours of audio-recording of them interacting with the target child during everyday activities in their home environment using the exact same procedure as during the baseline assessment. These data are not reported here.

Laboratory Visit 4: Follow-up EEG data collection (mother only). During their fourth and final visit to the lab, mothers were re-oriented to the EEG equipment. A research assistant explained the experimental procedures and seated each of 256 electrodes and checked electrode impedances. Mothers then completed the same five tasks they completed during Visit 2, in the same set order that did not vary across

participants: a resting state task, a passive viewing task with infant faces, an active viewing task with infant and adult faces, a go/no-go task, and a flanker task. Only procedures and analyses from the passive viewing task are reported here. The length of visit four ranged from 1-2 hours, varying with the length of electrode seating. At the end of this visit, participants completed a brief study debriefing.

Self-Report Measures

Handedness. Mothers' handedness was evaluated with the Edinburgh Handedness Inventory (Oldfield, 1971), a 10-item self-report measure that asks respondents to indicate their hand preference for a series of common tasks (e.g., writing, opening a box lid, and using utensils) by placing one or two check marks next to the activity under "right" or "left" depending on the strength of their preference. Respondents who do not have a preference or whose hand preference for the activity is equal for the activity are instructed to place one check mark in both columns. Where an activity requires two hands (e.g., using a broom), the part of the task or object for which hand preference is wanted is indicated in parentheses. The total number of check marks in each column is summed and both a cumulative total and difference score between right and left hand preference is calculated. A handedness score is computed by dividing the difference score by the cumulative total such that resultant scores < -40 indicate the individual is left-handed, scores between -40 and $+40$ indicate they are ambidextrous, and scores $> +40$ indicate they are right handed. In this sample, resultant scores ranged from 20-100 ($M = 93.20$, $SD = 16.52$), indicating that 52 participants (96.3%) were right-handed and 2 participants (3.7%) were ambidextrous. Since strong laterality effects by

hemisphere have been reported in prior work with infant face paradigms, the ambidextrous participants were excluded from the EEG analyses reported in this study.

Analytic Plan

To address Aim 3, the mean peak amplitude and mean latency-to-peak of the P100, N170, and P300 by condition (happy, neutral, distressed) and, where relevant, hemisphere were extracted (using the same method reported in Study 1) for the Visit 2 (pre-assessment) and Visit 4 (post-assessment) EEG data collection waves. After extraction, variables of interest were exported into SPSS Version 24. All variables of interest (mean amplitudes, latencies) were examined for normality and outliers greater than three standard deviations above or below the mean for all participants were identified. Separate repeated-measures analysis of variance (ANOVAs) were utilized to assess whether change in P100 or N170 measures differed as a function of intervention group over time. In these analyses, infant emotional expression (happy, neutral, distressed), hemisphere (left, right), and time (pre, post) were the within-subjects factors, group (FIND, Control) was the between-subjects factor, and demographic variables identified in Study 1 as correlating with ERP measures in this subsample (maternal age, target child age) were included as covariates. Similar analyses were conducted for the P300 amplitude and latency-to-peak, with the exception that hemisphere was omitted as a within-subjects factor. Alpha levels were set at $p < .05$ and effect sizes are presented as partial eta-squared (η^2_{partial}), where .01 represents a small effect size, .06 represents a medium effect size, and .14 represents a large effect size (Cohen, 1988). Where sphericity assumptions were violated, Greenhouse-Geisser (epsilon, $\epsilon < .75$) and Huyn-

Feld corrections (epsilon, $\epsilon > .75$) were utilized. Bonferroni corrections were used to adjust for multiple comparisons in post-hoc tests.

Results

Demographics

Mothers who dropped out of the study prior to completion of all study activities (8 FIND, 2 control) were significantly younger ($M = 26.00$, $SD = 4.35$) than mothers who completed all study activities ($M = 30.39$, $SD = 5.40$), $t(52) = 2.36$, $p = .022$, but did not differ on any other demographic or self-report measures collected at baseline ($ps > .13$). Of the participants who completed the study ($N = 54$), mothers randomly assigned to the FIND condition ($n = 28$) did not differ from mothers randomly assigned to the Waitlist Control condition ($n = 26$) with respect to mother's age, number of children, target child's age, or history of adverse childhood experiences ($ps > .30$). Likewise, mothers whose EEG data had too many artifacts to analyze or who were excluded for other reasons (i.e., income too high, ambidextrous on the EHI), and who were thus dropped from the ERP analyses presented here ($n = 14$), did not differ on any demographic variables from mothers whose data was included ($ps > .23$). Means and standard deviations of participants' demographics by intervention group and in the full sample for Study 2 ($N = 30$), as reported at baseline, are presented in Table 21.

Table 21*Means and Standard Deviations for Demographic Variables in Study 2 by Condition*

	Group					
	FIND (<i>n</i> = 12)		Waitlist Control (<i>n</i> = 18)		Full Sample (<i>N</i> = 30)	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Maternal Age	30.17	5.97	30.28	6.11	30.23	5.95
Income*	3.73	1.74	5.39	2.17	4.76	2.15
Education	3.00	1.13	2.78	.94	2.87	1.01
Age of TC	22.50	9.07	23.28	9.47	22.97	9.16
# of Children	1.92	.79	1.89	1.23	1.90	1.01

Note. * One mother in the FIND condition did not report her gross household income. Maternal Age = maternal age (years); Income = annual household gross income reported on a continuous scale where 1 = < \$4,999, 2 = \$5,000 – 9,999, 3 = \$10,000 – 14,999, 4 = \$15,000 – 19,999, 5 = \$20,000 – 24,999, 6 = \$25,000 – 29,999, 7 = \$30,000 – 39,999, 8 = \$40,000 – 49,999, 9 = \$50,000 – 59,000; Education = highest level of education achieved reported on a continuous scale where 1 = did not graduate from high school, 2 = earned a high school diploma or GED, 3 = completed some college or an associate’s degree, 4 = earned a bachelor’s degree, 5 = graduate education or beyond; Age of TC = age of target child (months); and # of children = total number of biological children.

ERP Measure Normality and Outliers

All ERP variables were normally distributed (skewedness values between -2 and +2). Two outliers were identified as being more than three standard deviations below the mean of the total sample for N170 amplitudes for distressed infant faces in the left hemisphere and one outlier was identified as being more than three standard deviations below the mean of the total sample for N170 amplitudes for happy infant faces in the left hemisphere. All analyses were run both with and without these outliers and results of parametric tests did not differ.

ERP Amplitudes by Group and Assessment Wave

Means and standard deviations for ERP amplitude measures by group and assessment wave are shown in Table 22.

Table 22

Means and Standard Deviations for ERP Amplitudes by Group and Assessment Wave

	Pre-Assessment		Post-Assessment	
	FIND	Control	FIND	Control
	(<i>n</i> = 12)	(<i>n</i> = 18)	(<i>n</i> = 12)	(<i>n</i> = 18)
	<i>M</i> (<i>SD</i>)			
<u>P100 Amplitude</u>				
Happy–L	7.34 (5.09)	5.48 (4.58)	1.85 (8.68)	1.78 (8.85)
Happy–R	4.28 (7.57)	5.83 (5.31)	4.66 (5.55)	9.35 (4.50)
Neutral–L	7.54 (3.64)	4.63 (4.70)	3.16 (8.43)	1.41 (9.93)
Neutral–R	5.86 (7.46)	4.64 (6.50)	6.35 (4.93)	9.58 (5.28)
Distressed–L	6.50 (4.91)	4.97 (4.47)	2.81 (8.71)	1.60 (8.82)
Distressed–R	2.60 (7.44)	5.59 (6.39)	5.51 (5.62)	9.40 (4.72)
<u>N170 Amplitude</u>				
Happy–L	0.76 (5.46)	-2.18 (4.32)	-3.53 (7.78)	-5.16 (8.90)
Happy–R	-3.92 (10.15)	-3.22 (6.37)	-4.01 (5.86)	1.11 (4.93)
Neutral–L	0.22 (4.75)	-2.53 (5.32)	-2.79 (8.04)	-5.45 (9.55)
Neutral–R	-4.06 (10.19)	-4.28 (8.11)	-1.92 (6.77)	1.90 (5.71)
Distressed–L	0.08 (5.44)	-2.18 (4.53)	-2.56 (7.46)	-4.96 (8.88)
Distressed–R	-6.10 (10.18)	-3.84 (7.40)	-2.78 (6.20)	0.99 (6.39)
<u>P300 Amplitude</u>				
Happy	6.58 (8.32)	8.63 (4.98)	4.17 (11.46)	6.35 (7.39)
Neutral	5.59 (8.10)	8.04 (4.41)	4.36 (10.91)	7.70 (6.03)
Distressed	6.54 (8.34)	8.46 (4.71)	3.89 (11.47)	6.69 (8.39)

Note. P100 Amplitude = mean peak P100 amplitude (microvolts, μV); N170 Amplitude = mean peak N170 amplitude (microvolts, μV); P300 Amplitude = mean peak P300 amplitude (microvolts, μV); L = left hemisphere; R = right hemisphere.

ERP Latencies by Group and Assessment Wave

Means and standard deviations for ERP latency-to-peak measures by group and assessment wave are shown in Table 23.

Table 23*Means and Standard Deviations for ERP Latencies by Group and Assessment Wave*

	Pre-Assessment		Post-Assessment	
	FIND	Control	FIND	Control
	(<i>n</i> = 12)	(<i>n</i> = 18)	(<i>n</i> = 12)	(<i>n</i> = 18)
	<i>M</i> (<i>SD</i>)			
<u>P100 Latency</u>				
Happy–L	99.08 (14.21)	90.70 (14.66)	99.38 (14.45)	98.81 (14.02)
Happy–R	98.12 (14.43)	89.74 (11.05)	102.46 (13.67)	95.19 (10.27)
Neutral–L	101.00 (13.92)	92.15 (13.58)	98.10 (17.16)	96.18 (13.58)
Neutral–R	97.28 (13.71)	95.99 (10.94)	99.16 (16.20)	96.87 (9.48)
Distressed–L	97.81 (17.44)	95.82 (14.96)	99.82 (19.64)	98.05 (12.78)
Distressed–R	100.31 (15.63)	95.35 (13.44)	97.20 (16.45)	93.48 (11.75)
<u>N170 Latency</u>				
Happy–L	155.93 (15.66)	146.59 (12.22)	152.32 (14.74)	148.31 (11.68)
Happy–R	153.06 (14.47)	145.97 (10.56)	153.65 (12.83)	145.54 (9.13)
Neutral–L	152.59 (12.84)	147.29 (10.74)	149.99 (14.40)	148.21 (11.65)
Neutral–R	149.30 (8.94)	145.89 (10.28)	153.95 (14.43)	146.64 (12.53)
Distressed–L	155.54 (13.83)	148.94 (9.14)	148.88 (8.95)	148.37 (13.79)
Distressed–R	150.73 (13.19)	146.18 (10.11)	152.07 (13.73)	146.97 (10.23)
<u>P300 Latency</u>				
Happy	272.79 (88.00)	303.79 (79.30)	270.17 (79.98)	289.43 (64.70)
Neutral	272.80 (71.49)	300.88 (66.39)	292.74 (81.30)	258.27 (60.36)
Distressed	288.25 (97.70)	296.71 (76.35)	282.30 (78.41)	283.58 (82.74)

Note. P100 Latency = mean P100 latency-to-peak (milliseconds, ms); N170 Latency = mean N170 latency-to-peak (milliseconds, ms); P300 Latency = mean P300 latency-to-peak (milliseconds, ms); L = left hemisphere; R = right hemisphere.

Intervention Effects

A series of repeated-measures ANOVAs were conducted to assess the impact of the FIND intervention on mothers' neural responses to unfamiliar infant faces for each ERP (P100, N170, P300) mean peak amplitude and latency-to-peak measures. For P100 and N170 tests, infant emotional expression (happy, neutral, distressed), hemisphere (left, right), and time (pre, post) were the within-subjects factors, group (FIND, Control) was the between subjects factor, and key demographic variables (maternal age, target child

age) were entered as covariates. For P300 tests, infant emotional expression (happy, neutral, distressed) and time (pre, post) were the within-subjects factors, group (FIND, Control) was the between subjects factor, and key demographic variables (maternal age, target child age) were entered as covariates.

P100 Amplitude. After controlling for maternal age, $F(1,24) = .270, p = .608, \eta^2_{\text{partial}} = .011$, observed power = .079, and target child age, $F(1,24) = 1.052, p = .314, \eta^2_{\text{partial}} = .042$, observed power = .166, a significant Emotion x Time x Group interaction effect was observed, $F(2,48) = 3.36, p = .043, \eta^2_{\text{partial}} = .123$, observed power = .619. Post-hoc comparisons indicated that all conditions differed by group over time and that this effect was driven by the decrease in P100 amplitudes in the FIND condition, compared with the P100 amplitudes for the Control condition, which increased or stayed the same (see Figure 14). The within-subject effect of time alone on P100 amplitude was not significant, $F(1,24) = .266, p = .611, \eta^2_{\text{partial}} = .011$, observed power = .079. No other Group x Time interaction effects were observed ($ps > .05$).

Figure 14. Change in P100 Amplitude by Group

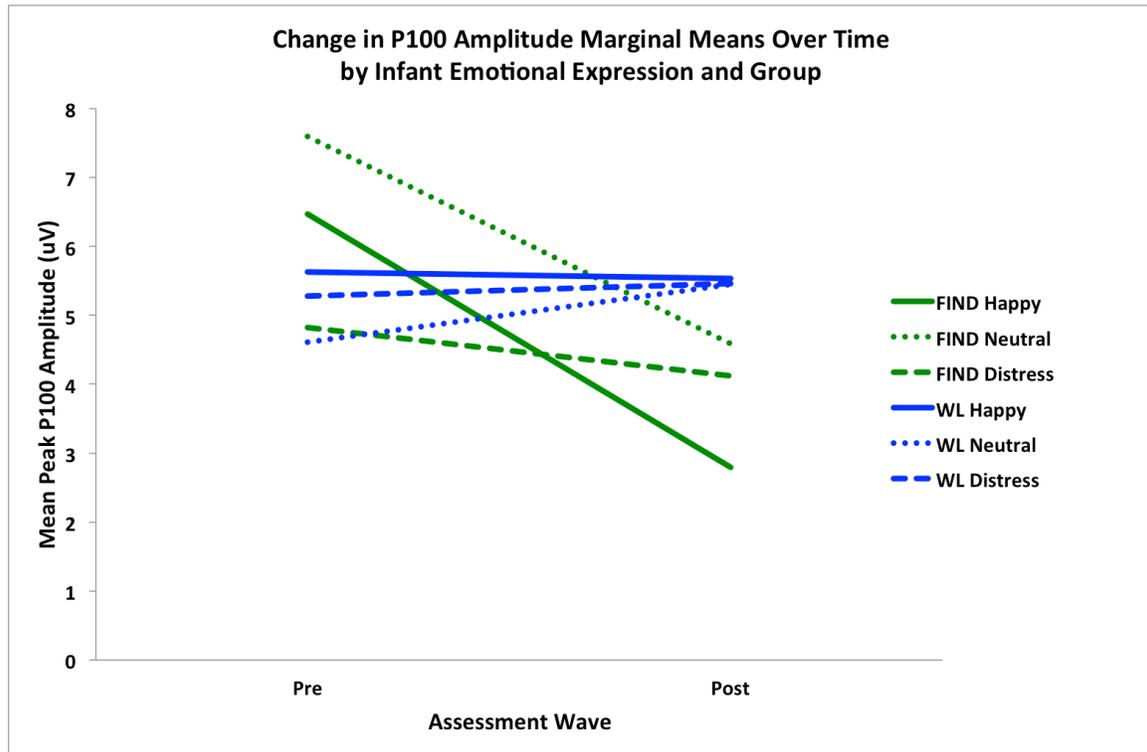


Figure 14. Change in P100 amplitude marginal means (microvolts, uV) over time (pre, post) by infant emotional expression (happy, neutral, distress), and intervention group (FIND, Waitlist Control) after controlling for maternal age and target child age. Note: FIND = Intervention group; WL = Waitlist Control group; Pre = Pre-assessment; Post = Post-assessment.

P100 Latency. After controlling for maternal age $F(1,24) = .243, p = .626, \eta^2_{\text{partial}} = .010$, observed power = .076, and target child age, $F(1,24) = .970, p = .335, \eta^2_{\text{partial}} = .039$, observed power = .157, a trend-level Hemisphere x Time x Group interaction effect was observed $F(1,24) = 4.098, p = .054, \eta^2_{\text{partial}} = .146$, observed power = .493. Post-hoc comparisons indicated that P100 latencies for the left hemisphere decreased (got faster) for mothers in the FIND condition and increased (got slower) for mothers in the Waitlist Control condition (see Figure 15). By contrast, P100 latencies for both groups increased over time in the right hemisphere. The within-subject effect of time alone on P100

latency was not significant, $F(1,24) = 2.562, p = .123, \eta^2_{\text{partial}} = .086$, observed power = .336. No other Group x Time interaction effects were observed ($ps > .05$).

Figure 15. Change in P100 Latency by Group

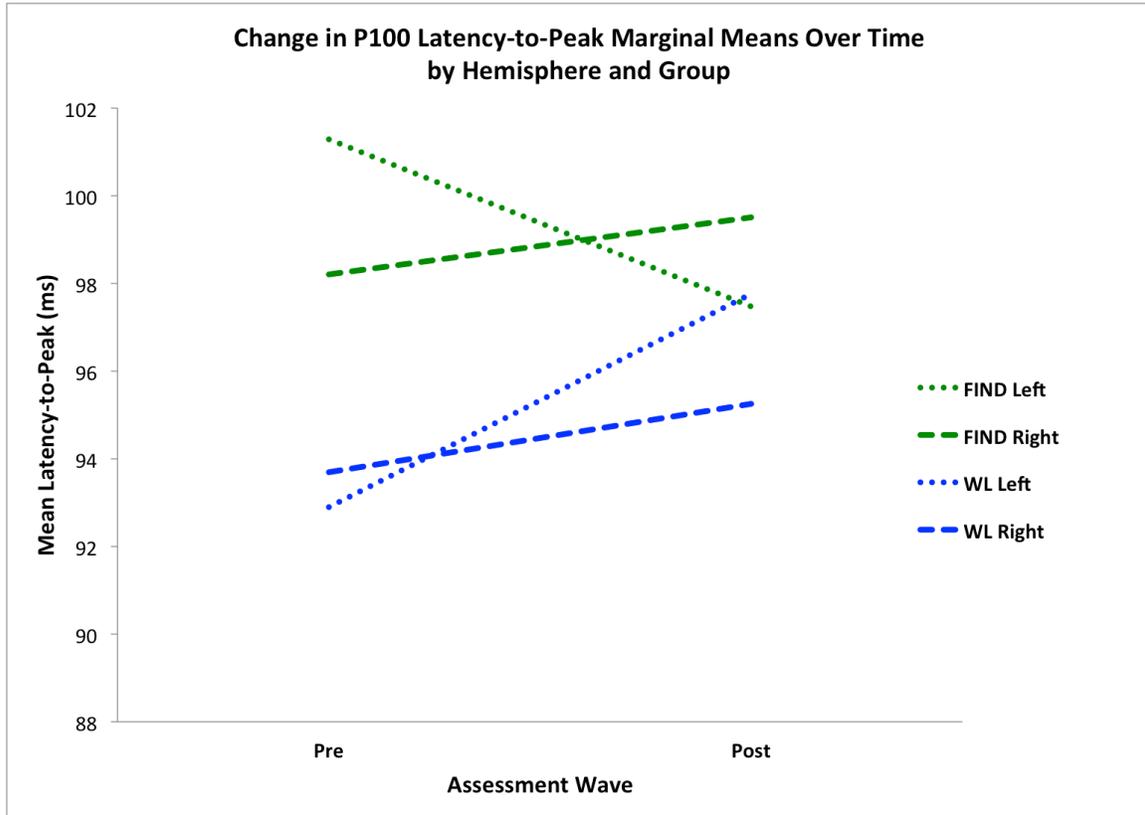


Figure 15. Change in P100 latency-to-peak marginal means (milliseconds, ms) over time (pre, post) by hemisphere (left, right), and intervention group (FIND, Waitlist Control) after controlling for maternal age and target child age. Note: FIND = Intervention group; WL = Waitlist Control group; Pre = Pre-assessment; Post = Post-assessment.

N170 Amplitude. Mauchly's test indicated that the assumption of sphericity for infant emotional expression had been violated, $X^2(2) = 5.96, p = .05$, therefore the degrees of freedom were adjusted using the Huynh-Feldt correction, epsilon (ϵ) = .974. After controlling for maternal age, $F(1,24) = .073, p = .790, \eta^2_{\text{partial}} = .003$, observed power = .058, and target child age, $F(1,24) = 2.810, p = .107, \eta^2_{\text{partial}} = .105$, observed power = .363, a trend level Emotion x Time x Group interaction effect was observed,

$F(2,48) = 2.958, p = .06, \eta^2_{\text{partial}} = .110$, observed power = .549. Post-hoc comparisons indicated that this effect was driven by a decrease in marginal means between the pre- and post-assessment waves for mothers in the FIND condition for all three infant emotional expressions, compared to an increase in marginal means for mothers in the Control condition (see Figure 16). In other words, after controlling for demographic variables, N170 amplitudes for mothers randomly assigned to the FIND condition became less negative after the coaching program. The within-subjects effect of time alone was not significant, $F(1,24) = .585, p = .452, \eta^2_{\text{partial}} = .024$, observed power = .114. No other Group x Time interaction effects were observed ($ps > .05$).

Figure 16. Change in N170 Amplitude by Group

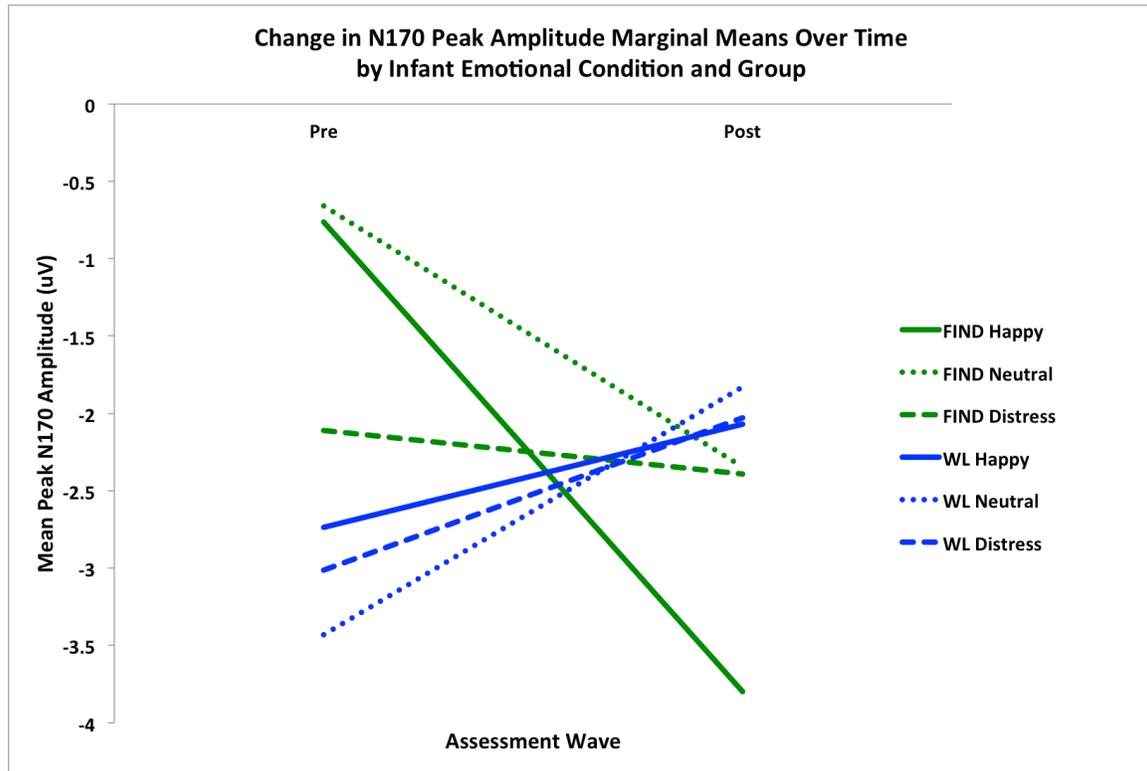


Figure 16. Change in N170 amplitude marginal means (microvolts, uV) over time (pre, post) by infant emotional expression (happy, neutral, distress) and intervention group (FIND, Waitlist Control), after controlling for maternal age and target child age. Note: FIND = Intervention group; WL = Waitlist Control group; Pre = Pre-assessment; Post = Post-assessment.

N170 Latency. Mauchly's test indicated that the assumption of sphericity for infant emotional expression had been violated, $X^2(2) = 16.171, p < .001$, therefore the degrees of freedom were adjusted using the Huynh-Feldt correction for infant emotional expression, epsilon (ϵ) = .777, Emotion x Hemisphere, epsilon (ϵ) = .962, and Emotion x Hemisphere x Time, epsilon (ϵ) = .869. After controlling for maternal age, $F(1,24) = .639, p = .432, \eta^2_{\text{partial}} = .026$, observed power = .120, and the main effect of target child age, $F(1,24) = 7.820, p = .01, \eta^2_{\text{partial}} = .246$, observed power = .765, a trend level Hemisphere x Time x Group interaction effect was observed, $F(1,24) = 3.609, p = .07, \eta^2_{\text{partial}} = .131$, observed power = .446. Post-hoc comparisons indicated that this effect was

driven by a decrease in FIND mothers' N170 latencies in the left hemisphere and increase in N170 latencies in the right hemisphere (see Figure 17). The within-subjects effect of time alone was not significant, $F(1,24) = 2.436, p = .132, \eta^2_{\text{partial}} = .092$, observed power = .323. No other Group x Time interaction effects were observed ($ps > .05$).

Figure 17. Change in N170 Latency by Group

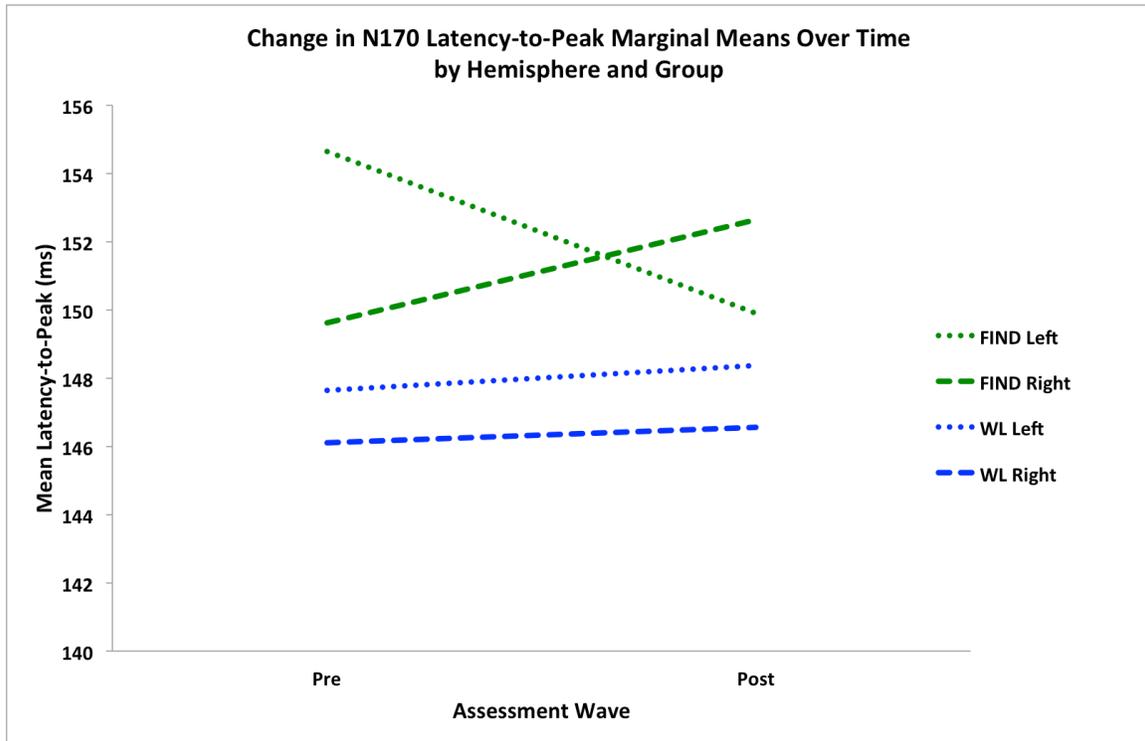


Figure 17. Change in N170 latency-to-peak marginal means (milliseconds, ms) over time (pre, post) by hemisphere (left, right), and intervention group (FIND, Waitlist Control) after controlling for maternal age and target child age. Note: FIND = Intervention group; WL = Waitlist Control group; Pre = Pre-assessment; Post = Post-assessment.

P300 Amplitude. No significant Group x Time interaction effects were observed for mean peak P300 amplitudes nor was the within-subjects effect of time alone significant ($ps > .05$).

P300 Latency. No significant Group x Time interaction effects were observed for mean P300 latency-to-peak nor was the within-subjects effect of time alone significant ($ps > .05$).

Chapter Three Summary

In this chapter, the method and results from Study 2 were presented. The purpose of this study was to assess whether low-income mothers' neural responses to unfamiliar infant faces were sensitive to change via the Filming Interactions to Nurture Development (FIND) video-coaching program (Aim 3). Although several group by time intervention effects were observed for the P100 and N170 ERP components, they were mostly in the opposite direction hypothesized. No intervention effects were observed for the P300. In the following chapter, these results are discussed and integrated with those of Chapter Two, alongside an explication of study limitations and directions for future research.

CHAPTER IV

INTEGRATED DISCUSSION

The purpose of this investigation was to characterize caregivers' neural responses to unfamiliar infant faces in a sample of mothers raising young children under conditions of economic adversity. To achieve this goal, this study utilized an event-related potential (ERP) paradigm—in combination with self-report and observational measures—to examine the temporal dynamics of mothers' infant cue processing and its relationship to other aspects of parental function. Three ERP components examined in prior work with caregivers (i.e., the P100, N170, and P300) were utilized to index the temporal dynamics of infant cue processing and two separate sets of analyses (Study 1 and Study 2) were conducted. Broadly speaking, the data collected in this investigation suggest that, for mothers raising young children under conditions of economic adversity, the parental brain begins differentiating between infant emotional expressions very early in the temporal course of stimulus perception and that mothers' ERPs for unfamiliar infant faces are associated with other aspects of parental function, including self-reported experience and observable caregiving behavior. Specifically, individual differences neural responses to infant faces as early as 100 ms post-stimulus onset differed significantly by infant emotional expression and, moreover, correlated strongly with individual differences in developmentally supportive parenting behavior, such that larger neural responses (i.e., greater mean peak amplitudes) were associated with higher quality parenting. Preliminary analyses suggest that ERPs for unfamiliar infant faces are sensitive to change with intervention, although differently than predicted. In the sections that follow, the results of the current investigation are discussed with reference to the

specific aims of the project, prior literature, their clinical implications, and directions for future research.

Aim 1

The first aim of this study was to delineate low-income mothers' neural responses to unfamiliar infant faces in three conditions (happy, neutral, and distressed) under passive viewing conditions. To address this aim, separate repeated-measures analysis of variance (ANOVAs) were utilized to assess modulation of the P100, N170, and P300 by infant emotional expression during a passive viewing paradigm that was designed for this purpose. In Study 1, a combined sample of mothers ($N=70$) raising young children (ages four and under) under conditions of economic adversity was drawn from two pilot datasets that utilized the same EEG assessment protocol to test the hypotheses associated with this aim.

Neural responses to unfamiliar infant faces at the P100. First, the P100 (an ERP component indexing early stimulus detection) was characterized. Since prior ERP work with mothers has not found the P100 to be modulated by the emotional valence of infant facial expression or to exhibit the laterality effects exhibited in non-parent populations (e.g., Proverbio et al., 2006; Noll et al., 2012), I predicted that neither the mean peak P100 amplitude or P100 latency-to-peak would be modulated by infant emotional expression or hemisphere in this study. Contrary to these predictions, a main effect for emotion was observed, such that happy infant facial expressions elicited significantly larger mean peak P100 amplitudes than distressed infant facial expressions; and no significant differences were observed between neutral infant facial expressions and the two emotional infant facial expressions (happiness, distress). These results were

surprising. Since prior research suggests that the P100 is strongly modulated by selective attention (Bornstein, Arterberry, & Mash, 2013; Van Voorhis & Hilyard, 1977), it is possible that these results indicate that mothers in this sample attended the more to happy infant faces than distressed infant faces in a manner that co-varies with parental function (see Aim 2). By extension, selective attention for happy infant faces may differ from caregivers who are not parenting under conditions of economic adversity. To further explore this possibility, I plan to integrate eye tracking with this ERP paradigm and quantify the gaze patterns mothers from different socioeconomic backgrounds utilize when processing unfamiliar infant faces to discern whether they attend to emotional visual stimuli differently across conditions. This future work will also explore the role the intensity of infant emotional expression plays in modulating caregivers' selective attention for infant visual cues.

In the current study, I did not control for intensity of infant emotional expression, which varied slightly across face images. As such, it is possible that the intensity of emotional expression represents an unmeasured confound that impacted selective attention. However, this is unlikely, since intensity of expression has been shown in prior work to predict P100 latency (e.g., Peltola et al., 2014) and in this study no main effect of emotion was observed for P100 latency.

Although no main effect was observed for modulation of the P100 by hemisphere, a significant emotion by hemisphere cross-over interaction effect was observed for both P100 amplitude and P100 latency, such that neural responses to distressed infant faces were smallest in amplitude yet fastest in the right hemisphere, whereas responses to happy infant faces were largest in amplitude and slowest in the left hemisphere. This

finding is consistent with the Valence-Specific Hypothesis of emotional perception, which posits that although both hemispheres contribute to the processing of emotional stimuli, the left hemisphere is dominant for positive emotions, whereas the right hemisphere plays a greater role in processing negative emotions (Adolphs, Jansari, & Tranel, 2001; Davidson, 1992; Fusar-Poli et al., 2009). Taken together, these findings indicate that, in this sample, neural differentiation of infant emotion occurred as early as 100 ms post-stimulus onset, that this differentiation was indexed most strongly by ERP amplitude not latency, and that mothers processed infant emotions differently in the left and right hemispheres.

Neural responses to unfamiliar infant faces at the N170. Second, the N170 (an ERP component indexing early perceptual processing and pre-attentive face processing) was examined. Given previous work documenting significant differences in N170 response to infant faces by emotional condition (e.g., Doi & Shinohara, 2012b; Colasante, Mossad, Dudek, & Haley, 2017) and the theoretical importance of rapid detection of infant distress for survival, I predicted that N170 amplitude would be largest and N170 latency would be fastest for distressed infant faces and, furthermore, that these effects would be largest in the right hemisphere. These hypotheses were partially supported by the study results. Specifically, a main effect for infant emotion was observed for N170 amplitude, such that distressed infant faces exhibited the largest negative deflection, followed by neutral infant faces, with happy infant faces exhibiting the smallest mean N170 peak.

Although—as with the P100—no main effect for hemisphere was observed, a within-subjects emotion by hemisphere interaction effect approached significance ($p =$

.075) and post-hoc tests indicated that N170 amplitudes were larger (more negative) in the right hemisphere compared to the left hemisphere. This is consistent with prior studies, which suggest the brain exhibits strong laterality in the early perceptual processing of emotional human faces (Kanwisher, McDermott, & Chun, 1997), including infant faces (Proverbio et al., 2006), and that the right hemisphere is dominant for processing of negatively valenced emotional stimuli in right-handed individuals (Fusar-Poli et al., 2009).

Contrary to my predictions, no significant effects were observed for N170 latency. However, N170 latency responses did differ as a function of parity, such that first-time mothers exhibited faster N170 latency-to-peak for unfamiliar infant faces than mothers who had more than one biological child. Interestingly, this finding is at odds with one recent study conducted with a similar size sample of community mothers not at elevated risk due to economic adversity, which did not find the N170 for unfamiliar infant faces to be modulated by parity (Maupin et al., 2018), possibility indicating that the impact of parity on early ERPs for infant faces is more pronounced in higher risk populations. Since other prior work documenting N170 latency effects has rarely include parity as a between-subjects variable, the findings of the current study suggest that prior caregiving experience may represent an unmeasured third variable in such studies that have conflicting findings.

Neural responses to unfamiliar infant faces at the P300. Finally, mothers' neural responses at the P300 (an ERP component indexing late salience detection and resource allocation) were delineated. Consistent with Johnson's (1984, 1986) postulate that uncertainty, stimulus probability, and resource allocation all contribute to P300

amplitude and the fact that the passive viewing paradigm used in the current study was designed to hold the probability of each emotional expression (happy, neutral, distressed) constant, I predicted that the amplitude of the P300 would differ significantly by condition in a manner that reflects the differential neural resources theoretically needed to process each type of facial expression (i.e., that neutral infant facial expression would elicit significantly greater P300 amplitudes than distressed or happy faces). Data in this study did not support this hypothesis and no evidence was found that P300 amplitude or latency-to-peak were modulated by the valence of infant emotional expression. However, since I did not directly measure mothers' certainty with respect to their perceptual processing of the infant faces in this study, I can not be sure that the absence of an effect for emotional expression was not confounded by individual differences in uncertainty. Future work could explore this by separately measuring mothers' certainty via an emotion categorization paradigm after passive viewing data has been collected. Although the absence of P300 modulation by infant facial expression was surprising, it is consistent with the results of another study conducted by Rutherford and colleagues (2017) with low-risk mothers that also found no main effect for infant emotional expression at the P300. As such, it is possible that the neural processes involved at this temporal phase of emotion processing (i.e., those underpinning salience detection and resource allocation) operate independently of the emotional valence of the stimulus.

Aim 2

Although the delineation of mothers' neural responses to unfamiliar infant faces is an important subject of study in its own right (with the potential to inform our general understanding of how the human brain processes emotional stimuli of evolutionary

importance), one could argue that these neural response patterns are only useful insofar as we understand how they relate to other aspects of parents' subjective experience and caregiving behavior. As such, the second aim of this study was to examine the relationship between low-income mothers' neural response to unfamiliar infant faces, aspects of maternal experience known to co-vary with caregiving quality (i.e., maternal adversity-related characteristics), and observed caregiving behavior. As this is the first study to explore the relationship between neural responses to unfamiliar faces and parental function in mothers raising young children under conditions of economic adversity, the results reported in this investigation must be treated as exploratory and interpreted with caution.

Neural responses to unfamiliar infant faces and mothers' history of psychosocial adversity. First, as expected, no significant associations were observed between mothers' neural responses to unfamiliar infant faces and their self-reported lifetime history of psychosocial adversity, which included adverse childhood experiences, betrayal trauma, childhood neglect, and their lifetime history of experiencing, witnessing, or learning about potentially traumatic events. As previously noted, individual reactions to childhood abuse and neglect (and psychosocial adversity, more generally) differ greatly and marked heterogeneity in responses to adversity exists (Noll, Clark, & Skowron, 2016). As such, although exposure to psychosocial adversity may impact the neural processing of infant cues indirectly via its effect on mothers' mental and physical wellbeing, no evidence from this study indicates that these variables exert a direct effect on mothers' neural responses to infant visual cues. Although it was beyond the scope of this investigation, in future work I plan to examine the potential moderating effects of

mothers' experiences of childhood adversity and lifetime exposure to potentially traumatic events on the associations observed in this study between mothers' neural responses to infant faces and other aspects of parental function.

Second, the relationship between mothers' neural responses to unfamiliar infant faces and their self-reported mental health symptoms, difficulties with emotion regulation, parental reflective functioning, and subjective experiences of parenting were examined. Self-report variables in these domains were selected for this exploratory work because each has been shown in prior research to co-vary with parenting quality. As expected, some but not all self-report measures correlated significantly with mothers' ERPs for infant faces.

ERPs and maternal mental health. In the domain of mental health symptoms, mothers' self-reported symptoms of depression and post-traumatic stress disorder (PTSD) were not associated with neural responses to unfamiliar infant faces in this sample. This was surprising as prior neuroimaging work documents significant associations between exposure to PTSD due to interpersonal violence and differential brain responses (compared to mothers without PTSD) to filmed interactions with infants (Schechter et al., 2012), significant associations between subclinical levels of depression and ERP responses to unfamiliar infant faces (Noll, Rutherford, & Mayes, 2012), and attenuated P300 responses to distressed infant faces during pregnancy (Rutherford, Graber, & Mayes, 2015). However, the demographic characteristics of the current sample (i.e., predominantly Caucasian mothers from the West Coast who are parenting under conditions of economic adversity) were significantly different from those in the aforementioned studies, insofar as the latter were markedly more heterogeneous with

respect to their demographic composition, on the one hand, and less varied with respect to participants' parenting experience, on the other. As such, it is possible that depression and PTSD do not co-vary with individual differences in neural responses to infant cues the same way in populations already at elevated risk for aberrations in caregiver function due to economic adversity or with a wide range of caregiving experience.

Despite the null findings for PTSD and depression symptoms in the current study, strong associations between mothers' self-reported anxiety and mean peak P100 amplitudes were observed, such that higher levels of anxiety were correlated with lower peak amplitudes across emotional conditions. This suggests that maternal anxiety may reduce early selective attention for infant faces in this population or vice versa. A similar association was also observed between anxiety and mean peak N170 amplitude in the left hemisphere (i.e., the hemisphere believed to be dominant for the processing of positive emotional stimuli), such that happy faces elicited larger peak amplitudes. Since depression and anxiety have high comorbidity in community samples (Preisig, Merikangas, & Angst, 2001; Ruscio & Khazanov, 2017) and PTSD is regarded as an anxiety disorder, it would be interesting to explore the implications of various profiles of mental health diagnoses (e.g., neural responses in mothers with PTSD, depression, and anxiety vs. anxiety alone, etc.) via an ideographic analytic approach. Such future studies may benefit from examination of both ERPs and EEG power analyses, as complex associations between negative affect (i.e., subclinical levels of depression and anxiety) and EEG alpha asymmetry (Mathersul, Williams, Hopkinson, & Kemp, 2008) have been observed. Furthermore, exploring these relationships in samples with more narrow child age inclusion criteria might provide useful information about the associations between

mental health symptoms and neural processing of infant cues during different phases of the perinatal period.

ERPs and difficulties with emotion regulation. With respect to mothers' self-reported difficulties with emotion regulation, several notable associations were observed between subscale scores on the Difficulties with Emotion Regulation Scale (DERS) and latency-to-peak for the P100 and N170 ERP components. Specifically, with respect to early stimulus detection and pre-attentive face processing, slower P100 and N170 latency-to-peak measures for infant faces in the right hemisphere were associated with greater difficulties engaging in goal-directed behavior, possibly indicating that individual difference in early stimulus perception of infant faces has downstream implications for the coordination of more complex goal-directed behavior or vice versa. One possibility is that slower latency-to-peak for these components indexes individual differences in decoding speed for emotional stimuli, as a positive association was also observed between mothers' self-reported lack of emotional awareness and N170 latencies for neutral infant faces (which are theoretically the most difficult to decode) in the right hemisphere, such that greater difficulty with emotional awareness was associated with slower N170 latencies for neutral infant faces. This interpretation is consistent with the results of one study that compared infant emotion recognition abilities of mothers with Borderline Personality Disorder (BPD)—who had significantly elevated DERS scores—to healthy controls, which found that mothers with BPD were more likely to categorize neutral infant faces as sad (Elliot et al., 2014), as well as other ERP work that has documented aberrations in adult face processing in women with BPD (Hidalgo et al., 2016). Examining the relationship between neural responses to infant faces in low-

income caregivers with and without a BPD diagnosis may represent an important site of future research to further explore the relationship between emotion regulation difficulties and the temporal dynamics of infant cue processing in caregivers of young children.

With respect to mothers' self-reported difficulties with impulse control, two seemingly divergent findings were observed. On the one hand, faster P100 latency-to-peak for neutral faces in the left hemisphere was associated with greater difficulties with impulse control; and on the other, mothers' difficulty with impulse control was positively associated with N170 latency-to-peak for distressed infant faces in the right hemisphere, such that greater difficulties in these areas of emotion regulation were associated with slower N170 latency-to-peak for distressed infant faces. One interpretation of these results is that more rapid reactivity to ambiguous infant cues relates to dysregulated activation of approach circuitry (which is dominant in the left hemisphere), whereas slower reactivity to distress cues relates to dysregulated activation of avoidance circuitry (which is dominant in the right hemisphere). However, further work is needed to explore these associations. Since associations with other infant emotional expressions were not observed, it is possible that these correlations are simply spurious and, thus, replication in an independent sample and convergent data from behavior measures of dysregulation are needed to make strong inferences about the relationship between the temporal dynamics of early infant cue processing and self-reported difficulties with emotion regulation.

ERPs and mothers' experiences of parenting. In the domain of mothers' self-reported experiences of parenting (stress, reward, and self-efficacy) several notable associations were observed. With respect to mothers' parenting stress, a negative association was observed between P100 amplitude and the Parenting Stress Index,

Dysfunctional Parent-Child Interactions (PSI-DI) subscale across conditions and hemispheres, such that smaller P100 neural responses to infant faces were associated with greater self-reported dysfunctional interactions between mothers and their young children. Since this was one of the most robust associations observed in this study (insofar as the associations held across conditions and hemispheres), it was selected for further examination (as discussed below). With respect to parenting reward, a positive association was observed between N170 amplitude for distressed infant faces in the right hemisphere and self-reported parenting reward (PRQ total scores), such that smaller (less negative) deflections at the N170 were associated with greater parenting reward, possibly suggesting that lower activation of withdraw circuitry in response to infant distress is associated with greater parenting reward. However, future work with other neuroimaging methods with high spatial resolution (e.g., fMRI, MEG) is needed to examine the relationship between withdrawal circuit activation and parenting reward.

Interestingly, both self-reported parenting reward (PRQ total scores) and parenting self-efficacy (PSOC total scores) were associated with N170 latency-to-peak, suggesting that not only the magnitude of neural response but also its timing is associated with these domains of parental experience. Specifically, slower latency-to-peak correlated with greater parenting reward in some conditions, possibly suggesting that more in-depth or complex processing during infant emotion decoding is associated with greater recruitment of reward circuitry. However, since these associations did not remain significant when averaging across conditions or hemispheres, replication is needed to confirm that they are not spurious and, regardless, convergent multimodal work with fMRI or MEG is needed to better understand the functional significance of these results.

Similarly, faster latency-to-peak for some infant faces in the right hemisphere was associated with greater parenting self-efficacy, possibly indicating greater confidence with infant emotion decoding is associated with faster latencies. However, as with the PRQ, these relationships did not remain significant after averaging across conditions and hemispheres and, hence, await replication and further exploration in future work.

EPRs and parental reflective functioning. With respect to mothers' self-reported parental reflective functioning (i.e., mentalization or the ability to hold her child's mind in mind) several positive associations were observed between scores on the high-low subscale of the Parental Reflective Functioning Questionnaire (PRFQ) and N170 amplitudes for emotional infant faces in the left hemisphere, such that smaller (less negative) N170 peaks were associated with higher maternal reflective functioning. These results are consistent with those of the only other published ERP study that has examined the relationship between scores on the PRFQ and neural responses to infant faces, which found that only N170 amplitudes were associated with maternal reflective functioning (i.e., Rutherford et al., 2017). However, a direct comparison between findings in the current study and those of the former is not possible, as Rutherford and colleagues (2017) utilized a different version of the PRFQ, which contains a subscale score for certainty. As such, it would be fruitful in future research to examine the certainty domain of parental reflective functioning in mothers at increased risk for aberrations in parental function due to economic adversity.

Neural responses to unfamiliar infant faces and parenting behavior. Third, the relationship between mothers' neural responses to unfamiliar infant faces and observed parenting behavior during free play with her own infant was examined. In

contrast to my prediction that only the P300 would be associated with caregiving behavior, mean peak amplitudes for all three components (P100, N170, and P300) were positively associated with maternal affection, encouragement, teaching, and overall caregiving quality. Specifically, greater (more positive) P100 and P300 amplitudes and smaller (less negative) N170 amplitudes were associated with higher parenting quality. The notable exception was that the maternal responsiveness subscale of the PICCOLO was unassociated with neural responses to unfamiliar infant faces in this sample. This was particularly surprising because caregiver responsiveness in the PICCOLO is operationalized as responding sensitively to a child's cues and includes items such as "pays attention to what child is doing," "responds to child's emotions," and "looks at child when child talks or makes sounds" (Roggman et al., 2013) and, hence, might theoretically be expected to have stronger associations to infant face ERPs than caregiver warmth, encouragement, or teaching. However, in this sample no such associations with responsiveness were observed. Although this surprising finding does not easily lend itself to clear interpretation, one possibility is that the ERP measures characterized in this study are more associated with domain-general parenting qualities that are not correlated with caregivers' behavioral responsiveness (at least as measured by the PICCOLO responsiveness items) toward their own infants. If this were the case, were we to observe these same mothers interacting with other (unfamiliar) infants, we would expect them to exhibit similar levels of affection, encouragement, and teaching but different levels of responsiveness. To explore this null finding further, I plan to examine the relationship between ERPs and parenting quality as rated from a different global coding scheme we have been developing in our laboratory for this purpose. This will allow us to gather more

information about whether there is truly no relationship between ERPs for unfamiliar infant faces and maternal responsiveness (regardless of scoring system) or whether the null finding reported here is specific to the PICCOLO measure.

Perhaps the most striking aspect of the observed associations between neural responses to unfamiliar infant faces and parenting behavior is that early stimulus detection was associated with parenting quality, indicating that the very earliest neural responses to visual infant cues may be associated with downstream behavior or vice versa. This is partially consistent with the results of one recent study where P100 amplitude for infant cues was associated with parents' self-reported activation of the parental care system (Endendijk, Spencer, van Baar, & Bos, 2018). However, the results of current study diverge insofar as P100 amplitudes in the current study were significantly associated with observed caregiver behavior, whereas P100 amplitudes in the study by Endendijk and colleagues (2018) were not. Additional cross-sectional work with caregivers across the socio-economic spectrum is needed to explore whether this difference is related to the difference in target population (i.e., that early perceptual aberrations to infant cues have a differentially large impact on caregiving behavior in caregivers raising children under conditions of economic adversity versus those who are parenting under low-risk conditions), measurement (i.e., operationalization of parenting quality), or a combination of the two.

Post-hoc mediation tests suggest that P100 amplitudes for unfamiliar infant faces indirectly impacted the negative association between parents' stress due to dysfunctional parent-child interactions and observed maternal encouragement during free play, after accounting for variability due to mothers' own history of early childhood neglect and the

age of each member of the parent-child dyad. In other words, although such stress is associated with lower levels of parental encouragement, individual differences in early perceptual responses to infant cues, in general, appear to modulate the strength of that link. More generally, these data suggest that there is a link between the dyadic stress domain of parental function and early perceptual responses to infant cues and, thus, this association warrants further investigation. One potential implication of these findings for intervention design is that programs that target both parenting stress and selective attention for infant cues (ideally together, e.g., by coaching caregivers in parenting stress reduction strategies *while* they are orienting toward infant preverbal communication) may be more effective than programs that target either aspect of parental function alone.

By contrast, other mediation tests indicated that although maternal anxiety was negatively associated with some aspect of parenting quality (i.e., teaching during free play), no indirect effects through early neural reactions of infant cues were observed. These results are at odds with the results of a recent fMRI study conducted with a sample of predominantly low-SES post-partum mothers, which showed that the severity of mothers self-reported symptoms of anxiety (mostly in the subclinical range, similar to the current study) modulated the brain-maternal behavior relationship, such that higher anxiety predicted a stronger association between positive caregiving behavior and functional connectivity between the amygdala and right posterior superior temporal sulcus—a brain area believed to be important for social perception (Guo, Moses-Kolko, Phillips, Swain, & Hipwell, 2018). However, since maternal anxiety in the latter was hypothesized as the mediator and not the predictor (as was the case in the current study), a direct comparison between the results is not possible. As such, follow-up analyses that

explore the potential mediating effect of maternal anxiety on the relationship between neural responses to infant cues and observed behavior may help delineate the divergence in study findings.

Aim 3

The third aim of this study was to assess whether low-income mothers' neural responses to unfamiliar infant faces are sensitive to change via the Filming Interactions to Nurture Development (FIND) video-coaching program. As expected, a response attenuation effect was observed between the pre- and post-assessment waves, such that mothers' neural responses to unfamiliar infant faces were attenuated (as evidenced by reduced raw mean amplitudes) during their second EEG/ERP assessment visit. However, this effect did not reach statistical significance, which was somewhat unusual since attenuation effects are often observed in ERP experiments where the same paradigm and stimuli are administered twice. However, in contrast to traditional ERP experiments, the length of time in between each administration in this study was comparatively long (approximately 12 weeks), so the observed null findings for attenuation (i.e., no within-subjects effect of time) are not surprising.

Consistent with the FIND 'theory of change' (Fisher et al., 2016), which emphasizes both the strength-based nature of FIND and its behavioral reinforcement of mothers' attention to infant communication, I hypothesized that FIND would increase both the magnitude and speed of mothers' neural responses to unfamiliar infant faces at all three ERP components of interest: the early P100, the face-sensitive N170, and the later P300 ERP. Although several group by time intervention effects were observed in this sample, they were significantly different than predicted for ERP amplitudes. By

contrast, the study hypotheses for ERP latencies were partially supported. These expected and unexpected findings are discussed in the remainder of this section.

Changes in P100 and N170 amplitudes by intervention group. Since FIND selectively reinforces mothers' early attention to children's bids for attention (e.g., caregivers' behavioral orientation to child visual cues), I predicted that FIND would increase mothers' selective attention for infant faces across conditions and that both the magnitude and speed of response at the P100 (when averaged across conditions since no differentiation by emotion was expected) would increase as a result of participation in the coaching program. Contrary to my hypotheses, a significant reduction in P100 amplitude across all three infant emotional expressions (happy, neutral, distressed) over time was observed in the FIND group compared to the Waitlist Control group, whose P100 amplitudes either increased or stayed the same. Since the main effect of time in this sample was not significant, these results cannot be accounted for by attenuation effects, but rather point toward a significant between-group difference for mothers' in the FIND program compared to mothers in the Waitlist Control group. Since larger P100 amplitudes were associated with better parental function across domains in Aim 2, it would appear at first glance that mothers in the FIND program showed a reduction in parental function (as indexed by the P100 biomarker for early selective attention to unfamiliar infant faces). A similar counterintuitive pattern of results was observed for N170 amplitudes. Since FIND pairs attending to and recognizing children's bids for attention (including those that are communicated via child distress) with warm positive reinforcement, I predicted that the magnitude of neural responses for distressed infant faces at the face-sensitive N170 would change in the direction of increased parental

function, perhaps due to an increase in top-down feedback that increases the reward value of infant faces, which in turn activates both approach and withdrawal circuitry. However, in this study, N170 amplitudes increased significantly across conditions in the FIND group. This effect was most pronounced for unfamiliar happy infant faces. By contrast, mothers in the Waitlist Control group demonstrated a decrease in N170 amplitudes over time. Since larger N170 amplitudes were associated with poorer parental function across domains in Aim 2, like with the change in P100 amplitude, it would appear that parental function (as indexed by these two ERP components) worsened for mothers in the FIND condition compared to those in the Waitlist Control condition.

Although it is certainly possible that FIND actually reduces mothers' early selective attention and pre-attentive perceptual processing for infant visual cues (via a mechanism not accounted for in our theory-of-change), this is largely at odds with mothers' self-reported experience of the program and our anecdotal observations of improvements in caregiver function after completion of the FIND program. Future work will examine change in observed parenting before and after the intervention in this sample (via the PICCOLO) and it will be interesting to see whether change in P100 and N170 amplitudes for unfamiliar infant faces are associated with change in intervention-related observed parenting quality. Although counterintuitive, should FIND be found to decrease observed parenting quality, it will be important to further explore the mechanisms underpinning such change, as it is unlikely to be isolated to this particular parenting program. An alternative possibility is that as mothers in the FIND program developed increase visual expertise for their own child cues, this resulted in specialized early visual processing for own child cues relative to unfamiliar child cues, thereby

reducing neural reactivity to the unfamiliar infant faces utilized in this paradigm. This interpretation is partially consistent with ERP research by Rossion and colleagues (2004), who suggest that visual objects of expertise compete for early visual perceptual processing in the occipitotemporal cortex. In other words, as mothers in the FIND program increase their expertise for their own child's cues, perhaps the neural resources supporting this specialization become differentially responsive to own versus other child cues. In the future, I plan to test this theory by including stimuli from participants' own infants alongside that of unfamiliar infants.

Change in P100 and N170 latencies by intervention group. The pattern of counterintuitive intervention effects observed for P100 and N170 amplitudes is at odds with an apparent increase in the speed of neural responses for unfamiliar infant faces in the left hemisphere (which is dominant for processing of approach circuitry) for mothers in the FIND group at both components. Specifically, P100 latencies in the left hemisphere decreased (got faster) for mothers in the FIND condition and increased (got slightly slower) for mothers in the Waitlist Control condition. Similar results were observed for N170 latencies, such that a decrease in FIND mothers' N170 latencies in the left hemisphere and increase in N170 latencies in the right hemisphere were observed. These results are partially consistent with my hypotheses and suggest that FIND may be increases the efficiency of neural responses for infant stimuli associated with approach circuitry during early perceptual processing, while simultaneously reducing activation of avoidance circuitry. More generally, it is possible that there may be a dissociation between intervention effects for the magnitude and speed of mothers' neural responses to

infant faces, such that FIND improves some neural underpinnings of caregiver function while worsening others.

Null findings for the P300. I predicted that FIND would increase the magnitude and speed of the P300 for all three infant emotional expressions and that these effects would be largest and fastest for happy infant faces since FIND behaviorally reinforces attention allocation for child serves, which are often paired with expressions of happiness. However, significant group by time intervention effects were not observed for this ERP component. There are several potential reasons why no effects were found at the P300. First, with respect to the null hypothesis, it is possible that FIND does not have an impact on caregivers' attention allocation for unfamiliar infant cues. As mentioned previously, it is also possible that the impact of the program on mothers' neural responses to infant cues is domain-specific (i.e., to the cues of their own children) and not domain-general (i.e., to the cues of unfamiliar infants), and thus would not be measurable with the current paradigm. Another possibility is that my selection of stimulus presentation time (240 ms) unintentionally introduced a demand characteristic into the paradigm, such that mothers unconsciously determined that they did not need to allocate attention for the face stimuli since the faces disappeared very quickly from the screen. However, undercutting this interpretation is the fact that P300 amplitudes were associated with observable maternal behavior during free play in Aim 2, which suggests the component, as measured in this study, has a meaningful association with parental function.

Even if the FIND program itself does not alter mothers' neural attention allocation for unfamiliar infant visual cues (as indexed by the P300), given the observed relationship between self-reported parental experience, ERPs for unfamiliar infant faces,

and observed parenting behavior in this study (as documented in Aim 2), it is possible that caregivers' baseline neural responses to infant cues mediate intervention-related changes in other domains. Although it was beyond the scope of the current investigation, future work will test other components of the FIND 'theory of change' (Fisher et al., 2016). Specifically, we will test the hypothesis that FIND improves maternal function across several domains, including self-reported parenting stress and self-efficacy, reflective function, and developmentally supportive behavior and examine whether such changes are mediated by mothers' baseline neural responses to unfamiliar infant face stimuli.

Limitations

Several limitations must be considered when interpreting the results of this investigation. In the section that follows, these limitations and additional future directions for research are noted.

Sample demographics. Due to the scope of the PANDA and FIND Community Pilot Studies, we excluded caregivers who were not biological mothers (e.g., adopting mothers, fathers, foster parents, child care providers) and caregivers of children over the age of four from participation. Although the sample was ethnically representative of our geographic region (i.e., predominantly Caucasian), one implication of this is that the sample did not contain enough ethnic minority participants to make inferences about non-white parents. Research on parenting has been conducted using a disproportionate number of Caucasian families (Gershoff, Aber, Raver, & Lennon, 2007), and it is important to acknowledge that this study furthers that pattern. All of the aforementioned populations warrant investigation in future studies that aim to characterize caregivers'

neural reactions to nonverbal infant communication. In a similar vein, the two samples in the current investigation represented a wide segment of the post-partum period (i.e., 0 to 4 years). Since child age co-varied with the variables of interest, future work should also consider each portion of the perinatal period (e.g., each of the three trimesters during pregnancy and each developmental phase post-partum) separately to track how caregivers' reactions of infant cues evolve over time. Such work will further our understanding of the temporal dynamics of infant cue processing as they unfold in time for the caregiver-infant dyad.

Operationalization of economic adversity. In this study, I utilized gross household income as a proxy for economic adversity. Although several convergent measures indicated that this sample was indeed at elevated risk for adversity-related disruptions in caregiving (e.g., having elevated scores for lifetime exposure to trauma relative to community samples that include individuals across the socioeconomic spectrum), it is important to note that having low household income—even well below the federal poverty line, as was the case for the majority of participants—is not equivalent to living in poverty or experiencing equivalent levels of economic disadvantage, as other contextual variables influence the extent to which low-income is experienced as adverse. In future work, I plan to examine the relationship between economic disadvantage and neural measures of caregiver responses to infant cues via a cross-sectional design that includes a more nuanced operationalization of economic adversity (i.e., one that includes income as one of a number of factors that confer contextual risk) and to directly study the impact of such adversity on parental function.

Stimulus presentation time. Most ERP studies that examine adults' neural responses to infant face stimuli show infant faces for 500-2000 ms. To minimize artifacts due to eye saccades, I chose to show infant faces for a shorter duration of time (240 ms), which is significantly shorter than most studies. Although this should not impact the early ERPs (P100, N170) that index brain activity that occurs prior to end of the stimulus presentation, as previously mentioned, it is possible that the presentation time in this study could have affected the amplitude and latency of the P300. Specifically, if mothers had more time to scan the infant faces, it is possible that they may have engaged in information processing strategies that impact emotional salience detection and attention allocation. To explore this further, future research could systematically study the impact of presentation time on mothers' neural responses to unfamiliar infant faces.

Stimuli. To avoid introducing between-subjects variability into the experimental paradigm and to allow for comparison to the largest extant literature of studies documenting neural responses to infant faces (i.e., research that utilizes passive viewing paradigms with unfamiliar infant faces), I elected to conduct my first ERP study with this population using infant stimuli that were unfamiliar to participants. However, substantial emerging evidence indicates that caregivers process familiar and unfamiliar infant stimuli differently. For example, fMRI work with infant stimuli documents differential reward circuitry activation for mothers viewing their own versus unfamiliar infants (e.g., Strathearn, Li, Fonagy, & Montague, 2008). More recently, Esposito and colleagues (2015) investigated EEG power differences between primiparous mothers' brain response to own versus unfamiliar infant faces and found that, although cortical activation patterns observed in the scalp topography were similar, responses to own infant faces differed

both in magnitude and direction compared to appearance-matched unfamiliar infant faces. Such differences may also index differences in behavioral patterns for decoding familiar versus unfamiliar infant stimuli. When Doi and Shinohara (2012a) used an odd-ball paradigm to investigate whether mothers showed differential ERP responses to the gaze information of their own versus unfamiliar children's faces, they found that the peak amplitudes of the N170 were larger for straight compared to averted gazes of mothers' own children but not unfamiliar children. Gaze-related neural differences by face familiarity were also observed at the P300, suggesting that the processing of gaze information is impacted by familiarity at both the perceptual and evaluative stages of face processing. Importantly, these differences may have significant implications for the application of infant face ERP paradigms to intervention research. For example, in one recent study with child protective services (CPS)-involved mothers and low-risk controls, it was the relationship between neural responses to own versus unfamiliar infant stimuli that predicted maternal sensitivity (Bernard, Kuzava, & Simons, 2018). Taken together, these data suggest that caregivers' neural responses to familiar and unfamiliar children differ significantly and, as such, future work with mothers raising young children under conditions of economic adversity should include paradigms that include stimuli from both. Such research would also benefit greatly from the integration of eye tracking with EEG/ERP data collection in order to evaluate the relationship between behavioral decoding strategies and ERP responses to familiar and unfamiliar child cues.

Unmeasured variables. In this study, I relied on mothers' self-report to screen out mothers struggling with substance use or addiction. As such, it is possible that the neural responses of some participants were impacted by undisclosed substance use. Since

previous work suggests that neural responses to infant cues may be significantly impacted by maternal substance use (e.g., Landi et al., 2011), studies that include urine toxicology screening during pregnancy and the perinatal period (as done recently in a study by Maupin et al., 2018) may be able to make stronger inferences that their results are not confounded by neural aberrations due to substances.

Although the current study included a large number of domains of parental function, it was not possible to examine all aspects of parental function with links to infant cue processing. Most notably, to avoid further increasing the assessment burden on participants, in this study I did not examine ERP modulation by mothers' attachment classification. However, some evidence suggests that both the N170 and P300 components may be modulated by attachment style (e.g., Fraedrich, Lakatos, & Spangler, 2010; Leyh, Heinisch, Behringer, Reiner, & Spangler, 2016; Ma, Ran, Chen, Ma, & Hu, 2017). For example, in one small sample of mothers, Fraedrich and colleagues (2010) found that mothers with an insecure attachment style exhibited larger N170 amplitudes for unfamiliar faces presented in an odd-ball paradigm than mothers with a secure attachment style. These findings are consistent with the results of the current study insofar as larger N170 amplitudes were associated with reduced parental function across several domains in Aim 2. Future ERP studies with low-income mothers should examine the role of attachment in modulating the temporal dynamics of infant face processing.

Other ERPs. In this study, I did not examine mothers' neural responses to infant stimuli between 600-900 ms post-stimulus onset. In future analyses with these data, I plan to extract this late wave, i.e., the late positive potential (LPP) and examine its relationship to mothers' self-report and behavioral data. Analyses of the LPP may be

particularly important in future data collection initiatives that include paradigms with both familiar and unfamiliar infant faces, as Bornstein and colleagues (2013) found that although first-time mothers of 3- and 6-month old infants exhibited equivalent N/P100 and N170 responses to their own and unfamiliar infant faces, neural differentiation by familiarity emerged in ‘late wave’ (N/P600) activity. Although the current study focused on mothers with a comparatively wide age range of children, examination of the LPP may also be important for work that aims to delineate neural responses to infant cues early in the perinatal period, as Rutherford and colleagues (2017) found that, while the N170 for adult and infant faces was not impacted by antenatal anxiety, greater levels of antenatal anxiety were associated with larger LPP responses for neutral infant faces. Finally, although only the presence or absence of developmentally supportive behavior was quantified in the current study, future work that codes for caregiving behavior that is actively detrimental to children’s development may benefit from examination of the LPP, as recently Endendijk and colleagues (2018) reported that mothers’ LPP activity in response to infant faces was associated with observed intrusiveness with her own infant. Notably, no association between the LPP and maternal sensitivity was observed in that study, so further explication of the relationship between each phase of infant cue processing and different domains of maternal behavior is needed.

Conclusion:

Study Assumptions Revisited

Despite these limitations, the current investigation represents the first study of its kind to examine the temporal dynamics of infant cue processing in mothers raising young children under conditions of economic adversity. As such, the associations observed in

this study between neural responses to unfamiliar infant faces, self-reported parental experience, and observed parenting quality, combine to provide preliminary evidence that ERP responses to unfamiliar infant faces may have utility as a biomarker for caregiver function in this population—one that may provide useful information for intervention target selection and intervention evaluation. To my knowledge, this is the first study to examine caregivers ERP responses for infant faces before and after a parenting program. As such, it is important to note that the initial results reported here suggest that ERPs for infant faces are sensitive to change over relatively short periods of time (weeks to months), further suggesting that they may have utility as a biomarker for changes in parental function associated with intervention-related change.

Some of the findings in this study were different from those observed in similar research with lower-risk caregivers. This suggests that economic adversity may significantly impact the perceptual processing of infant cues and, thus, warrants further investigation. Specifically, cross-sectional work that compares caregivers' neural responses to infant cues across different segments of the contextual risk and socioeconomic spectrums may provide important information about the direct and indirect impacts of economic adversity on the neural processing of preverbal infant communication. Such data may be useful in future basic science work that aims to examine differential responses to infant cues across the socioeconomic spectrum and in the design of interventions that aim to bolster caregivers' intuitive parenting capacities that have been adversely impacted by inequality.

However, care must be taken in such work to avoid localizing the burden of change harmfully within individuals who are already marginalized and, as such, the

social and institutional causes of economic inequality must themselves be addressed. Mothers raising young children under conditions of economic adversity are doing the best they can with the resources the available to them and the problems of economic inequality that adversely impact mothers raising young children cannot be solved by family-based interventions alone. In the face of intractable economic inequality, clinical scientists must work to ameliorate the negative impact of such adversity on families by identifying intervention targets that maximally bolster parents' intuitive caregiving capacities, while advocating for systemic change. Strength-based interventions that aim to translate the knowledge from basic science work—such as that such of the current study—into clinical practice may be most effective when paired with system initiatives that address the root causes of inequality.

APPENDIX A

SUPPLEMENTARY MATERIALS FOR THE PANDA PILOT

Promoting Actions that Nurture Developmental Advancement Research Study: Initial Script for Research Team

VOICEMAIL MESSAGE IF RETURNING A CALL AND PARENT DOESN'T PICK UP

Hello, this message is for (*parent name*). My name is (*your name*) and I got your message about your interest in our research study. Please give us a call back at the University of Oregon SNAP Lab at (541) 600-4485 with some times that might be good for us to reach you. Thank you, in advance, for your time and I look forward to talking to you soon.

Phone Script for Mom's Calling to Ask about the Study

Hi! Thanks for your interest in our study! My name is _____(*recruiter name*) and I am the main contact person for this project. (*Take down name and contact phone number of interested mom*). First, if you don't mind me asking, how did you hear about the study? (*write down recruitment source*). Thanks!

Now, I'd like to tell you a bit about the study. Do you have 5 or 10 minutes to talk?

If NO: (arrange a different time to talk)

If YES: Okay, great! Well, to start off, I'll tell you a brief overview of the study to see if this is something you're interested in. This is a study conducted by a professor in the psychology department named Dr. Phil Fisher and some of his graduate students at the University of Oregon. Since the goal of the study is to learn more about how we can support mom's of young kids, we are recruiting moms who have kids under the age of 4. Everyone who agrees to be in the study will visit the University of Oregon 2 times over about 1 week and participate in one phone interview in between the two lab visits. During the first visit you would complete some questionnaires, talk to a researcher, and participate in a videotaped play task with your child. You would also be asked to give the researchers a sample of your saliva (or spit) so we can measure a hormone in your spit that changes when moms are with their babies. During the phone interview, a researcher would call you and ask you questions about different experiences you might have had. For the second visit you would go back to the U of O without your child and wear a stretchy EEG cap that helps a computer record your brain waves while you watch another computer screen and play some games.

There are no costs of participating for you or your child and participation is COMPLETELY voluntary. Your child would be given breaks, a snack, and a prize at each visit. You will receive \$35 for participating in each of the lab visits, \$15 for

completing each of the phone interviews, and \$15 for transportation and childcare costs.

Based on what you've heard so far, are you interested in seeing if you're eligible to participate in the study?

If NO: Okay, thanks so much for your time.

If YES: Okay, great! First, how old are you?

If under the age of 19: Okay. For this study we are only able to enroll parents who are over the age of 19. Thanks so much for your time.

IF YES: Okay, great! Am I correct in understanding that you have a child under the age of 4?

If NO: Oh, okay. Since this is a small study, we are only focusing on the experiences of parents of young kids. Thanks so much for you time.

If YES: Okay, great! How many people are currently living in your household? _____(record household size) And what is your annual household income? _____(record household income)

Establish whether the family is living below the poverty line according to the Federal Poverty Guidelines below:

2014 POVERTY GUIDELINES FOR THE 48 CONTIGUOUS STATES AND THE DISTRICT OF COLUMBIA	
Persons in family/household	Poverty guideline
For families/households with more than 8 persons, add \$4,060 for each additional person.	
1	\$11,670
2	15,730
3	19,790
4	23,850
5	27,910
6	31,970
7	36,030
8	40,090

If living ABOVE the poverty line: Okay. For this study we're focusing on families with an income of less than that. Thanks so much for your time.

If living BELOW the poverty line: Okay. Have you ever had a substance use disorder?

If YES: Since this is a small study and we're hoping to recruit mothers who are similar to one another as possible, we aren't enrolling anyone with a past substance use disorder. Thanks so much for your time.

If NO: Okay, are you right handed?

If NO: It sounds funny but since this project is just a small study, and we need to focus on mothers that are right handed because handedness can affect some of the measurements we are collecting. Thanks so much for your time.

If YES: Have you ever had a seizure or been diagnosed with epilepsy?

If YES: As you know, when you have a seizure it changes your brain waves. Since we're studying brain waves and this is a small study, we can't include people who have seizures at this time. Thanks for your time.

If NO: Do you have any open head wounds or lice?

If YES: Okay. Thank you for your time. Since this study involves wearing a tight cap on your head, participating in this study might not be a good fit at this time, but we appreciate the opportunity to talk to you.

IF NO: Would you be ok with you and your child being separated for about 15 minutes during two of the lab visits? During these separations, you would be in a room answering some questions while a trained researcher looked after your child in a room next door.

IF NO: Thank you for your time. Since we need to separate parents from their children for this study, it seems that participating in this study at this time might not be a good fit but we appreciate the opportunity to talk to you.

IF YES: If you breastfeed, would you be comfortable not breastfeeding for the first hour of the assessment? The reason why we ask this is because the contact may change the hormones we're measuring.

IF NO: Thank you for your time. Since we need to measure how hormones fluctuate during the study and breastfeeding can complicate our measures, it seems that participating in this study at this time might not be a good fit but we appreciate the opportunity to talk to you.

IF YES: Great. Do you or your child have any physical or medical condition that might make the assessment visits uncomfortable or difficult to complete?

If YES: Thank you for your time.

IF NO: One last question. Is there someone else who might need to know about you or your child being in this study, such as your child's father or an attorney?

If YES: Thanks! Is it okay with you if I contact them? We may need to make sure they agree to the study, too. (*Get contact info and say that you will re-contact the mother*).

If NO (it is not okay to contact someone else who needs to consent): Thank you for your time.

If NO (there is not anyone else who needs to consent): Great, thank you for your time! It sounds like you are eligible to participate. Assuming you are still interested, the next step is to schedule your first study visit. (*Schedule first and second lab visits. Schedule the first telephone interview. Trying to accommodate after nap time and typical feeding time. Ask the mother if she would like us to send a copy of the consents for her to review and, if so, get mailing address. Fill out the participant tracking spreadsheet. Answer any additional questions/concerns she might have*).



UNIVERSITY
OF OREGON

**Promoting Actions that Nurture Developmental Advancement:
Consent Form**

I understand that:

- The purpose of this study is to better understand how early experiences and parenting affect young children. It is my decision to be in this project.
- I was selected for this study because I have a child who is 0-4 years old and responded to an electronic advertisement or flyer.
- For the research assessments, I will be asked to complete 2 visits plus a telephone interview between the two visits. The first and second visits will be about a week apart. I will be asked to sign this consent form at the first visit, and will review this form at the second visit.
- My child will be asked to be present with me at the 1st research visit. During this visit my child will be separated from me for about 30-45 minutes while they play with research staff. They will also engage in a few interaction tasks with me that will be video recorded.
- This study consists of two laboratory visits and a telephone interview, which will be scheduled over the course of approximately one week.
 - The first laboratory visit (*me and my child*) will consist of questionnaires about parenting and child development; a brief free play and cuddling task; and collection of my saliva to measure a hormone called oxytocin. This will be collected by spitting into a test tube through a straw. This visit will take up to two hours.
 - At the second laboratory visit (*me only*) I will complete computer tasks while information about brain activity is collected with EEG. This will require wearing a special EEG net on my head. This visit will take up to two hours.
 - In between the first and second laboratory visits, I will participate in a telephone interview during which I will be asked about my life history and parenting. This interview will take about 30 minutes.
- If I choose to be in the project or not to be in the project, this will not hurt or help any parenting or other services I am receiving from any local agency.

- The staff collects information from me and my child through an interview that will be audio-recorded, questionnaires, and videotapes of me interacting with my child.
- I will receive \$35 for completing each research visit and an additional \$15 when I am asked to visit the lab without my child (second visit). I will also receive \$15 for completing a phone interview in between Visits 1 and 2. If I complete all research activities, I will be compensated as described above. If I choose to withdraw from the study, elect not to participate in some activities, or the research team decides it would be best for me not to continue participating, I will still receive compensation for the visit(s) I attend.

I understand that my child and I have certain rights:

- I have the right to change my mind about being in this project at any time. If I decide to quit the project, there will be not be any negative results.
- I can skip or not answer any question(s). I can skip or choose not to do parts of the project.
- I will be given a copy of this Consent Form.
- I can ask the staff questions about the project at any time. I may contact the Principal Investigator, Dr. Phil Fisher, his graduate students Brianna Delker, Laura Noll, Melissa Yockelson, and Amanda Van Scoyoc or the Project Coordinator Kristen Greenley. The phone number is: (541) 600-4485.
- You can also contact Research Compliance Services at the University of Oregon (541-346-2510) or ResearchCompliance@uoregon.edu with any questions or concerns.

I understand that our privacy will be protected:

- Project staff will use a number instead of names on all information that they study and analyze. All information is stored in safe, locked areas.
- Project staff studies information from everyone in the project as a group, not as individuals. When they share project results and data, they will not identify any one person. The project will use our information for research and education only.
- This project has no connection to immigration (Immigration and Customs Enforcement Agency [ICE]).
- Project staff will not share my answers with anyone without my permission. They will not share anyone else's answers with me.

I understand that there might be times when my information is shared. These are called "exceptions to confidentiality."

- Project staff may hear or see something that they know or think is abuse of a child. They might see or hear something that tells them that a child is in danger. In these cases, project staff will take action to protect the child including being in contact with child welfare.

- Project staff will also report when they hear that someone plans to hurt themselves or someone else.

As a participant in this project, I understand that there are possible risks:

- My child or I might feel uncomfortable with some parts of the project. We are free to say “no” to any part.
- Project staff collects personal information about my child and me. Although research staff will make every effort to protect my confidentiality, there is the chance that someone who should not see my family’s information might see it.

As a participant in this project, I understand that there are no direct benefits to participating in this study, however the information from this project might help us understand more about how to best support parents and young children.

I have read and I understand the information on this consent form. I have had all my questions answered. I agree to take part in and give permission for my child to take part in the Promoting Actions that Nurture Developmental Advancement Project. I have received (or will receive) a copy of this form.

Parent Signature

Participating Child's Full Name (Please Print)

Parent Name (Please Print)

Date __/__/__

PANDA Project

Consent to Video and Audio Recording

I have received an adequate description of the purpose and procedures for the video and audio recording included as part of the activities for this study.

I give consent for myself and my child to be recorded on video and audio during participation in the study and for those recordings to be viewed and listened to by project staff involved in the study. Project staff will code these recordings, identifying specific mom and child behaviors.

I understand that the video and audio recordings will only be labeled with an identification number (no names).

I understand that all project staff members have been trained in confidentiality protection and are required to sign confidentiality agreements, including coders.

I understand that all information will be kept confidential and no identifying information will be included on the video and audio recordings. I understand that the recordings will be erased after the completion of the study. I further understand that I may withdraw my consent at any time.

Parent Signature

Date

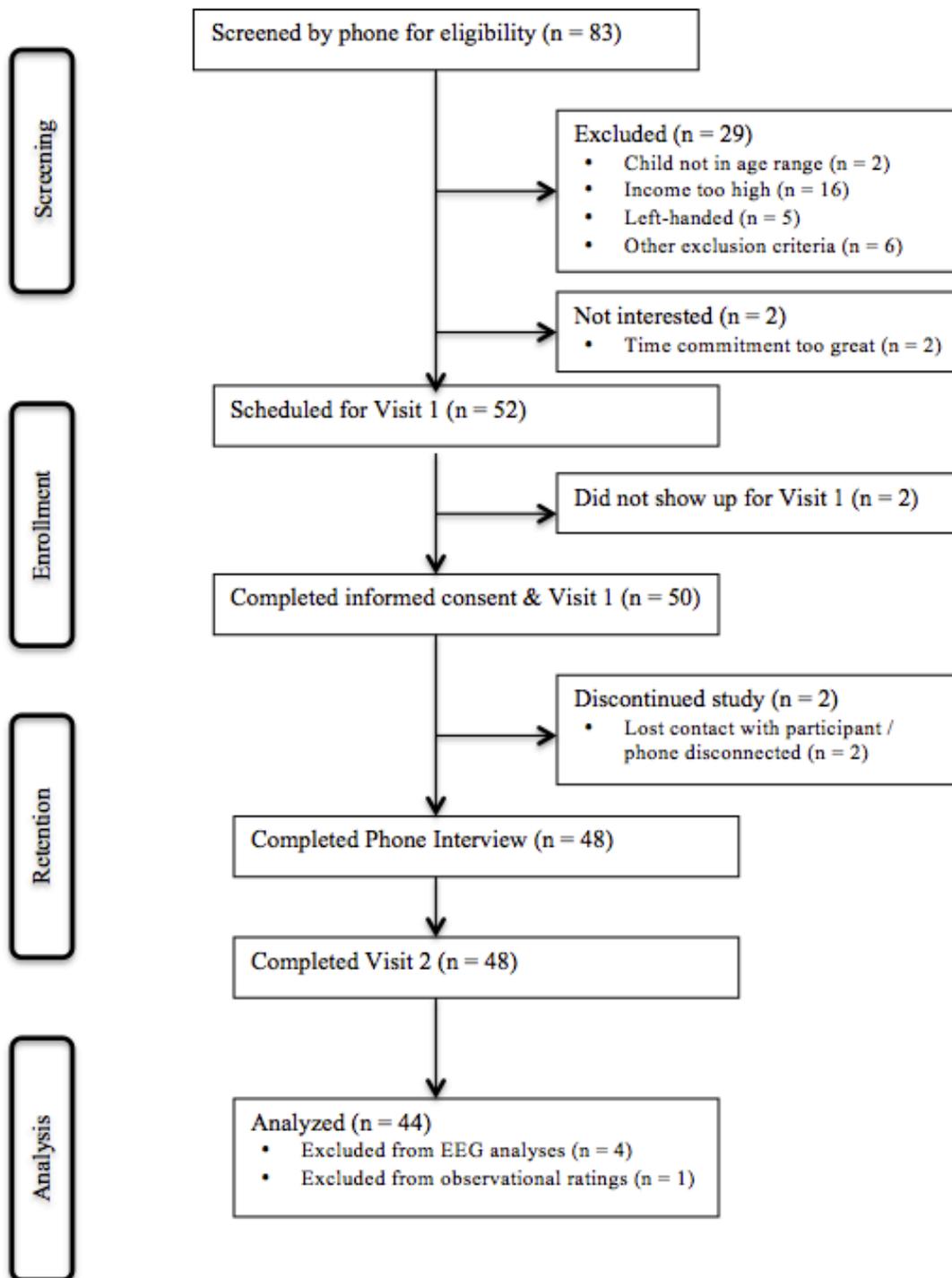
Parent Name (Please Print)

Target Child's Full Name (Please Print)

Witness/Staff Signature

Date

Figure 18. Recruitment and retention flowchart for the PANDA research project.



Note: Study enrollment was completed between February 16, 2015 and September 16, 2015.

APPENDIX B

SUPPLEMENTARY MATERIALS FOR THE FIND COMMUNITY PILOT

Example Recruitment Material

FIND Community Project

A University of Oregon Research Project for moms and their children



FIND is a research project that looks at how moms can support their young children's development.

- → You are eligible to participate in this study if you:
 - → Have a child between the ages of 1 and 4
 - → Have a family income below the poverty line
 - → Are not involved in the child welfare system
- → If you decide to participate, we will ask you to:
 - → Be randomly assigned to start the FIND program, or be on a waitlist to receive it later
 - → Fill out a set of questionnaires
 - → Be videotaped interacting with your child
 - → Audio-record interactions between you and your child in your home
 - → Allow us collect information about the way that you think using an EEG
- → This study takes place at the University of Oregon. You will be asked to come to the lab four times (for 1-2 hours each time), audio record in your home for several days, and be contacted once by phone to fill out questionnaires. You will be compensated up to \$200 for your time.

FIND Community
(541-316-8264)
FINDcommunity.uoreg@gmail.com

FIND Community
(541-316-8264)
FINDcommunity.uoreg@gmail.com

[A...]
FIND Community
(541-316-8264)
FINDcommunity.uoreg@gmail.com

FIND Community Pilot Study:
Initial Screening Script for the Research Team

VOICEMAIL MESSAGE IF RETURNING A CALL AND PARENT DOESN'T PICK UP

Hello, this message is for *(parent name)*. My name is *(your name)* and I got your message about your interest in our research study. Please give us a call back at the University of Oregon SNAP Lab at (541) 316-8264 with some times that might be good for us to reach you. Thank you, in advance, for your time and I look forward to talking to you soon.

Phone Script for Mom's Calling to Ask about the Study

Hi! Thanks for your interest in our study! My name is _____*(recruiter name)* and I am the main contact person for this project. *(Take down name and contact phone number of interested mom)*. First, if you don't mind me asking, how did you hear about the study? *(write down recruitment source)*. Thanks!

Now, I'd like to tell you a bit about the study. Do you have 5 or 10 minutes to talk?

If NO: (arrange a different time to talk)

If YES: Okay, great! Well, to start off, I'll tell you a brief overview of the study to see if this is something you're interested in. This is a study conducted by graduate students at the University of Oregon under the mentorship of a professor in the psychology department named Dr. Phil Fisher. Since the goal of the study is to learn more about how we help mothers support their young kids, we are recruiting moms who have kids between the ages of 1 and 4. Everyone who agrees to be in the study will be randomly assigned to either participate in a parenting program called FIND right away, or be offered to participate in the FIND program after the research part is over, this is called the waitlist group. If you are assigned to FIND, a FIND coach will visit you and your child at your house once a week for 10 weeks. During these visits, the coach will alternate between taking a video recording of you interacting naturally with your child, and showing you edited clips of examples of when you are supporting your child's development. If you are in the waitlist group, you will be able to participate in a group version of FIND where you and other moms who were in the study will meet with a FIND coach once a week for ten weeks. This version will also include video-taping and seeing edited videos as a group. This is optional if you are in the waitlist group.

Based on what you've heard so far, are you interested in hearing more about the study?

If NO: Okay, thanks so much for your time.

If YES: Great!

Let me tell you more about the research visits. All mothers in the study will visit the University of Oregon 4 times, collected approximately two days of audio recording when they are home with their child, and participate in one phone interview. During the first and third visits you would complete some questionnaires and participate in a few videotaped play tasks with your child. For the second and fourth visits you would go back to the U of O without your child and wear a stretchy EEG cap that helps a computer record your brain waves while you watch another computer screen and play some games. In between these visits, we will send you home with a very small audio recording device that fits into a special item of clothing that your child wears. You will be asked to turn the recorder on for as much of the day as possible, on two days, when you are the only adult female home with your child. During the phone interview, a researcher would call you and ask you questions about different experiences you might have had.

There are no costs of participating for you or your child and participation is COMPLETELY voluntary. Your child would be given time to play with trained staff members, a snack, and a prize at each visit. You will receive \$35 for participating in each of the lab visits, \$15 for each audio recording session (\$30 total), \$15 for completing the phone interviews, and \$15 for transportation and childcare costs when you are asked to visit the lab without your child. If you complete all of the parts of the study you can earn up to \$200.

Based on what you've heard so far, are you interested in seeing if you're eligible to participate in the study?

If NO: Okay, thanks so much for your time.

If YES: Okay, great! First, how old are you?

If under the age of 18: Okay. For this study we are only able to enroll parents who are over the age of 18. Thanks so much for your time.

IF YES: Okay, great! Am I correct in understanding that you have a child between the ages of 1 and 4?

If NO: Oh, okay. Since this is a small study, we are only focusing on the experiences of parents of young kids. Thanks so much for you time.

If YES: Okay, great! How many people are currently living in your household?
_____(record household size) And what is your annual household income? _____
(record household income)

Establish whether the family is living below the poverty line according to the Federal Poverty Guidelines below:

**2014 POVERTY GUIDELINES FOR THE 48
CONTIGUOUS STATES
AND THE DISTRICT OF COLUMBIA**

Persons in family/household	Poverty guideline
For families/households with more than 8 persons, add \$4,060 for each additional person.	
1	\$11,670
2	15,730
3	19,790
4	23,850
5	27,910
6	31,970
7	36,030
8	40,090

If living ABOVE the poverty line: Okay. For this study we're focusing on families with an income of less than that. Thanks so much for your time.

If living BELOW the poverty line: Okay, are you currently involved with child welfare or DHS?

If YES: Thank you so much for taking the time to talk to us, this study on focuses mothers who are not currently involved with child welfare. Thank you so much for your time and patience.

If NO: Okay, are you right handed?

If NO: It sounds funny but since this project is just a small study, and we need to focus on mothers that are right handed because handedness can affect some of the measurements we are collecting. Thanks so much for your time.

If YES: Have you ever had a seizure or been diagnosed with epilepsy?

If YES: As you know, when you have a seizure it changes your brain waves. Since we're studying brain waves and this is a small study, we can't include people who have seizures at this time. Thanks for your time.

If NO: Do you have any open head wounds or lice?

If YES: Okay. Thank you for your time. Since this study involves wearing a tight cap on your head, participating in this study might not be a good fit at this time, but we appreciate the opportunity to talk to you.

IF NO: Would you be ok with you and your child being separated for about 45 minutes to an hour during two of the lab visits? During these separations, you would be in a room answering some questions while a trained researcher looked after your child in a room next door. You are free to see your child at any point.

IF NO: Thank you for your time. Since we need to separate parents from their children for this study, it seems that participating in this study at this time might not be a good fit but we appreciate the opportunity to talk to you.

IF YES: Great. Do you or your child have any physical or medical condition that might make the assessment visits uncomfortable or difficult to complete?

If YES: Thank you for your time.

IF NO: One last question. Are you currently a part of another research study that is offering an intervention or parenting program?

If YES: Thanks! Because this study is looking at how to help parents support their children, we are not able to include mothers are currently a part of another similar study. Thank you so much for your time.

If NO: Great, thank you for your time! It sounds like you are eligible to participate. Assuming you are still interested, the next step is to schedule your first study visit.

(Schedule first and second lab visits. Schedule the first telephone interview. Trying to accommodate after nap time and typical feeding time. Ask the mother if she would like us to send a copy of the consents for her to review and, if so, get mailing address. Fill out the participant tracking spreadsheet. Answer any additional questions/concerns she might have).

FIND Community Research Pilot
CONSENT FORM



UNIVERSITY
OF OREGON

Melissa Yockelson, M.S., Laura Noll, M.S., Phil Fisher, Ph.D.

I understand that I am participating in the Filming Interactions to Nurture Development (FIND) Community Pilot study at the University of Oregon (UO). Funding for this project has been provided by Oregon Social Learning Center as part of the Translational Drug Abuse Prevention Center grant from the National Institute on Drug Abuse and the Fisher Stress Neurobiology and Prevention (SNAP) lab at the UO Psychology Department.

I understand that:

- This project is about how early experiences and parenting affect children and ways to support parents of young children. It is my decision to be in this project.
- For the research assessments, I will be asked to complete 4 visits, a total of 4 at home audio recordings using LENA, plus 1 telephone interview. The 1st and 2nd visits and the 3rd and 4th visits will be several days apart, there will be about 3 months between the 2nd and 3rd visit. I will be asked to sign this consent form at the first visit, and will review this form at all other visits. For this study, I will be asked to be at the research laboratory for a total of 6-8 hours. I will spend 30-45 minutes on a phone interview, and create audio recordings over 4 days.
- The staff collects information from me and my child through audio-recordings when I am home with my child, questionnaires, and videotapes of me interacting with my child. They will also collect physical information through EEG (brain waves).
- A research staff member may come to my house to drop off and/or pick-up a LENA device for the audio recording sessions.
- I will be randomly assigned to either receive the FIND program right away, or put on a waitlist to receive a group version of the FIND program after the study is finished.
 - If I am in the FIND group, a FIND Coach will visit me and my child in our home once a week for 10 weeks. The coach will video record me and my child together doing everyday activities like playing or feeding. The next week the coach will share very short clips of the

video recording to show key moments when I was doing really good things with my child.

- If I am in the waitlist group, after completing the research visits I will be allowed to participate in a group based FIND program with other mothers in the study. We will meet as a group with a FIND coach once a week for 10 weeks. The coach will video record us playing and interacting with our children and then show short clips of us doing good things with our children to the group the following week. If I am in the waitlist group, completing the FIND program is optional.
- I will receive \$35 for completing each research visit and an additional \$15 when I am asked to visit the lab without my child (Visits 2 and 4). I will also receive \$15 for completing each of the at home audio recordings, and \$15 for completing a telephone interview. If I complete all research activities I will be compensated a total of \$215. If I choose to withdraw from the study, elect not to participate in some activities, or the research team decides it would be best for me not to continue participating, I will still receive compensation for the visit(s) I attend. I will have the choice to receive payment in cash or check. I will receive compensation at each lab visit. I will be compensated for the audio recordings at the lab visit after my recording sessions, and once the LENA device is returned. I will receive compensation for the telephone interview at the next lab visit after I complete the interview. If I do not have another lab visit a check may be mailed to me. I understand that cash cannot be mailed.
- That there is no financial compensation for completing the FIND home visits or group visits.

I understand that my child and I have certain rights:

- I have the right to change my mind about being in this project at any time. If I decide to withdraw from the project, there will not be any negative results.
- I can skip or not answer any question(s). I can skip or choose not to do parts of the project.
- I will be given a copy of this Intervention Description and Consent Form. This form will be signed at the first visit to the lab, and reviewed at all the following visits.
- I can ask the staff questions about the project at any time. I may contact the Principal Investigator and Project Coordinator, Melissa Yockelson at any time by calling (541) 316-8264.
- I can also contact Research Compliance Services at the University of Oregon (541) 346-2510 or ResearchCompliance@uoregon.edu with any questions or concerns.

I understand that our privacy will be protected:

- Project staff will use a number instead of names on all our data (e.g. questionnaires, EEG files, LENA audio files, and videotapes etc.) that they study and analyze.
- All information is stored in safe, locked areas.
- Project staff studies information from everyone in the project as a group, not as individuals. When they share project results and data, they will not identify any one person. The project will use our information for research and education only.

I understand that there might be times when my information is shared. These are called “exceptions to confidentiality.”

- Project staff may hear or see something that they know or think is abuse of a child. They might see or hear something that tells them that a child is in danger. Or they might learn that a child has witnessed violence. In these cases, project staff will take action to protect the child. This may include talking to a child welfare agency if needed.
- Project staff will also report when they hear that someone plans to hurt themselves or someone else.

As a participant in this project, I understand that there are possible risks:

- Research staff will collect personal information about my family. Staff will work very hard to protect our privacy but there is always the chance that someone who should not see our family's information might see it.
- My child or I might feel uncomfortable with some parts of the project. We are free to say “no” to any part.
- Some individuals may experience discomfort or embarrassment while being filmed interacting with their child during home visits.
- If I am in the waitlist group, I understand that all group participants are encouraged to maintain confidentiality by not talking about or sharing the names of other group members. However, group facilitators cannot guarantee that other group members will maintain confidentiality.

As a participant in this project, I understand that while there are no direct benefits to participating in this study:

- The information from this project might help us understand more about how young children grow and how best to support parents.
- If I am randomly assigned to the FIND Program, or choose to engage in the group version of FIND, I will view video clips of myself doing things that help my child grow. Parents have told the research team that they enjoy working with a FIND Coach and that it has given them more confidence in their parenting. However, since this research is testing the effectiveness of the FIND Program, I may or may not benefit from the intervention

I have read and I understand the information on this consent form. I have had all my questions answered. I agree to take part in and give permission for my child to take part in the FIND Community Pilot at the UO. I understand that by signing this form I understand that I have been randomly assigned either to the FIND program group, or the waitlist group. I have received (or will receive) a copy of this form.

I understand that I have been assigned to the:

FIND Program group

Waitlist group

Parent Signature

Date

Print Parent Name

Staff Signature

**FIND Community Research Pilot-
Project Description**



UNIVERSITY
OF OREGON

You are invited to be in a research project at the University of Oregon (UO), a public university. Researchers at UO study many topics. This project is about how early experiences and parenting affect children and ways to support parents of young children. The researchers in charge of this project are Melissa Yockelson and Laura Noll, graduate students working with Dr. Phil Fisher. The National Institute of Health and the Fisher Stress Neurobiology and Prevention (SNAP) lab at the UO Psychology Department are paying for this project.

Do you want to participate?

It is your decision to be in the project. Before you decide, you need to know the risks and benefits. You should also know what we will ask you to do. Please take your time to read this form. The form explains the project. A staff member will also explain the project and answer your questions. There are no negative results for choosing not to be in the project or for quitting the project.

If you agree to be in this project, you will sign this description and a consent form. The consent form is a shorter version of this form and has all of the important information about the project. When you sign the consent form, you “give consent.” This means that you agree to be in the project. It also means that you understand what we will ask you to do. Please review this form and the consent form carefully. Staff will answer any questions you have before you sign these forms.

What is the purpose of the project?

This project is a research study. We collect information about people’s lives. We will use this information to learn more about how young children grow and how best to support their parents. Participants in this study will be randomly put into one of two groups: one group which will receive an individual form of the FIND program right away and the second group will be put on a waitlist to receive the FIND program as a group with other study members after

completing all of the research visits. In between the research visits, the FIND Program group will complete a 10-week in-home video-coaching program called FIND and the waitlist group will continue on with their normal schedules until their second set of research visits.

What will we ask you to do if you choose to be in the project?

We will ask you and your child to participate in four visits over the course of about four months, two home assessments where you will be asked to keep a small audio recorder on when you are home with your child, and one telephone interview. The first two visits will be about a week apart, and the home audio recording will take place in between the two visits followed by 3 months when you will either receive the FIND program or carry on as usual, and then you will come in for the last two visits- again about a week apart with the home audio recording in between. The telephone interview will be scheduled shortly after your first two visits to the lab. Each lab visit will last between 1 and 2 hours. In order to compare the FIND program to other services, families interested in the study have been randomly put into one of two groups. Both groups will do the research visits; one group will also complete the FIND program and the other will be on a waitlist. If you are participating in the FIND program, one of our trained coaches will visit you and your child in your home once a week for 10 weeks. If you are on the waitlist you will complete all of the research visits and afterwards you will be able to engage in a group version of the FIND program with other study participants. Participation in the group version of FIND is completely voluntary.

Research Visits:

The 4 research visits will take place at the UO Stress Neurobiology and Prevention (SNAP) Research Lab, which is located on the 4th Floor of the Lewis Integrative Science Building at 1440 Franklin Blvd. in Eugene, OR.

During the visits to our lab, you will fill out questionnaires about your experiences and your child's behavior. You will also be asked to play with your child in a room with toys and read books with your child in a comfortable chair. Trained childcare staff will take care of your child while you are busy. The staff member will engage your child in age appropriate activities such as playing with toys or reading books. If at any point your child would like to see you, or you would like to see your child you can take a break from the study tasks. During your 2nd and 4th visits, you will come to the lab without your child and wear the EEG net while you play a few games on the computer and play one game on the computer without wearing the EEG net. .

Brain Activity (EEG): During your 2nd and 4th visits, we will record your brain activity (or EEG). EEG is short for electroencephalogram, which is a way to see brain activity (brain waves) from the scalp. Each of these visits will take about an hour and a half and you will be asked to wear a plastic EEG net on your head. This net is like a swim cap and has little electrodes that record brain activity and are connected by wires to a computer. Since the net is very sensitive, you can help us by not using hair sprays, gels, or oils on your hair on the day of these visits and leaving long hair down (ponytails or braids sometimes get in the way of the net). It is also much easier to make the EEG net work properly if your hair is clean but not damp.

At Home Audio Recording: In between the 1st and 3rd visits and in between the 2nd and 4th visits, you will be asked to take a small audio recorder home with you. This audio recorder is called LENA and it is an exciting new device to help learn about children's language environment. We will be using LENA to better understand how mothers and their children interact. We would like you to record for as much time as possible for two days during the first part of the study, and for two days during the second part of the study. We only want you to record when you are the only adult female at home with your children so that we know it is you talking to your child, and so that we protect the privacy of other people. If you leave the house, or if you have visitors you should turn off the LENA device. To make this recording, your child will wear LENA in the pocket of a custom-made vest. The LENA device weighs about 2.5 ounces and is about the size of a pack of gum. We will provide you with a demonstration of how to use LENA with your child. To keep your audio data secure, the stored audio cannot be played back on the LENA device. Research staff will connect the LENA device to a computer with special software. The audio file will be kept in a secure and locked digital file that is only labeled with your unique research participation number. Only trained research staff will listen to and code the audio file. Upon completion of the study, all audio files will be destroyed.

Phone Interviews: Early in the study we will call you to do a phone interview that will take about 30 minutes. We will ask you questions about your life history and parenting.

What other types of information will the project collect?

This project collects information in different ways. We will explain everything we will be asking you to do as we go along. You will be answering questions on the computer or by interview, playing the computer games while wearing the EEG net, playing and reading with your child, audio recording time at home, and completing a phone interview. We will video record your playtime with your child. Trained staff members will watch and listen to these recordings to learn more about how moms and young children play and interact.

Compensation:

If you complete all research activities you will be compensated up to \$200. If you choose to withdraw from the study, elect not to participate in some activities, or our research team decides it would be best for you not to continue participating, you will still receive compensation for the visit(s) you attend.

What will we ask you to do if you are in the group doing the FIND program?

If you are randomly assigned to the FIND program, you and your child will participate in a 10-week video coaching program. One of our coaches will visit you and your child in your home once a week for 10 weeks. The details of each visit are listed in the chart below.

Visits	How	What will happen
Filming Sessions	About 10-20	- Videotaping of natural interactions with
Coaching Sessions Parent	About 30 minutes	- Introduce new element - Review edited film

Home Visits:

You will meet once a week with your coach. The first week the coach will video record you and your child together in your home doing everyday activities like playing or feeding. The next week the coach will share very short clips of the video recording to show you key moments when you were doing really good things with your child. In this session you will have a chance to discuss what you have seen with the coach. Between sessions your coach may ask you to complete very short practice assignments at home before the next session. You will continue this format over the 10-week program. There is no financial compensation for completing these home visits.

What will we ask you to do if you are in the waitlist group?

If you are randomly assigned to the waitlist group, you will have the opportunity to participate in a group version of the FIND program with other study participants after you've complete all of the research visits. This is voluntary, and you are not required to do the group program. The group will meet with one of our coaches once a week for 10-weeks. The details of each visit are listed in the chart below.

Visits	How	What will happen
Filming Sessions	About 10-20	- Videotaping of natural interactions with
Coaching Sessions Parent	About 30 minutes	- Introduce new element - Review edited film as a group

How long will I participate in the project?

You and your family will be asked to participate for about 3 to 4 months to finish the research visits. Being part of this project one time does not mean you have to be in the project in the future.

Who else will take part?

About 50 moms and their young children will be in this project. All of the moms will have a child who is between the ages of 1 and 4.

Would we ever ask you to stop participating?

Yes, sometimes situations change. If we think that you or your child are distressed while visiting our lab, we may ask that you take a break or that you and your child stop participation.

What happens if you need more or different services/treatment?

Sometimes you or project staff might feel that you or your family needs other or additional help. We can give you information or contacts for other services.

What are your rights as a participant in this project?

You have certain rights while you are in this project. These rights help protect you.

- You decide to be in the project or not. It is voluntary and always your choice.
- You can change your mind about being in this project at any time. If you decide to quit the project, there will be no negative results of any kind.
- You can skip or not answer any question. Some questions might be personal or sensitive. They are important to the project and we would like you to answer them honestly. But if there are some questions you do not want to answer, you may skip them and move on to other questions.
- You will get a copy of this Project Description and the Consent Form(s).
- You are free to ask questions about the project at any time. You may contact the Principal Investigator and Project Coordinator Melissa Yockelson at any time by calling (541) 316-8264.
- You can also contact Research Compliance Services at the University of Oregon (541-346-2510) or ResearchCompliance@uoregon.edu with any questions or concerns.

How will your privacy (or confidentiality) be protected?

We will do all we can to keep everything about you and your family completely private. Here are the ways that the project protects your privacy.

- We use a number instead of your name on all the information about you that we study and analyze.
- We store all information in safe, locked areas.
- We study information from everyone in the project as a group, not as individuals. When we share project results, we will not identify any one person. We will not use names or other personal information.
- We train all staff members to protect your privacy. Only a small number of staff will see your information. In some cases, the National Institute of Mental Health, which is responsible for the project and for funding might see information about you as part of their review of our project. They are also required to protect your privacy.
- We will not share your answers with anyone without your permission. We will not share anyone else's answers with you.

Are there times when we will share information about you?

Yes, these are called "exceptions to confidentiality." Project staff will keep all of your information private, except in the following cases.

- Project staff may hear or see something that they know or think is abuse or neglect of a child.
- They might see or hear something that tells them that a child is in danger. Or they might learn that a child has witnessed violence. In these cases, project staff will take action to protect the child. This may include contacting a child welfare agency.
- We will also report when we hear that someone plans to hurt themselves or someone else.

What are the possible risks to you as a participant in the project?

As a participant in this project, there are a few risks to you:

- We collect personal information about your family. We will work very hard to protect your privacy but there is always the chance that, without our meaning to, someone who should not see your family's information might see it.
- You might feel uncomfortable with some parts of the project. For example, some questions we ask are personal. Or you might feel uncomfortable with wearing the EEG net, being videotaped, or audio recording in your home. Your child may not like being apart from you while you are doing the study tasks. You are free to say "no" to any part of the project.

If you want to talk to someone about any of these risks, please let us know or contact one of the people listed above.

What are the benefits to you as a participant?

There are no direct benefits for participating in this study.

The information from this project might help us understand more about how young children grow and how best to support parents. This information might be used to help others.

Families who participate in the FIND Program, either individually or in the group will view video clips showing them doing things that help their children grow. Parents have told us that they enjoy working with a FIND Coach and that has given them more confidence in their parenting. However, since this research is testing the effectiveness of the FIND Program, you may or may not benefit from the intervention.

What will be done with the information we collect for this project?

We will use information from this project for research and education only. We will share the results of the project in papers, books and presentations. We might share results and data with other education or research centers. We will not use names or other personal information when we share project results or data.

How will we make it easy for you to be in the project?

We offer:

- Flexible appointment times during daytime, evenings and weekends
- Free parking at our lab
- Payments for some travel costs related to being in the project
- Snacks and breaks for you and your child during visits.

Please sign below to show that you have read and understand this Project Description.

Parent Signature

Date

Parent Name (Please Print)

Target Child's Name (Please Print)

Witness/Staff Signature

Date

FIND Community Research Pilot:
Parent Consent to Video and Audio Recording

I have received an adequate description of the purpose and procedures for the video and audio recording included as part of the activities for this study.

I give consent for myself and my child to be recorded on video or audio during participation in the study and for those recordings to be viewed or listened to by project staff involved in the study for coding purposes such as describing the child's behavior.

I understand that copies of the video and audio recordings will be coded by project staff. The video and audio recordings will only be labeled with an identification number (no names). Project staff at the UO will not have access to any personal information about my child or my family.

All project staff members have been trained in confidentiality protection and are required to sign confidentiality agreements, including coders.

I understand that all information will be kept confidential and no identifying information will be included on the video and audio recordings. I understand that the recordings will be erased after the completion of the study. I further understand that I may withdraw my consent at any time.

_____ (Please initial if this applies) If my family is participating in the FIND program:

- I understand my other children might be included in FIND video recordings. I give my consent for these children to be included in FIND videos.
- I understand that interactions between me and my child will be video-recorded and edited by trained FIND editors to use in the FIND coaching, as well as for other study-related purposes such as evaluating the coach's performance and training new coaches.
- I understand that if I am in the waitlist group and choose to participate in the group version of FIND, I will be video-recorded with other mothers in the study during our group meetings. I also understand that edited clips of my doing good things with my child will be shown during the group meetings.

Parent Signature

Date

APPENDIX C

SUPPLEMENTARY INFORMATION ABOUT THE FIND PROGRAM

Flier about the FIND Video Coaching Program Provided by the Clinical Team

ABOUT THE FIND PROGRAM



Filming Interactions to Nurture Development (FIND) is a video coaching program for parents and other caregivers of high risk children, including children from economically disadvantaged communities, maltreated children and children in foster care, domestically and internationally adopted children, and children with developmental delays. FIND employs video of caregivers' natural interactions with their child to show them ways that they are supporting their child's healthy development. FIND is a simple and practical approach that emphasizes caregivers' strengths and capabilities.

The FIND program begins with the FIND Coach recording a video of caregiver and child in their home or other natural setting. The film is carefully edited to show brief clips in which the caregiver is engaged in developmentally supportive interactions with the child. At the subsequent coaching session, the FIND Coach reviews the edited clips in detail with the caregiver. The sequence of alternating filming sessions and coaching sessions is repeated 5 times, for a total of 10 sessions.

FIND utilizes the concept of "Serve and Return" that was developed at the Harvard Center on the Developing Child as the framework within which developmentally supportive interactions are identified. A serve occurs when a child initiates an interaction using words or gestures, or by focusing their attention on something or someone. The serve is returned when the caregiver notices and responds. Within the context of FIND, 5 specific elements of serve and return are emphasized, with one element introduced in each coaching session.

The five FIND elements are:

- Sharing the Child's Focus: This occurs when the adult identifies or notices what the child is interested in and then puts his/her attention there as well.
- Supporting and Encouraging: Having noticed the child's focus of attention, the adult responds in a supportive and/or positive way, adding his or her own reaction by giving the child further information about or acknowledging what he/she is seeing, doing, or feeling.
- Naming: An extension of the Supporting and Encouraging element, Naming occurs when the caregiver uses words to label what the child is seeing, doing, or feeling.
- Back & Forth Interaction: After the child has "served" and the caregiver noticed and returned the serve by Supporting and Encouraging or Naming, the interaction continues. The interaction goes back and forth between child and adult, with the adult waiting for the child's further initiations.
- Endings and Beginnings: This occurs when a Back and Forth interaction between child and caregiver ends and a new serve and return interaction begins. The end of the back and forth interaction is signaled by the child or the episode naturally comes to its conclusion (e.g., the book is finished).

The FIND Program was developed at the Oregon Social Learning Center (OSLC) and the University of Oregon under the direction of Dr. Philip Fisher. FIND is a brief, targeted intervention that is based on a confluence of research in social learning and attachment theory with the most recent findings about how experiences shape the architecture of the developing brain. FIND seeks to reinforce and strengthen the naturally occurring supportive interactions seen between young children and the adults in their lives using a very clear system of feedback utilizing brief video recordings.

The FIND team at the University of Oregon is currently testing the intervention in a variety of settings. FIND micro-trials have been completed with parents enrolled in drug treatment programs and with parents who are working to regain physical custody of their children following placement in foster care. Larger scale projects are moving forward with parents enrolled in Early Head Start programs in Colorado and Washington State. The work in Washington State is funded by the Harvard Center on the Developing Child's Frontiers of Innovation (FOI) program. Also funded by the Harvard FOI, plans are in development to train in-home childcare providers to utilize FIND in their programs. Many other agencies in Oregon, Washington, New York, and Missouri have expressed interest in incorporating FIND into existing programs, and plans are underway to implement FIND at these sites.

Why so much interest in FIND? FIND is elegantly simple, avoiding information overload or corrective teaching. It quickly shows the parent instances in which they are already making supportive connections with their child. The FIND coach breaks down each element of the serve and return process into manageable pieces of information. FIND offers an opportunity to intervene quickly, easily and earlier than ever before to improve the chances of healthy relationships and brain development. FIND is also highly transportable in that the coaching can be delivered by professionals or paraprofessionals, and the editing can be completed either by the coach or at a centralized editing “hub” where videos can be sent from field locations, and edited films can be returned to coaches. This means that the program can be delivered in contexts in which resources are quite limited and/or staff have only limited training (e.g., rural mental health centers; child welfare supervised visits).

It is important to acknowledge that while the FIND approach is evidence informed it is at present not an “evidence-based treatment.” The FIND development team is committed to collecting data on outcomes for those who receive FIND coaching at all sites in which it is being implemented, with the goal of determining for whom FIND is effective and what sorts of supplemental services might increase effectiveness for those with mental health problems or other issues that limit their ability to benefit from FIND coaching.

Note: This flier was provided to local agencies, funding agencies, the UO IRB, and other collaborators interested in learning more about the program. It was not provided to research participants.

Optional Group-Based FIND for Waitlist Control Participants

Mothers who elected to participate in the voluntary group-based version of FIND after completion of the study were assigned to a FIND group according to the timing of their study completion, schedule, and coach availability. Two groups were initiated: Group 1 and Group 2. Participants in Group 1 met as a group with a FIND coach once a week for 10 weeks. Visits ranged in length from 30 minutes to 1 hour depending on the number of mothers participating each week. Every other week, FIND coaches collected 15-20 minutes of film capturing mother-child interactions in the group setting. These films were then edited to find examples of the five FIND elements. During coaching sessions that occur in the intervening weeks, the coach showed parents the edited film with a frame-by-frame analysis of the micro-social interactions with information about why the behavior supports healthy child development. Throughout the 10 weeks, film of all the participating mothers was shown to the group. After completion of Group 1, the group-based program was modified to be 6-weeks based on feedback from the first group of participants. For Group 2, a FIND coach visited the participant once at their house to film the mother and child for about 20 minutes doing everyday activities like having a snack, playing with toys or reading a book. This film was edited and then shown during group coaching sessions to describe and reinforce developmentally supportive behavior that mothers are already using. In both groups, parents viewed video clips of themselves and their child as well as clips of other parents and children who are participating in the group. Video recordings from both versions of FIND for waitlist participants were not used for research purposes.

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