MOTHER-INFANT BEHAVIOURAL SYNCHRONY AND INFANT STRESS PATTERNS DURING MATERNAL MOBILE DEVICE USE: THE ROLE OF MOTHERS' SENSITIVITY AND ATTACHMENT STYLE

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A DISSERTATION SUBMITTED TO THE FACULTY OF GRADUATE STUDIES IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

GRADUATE PROGRAM IN CLINICAL DEVELOPMENTAL PSYCHOLOGY
YORK UNIVERSITY
TORONTO, ONTARIO

April 2026

Abstract

The ubiquity of mobile technologies in recent years has led to growing concerns about caregivers' frequent engagement with mobile phones while interacting with their infants. This "technoference" may produce a "still face" effect that is stressful for infants. The current study aimed to replicate previous work on the impact of mothers' distraction with a mobile phone in their child's presence by examining changes in infant stress behaviours across the three phases of a modified Face-to-Face Still-Face Paradigm. The effect of maternal sensitivity on those stress behaviours was also examined. Additionally, this study sought to address gaps in the literature on the relationship between infant stress and other relational factors including dyadic behavioural synchrony and maternal attachment style, respectively, in the context of technoference. One hundred and eight mother-infant dyads participated in a virtual session that required the mother to become engaged with her cell phone and withdraw attention from her infant in a modified still-face set up. The proportion of infant stress behaviours across phases of engagement was assessed, and mothers' sensitivity during the mother-infant interaction was evaluated with the mini Maternal Behaviour Q-Sort-video. The behavioural synchrony between mothers and infants across phases was also coded. Mothers' attachment-related anxiety was assessed using the Experiences in Close Relationships-Revised Scale. Results revealed a robust still-face effect consistent with previous research. Maternal sensitivity was found to significantly predict reduced odds of pulling away and negative facial expressions in infants as expected, but greater odds of self-comforting. Contrary to hypotheses, mother-infant synchrony did not change meaningfully during maternal cell phone engagement and was not found to be significantly associated with sensitivity. Additionally, there was no meaningful association between maternal attachment-related anxiety and infant stress or synchrony, respectively. These findings illustrate the complexity of defining and measuring dyadic synchrony, particularly in a virtual, naturalistic context and emphasize the need for guidelines and parenting interventions focused on the mindful use of mobile technology during infant care. Future research could explicate the effects of infant stress on the synchronicity of their interactions with mothers, and the role of maternal sensitivity and maternal attachment anxiety in this relationship.

Dedication

This dissertation is dedicated to my parents, who were my first models of sensitive caregivers, and to my husband, whose unwavering support and encouragement made this work possible.

Acknowledgements

First and foremost, I want to thank God for His grace and guidance throughout this project and my life.

Thank you to my supervisor, Dr. Yvonne Bohr, who has supported and inspired both my research and clinical pursuits, since the day I first joined her lab. I am deeply grateful for the opportunity to complete this project, and my graduate school journey, under your mentorship. Thank you for encouraging my pursuit of parent-infant research through your valuable insights, collaborations, and teaching. I would like to sincerely thank my committee members, Dr. Heather Prime and Dr. Hala Tamim, for their thoughtful input throughout the various stages of this dissertation. I am also grateful to the other members of my dissertation committee (Dr. Nicole Racine, Dr. Lara Pierce, and Dr. Celina Da Silva) for their time and contributions to my defense.

A very special thank you to Dr. Robert Cribbie for his support and dedication in helping me conduct the statistical analyses for this project. I am incredibly thankful for the countless hours dedicated by Brittney Robinson and Marette Abdelmaseh in assisting me with the behavioural coding for this project. I am particularly indebted to Brittney Robinson for her tireless work throughout the process of learning new coding software and achieving reliability for video coding. I am also appreciative of the support provided by the members of the Infant and Child Mental Health Lab (Alaina Thomas, Khadija Bint Misbah, Nichaela Garvey, Riya Trikha, Emma Puric, Sierra DiMarco, Sabrina Da Silva, and Fernanda de la Mora) with various parts of this project.

I would like to thank my family for their endless support and encouragement during my graduate school journey. To my parents, thank you for teaching me the value of hard work and for your sacrifices in helping me pursue this dream. This achievement is as much yours as it is mine. To my brother, thank you for being there through the high and lows of my academic journey and for always cheering me on. To my husband, I could not have done this without you. Thank you for your incredible patience, strength, and calming presence throughout these years. I am deeply grateful for your continuous belief in me. To my son and daughter, thank you for inspiring me each day to continue doing this work and for creating new meaning within my role as a developmental researcher and clinician.

Finally, I am incredibly grateful for the mothers and infants who chose to share valuable moments of their days with us – your participation has helped us better understand the impact of mobile technology on parenting practices in an increasingly digital world.

Table of Contents

List of Tables

Chapter 1: Introduction

The use of mobile devices[1] has become increasingly prevalent in social settings, with potentially undesirable repercussions for human relationships. Cell phones are the most commonly used electronic devices worldwide (Lin, 2010), having become a constant companion due to their ease of transport (e.g., Oulasvirta et al., 2012). However, smartphone usage can cause interruptions in social relationships that lead to a decreased quality of interaction between romantic partners (e.g., Wang et al., 2017), parents and children (e.g., Kildare & Middlemiss, 2017), work colleagues (David & Roberts, 2017), and communicators in general (Chotpitayasunondh & Douglas, 2016).

Despite the many visible manifestations of our modern-day digital era, there is a significant gap in the scientific literature when it comes to the ramifications of unremitting mobile device use, an environment to which an increasing number of young children are exposed. My earlier research yielded a preliminary study that showed that mothers are generally less engaged with their infants when focused on a mobile device, and that infants may experience distress in this context of divided attention (Bimm [Khourochvili] et al., 2018). Divided maternal attention in the context of cell phone engagement may be similar to that first demonstrated in Tronick et al.'s (1978) *Face-to-Face Still-Face (FFSF) paradigm* experiments, in which mothers were asked to assume a neutral facial expression when interacting with their infants. Facial unresponsiveness is known to be a stressor for young infants (Cohn & Tronick, 1983). Importantly, however, Weinberg and Tronick found that "infants are able to regulate arousal and resume social interactions after an emotional challenge" (as cited in Haley & Stansbury, 2003, p.

[1] "Mobile device", "cell phone", "mobile phone", "smartphone", and "mobile technology" will be used interchangeably throughout this paper.

1534) and this capacity is influenced by the quality of parent-infant interactions during natural (non-stressful) play (e.g., Kogan & Carter, 1996).

To better understand that phenomenon, the current study built on earlier exploratory work by investigating the patterns of behavioural stress experienced by infants and the behavioural synchrony between infants and mothers, when the latter are engaged with a mobile device in their child's presence. The current study also queried the effect of mothers' general level of sensitivity (in typical daily life) on both infant stress behaviours and mother-infant behavioural synchrony[2], respectively, while the mother was engaged with a mobile device in their child's presence. Finally, the influence of maternal attachment style on mother-infant behavioural synchrony, and on infant behavioural stress, respectively, was explored. The current research adds to an understudied area of maternal sensitivity and adult attachment style by using micro-coding approaches to measure maternal and infant behaviours while dyads were engaged in the increasingly common social context of maternal mobile device use.

Mobile Device Use

With the rapid advancement of communication technology in recent years, smartphones have become embedded in daily life (e.g., Jones, 2014). According to estimates from the Pew Research Center (2024), 98% of American adults own a cell phone and 91% own a smartphone. Among 18- to 49-year-old adults specifically, 99% own a cell phone; moreover, 98% of 18- to 29-year-olds and 97% of 30- to 49-year-olds own a smartphone. Ninety percent of U.S. adults reported that they "go online every day", with 41% reporting that they use the internet almost constantly. It follows that mobile devices are present in almost all households and are being used during regular family activities such as playtime (McDaniel & Coyne, 2016). Although other

[2] "Mother-infant behavioural synchrony" and "dyadic synchrony" will be used interchangeably throughout this paper.

electronic devices, such as TVs and computers, are present in family life, mobile phones are considered especially intrusive as they are constantly with the user and are almost always powered on (Rainie & Zickhur, 2015). Thus, for infants growing up today, caregiver[3] cell phone use is ubiquitous. Indeed, caregivers use their smartphones in many ways, such as staying connected with family and friends, taking photos, working, and playing games (Hiniker et al., 2015; Radesky et al., 2016). Smartphones can also be used to reduce stress through connecting with loved ones for social support (Radesky et al., 2016). However, research has also shown that 10-25% of cell phone users have developed problematic behavioural patterns with their usage (Smetaniuik, 2014), such as engaging in mobile phone use when socially inappropriate or in physically dangerous contexts like texting while driving, and experiencing anxiety when the cell phone is inaccessible (Merlo et al., 2013). Moreover, users may become "absorbed" or "immersed" in digital devices. "Immersion means withdrawal of attention from the environment and focusing of attention on the device and its many online diversions and communicative options" (Braune-Krickau et al., 2021, p. 162). Mobile phone usage can also lead to "phubbing" (a portmanteau of "phone" and "snubbing"), which is a form of interpersonal neglect (David & Roberts, 2017). Partner phubbing has become a widespread concern in contemporary relationships (Carnelley et al., 2023). Extant literature suggests that partner phubbing significantly decreases relationship satisfaction (Beukeboom & Pollmann, 2021; Roberts & David, 2022) and has a negative influence on conversation and intimacy (Vanden Abeele et al., 2019), as well as on the mental health of the spouse and marital quality (Ahlstrom et al., 2012; Roberts & David, 2016; Wang et al., 2017; Wang et al., 2019). Despite a multitude of studies on

[3] The term "caregiver", as used throughout this paper, will refer to "a person who provides direct care (as for children, elderly people, or the chronically ill)" (Merriam-Webster, n.d.). "Caregiver", "parent", and "mother" will be used interchangeably throughout this paper.

the negative repercussions of partner phubbing, the research on the impact of phubbing on parent-child interactions and infant development is in its inception.

Similar to trends for the general population, maternal smartphone use has recently increased (Interactive Advertising Bureau and Babycenter, 2015), with modern-day parents spending considerable time using technological devices. One study examined mothers of 114 infants and found that mothers spent an average of 3 hours per day on their smartphones; 16% reported using their smartphones for 5-15 hours per day, and 6.7% felt they were addicted to their phones (Ali et al., 2020). Another study of 553 mothers and their children reported that mothers spent 4.33 hours on average per day on a technological device (Poulain et al., 2019). This is concerning in light of the research showing that mothers typically engage with mobile phones while in the presence of their children. Indeed, parents frequently use smartphones in daily family situations including play, meal, and bedtimes (Barr et al., 2020; McDaniel & Coyne, 2016; Vanden Abeele et al., 2020; Wolfers et al., 2020; Yuan et al., 2019). Hiniker et al. (2015) found that 59% of 111 caregivers used their mobile phones while on the playground with their infants. Looking specifically at social media use, a study of 154 mothers found that 44% reported an increase in their Facebook use since the birth of their child (Bartholomew et al., 2012), and another study of 309 mostly US-American mothers found that 94% reported “often” being on social network sites while breastfeeding, while 28% used these sites “all the time” while breastfeeding (Tomfohrde & Reinke, 2016). In a study that examined maternal behaviour while mothers fed their children, decreased verbal and nonverbal interaction occurred between the dyads when mothers were engaged with a smartphone (Radesky et al., 2015). A study that evaluated caregivers’ reactions to their children’s bids for attention showed that 56% of parents who were absorbed with a mobile phone did not respond to their children, compared to 11% of parents who were not engaged with a mobile phone (Hiniker et al., 2015). In another observational study, Radesky et al. (2014) observed 55 caregivers and their children while they were eating in fast-food restaurants. The researchers found that parents who were more absorbed with their smartphones interacted less with their children and reacted more inappropriately to their children's behaviours. This body of research suggests an increasing popularity of digital communication devices and social media among caregivers, which may have unintended detrimental effects in the context of child rearing.

Developmental Outcomes Associated with Mobile Device Use

Increased technology interference in parent-child interactions may adversely impact several areas of early childhood development. Carson and Kuzik (2021) found that higher parent-child technology interference was linked to reduced executive functioning and self-regulation, as well as increased externalizing and internalizing behavioural problems. Other studies have also found associations between technology interference and more behavioural problems in children as caregivers' attention gets directed away from their children's needs and towards their phone (McDaniel & Radeksy, 2018a, 2018b). Furthermore, parental technology use was found to be associated with children's psychosocial difficulties in studies of underprivileged families (Wong et al., 2020). Frequent use of mobile devices during parent-infant interactions can also reduce opportunities for emotional feedback in the moment, which is crucial for developing emotion regulation (Field, 1994). Indeed, a review of the literature indicated that frequent technology disruptions in the parent-child relationship can influence children's long-term well-being and relationships (McDaniel, 2019). For example, children may: form a less secure attachment with distracted parents, be perceived by their parents as having more problem behaviours when their interactions with their parents are interrupted by technology (McDaniel & Radesky, 2018a, 2018b), experience negative feelings about their parents' phone use (Steiner-Adair & Barker, 2013; Radesky et al., 2016), and have decreased learning and/or achievement in various areas (e.g., Reed et al., 2017). While the impact of technology interference on older children has been documented (Dixon et al., 2023; Sundqvist et al., 2020), there is a scarcity of research on its impact during infancy.

Maternal Sensitivity

The consequences of technology interference on parent-child interactions can be explained theoretically by attachment theory (Ainsworth, 1979; Bowlby, 1969). Forming a secure attachment between the parent and child is critical during infancy, with evidence indicating that it can predict areas of child development such as cognitive performance (e.g., West et al., 2013), emotion regulation (e.g., Zimmer-Gembeck et al., 2017), and social competence (e.g., Groh et al., 2014). According to attachment theory, one of the strongest predictors of parent-child relationship quality is the mother's sensitivity, which in turn has enduring effects on children's psychosocial and health outcomes (e.g., Fearon et al., 2010). Sensitivity was first conceptualized by Mary Ainsworth (1967), who described it as a mother's prompt and appropriate response to her infant's signals that are perceived and interpreted correctly. Sensitive responding includes an attunement to the infant's state and mood and occurs according to the baby's timing. Of highest importance is the timely, responsive interaction between mother and child (not merely care), with positive exchanges characterized by mutual delight (Ainsworth, 1967). Given that attending to a smartphone may divide a mother's attention when caring for their child (Bimm [Khourochvili] et al., 2018; Bohr et al., 2017), long and frequent engagement with a mobile phone could limit a mother's ability to be sensitive towards their child.

Ainsworth developed four dichotomous 9-point scales to describe maternal care: (1) Sensitivity-Insensitivity; (2) Cooperation-Interference; (3) Acceptance-Rejection; (4) Accessibility-Ignoring. The Sensitivity-Insensitivity scale is characterized by a mother's "prompt and appropriate responsiveness to her baby's accurately perceived signals and communications" (Bretherton, 2013, p. 465). Cooperation-Interference refers to a mother's view of her baby as an autonomous person and the degree to which her initiations of interaction interrupt her baby's ongoing activity. Acceptance-Rejection ratings represent the balance between a mother's positive and negative feelings toward her baby. Finally, the Accessibility-Ignoring scale is scored according to the extent of a mother's physical and psychological accessibility to her infant (Bretherton, 2013). The high end of these scales describe mothers who demonstrate sensitive behaviours such as flexibly adapting to and being attentive of their infant's cues, cooperating with their baby, and accepting their infant and being a mother. At the lower end of the scales are mothers who seem preoccupied with themselves and demonstrate more arbitrary behaviours (e.g., interfering with their infant's activities and wishes for no reason). The mid-range of the scales characterize mothers who are inconsistent in their sensitivity, interference, acceptance, and accessibility (Bretherton, 2013). These scales capture differences in the level of maternal sensitivity and are foundational to video-coding of dyadic interactions during which a mother's degree of sensitivity is typically evaluated.

Developmental Outcomes Associated with Maternal Sensitivity

Sensitive and responsive caregiving meets the infant's needs for survival and thus enhances their well-being. Specifically, it "ensures that the infant will be fed when signaling hunger, protected when signaling fear, and cared for when signaling pain" (Mesman et al., 2018, p. 838). Indeed, the quality and consistency of caregiving can impact behavioural patterns for emotions, attention, and social functioning from birth (Stern, 1985) and throughout childhood (Waters et al., 2000). Theorists have suggested that caregiver responses to distress cues or safety bids are especially important for the development of attachment security (Ainsworth, 1967; Bowlby, 1951; Goldberg et al., 1999; Thompson, 1997), and maternal insensitivity is a strong precursor for later attachment difficulties in children (Ainsworth et al., 1979). Using the Strange Situation procedure to study infants' attachment-related behaviour, Ainsworth and colleagues (1978) found a strong association between maternal sensitivity and infants' attachment security. Namely, secure infants had mothers "who consistently responded to them in a prompt, warm and sensitive manner" (Leerkes & Zhou, 2018, p. 754). Conversely, mothers of avoidant infants were slow to respond if at all, sometimes showing rejection. Mothers of resistant infants responded inconsistently, with both sensitive and negative responses. Notably, mothers of both resistant and avoidant infants were less responsive to their distress cues (Ainsworth et al., 1978). A recent systematic review of the literature (Montealegre-Ramon et al., 2024) further supports the positive relationship between maternal sensitivity and attachment security, with children of more sensitive mothers demonstrating more secure attachment. These early sensitive interactions between infants and their mothers are also thought to form the foundation for infants' later socioemotional development and adaptive relationship schemas (Ainsworth et al., 1978). Indeed, maternal sensitivity has been associated with decreased externalizing behaviours (Leerkes et al., 2009), increased cognitive and language development (Landry et al., 2006), reduced physiological stress responding (Bosquet Enlow et al., 2014), and improved physical health (Anderson & Keim, 2016; Letourneau et al., 2017). Extant findings highlight the many benefits of highly sensitive caregiving, thus warranting concern for children's wellbeing in contexts of decreased maternal sensitivity.

Maternal Sensitivity and Mobile Device Use

Only a small number of studies have directly assessed the relationship between maternal sensitivity and smartphone use (e.g., Golen & Ventura, 2015; Hiniker et al., 2015; Vanden Abeele et al., 2020), although a growing body of research is emphasizing the negative repercussions of smartphone usage on parent-child interaction more generally (e.g., McDaniel, 2019). The omnipresence of smartphones and their potential for interfering with parent-infant interactions may reduce maternal sensitivity in an unprecedented way (Braune-Krickau et al., 2021). Mothers' smartphone use in the presence of their child can interfere with sensitivity in two ways: distraction and interruption (Wolfers et al., 2020). Distraction has been found to be negatively related to sensitivity (Golen & Ventura, 2015; Lohaus et al., 2001). When distracted by her phone, a mother may be less perceptive of her child's signals and may miss opportunities for shared engagement (Radesky et al., 2014, 2015; Tomfohrde & Reinke, 2016). Mothers may also not react as appropriately when distracted because they miss important information conveyed by their child (Golen & Ventura, 2015; Radesky et al., 2014). Sensitive mothers, however, should be able to attend to their child's signals even when their attention is divided between their child and another demand (Smith & Pederson, 1988). Yet, arguably, smartphones are more absorptive than other forms of distraction, making it more challenging to pay attention to both smartphone and child (Ante-Contreras, 2016). Indeed, compared to other distractions such as conversing with other adults, or partaking in other activities such as smoking, use of a smartphone appeared to make it more difficult for parents to turn their attention back to their children (Lemish et al., 2020; Vanden Abeele et al., 2020). Thus, a mother who is distracted by her smartphone may be inclined to interact less with her infant, to react less appropriately, and consequently to be less sensitive. This can in turn negatively influence child attachment and development (Kildare & Middlemiss, 2017).

The second way that smartphone usage can conflict with sensitivity is through interrupting mother-child interactions (McDaniel & Coyne, 2016). These everyday interruptions in interpersonal interactions or shared time due to technological devices have been termed "technoference" (i.e., technology interference; McDaniel & Coyne, 2016). McDaniel and Radesky (2018b) found that parents who reported problematic smartphone usage (e.g., an inability to resist checking new text messages), also reported a higher number of interruptions in their interactions with their children. These interruptions are associated with less appropriate reactions by the mother (Kildare & Middlemiss, 2017) and can result in lower sensitivity. The ramifications of such interruptions were demonstrated by Kildare (2017), who used a modified still-face procedure with 34 mother-child dyads. After interacting normally with their children, mothers were asked to type the alphabet as fast as possible into their mobile phone without responding to their child's signals. The results showed that 3- to 6-month old infants reacted with less positive and more negative affect when their mothers were using their phones as compared to when they were not, in line with the reactions observed in other still-face studies.

Several observational studies have examined the effect of caregivers' smartphone use on their sensitivity or responsiveness to their young children. Wolfers and colleagues (2020) conducted a study that focused on the relationship between mothers' smartphone use and maternal sensitivity. They observed 89 mother-child dyads on playgrounds in a German city, with children ranging from 7 to 37 months (mean age = 20 months). The results revealed that nearly half of the mothers were engaged with their smartphones during the 10-minute observation period, for an average of 1.3 minutes. Mothers who used their phones for longer were rated lower on sensitivity, in line with previous findings (e.g. Radesky et al., 2014). Similarly, Vanden Abeele et al. (2020) observed 53 parent-child dyads in consultation bureau waiting rooms and playgrounds. Their findings revealed that parents were five times less likely to respond to their child's bid for attention while using a phone compared to when not using one. Notably, caregivers' responses were less prompt, weaker, demonstrated less affect, and tended not to prioritize the child over other activities. Another study conducted with older children (2 to 6 years of age) assessed the effect of smartphone use on parental responsiveness during mealtime in eateries in Israel and in the U.S. (Elias et al., 2020). Parents who were absorbed with their phones were observed to ignore children's bids for interaction and were less emotionally supportive. The researchers also observed a relatively high frequency of smartphone use in parents, varying from 65% of parents in Israel to 70% of parents in the U.S. Approximately one third of parents engaged with their smartphones between 40-100% of the entire meal time. Consistent with these observational studies, Konrad et al. (2021) found that mothers were not as responsive and initiated fewer activities while using smartphones in the presence of their 20- to 22-month-old children. Therefore, longer absorption with a smartphone may distract mothers from responding to their children's communications, thereby reducing their sensitivity (Knitter & Zemp, 2020; McDaniel & Radesky, 2018b).

Face-to-Face Still-Face Paradigm

The Face-to-Face Still-Face Paradigm (FFSF) is a well-established experimental protocol designed for infants between 1 to 12 months of age to study their communicative competencies, attentional and affective regulation, and reactivity to changes in maternal behaviour (Adamson & Frick, 2003). This experimental structured face-to-face interaction creates a stressed state in infants as a result of their mothers' lack of responsiveness. According to Tronick (1980, 1989), the mother's lack of responsiveness interferes with the infant's desire for social engagement, which creates negative emotions and efforts to manage these by disengaging and self-comforting. Importantly, it can simulate the effect of disrupted interactions on infants' behavioural organization (Tronick et al., 1975) and demonstrate that behavioural contingencies are important for infants when interacting with their caregivers, thus illustrating the potential repercussions of extreme lack of maternal sensitivity. Indeed, maternal sensitivity can predict infant behaviour in the FFSF, as well as future attachment security (Mesman et al., 2009).

The FFSF consists of three phases: 1) a "normal" free-play play interaction between mother and infant; (2) a "still face" (SF) episode, wherein the mother is asked to assume a neutral facial expression and remain unresponsive to their infant; (3) a "reunion" phase when the mother resumes their typical interaction with their infant. Each of these conditions are 2 or 3 minutes in duration (Weinberg & Tronick, 1996). The free-play condition acts as the baseline for mother-infant play, while the still-face episode interrupts this exchange by having the mother stop initiating or responding to the infant, while maintaining eye contact (Myruski et al., 2018). During the still-face phase, the absence of maternal regulation can often lead infants to become distressed as their bids fail to evoke a response from their mother (Montirosso et al., 2015), and the anticipated social dynamic created by dyads over time is disrupted (Porter et al., 2009). Indeed, a robust pattern known as the "still-face effect" is observed in response to the FFSF starting from 1 month of age (Bertin & Striano, 2006; Tronick et al., 1978), which is characterized by a decrease of positive and increase of negative affect from the typical play interaction to the still-face episode. During the reunion phase, infants typically demonstrate a "reunion effect" with a partial carry-over of negative affect and gaze aversion, with only partial recovery of positive affect and social engagement with the mother following the still-face

(Mesman et al., 2009; Weinberg & Tronick, 1996). The infant therefore must manage the resumption of their mother's behaviour (which is likely positive for the infant) and the carryover of negative affect from the still-face episode. The literature supports the idea that reunion elicits both positive and negative affective reactions from young infants (e.g., Mesman et al., 2009; Stockdale et al., 2020; Swider-Cios et al., 2024). The reunion phase also allows the dyad to resume interactive play and therefore creates the possibility of repairing subsequent mismatches (Myruski et al., 2018).

The FFSF has become a widely used framework for investigating hypotheses about infants' socioemotional development (e.g. Adamson & Frick, 2003; Cohn & Tronick, 1987; Field et al., 1990). It also allows for the study of maternal sensitivity in response to both infant stress (during still-face and reunion) and non-stress (during play), highlighting the versatility of this protocol. In addition, a number of studies have used modified versions of the FFSF, primarily varying the still-face condition (Delgado et al., 2002; Jean et al., 2014; Legerstee & Markova, 2007). Overall, these studies suggest that modified versions of the FFSF (e.g., during the still-face episode: parents looking at a picture located above and behind the infant, mothers being instructed to use a mobile device, allowing infants to move freely and have access to toys) still have a relatively robust still-face effect (Delgado et al., 2002; Myruski et al., 2018; Stockdale et al., 2020; Tidemann & Melinder, 2022). Repeated still-face designs (consisting of a second still-face episode and second reunion episode) have also been studied, revealing that the still-face effect is maintained (DiCorcia et al., 2016; Haley & Stansbury, 2003). For example, a recent study by Ginnell et al. (2022) used a repeated still-face design wherein the caregiver was asked to adopt a neutral facial expression, stop physical contact with their infant, and avoid directly looking at the infant, while continuing to face the child. Results showed that negative affect increased significantly between play and still-face conditions, and between play and reunion phases, for both preterm and full-term infants at 9 months of age. Moreover, larger effect sizes have been found with repeated still-face designs compared to the original three-phase design. For example, maternal unresponsiveness had a significant effect on Hypothalamic-Pituitary-Adrenal (HPA) axis reactivity when using the 5-episode FFSF, but showed no significant effect size with the 3-episode FFSF (Provenzi et al., 2016). Moreover, Puhakka and Peltola (2020) found that the 5-episode FFSF "had a relatively large combined effect size (g = .25), whereas the combined effect size of the 3-episodic stressors was small" (p. 7).

With smartphones becoming integrated into daily family life, mother-infant interactions are at risk of technological disruptions that resemble a classical still face (Myruski et al., 2018). When checking their mobile devices, caregivers' faces often lack expression and are not responsive to infant's cues. To young children, such periods may resemble a "still face" and prompt adverse reactions (Adamson & Frick, 2003). For example, Myruski and colleagues used a modified FFSF in which mothers of infants ranging from 7-23 months of age were asked to focus on a mobile device during the still-face condition. The findings showed a still-face effect similar to earlier studies (Mesman et al., 2009), with reduced positive affect and higher negative affect when moving from free play to still-face, and partial recovery during reunion. Stockdale and colleagues (2020) extended Myruski et al.'s prior work by recruiting a sample of 227 caregiver-infant dyads who also demonstrated a robust still-face effect across the FFSF's three phases. Tidemann and Melinder (2022) also used a modified FFSF in which parents became occupied with a smartphone during the still-face condition. They used a cross-sectional experimental design to study the behavioural responses of infants of 6, 9, and 12 months of age. Their findings indicated that all groups of infants demonstrated higher levels of protest behaviour, and decreased levels of positive engagement and social monitoring when interaction with their parent was interrupted due to phone use. In a more recent study (2025), Nazzari et al. used an adapted FFSF with 3-5 month old infants that included both digital (smartphone) and non-digital (paper questionnaire) distractions. Findings demonstrated that infants showed behavioural distress during both types of distractions – reduced gaze toward parents, reduced positive affect, and increased self-comforting. Another recent study used a smartphone-adapted still-face protocol to reveal decreased positive affect and increased negative affect of 5- to 12-month-old infants during two still-face episodes (Swider-Cios et al., 2024).

In light of these studies, there is potential to provide additional support for these findings by further examining infants' responses to this kind of stressful context, specifically with younger infants (3- and 4-month-olds), and a wider variety of infant stress behaviours. The current study addresses this gap and adds to the literature by employing a modified FFSF dubbed the *cell phone engagement protocol* (Bimm [Khourochvili] & Bohr, 2018; Bohr et al., 2017) with 3- to 10-month-old infants to examine less frequently studied, specific infant stress behaviours in response to the smartphone-induced still-face. It also provides further evidence for the patterns of infant facial expressions when infants are faced with stress. This protocol starts with a typical face-to-face interaction ("free-play" phase; Phase 1), then moves to a "still-face" phase (Phase 2) during which mothers are prompted to use their mobile phone, and ends with a "reunion" phase (Phase 3) where the dyad resumes typical interaction. This protocol incorporates prompted mobile phone use during the still-face phase, in which the mother's attention is shifted to their mobile phone thereby interrupting reciprocity of the interaction and removing eye contact. This broadening of the still-face effect to common caregiver-infant settings allows us to better understand how interruptions to dyadic interactions by technology influence infants' behavioural response.

Infant Stress Behaviours

Infants differ in how well they can regulate their emotional arousal during early face-to-face interactions, with younger infants often having difficulty regulating their emotions (Fuertes et al., 2024). A key developmental goal for infants is to learn how to regulate themselves when faced with stress (Erickson et al., 2022), which they learn to do through social interactions with their caregivers (Leerkes & Parade, 2015). During the first year of life, infants begin to develop both reactive and regulatory mechanisms pertaining to stress (Posner & Rothbart, 2000). Stress reactivity can be defined as a response to a stressor, while regulation is the recovery of that response (Barr & Gunnar, 2000; Lewis, 1989) through both internal and external (e.g., dyadic) ways (Geeraerts et al., 2020). Infants' reactivity includes both negative emotionality (defined as a pattern of reacting with negative affect like crying), and positive emotionality, which refers to a tendency to respond with positive affect (Rothbart & Bates, 2006). During the first three months of life, infants demonstrate more reflexive stress responses like crying. From three to six months, they acquire more control over their affective arousal and actively evoke their mothers' support through more coordinated use of visual attention and social smiles (Messinger & Fogel, 2007). From six months, infants can initiate interactions, signal their needs, and reciprocate social behaviors of their mothers (Tronick, 2007).

The stress response involves several behavioural and physiological systems which facilitate a return to homeostasis after a disruption. Indeed, Als's (1983) Synactive Theory of Development purports that infants use five subsystems to interact with their environment, and these are interdependent and interrelated: (1) autonomical/physiological; (2) motor; (3) state; (4)

attention/interaction; and (5) self-regulation. She suggests that specific behavioural signs of stress may be associated with each subsystem. Holditch-Davis et al. note that:

> Autonomic system stress signs include startles, hiccups, gasping, tremors, twitching, yawning, and sneezing. Motor system stress signals include fingersplays, arching, fisting, or hypertonia or hypotonia. State system changes that indicate stress include grimace, abrupt state changes, or diffuse states. Attentional-interaction system stress signs include gaze aversion, staring, panicked or dull look, or eye floating. Signs of stress in the self-regulatory system include behaviors that reflect the infant's attempts to gain balance, including postural changes and self-quieting behaviors such as leg/foot bracing, sucking, or grasping (as cited in Harrison et al., 2004, p. 237).

Assessing the behavioural cues that are associated with each of these subsystems may be important for evaluating the infant's functional stability and response to stress (Holditch-Davis et al., 2003). Indeed, infants interact with their social environment using two types of cues: stress cues and stability cues (Lavallée et al., 2022). Stress cues (e.g., facial grimacing, crying) signal an unstable state and that help is needed to regain stability. Stability cues (e.g., sucking, grasping) signal that minimal handling is needed. Broadly, the Synactive Theory of Development highlights the importance of continual reading of infants' behavioural cues as these communicate their needs to others (Lavallée et al., 2022). Importantly, long-term, behavioural and biological reactions to stress early in childhood can affect internalizing, externalizing, and attachment behaviours across childhood (Dale et al., 2011; Qu & Leerkes, 2018; Zeytinoglu et al., 2022).

Stress regulation refers to the management of elevated levels of both negative and positive emotions (Braungart-Rieker & Stifter, 1996), and may be indexed by emotion regulation (Erickson et al., 2022). Emotion regulation is mostly achieved through physiological means in the first months of life. During the second half of the first year, infants become more proficient at regulatory behaviours such as self-soothing (e.g., thumb-sucking) and self-distraction during maternal unavailability (Calkins & Leerkes, 2011). Attentional strategies like gaze aversion, as well as avoidance behaviours, are also used to regulate (Rothbart & Derryberry, 1981). Emotion regulation begins to develop during the infant's first year through caregiver interactions, especially when presented with stressors (Haley & Stansbury, 2003; Provenzi et al., 2017). Indeed, more adaptive stress recovery in infants has been characterized as socially engaging with the mother after a stressor (e.g., Montirosso et al., 2010), and the development and organization of stress response systems can partially depend on a caregiver's interactive behaviours. This is because the infant is part of an emotion communication system in which their attempts to accomplish their goals are aided by their caregiver's capacities (Tronick, 1989).

It follows then that experimentally induced episodes of maternal unavailability to interact (such as in the FFSF) are known sources of social stress for infants (Adamson & Frick, 2003; Mesman et al., 2009), and thus allow for assessment of infants' behavioural and physiological stress responses. Indeed, infant reactivity to stress (i.e., the still-face) has been operationalized as the change in negative affect from the free-play to the still-face phase, while infant recovery from stress was characterized as the change in negative affect from the SF to the reunion phase (Somers et al., 2025). The perturbation in maternal communication can elicit a dramatic increase of negative emotionality (Haley & Stansbury, 2003; Tronick et al., 1978), heart rate, gaze aversion, and self-comforting behaviours, and a decrease in social attend (Haley & Stansbury, 2003), positive affect, and gaze at the mother (Mesman et al., 2009). For example, my earlier work showed a significant increase in the percentage of infant distress behaviours (distressed affect and gaze away) and a significant decrease in attempts to engage mothers (neutral or positive affect and gaze toward mothers), when moving from the "normal" play interaction to the "still-face" episode (i.e., mother focused on a mobile phone) of the *cell phone engagement protocol* (Bimm [Khourochvili] et al., 2018). Similarly, when infants were confronted with an unresponsive mother in the FFSF, Gianino and Tronick observed two different types of behaviours: "(1) *self-directed regulatory behaviours* (e.g., looking away, self-comforting, and self-stimulating), used to modulate their levels of arousal and affect; and (2) *other-directed regulatory behaviours*, used to elicit and capture the interactive and regulatory behaviour of the mother (e.g., pick-me up gestures)" (as cited in Montirosso et al., 2012, p. 819). Self- and other-directed regulatory behaviours are part of the infant's typical coping capacities when experiencing sadness, uncontrolled anger, or extreme positive emotion. These coping behaviours allow the infant to accomplish the simultaneous goals of controlling their affective state while interacting with their environment (Tronick, 1989). When experiencing maternal unavailability, most three-month-old infants express other-directed behaviours such as facial expressions and gestures to prompt their mothers to resume their usual behaviour. When these fail, the infant expresses negative affect and controls their emotional responses through self-directed regulatory behaviours. These reactions occur even after a few seconds of mothers being in a still-face position. Furthermore, infants' negative mood and looking away from their mothers continues for the next few minutes (Tronick, 1989). Other research on the period of maternal unavailability has found increased pointing by infants (Fogel et al., 1982), a closed-hand accompanying distressed facial expressions and gaze aversion (Legerstee et al., 1990), and increased attempts to touch their mothers during normal play than during the still-face condition (Moszkowski & Stack, 2007).

Despite the focus on infant responding during the still-face episode, it is infants' responses during the reunion phase that may be significant for the development of self-regulation. These responses during the reunion phase are presumed to represent attempts to return to homeostasis following disturbances in behavioural and physiological functioning during the still-face phase (Gunning et al., 2013). Infants exhibit a mixture of positive and negative affect during the reunion phase (as mentioned above), in addition to various regulatory techniques (e.g., gazing at their mother, thumb-sucking, arching the back, etc.) (Conradt & Ablow, 2010; Rosenblum et al., 2002; Weinberg & Tronick, 1996). Indeed, infants use various behavioural strategies to regulate excitement and arousal (Buss & Goldsmith, 1998; Kopp, 1989). For example, infants avert their gaze when over- or under-stimulated during face-to-face interactions (Beebe, 2000; Field, 1981), which can lead to decreased autonomic arousal (Field, 1981) and negative affect (Harman et al., 1997; Stifter & Braungart, 1995). Infants also modulate affect by being attentive to what their hands are doing, putting their hands in their mouths (Toda & Fogel, 1993), or by seeking eye contact from their caregiver (Braungart-Rieker et al., 2001). Their numerous expressive gestures and hand movements function as regulatory behaviours for managing both negative and positive emotional states (Gianino & Tronick, 1988). Expressive gestures appear to be context-dependent, such as when infants display active limb movements, increased handling of clothes, face-touching and sucking during the still-face episode of the FFSF versus the normal play episodes (Moszkowski & Stack, 2007; Murray & Trevarthen, 1985; Toda & Fogel, 1993). Importantly, infants who experience physically present but emotionally unresponsive parents may have poorer emotional regulation ability and increased negative affect (Myruski et al., 2018). Therefore, early support of infant emotion regulation in distressing contexts is foundational for their socioemotional development (Green et al., 2025). Indeed, early experiences of stress recovery are believed to be associated with regulatory resilience (DiCorcia & Tronick, 2011), greater social competence, and fewer behavioral problems (e.g., Moore et al., 2001; Noten et al., 2020). Given this important impact on developmental outcomes, more research is needed to expand the literature on how young infants respond to stressful relational contexts of technoference, and the dyadic factors (e.g., synchrony, caregiver sensitivity and attachment style) that may be at play during caregiver-infant interactions in those contexts.

Behavioural Indicators of Infant Stress

Indicators of infants' stress behaviours have been researched for many decades. One of the most used measures in that research is the Nursing Child Assessment Satellite Training (NCAST) Parent-Child Interaction (PCI) Teaching and Feeding Scales (Oxford & Findlay, 2013, 2015). The PCI Scales were based on the Barnard Model (Barnard et al., 1988), which describes optimal parent-child relationships as "mutually adaptive, positive interactions that promote optimal child development and crucially, in which both parents and children have important roles" (Letourneau et al., 2018, p. 48). The NCAST Scales have been shown to be reliable and valid assessments of PCI quality and consist of six subscales for evaluating caregiver behaviour and young children's regulation (Sumner & Spietz, 1994a, 1994b). Importantly, children's contribution to the interaction is measured by two of the subscales, which assess the clarity of their cues and their responsiveness to their caregiver. Cues are split into two categories: engagement and disengagement (Mischenko et al., 2004). Engagement cues are indicative of the infant's desire to continue interacting, while disengagement cues (indicative of stress; Hu et al., 2025) suggest that the infant needs a break from the interaction. *Potent disengagement* cues consist of "back arching", "cry face", "pulling away", and "maximal lateral gaze aversion", while *subtle disengagement* cues include "facial grimace", "gaze aversion", "hand-to-mouth", “increased sucking movements”, and “turning head” (Oxford & Findlay, 2013, 2015). Of relevance for the current study, disengagement cues represent behaviours that infants may engage in when facing stressful situations such as the FFSF.

Varying levels of infant engagement (or stress) are also captured by the Infant Caregiver Engagement Phases – Revised (ICEP-R; Reck et al., 2009). The ICEP is a coding system that similarly defines negative engagement in infants as, for example, having negative facial expressions (e.g., anger, sadness, cry or grimace faces), arching the body, and pulling away, while positive engagement is characterized by behaviours such as joyful facial expressions (e.g., smiles), looking toward the caregiver’s face, and social play-games. For example, a recent study (Hu et al., 2025) adapted the ICEP to conceptualize infant behavioral distress as the infant showing negative engagement, while behavioral stress recovery was characterized as the degree to which infants engaged socially with their mother with positive or neutral affect.

Based on the behaviours captured by NCAST and ICEP described above, the present study examined infant stress as indicated by negative facial expressions, pulling away behaviours, and self-comforting. Micro-coding approaches were used to determine patterns of stress behaviours in infants, to promote an understanding of the infant’s experience while their mother is engaged with a mobile device in their presence.

Maternal Sensitivity and Infant Stress

A sensitive caregiving environment promotes infants’ ability to manage distress (Ainsworth et al., 1978). The caregiver’s ability to read their infant’s cues enables them to more successfully soothe their infants or to shift their infant’s attention in order to reestablish regulation and social engagement (Fuertes et al., 2024). Reliable responding to infant cues and distress uniquely predicts child attachment security, physiological and behavioural regulation, and social competence (Conradt & Ablow, 2010). Indeed, mothers' contingent responses to their children's behaviour have been shown to instill self-efficacy in the infant (Brazelton et al., 1974), and promote emotional (e.g., Kochanska & Coy, 2002), social (e.g., Legerstee & Varghese, 2001), and cognitive development (e.g., Tamis-LeMonda et al., 2001). Contingent responses can include behaviors that reflect the infants' affect, respond to what the infant is attending to, and consider the underlying subjective state of the infant's behavioral signals (Haley & Stansbury, 2003). These communications may serve as an external source of regulation from the mother (Tronick, 1989). When this regulatory source becomes temporarily unavailable, the infant can become stressed and recovery from this kind of disruption may be difficult for both the child and mother (Weinberg & Tronick, 1996; Weinberg et al., 1999).

The FFSF is often used to study individual differences in infants' regulatory abilities in response to brief emotional unavailability of their mothers and provides an opportunity to study their developing regulatory abilities starting at 2 months of age (Adamson & Frick, 2003). Maternal sensitivity displayed during the FFSF has been associated with decreased negative affect and more social gaze during those situations (Braungart-Rieker et al., 1998; Haley & Stansbury, 2003). Indeed, studies have shown that mothers who are more sensitive during the first play episode are more likely to have infants who show positive affect and look longer at their mother during the still-face episode (Barbosa et al., 2019; Carter et al., 1990; Lowe et al., 2012; McQuaid et al., 2009; Mesman et al., 2009), demonstrate fewer avoidant and/or resistant behaviours during re-engagement (Kogan & Carter, 1996), and show better regulation of negative affect and heart rate during re-engagement (Haley & Stansbury, 2003; Mesman et al., 2013; Rosenblum et al., 2002). These mothers have also been found to exhibit less intrusiveness and more capacity to comfort their infant during reunion (Barbosa et al., 2019). Bigelow and

Power (2014) found that infants with more contingently responsive mothers demonstrated greater attention and positive affect to their mothers during the interactive phases of the SFP. Furthermore, research has shown that mutual gaze, together with shared positive affect, predicted positive expressive behaviours in infants during *both* still-face and reunion, as well as greater joy, social gaze, and interest during reunion (Weinberg et al., 1999). When transitioning from the still-face episode to the reunion phase, infants with more sensitive parents exhibited greater increases in positive affect and self-comforting (Braungart-Rieker et al., 2014), suggesting better affect recovery. More sensitive parents thus appear better attuned to infants' emotional cues and help infants reengage in more positive interactions (Leerkes, 2011). Additionally, Braungart-Rieker et al. found that maternal sensitivity also predicts "attention-seeking, positive affect and re-engagement during the reunion phase" (as cited in Mastergeorge et al., 2014, p. 389). A recent study by Girod et al. (2024) further supports these findings, as infants of highly sensitive mothers were more likely to have lower negative reactivity followed by recovery during the still-face procedure. Girod and colleagues posited that these infants have gradually learned that their mothers can provide security and use their mothers for emotion regulation. Another recent study (Green et al., 2025) looked at maternal warmth, which is considered a key aspect of maternal sensitivity (Ainsworth et al., 1978). The study examined maternal warmth during a 5-minute reunion episode of the FFSF, defining warmth as an average of maternal interactiveness and positive affect. The researchers found that an elevated baseline level and increase of maternal warmth was linked to less negative affect in infants at the end of reunion (Green et al., 2025).

In sum, these findings suggest that maternal sensitivity has a significant impact on the dyad's ability to re-establish positive engagement following the stress resulting from maternal still-face. Given that contingent maternal responses may contribute to intersubjectivity (Tronick, et al., 1978) and attunement (Stern, 1985) between mothers and infants, we posit that maternal sensitivity may also pay a role in behavioural synchrony between mother-infant dyads.

Mother-Infant Behavioural Synchrony

Decreased maternal sensitive behaviour, such as changes in maternal care during the post-birth period, can permanently alter stress regulation systems (Meaney, 2010), highlighting the importance of responsive social contact in infant development. In the context of FFSF situations, mothers' supportive responses to infants after that infant has experienced a stressor constitute a so-called "reparatory process", and successful reparation of the dyadic interaction serves as a marker of early attunement and mother-infant behavioural synchrony (Mastergeorge et al., 2014).

Definitions of Synchrony

Synchrony has been broadly defined as "the dynamic and reciprocal adaptation of the temporal structure of behaviours between interactive partners" (Leclère et al., 2014, p. 2). This implies that synchronous interactions involve coordination of behaviours between the partners across different communicative modalities (e.g., facial expression, gaze). As such, synchrony depicts the complex "dance" that occurs during brief interactions (Leclère et al., 2014), and can be viewed as a quality of dyadic coordination. Several other authors offer similar definitions of synchrony. Provenzi et al. provide a broad operationalization of the synchrony process, describing it as the "degree of congruence between transmodal behaviors of two partners, which is lagged in time and which promotes infants' learning of emotional regulation skills and the emergence of expectations on interactive repertoires" (2018, p.12). It has also been defined as "the temporal coordination of partners' states, independent of affective valence (e.g., Feldman, 2007)" (Moore et al., 2016, p. 61), and similarly, "the degree to which parents and infants change their affective expressions consistently together across time without regard for the type of expression that either partner is showing" (Moore & Calkins, 2004, p. 1068). Busuito et al. (2019) describe dyadic behavioural synchrony as the *degree of coordination* between mothers' and infants' behaviours over time, citing it as an important quality of dyadic interactions. For example, changes in infants' behaviours can lead mothers to respond by modulating their own behaviours to become more or less positive (e.g., Busuito & Moore, 2017; Conradt & Ablow, 2010). In humans, unlike in other mammals, early mother-child social interactions involve matching of socioemotional facial signals (Feldman et al., 2011). Face-to-face interactions, in which infants begin to engage around three months of age, are characterized by synchrony of non-verbal cues (Stern, 1985; Tronick, 1989). Nonverbal synchrony has been classified into three key types: gaze synchrony, in which parent and child share social gaze (Kaye & Fogel, 1980); affect synchrony, in which the dyad's affective expressions are matching (Cohn & Tronick, 1988a); and vocal synchrony in which the parent and child engages in "proto-conversations" (Jaffe et al., 2001).

Notably, synchrony has been used interchangeably with the terms *coordination*, *contingency*, and *coregulation* (e.g., Feldman, 2007c; Van Egeren et al., 2001; Yu & Smith, 2013), and defined similarly to the related concepts of *dyadic affect regulation*, *behaviour state matching* (Harrist & Waugh, 2002), and *dyadic reciprocity* (Dollberg, 2022). Yet, Golds et al. (2022) describe reciprocity, mutual regulation, self- and inter-active contingencies, and synchrony as *different* dyadic processes that are co-occurring simultaneously. Of note, the construct of reciprocity significantly overlaps with the concept of synchrony, with the main difference being the time scale – reciprocity involves a large time scale while synchrony may be evaluated on both a macro and micro time scale (Leclère et al., 2014). Nevertheless, synchrony is frequently viewed as a behavioural process that encompasses mutuality and reciprocity (Harrist & Waugh, 2002; Provenzi et al., 2018). In light of these varying definitions, it follows that synchrony has been subject to inconsistencies in definitions and measurement (Harrist & Waugh, 2002).

Several key characteristics of synchrony have also been described in the literature and expand the definitions above: It can be observed within multiple sensorial or behavioural modalities (e.g., Messinger et al., 2009); dyads are only synchronous for a short proportion of time even if their synchrony increases over time (Tronick & Cohn, 1989); synchrony depends on parental attributes including maternal sensitivity (Thompson & Trevathan, 2009); and synchrony is not all or none, but rather dyads are thought to move toward or away from synchrony (Harrist & Waugh, 2002).

Measures of Synchrony

To examine how synchrony changes during a mother-infant interaction, it is important to consider the various methods with which it can be measured. Leclère et al. (2014) "distinguished three categories of measurement: (1) global interaction scales; (2) synchrony scales; and (3) micro-coded time-series analyses" (p. 7). Global interaction scales examine infant and maternal behaviours during their interactions and consist of dyadic parameters. One such scale is the ICEP (Tronick & Weinberg, 1990; Weinberg & Tronick, 1999) discussed above, from which dyadic synchrony behaviours were selected in the current study. The ICEP is based on the Monadic Phase Scoring System (MPSC; Tronick et al., 1980), which is used in the current study to calculate level of synchrony (discussed below in the Methods section). The second type of measurement, synchrony scales, are also global scales but differ in that their focus is on synchrony and they do not have subscores for each partner's behaviours. Finally, micro-coded time-series analyses are mainly based on statistical approaches, with synchrony assessed by frequency counts of infant and parent behaviours, proportions, mean durations and latencies of specific behaviours, lead-lag analyses, or the correlations between second-by-second affective state codes assigned to infants and mothers. Time-series analysis is a contingency approach that studies temporal dynamics to capture the process of relating (Beebe et al., 2024). While event-based measures of contingency look at sequences of behaviours, time-series contingency measures involve ongoing sampling of equivalent time intervals to describe the interaction (Beebe et al., 2024).

When measuring synchrony, three main kinds of coordinated relationships tend to be examined (Northrup & Iverson, 2020): (a) concurrent relationships, or matching behavioural states (e.g., speaking simultaneously); (b) sequential relationships between one partner's behaviour and the other partner's following behaviour (e.g., gaze following); and (c) the continuous lagged associations between each partner's behaviour (i.e., the extent that one person's behaviour matches or predicts the other's lagged behaviour). Though these measures of coordination all assess the structured timing of behaviours within a dyad, they do so in different ways. Northrup and Iverson (2020) examined multiple measures of coordination in their study to determine how they relate to one another. They used cross-recurrence measures of coordination to assess simultaneous and lagged temporal relationships between mothers and infants for vocalizations and gaze. This analysis involves aligning two categorical temporal data streams and measuring their temporal coordination with different degrees of lag. Secondly, they used event-based measures of coordination, which clarified the particular leader/follower (i.e., mother leading/infant following or infant leading/mother following) processes in concurrent and lagged coordination. The event-based measures included several coordination variables: for vocalizations – frequency of contingent responses, average latency to respond, frequency of simultaneous speech; for gaze – frequency of follows to simultaneous attention (i.e., number of instances when one person shifted their gaze to a location and their partner subsequently looked at the same location), and mean latency of follows (i.e., average duration of the lags between the first gaze shift and when the partner then looked at the same location). This study illustrates the various ways in which synchrony may be measured and highlights the challenge of finding a standard and commonly used method of measuring synchrony due to its multimodal nature and temporality (Leclère et al., 2014).

Mother-infant behavioural synchrony was examined in the current study using micro-coded time-series analysis and global interaction scales (discussed above). Indeed, a multitude of studies in the literature have used micro-analytic coding schemes (e.g., Markova et al., 2020; Tuladhar et al., 2018), with several specifically using "Monadic Phases" (e.g., Busuito et al., 2019; Moore et al., 2016), and the ICEP (e.g., Kaitz et al., 2010; Montirosso et al., 2010) to measure dyadic synchrony between mothers and infants. Though synchrony was measured using concurrent data (the infant and mothers' behaviours moment-by-moment), it did not reflect exact state matching but rather the co-variation of behaviours (discussed in the Methods section).

Developmental Outcomes Associated with Mother-Infant Behavioural Synchrony

A multitude of research studies have demonstrated the importance of synchronous interactions between caregivers and infants for infant development across multiple developmental domains, including emotional regulation (e.g., Feldman, 2007a), attachment formation (De Wolff & van IJzendoorn, 1997; Evans & Porter, 2009; Tronick et al., 1975), and language, motor, social, and cognitive development (e.g., Harrist & Waugh, 2002; Kirsh et al., 1995). Indeed, greater behavioural synchrony during infancy can be predictive of secure attachment (Lindsey & Caldera, 2015), greater empathy (Feldman, 2007b), higher levels of self-control (Feldman et al., 1999), and better self-regulation in early childhood (Davis et al., 2017; Lindsey et al., 2009). More specifically during the critical period of 3-6 months, dyadic synchrony has an impact on cognitive, social, and emotional growth (Feldman, 2007c; Johnson et al., 2005; Jaffe et al., 2001). For example, dyadic synchrony influences how infants respond to social stressors (Feldman, 2007a). Affect synchrony specifically is associated with socioemotional capacities like empathy, behavioural adjustment, attachment security, and self-control (Beebe et al., 2010; Feldman, 2003, 2007c, 2012; Feldman & Eidelman, 2004; Feldman et al., 1999; Harrist & Waugh, 2002).

Lower levels of synchrony have been related to decreased social stress regulation in 3-month-old infants, as well as more negative engagement and less positive affect during the still-face condition (Moore & Calkins, 2004). When there is a lag of a couple of seconds (asynchrony) during an interaction, 2- to 4-month-old infants can notice this and consequently display less smiles and decreased eye gaze towards their mother (Skotheim et al., 2013). In parent-infant relationships, when there is repeated or lasting violations of the expected synchrony, infants cope through relational withdrawal (Puura et al., 2010). Therefore, synchrony is important for social and emotional development, and in normal populations, influences infants' cognitive processing (Thompson & Trevathan, 2009), IQ (Feldman, 2007d), and school adjustment (Harrist et al., 1994).

Mutual Regulation Model

Infants begin to coordinate their behaviour with their adult partner's from approximately 2 months of age (Crown et al., 2002; Jaffe et al., 2001), engaging in reciprocal social transactions which are mostly led by the adult partner (Bigelow & Power, 2014). Their reciprocal communication increases and develops more complexity over time (Lavelli & Fogel, 2002, 2005). It is well established in the literature that face-to-face interactions between infants and adults are bidirectional (mutually regulated) starting at three months (Tronick, 1989). That is, infants alter their affective displays and behaviours based on that of their mothers' (Cohn & Tronick, 1987; Lester et al., 1985). In turn, adults make similar modifications. Therefore, behavioural synchrony may be theoretically grounded within the Mutual Regulation Model (MRM; Gianino & Tronick, 1988), which was developed as a framework for the findings emerging from examinations of the uniquely stressful FFSF (Beeghly & Tronick, 2011; Beeghly et al., 2011; Tronick, 1989). Indeed, synchrony is known to be an important aspect of mutual regulation of emotion during parent-infant interactions (Moore & Calkins, 2004). According to the MRM, mother-infant relationships are entrenched in a dyadic, mutually regulated system, which Tronick and Beeghly note is "driven by moment-to-moment initiations and reactions to affective and behavioral displays such that the mother-infant relationship is not static, but rather, is jointly shaped bidirectional interactions" (as cited in Mastergeorge et al., 2014, p. 388). Indeed, the mother and infant each have a set of capacities to achieve the interactive goal of mutual regulation (i.e., synchrony). In order to achieve synchrony, they use interactive behaviours (primarily affective displays) to jointly regulate their interactions. This reciprocity is certainly relevant to the most advanced phase of the parent-child attachment relationship, known as the *goal-corrected partnership* (Bowlby, 1973; 1988). This attachment is characterized by the child being able to understand that their parent has separate and different goals than their own, and as noted by Marvin (1977), "the ability of both parent and child to negotiate individual perspectives in order to achieve a shared perspective about emotional and relational issues " (as cited in Gini et al., 2007, p. 149).

However, a state of synchrony is not always achieved, for example due to mistimed behaviour, misreading of the partner's signals, or differences in the immediate goals of each partner (Tronick et al., 1978). Notably, coordination in the first year occurs only about 30% of the time or less during face-to-face interactions, and transitions between coordinated and uncoordinated states happen once every three to five seconds (Tronick & Cohn, 1989). A "normal disruption", or *mismatch* (e.g., Stern, 1977; Tronick et al., 1980), motivates the infant to adjust or modify the disruption using their interactive skills. Well-regulated exchanges generate positive affect, while mismatched exchanges generate negative affect. The infant's positive affective expressions indicate to the partner that she should continue interacting or engaging as she is (Tronick et al., 1978), while negative affective expressions (e.g., distress, anger, sadness) during a mismatched interaction communicate to the partner to change her behaviour (Campos et al., 1983). Therefore, a *normal* interaction can be characterized as one that "frequently moves from affectively positive, mutually coordinated states to affectively negative, miscoordinated states and back again on a frequent basis" (Tronick, 1989, p. 116). In contrast, an *abnormal* interaction can be described as the members of the dyad being stuck in "affectively negative miscoordinated interactive states" with their cues for change being disregarded (Tronick, 1989, p. 116).

Maintaining and reestablishing reciprocity are believed to promote infants' ability to actively engage with their mothers and modify social exchanges to meet their emotional needs and, in turn, facilitate stress regulation during mother-infant interaction (e.g., Gianino & Tronick, 1988). Over time, infants become more sensitive to interactive patterns with familiar partners, and they become distressed when interactive errors, such as lack of responsiveness that characterizes a "still face", occur (Tronick, 1989). Caregivers must then try to repair these errors to help infants achieve a regulated state. The still-face episode is a prolonged interactive error and the reunion episode allows the mother and infant to repair their interaction (Weinberg & Tronick, 1996). In normal mother-infant interactions, there are multiple mismatches that are rapidly repaired, and the interaction quickly moves between coordinated and miscoordinated states (Tronick & Cohn, 1989). Without repair infants are likely to continue experiencing distress, and as these interactive errors accumulate through time, they may lead to negative developmental outcomes (Tronick & Beeghly, 2011). Repair of miscoordinated states is essential for affect synchrony and provides the foundation of children's expectations of mutual regulation (Tronick, 1989).

Using the FFSF, earlier studies have reinforced the mutual regulation model by connecting microtemporal measurements during dyadic interactions between mothers and infants to infants' improved socioemotional outcomes, such as stress recovery (Provenzi et al., 2018; Rattaz et al., 2022). To examine the dyad's ability to achieve reciprocity, one microtemporal process that has been assessed during the FFSF is *positive matching*. This process has been conceptualized as "the simultaneous display of positive social engagement behaviours (e.g., shared positive affect, mutual gaze) by the mother and her infant" (Hu et al., 2025, p. 1453). The amount of time the dyads are in a positive matching state captures their capacity to maintain reciprocity during interactions (Hu et al., 2025), with positive matching thought to promote infant stress recovery (e.g., Moore & Calkins, 2004). A second dyadic process is *interactive repair*, which is characterized as the transition from unmatched to matched dyadic states. The duration of time a dyad needs to repair (i.e., latency to interactive repair) reflects their ability to reestablish reciprocity, with shorter latency to repair thought to promote infant stress recovery (e.g., Muller et al., 2015). In a recent study, Hu et al. (2025) found that more dyadic matching (a combination of positive matching and shorter latency to interactive repair) during the free-play episode was associated with more social engagement (i.e., stress recovery) during reunion, supporting the MRM. Higher levels of positive matching suggests that the mother and infant are more attuned to each other, and these infants may be more easily soothed and reengaged by their mothers during reunion. Thus, the association between mother-infant interactions and infant stress recovery is well established (Hu et al., 2025).

Ultimately, positive and negative affect allow the infant to regulate the interaction to achieve mutual regulation. This repeated regulation of emotions and recovery from distress is thought to be scaffolded by behavioural synchrony, which measures coordination between the affective behaviours of two individuals, regardless of the type of behaviour that is expressed (Busuito et al., 2019). Indeed, synchrony during times of recovery from stress (e.g., reunion phase of the FFSF) is likely co-regulated (Lotzin et al., 2016), particularly during the second half of the first year (Feldman, 2012; Tronick & Gianino, 1986). Thus, synchrony reflects an attunement between caregivers and infants, which promotes active regulation of stress and can enable the transition from mutual regulation to self-regulation (Cohn & Tronick, 1988a; Feldman et al., 1999). This is only true, however, when the infant is with a sensitive caregiver who will modify her behaviour in response to the infant's cues.

Maternal Sensitivity and Mother-Infant Behavioural Synchrony

Sensitive maternal behaviours, such as prompt, contingent, and consistent responses to infant's cues, contribute to mother-infant behavioural synchrony, which consists of contingent and predictable behaviours between mother and infant (Brazelton et al., 1975). Prior conceptualizations suggest that maternal sensitivity *facilitates* reciprocal (i.e., synchronous) mother-infant interactions (Hane et al., 2003). Indeed, it makes sense to consider maternal sensitivity as an essential *aspect* of synchrony (Dollberg et al., 2010) given that sensitive mothers respond more promptly and appropriately to infants' cues (Kochanska et al., 1999); one would expect mother-infant dyads who display higher levels of synchrony to have higher levels of maternal sensitivity (Skuban et al., 2006). Yet, only a small number of studies have examined the relation between maternal sensitivity and dyadic measures of mother-infant interactions, such as mother-infant behavioural synchrony. Among the existing literature, however, research does show that sensitivity is generally related to higher levels of synchrony (Hammer et al., 2019; Hane et al., 2003; Kochanska et al., 1999; Skuban et al., 2006). Despite the clear correlation between sensitivity and synchrony, there are also meaningful distinctions. Unlike the mutual regulation between mother and infant that is involved in synchrony, "[maternal] sensitivity is a unidirectional measure that does not fully capture children's contributions" (Hammer et al., 2019, p. 2). In other words, maternal sensitivity focuses solely on the mother's behaviour *towards* the child while synchrony comprises both the mother and child's responsivity and their affective availability to each other (Skuban et al., 2006).

Given that maternal sensitivity promotes infants' physiological, behavioural, and affective regulation (Bigelow et al., 2010; Braungart-Rieker et al., 2001; Cohn et al., 1991) and may be a prerequisite for synchrony (Skuban et al., 2006), it is especially important to consider a mother's general level of sensitivity when examining how the presence of a mobile device may influence mother-infant synchrony. Thus, the current study investigated changes to mother-infant behavioural synchrony when mothers became engrossed with a mobile device, and whether more sensitive mothers displayed more synchronous interactions with their infant.

Maternal Attachment Style

One of the characteristics of a mother that has been associated with their ability to respond to, and interpret, her infant's cues is the mother's own working model of attachment (Main & Goldwyn, 1984-1998). These internal working models are developed in infancy (Bretherton, 1985; Crowell et al., 2008) and include beliefs and expectations about close relationships (Bowlby, 1969). As such, these models govern attachment behaviours throughout an individual's life (Bowlby, 1969; Hazan & Shaver, 1994) and serve as the foundation for their attachment dimension. Importantly, attachment style is transmitted across generations (Bowlby, 1969/1982) and maternal sensitivity is a key factor in this transmission (Verhage et al., 2016). Adult attachment style can be conceptualized as a two-dimensional model consisting of attachment-related avoidance and attachment-related anxiety (Shaver & Mikulincer, 2002), with every person falling somewhere on each dimension. Individuals with high attachment anxiety "have an intense need to be close, accepted, supported, and reassured" while those scoring high on attachment avoidance "are uncomfortable with closeness, self-disclosure, feelings and expressions of vulnerability, and dependency" (Shaver & Mikulincer, 2002, p. 136). Those with a preoccupied attachment style (low attachment-related avoidance, high attachment-related anxiety) have a strong need for proximity, fear rejection, and worry about relationships (Mikulincer & Shaver, 2007; Vrticka et al., 2012). Those high in avoidance are distinguished as "dismissing avoidant" (high avoidance, low anxiety) and "fearful-avoidant" (high avoidance, high anxiety) (Bartholomew, 1990; Bartholomew & Horowitz, 1991). In contrast, those with a secure attachment style (low attachment-related avoidance, low attachment-related anxiety) have "positive expectations about others' availability in threatening situations; positive views of the self as competent, loved, and valued; and increased confidence in the seeking of proximity and support as effective ways of regulating distress" (Shaver & Mikulincer, 2002, p. 137).

A core principle of attachment theory is that mothers' own attachment style influences their parenting (Bowlby, 1969/1982; Feeney & Woodhouse, 2016). Given that maternal attachment style guides mothers' emotions, interpretations, perceptions, and behaviours with her infant (Main et al., 1985; van IJzendoorn & Bakermans-Kranenburg, 1997), differences in attachment styles can lead to a selective bias in attention toward particular kinds of emotional information in the environment (Edelstein & Gillath, 2008). Mothers who are themselves securely attached are able to correctly perceive infants' signals and promptly and appropriately respond to them (Grossmann et al., 1985; Fraedrich et al., 2010; Leyh et al., 2016a,b), thus demonstrating high sensitivity and promoting security in their infants (Lenzi et al., 2013). Indeed, the literature has shown a consistent association between adult attachment security and infant attachment security (Benoit et al., 1991; Fonagy et al., 1991; Jacobvitz et al., 1991). Also noteworthy is that secure attachment in parents has been linked to a higher degree of mother-infant behavioural synchrony: Crandell et al. (1997) found that "secure mothers and their children were more responsive to each other's cues and engaged in a more fluid process of give-and-take than insecure mothers and their children" (p. 256).

In contrast, insecure attachment styles in caregivers can lead to intrusive, restrictive, and/or inconsistent responses to their children's behaviour (Crandell et al., 1997). Analogously, self-report studies of caregiving patterns in adult intimate relationships have shown that preoccupied individuals (high anxiety, low avoidance) report low levels of sensitivity but relatively high levels of proximity and compulsive behaviours in their caregiving toward partners, suggesting they may be inconsistent and intrusive of their partner's needs (Feeney & Collins, 2001). Overall, these caregivers are available but are likely to provide care that is intrusive or excessive. Indeed, mothers' anxiety has been linked to intrusiveness with their infants (e.g., Biringen, 1990), and that intrusiveness was found to consist of quicker and more intense responses than other mothers' (Feldman et al., 1997). Moreover, they may exaggerate their infant's negative affect in order to meet their own emotion regulation needs (Haltigan et al., 2014). In addition, a negative association has been found between mothers' self-reported attachment-related anxiety and global maternal sensitivity (Selcuk et al., 2010). Avoidantly attached mothers in turn, may have a restricted ability to perceive and communicate their infant's feelings and to integrate affective information during mother-infant interaction (Fraedrich et al., 2010).

During infant distress, adult attachment style may also predict how adults respond emotionally and cognitively to their infants. Parents with a secure attachment style tend to view the parent-child relationship more favourably and experience more empathy for their child's distress (e.g., Finzi-Dottan et al., 2006). Insecurely attached parents have been found to experience more negative feelings and thoughts about their children than secure parents (e.g., Jones et al., 2015). To illustrate, both anxious and avoidant parents view their children as more challenging, more reactive, less flexible, and more interfering (e.g., Pesonen et al., 2004; Priel & Besser, 2000), as compared to securely attached parents. In their study (2006), Leerkes and Siepak found that adults who had an insecure attachment style less accurately identified infant distress (fear and anger), were more likely to make negative attributions about a distressed infant and had a greater tendency to respond to infant distress with neutrality or amusement, as compared to securely attached adults. Parents with higher attachment anxiety specifically, perceive infant distress as less tolerable than those who are less anxiously attached (River et al., 2019). In their recent study, Gross et al. (2023) demonstrated that maternal attachment anxiety predicted less supportive responses to preschoolers' negative emotions after 4-6 months, and this association was accounted for by mothers' negative attributions and emotions. Parents' negative thoughts and feelings about their children in turn strongly predict insensitive parenting (e.g., An et al., 2022; Leerkes et al., 2020). Therefore, mothers' attachment style can be predictive of how they respond to infants' needs (Ma et al., 2017), of the quality of their interactions with their children, and of their children's security of attachment (Crowell & Feldman, 1987; Grossmann et al., 1988; Main et al., 1985).

Attachment Style and Mobile Device Use

With mothers' attachment styles serving to structure dyadic interactions on a behavioural and emotional level, it is interesting to consider attachment style in the context of mothers' mobile phone use when caring for their infants. Mothers who have high attachment-related anxiety may be particularly vulnerable to distraction by mobile phones due to their need for social connection (Bartholomew & Horowitz, 1991; Feeney & Collins, 2001). Given that a mobile device can serve as a potential direct conduit to social relationships with attachment figures (i.e., caring and supportive others; Bowlby, 1969), it can be very challenging for those with high attachment-related anxiety to resist its "pull". Indeed, it is believed that individuals who are uncertain about significant others' responsiveness (i.e., those with high attachment anxiety) are particularly susceptible to forming an "attachment" to mobile phones (Billieux, 2012; Konok et al., 2016). They may be driven by the attachment system to use it for safety, security, and comfort as a way to protect themselves from physical and mental harm. In contrast, individuals high in attachment avoidance, who generally avoid developing new attachments, would likely not form an "attachment bond" with their smartphones (Parent & Shapka, 2020). Indeed, Parent et al. (2023) found that there was no association between attachment avoidance and smartphone attachment in their study with young adults. However, participants higher in attachment anxiety experienced a greater degree of problematic smartphone use, which was explained by their use of their smartphone as an attachment target (i.e., a caring and supportive other).

Konok et al. (2016) demonstrated that higher attachment anxiety predicted a greater need for contact through a mobile phone, and for anxiously-attached individuals, the relationship-facilitating function of smartphones was most important. This could be because smartphones enable checking on the availability of close others, which may be especially important for individuals who are chronically concerned about their relationships (Chopik & Peterson, 2014). Insecurely-attached individuals may also use cell phones excessively in order to seek and gain reassurance from others (Billieux et al., 2015). Thus, for people with high attachment anxiety, smartphones may act as an alternative source of security and anxiety reduction. Of concern, however, is that attachment insecurity has been linked to smartphone addiction according to several studies (Ge, 2014; Ghasempour & Mahmoodi-Aghdam, 2015; Monacis et al., 2017). Indeed, Keefer et al. (2012) found that individuals primed with insecurity about their relationships experienced higher separation anxiety when separated from their smartphones. In a more recent study of young adults, those with higher attachment anxiety were found to experience more problematic smartphone use, and smartphone attachment mediated this relationship (Parent et al., 2023). In accordance with attachment theory (Bowlby, 1969), the perceived lack of reliable support from important social partners acts as a perceived threat, which leads those with greater attachment anxiety to seek reassurance excessively. In Parent et al.'s study (2023), those behaviours were directed at their smartphones. In their study of romantic partners, Ni et al. (2025) found that increased attachment anxiety and avoidance was associated with increased partner phubbing behaviours and reduced relationship satisfaction. Although insecure attachment has also been associated with a higher likelihood of perceiving or participating in partner phubbing in couples (e.g., Mosley, 2022), less is known about its effect on mother-infant interactions. It is thus worth exploring how mothers' attachment-related anxiety might interfere with important caregiving processes in the context of mobile phone use, such as mother-infant behavioural synchrony and infant stress responses, which are predictive of children's healthy socioemotional development.

Current Study

The use of mobile technology by mothers in the presence of their infants has risen significantly in the last decade, and has been associated with negative developmental outcomes (e.g., Carson & Kuzik, 2021). From an attachment perspective, an important predictor of mother-child relationship quality is the mother's sensitivity (e.g., Fearon et al., 2010), which may be compromised through long and frequent engagement with a mobile device. As described above, sensitivity is associated with various domains of children's wellbeing, such as attachment security, socioemotional development (Ainsworth et al., 1978), language and cognitive development (Landry et al., 2006), and physical health (e.g., Letourneau et al., 2017). It can also, along with mother-infant synchrony, promote infants' regulation of stress (Ainsworth et al., 1978; Cohn & Tronick, 1988a). Further associated with mothers' level of sensitivity is maternal attachment style (Main & Goldwyn, 1984-1998). The current study therefore sought to not only examine the effects of this ubiquitous technology on the lives of young children, but to also examine factors such as maternal sensitivity, attachment style, and mother-infant synchrony, which may modulate the detrimental effects of such "technoference".

First, we focused on infant stress when their mothers are engaged in cell phone activities. When mothers are distracted by a mobile device and cease to respond to their infant, this creates a context similar to that first demonstrated in Tronick et al.'s (1978) FFSF paradigm, which is known to be stressful for young children. Our study relied on a modified FFSF in the form of a *cell phone engagement protocol* to assess changes in the frequency of stress behaviours exhibited by infants when their mother's attention is diverted to a mobile device.

Second, we endeavoured to understand what role maternal sensitivity may play in mitigating infant stress created by "technoference". Many studies have focused on the role of maternal sensitivity in improving mother-infant interactions and infants' socioemotional outcomes, however, only a limited number have directly examined the association between maternal sensitivity and effects of smartphone use on infants' stress, specifically. The current study sought to address this gap in the literature.

Third, this study aimed to extend the literature by considering the role of less-studied caregiver and infant factors during distracted caregiving. One such factor is dyadic behavioural synchrony, which is a critical part of early parent-child social interactions and has been associated with infant emotion regulation (e.g., Feldman, 2007a). The Mutual Regulation Model (MRM; Gianino & Tronick, 1988) was used as a theoretical framework to understand the regulation of exchanges between mothers and infants during and following the intrusion of a mobile device during the still-face phase. Importantly, when stressed but with a sensitive mother, infants can achieve mutual regulation, or synchrony, in their dyadic interactions (Gianino & Tronick, 1988). Though a small number of studies have examined the relationship between maternal sensitivity and mother-infant synchrony, none to date have investigated this relationship during a smartphone-adapted FFSF as was done in the current study.

Fourth, mothers' level of attachment-related anxiety (determined through self-report on the Experiences in Close Relationships – Revised (ECR-R) scale; Fraley et al., 2000) was examined in relation to dyadic synchrony and infant stress, respectively. Caregiver attachment style is known to impact parenting (Bowlby, 1969/1982) and caregivers high in attachment-related anxiety may be more involved with their mobile phones (Konok et al., 2016) and less sensitive toward their infants (Jang et al., 2019; Oyen et al., 2000). Yet the literature is scarce on the association between attachment anxiety and important aspects of mother-infant interactions. No known studies to date have investigated the role of maternal attachment style in the context of smartphone-induced maternal distraction during infant care.

Objectives and Hypotheses

Objective 1

The first objective of this study was to **examine patterns of behavioural stress experienced by infants when mothers become engaged with a cell phone** in their child's presence after they have been involved in a playful dyadic interaction (i.e. moving across the three phases of a modified FFSF, the *cell phone engagement protocol*), **and whether mothers' general level of sensitivity affects these patterns**.

Hypotheses.

1. a) That infants would demonstrate behavioural signs of stress when their mother's attention is directed to a mobile device (still-face phase) after having first been engaged in a playful dyadic interaction during the free-play phase.

   b) That there would be a "carryover effect" of stress, in which infants continue to demonstrate behavioural signs of stress after their mother re-directs their attention to the infant during the reunion phase.

c) That infants of mothers who are generally more sensitive would demonstrate lower observed signs of stress when their mother's attention is directed to a device, as compared to infants of mothers who are generally less sensitive.

Objective 2

The second objective of this study was **to assess behavioural synchrony between infants and mothers** as the dyad moves across the phases of the *cell phone engagement protocol*, and **the relationship between that synchrony and mothers' general level of sensitivity**.

Hypotheses.

2. a) That the behaviours of a mother and their infant would be less synchronized when the mother is engaged with a mobile device versus when the dyad is involved in a typical face-to-face interaction (as in the first and last phase of the *cell phone engagement protocol*).

   b) That, in dyads with mothers who are generally more sensitive, maternal and infant behaviours would be more synchronized across all three phases (even while the mother is engaged with a device), as compared to dyads with mothers who are generally less sensitive.

Objective 3

The third objective of this study was to **query the role of mothers' attachment style in mother-infant behavioural synchrony** (while involved with devices) and **in infant stress**, respectively, during the still-face phase of the *cell phone engagement protocol*.

Hypotheses.

3. a) That in dyads with mothers who have higher attachment-related anxiety, maternal and infant behaviours would be less synchronized while the mother is engaged with a mobile phone, as compared to dyads with mothers who have lower attachment-related anxiety.
   b) That infants of more anxiously attached mothers would experience greater stress than those of less anxiously attached mothers in a context of mobile phone intrusion, as demonstrated by the infants' behavioural signals.

Chapter 2: Methods

This study was reviewed and approved by the Human Participants Review Sub-Committee of York University's Ethics Review Board (Certificate #: e2021-328). Data were collected as part of a larger project entitled, "An investigation of caregiver sensitivity across diverse caregiving contexts" (Principal Investigator: Dr. Yvonne Bohr). All study components had to be administered virtually as the study was conducted during the COVID-19 pandemic.

Participants

Two hundred and thirty-one caregivers from across Canada expressed interest in participating in the study. Of these, 166 caregivers-infant dyads were eligible to participate in the virtually administered protocol, with online sessions occurring from December 2021 to April 2023. Exclusionary criteria for this study included infants diagnosed with psychiatric disorders and/or significant developmental delays, families who did not have the necessary technology to complete the study protocol, and caregivers who did not speak English. Participants were recruited through: posting a recruitment flyer (see Appendix A) on social media (e.g., Facebook groups, paid Facebook ads, Instagram, Kijiji), Mommy Connections newsletters, Ontario Early Years Centres, midwifery/birthing centres, family resource centres, community health centres, Psychology departments at Canadian universities, physical study flyers posted on York University campus and in various Toronto neighbourhoods, word of mouth, and snowball sampling (whereby initial participants recruited future participants from among their acquaintances).

Of the 166 dyads that were recruited, 53 did not proceed with completing the online session for a variety of reasons: the caregiver was unresponsive (*n* = 30), did not show up to the scheduled session (*n* = 1), was no longer interested in the study (*n* = 6), was too busy to participate (n = 2), did not want to be recorded (n = 3), could only join the session by phone (n = 1), did not speak English (n = 1), did not receive a reminder email (n = 1); or that the infant had ongoing health concerns (n = 1), was sick (n = 1), was not of an eligible age for the study (n = 4), would not tolerate being seated long (n = 1), or had conflicts with their sleep schedule (n = 1). Of the 113 dyads who moved forward with completing the virtual protocol, one dyad was later deemed ineligible due to infant age and another decided to withdraw all their data. Of the remaining 111 caregiver-infant dyads, three caregivers were self-identified males. Given the small percentage of fathers, those three participants were removed in order to retain a homogenous sample of mothers. Thus, the final sample of participants consisted of 108 self-identified females (mothers) and their infants.

Infants ranged from 3 to 10 months of age (M = 6.5 months), and included 53 biological females and 55 biological males (as reported by their mothers). The majority (80.6%) were born full-term (at least 37 weeks gestation) while 4.6% were born prematurely (before 37 weeks gestation); gestational age was not available for 14.8% of the sample. Developmental concerns were reported for only 5 infants and included: language concerns (n = 1); delay in rolling and crawling (n = 2), torticollis (1); and auditory concerns (n = 1).

Mothers ranged from 22 to 42 years of age (M = 33.7 years). The majority of mothers identified as European (n = 67) and were well-educated (96.3% had graduated college/university or had at least some postgraduate/professional training; see Table 1). Most of the mothers were primiparous (70.4%). A total of 75% (n = 81) were married, 23.1% (n = 25) were common-law, one mother was in a relationship but not living together, and one did not specify their relationship status. The majority of participants lived in a two-adult household (96.3%), with an annual household income of $100,000 or greater (80.6%; see Table 1 below).

Setting & Equipment

Data were collected virtually through video call sessions with participants using Zoom for Healthcare, a secure, PHIPA-compliant third-party cloud platform used for video and audio communication, and content sharing. Each session was moderated online by either two graduate

Table 1

Demographics of mothers

Characteristic	***N***	***%***
Self-identified Ethnicity		
European	67	62.0
Asian	8	7.4%
South Asian	8	7.4%
More than one race (mixed)	6	5.6%
Latin, Central, or South American	4	3.7%
Caucasian	2	1.9%
Ashkenazi Jewish	2	1.9%
Indigenous	2	1.9%
Canadian	1	0.9%
French Canadian	1	0.9%
Middle Eastern	1	0.9%
Caribbean	1	0.9%
African	1	0.9%
Did not specify	4	3.7%

Education		
Postgraduate/professional degree	58	53.7%
College/university graduate	36	33.3%
Some postgraduate/professional training	10	9.3%
Some college/university	3	2.8%
Some high school	1	0.9%
Income/year		
\$20,000-\$29,000	1	0.9%
\$40,000-\$49,000	1	0.9%
\$50,000-\$59,000	1	0.9%
\$60,000-\$69,000	4	3.7%
\$70,000-\$79,999	2	1.9%
\$80,000-\$89,000	8	7.4%
\$90,000-\$99,000	4	3.7%
\$100,000-\$149,000	29	26.9%
>\$150,000	58	53.7%

students, or a graduate student and an undergraduate Research Assistant. The experimental set-up was modelled after the original FFSF protocol (Field et al., 1986; Stoller & Field, 1982). Mothers were asked to position their infant in an infant seat on a table or on the floor, at eye level with the mother, who was seated facing the child approximately an arm's length away. A webcam/built-in camera on the mother's laptop recorded the profiles of the mother and infant from a distance (approximately 3 feet away) that allowed the infant's full body (including their feet) to be visible, as well as the mother's face and upper body. Videos were recorded on Zoom and saved securely onto a password-protected hard drive by the researcher.

Procedure

When a participant contacted the researchers to indicate their interest in the study (via e-mail or the Infant and Child Mental Health Lab website), they were asked several screening questions: 1) "Has your child ever been diagnosed with a psychiatric disorder and/or significant developmental delay?"; 2) "Do you have access to a private space where you are able to sign on to Zoom (the secure platform we will be using for our online study)?"; 3) "Do you have access to a laptop/tablet/desktop computer with a camera that would allow us to see you and your infant interacting during the Zoom session?"; 4) "Do you have access to some form of infant seat to place your infant in?" Once their eligibility was confirmed, they were directed to an online secure platform (Qualtrics) to complete the study's informed consent form (see Appendix B). If consent was provided, participants were then asked to complete a demographics questionnaire (see Appendix C) and the Experiences in Close Relationships – Revised (ECR-R) scale (Fraley et al., 2000) through Qualtrics. They were also asked to provide their phone number, which was used by the researchers during the virtual session.

After completion of the questionnaires, a virtual session was scheduled in order to complete the experimental protocol with two researchers. One day prior to the session, a reminder e-mail was sent that included an infographic providing an overview of the session and some reminders for the mother (see Appendix D). Fifteen minutes prior to the session, a reminder text was sent to participants' phones, asking them to reply "yes" to confirm their attendance or "no" if they could no longer attend (this was to ensure their phone was receiving text messages). To start the session, mothers and researchers signed in to Zoom at their scheduled time and turned on their video. The researchers greeted the mothers and infants, introduced themselves, and answered any questions from the mother related to the consent form, questionnaires, or study protocol. Next, mothers were asked to position themselves and their infants in front of their computer camera as described above under “Setting & Equipment”.

Mothers were first asked to interact with their infants for five minutes, while keeping their cell phone nearby. Next, mothers were asked to play with their infants as they usually would at home for several minutes, with or without toys. One minute into this free-play time, the *cell phone engagement protocol* (Bimm [Khourochvili] & Bohr, 2018; Bohr et al., 2017) began, but this was not explicitly stated to participants. As mentioned above, the protocol consisted of three phases: (1) A “typical face-to-face” interaction (free-play) during which the mother continued to play with their infant as they typically would at home, with or without toys (**2 minutes**); (2) A still-face phase during which the mother received text messages from the researcher (see Appendix E) while in the presence of their infant (**5 minutes**). This phase was further split into two phases: for the first 2.5 minutes, mothers *were not* informed that a researcher would be sending text messages to their phone during this time (“**Deception Texting**”); for the last 2.5 minutes, mothers *were* informed that the researcher would be sending text messages to their phone **(“Explicit Texting”)**. Concealing the identity of the message sender during this first half of the still-face phase aimed to reduce social desirability bias in the participants; (3) A reunion phase during which the mother was asked to resume typical play with their infant (**2 minutes**). If an infant became too distressed (cried intensely for approximately 20 seconds), the protocol was stopped and a break was suggested. Once the infant was calmed, the protocol was resumed. The protocol lasted for a total of 15 minutes (i.e., 6-minute free-play and 9-minute *cell phone engagement protocol*). All of the aforementioned mother-infant interactions were recorded through Zoom and saved by the researchers (see Appendix F for procedural violations that were observed in the study).

Next, the researchers debriefed the mothers about the study and answered any questions from the mothers. After the virtual session, participants were sent an email to notify them that $20 would be e-transferred to them as a token of appreciation for their time. A Resource List on mother-infant interactions (prepared by the researchers) was also sent in the e-mail (see Appendix G). Finally, participants were asked in the email to pass on information about our study to others from among their acquaintances (if desired) to assist with our recruitment efforts. After every 25 participants that completed the study, the researchers entered the participants' names into a raffle for a chance to win a prize valued at approximately $150-$200 (e.g., a subscription to developmentally-appropriate play kits, Montessori toys, spa gift card).

Measures

Demographics Questionnaire

The demographics questionnaire (Appendix C) consisted of 20 questions that asked about mothers' age, education level, ethnic background, number of places lived in the last 5 years, current employment, marital and economic statuses, number of adults and children in their household, and their child's age and developmental history.

Experiences in Close Relationships – Revised (ECR-R) Scale (Fraley et al., 2000)

This self-report inventory was used to measure mothers' attachment-related anxiety. The ECR-R assesses two dimensions: anxiety and avoidance. It is a 36-item questionnaire consisting of two 18-item subscales that measure each dimension, respectively. Each item is relevant to adult romantic relationships, with participants being asked how they generally experience emotionally intimate relationships (not just their current relationship). It is rated using a Likerttype scale from 1 (*strongly disagree*) to 7 (*strongly agree*). Scores are reverse-coded for negatively worded items and attachment anxiety scores are determined by taking the mean of item scores from the anxiety subscale. Thus, final scores range from 1 (low attachment-related anxiety) to 7 (high attachment-related anxiety). The ECR-R demonstrates good reliability and validity as a measure of romantic attachment (Sibley et al., 2005). Though this tool was primarily designed for relationships with romantic partners, patterns of adult attachment style transcend specific relationships (Bartholomew & Horowitz, 1991). Moreover, this scale has often been used to assess attachment in a parenting context (e.g., Egmose et al., 2024; Ferreira et al., 2024; Guerrero, 2015; Kim et al., 2019; Perzolli et al., 2025; Tasel-Gunal & Arikan, 2024), with evidence that ECR-R scores are related to parenting behaviour (e.g., Jones et al., 2015; Selcuk et al., 2010) .

Behavioural Coding

Both maternal and infant behaviours were coded by two trained coders for each of the 108 interaction videos.

Maternal Sensitivity

Maternal sensitivity was coded using the Mini-Maternal Behaviour Q-Sort – Video (Mini-MBQS-V; Pederson et al., 1990). The MBQS is a measure of sensitivity that is typically used with mothers of children aged 8 months to 3.5 years (National Collaborating Centre for Mental Health [NCCMH], 2015), though its use has also been supported with infants as young as 2 months of age (Bailey et al., 2009) and those from 3 to 20 months of age (Lindhiem et al., 2011). The standard version of the MBQS consists of 90 items that reflect a variety of maternal behaviours, with each one describing some aspect of the quality of the mother-child interaction (Pederson et al., 1990). The Mini-MBQS-VR used in the current study consists of a 25-item subset of the original 90 items, and is designed for use with video records and for quicker descriptions of interactions (Moran et al., 2009). Each q-set item contains a description of an aspect of the quality of the mother's interaction with her infant, and describes either sensitive or insensitive maternal behaviour (e.g., "Appears to tune out and not notice bids for attention"). When choosing the score for each item, the researcher must assess the extent to which each item descriptor characterizes the quality of the mother's interactions based on her observations. The coder must then assign a score from -2 "Most unlike the Mother" through +2 "Most like the Mother". The coding process involves a forced sort, so that only a specific number of items may be assigned each of the scores from -2 to +2, resulting in five groups with five items in each (Pederson et al., 2013).

The MBQS has demonstrated sound psychometric properties, specifically, convergent validity with the Strange Situation Procedure (SSP) and with the Attachment Q-Sort (AQS), good concurrent and predictive validity, very good inter-rater reliability, and test re-test reliability (NCCMH, 2015). The Mini-MBQS has also been shown to be reliable ($r = .94$), and related to the full MBQS when assessed 6 months ($r=.35$), to cognitive development ($r=.48$) and to attachment security ($r = .34$) (Tarabulsy et al., 2009).

Coding Reliability. The coders had attended a rigorous two-day training delivered by experienced coders, and then achieved reliability for MBQS based on the reliability procedure required by the developers. This procedure required completion of 10 "practice videos" of mother-infant interactions, the first three of which were reviewed as a team with an established coder and the rest of which were completed independently. The trainees were then required to independently code three consecutive videos reliably, meaning item placement difference was not greater than 1 in the 25-item sort.

Coding Process. The level of sensitivity displayed by each mother was video-coded throughout the full 15-minute protocol. First, coders reviewed the Ainsworth Maternal Sensitivity Scales (Bretherton, 2013) described above. These scales are known as the gold standard for assessing maternal sensitivity of mothers of children ages 3 to approximately 24 months (National Institute for Health and Care Excellence [NICE], 2015). Coders assigned ratings to each mother for each of the four sensitivity scales based on their observations, ranging from 1 (low) to 9 (high). This process helped focus their attention on relevant, key parts of the interaction.

Next, the coder used the Mini-MBQS-V to determine a sensitivity score for each mother. Upon opening the MBQS-V software, the coder saw a list of all items in the q-set in random order. She moved through each item and assigned a score based on her observations, without any constraints (Unforced Sort). She then clicked the “Update” button on the screen, which sorted the items based on their assigned scores. The coder then imported the scores into Excel for calculation of a global sensitivity score. The coder then returned to the sorting program and completed the Forced Sort by reviewing the items and changing the scores until there were an equal number of items in each category. The rest of the process was the same as that of the Unforced Sort. The mother’s sensitivity score was the item-by-item Pearson correlation (r) between the sort describing their behaviour versus the aggregate sort describing the prototypical sensitive mother conducted by a group of attachment experts (Pederson et al., 2013).

Approximately 21% (n = 23) of the videos were double-coded to determine inter-rater reliability (IRR) for sensitivity coding with the Mini-MBQS-V coding. An intraclass correlation coefficient of 0.875 was achieved between the two coders. Any discrepant MBQS Forced Sort scores were discussed between the coders until consensus was reached. These discussions involved first reviewing their Ainsworth Scales ratings to determine more general disagreements in their coding, and then reviewing specific MBQS items that they had disagreed on (watching relevant portions of the videos as necessary). When agreements were reached, either one coder's score was chosen as the final sensitivity score, or one or both of the coders re-coded the relevant videos to determine a more accurate score following discussions. Out of the 23 videos that were double-coded in this study, five were re-coded by one of the coders, one was re-coded by both coders, and one maintained the initial score it had been assigned by one of the coders.

Infant Stress and Mother-Infant Behavioural Synchrony

Two coders (one of whom also coded maternal sensitivity) coded each video for infant stress behaviours and mother-infant behavioural synchrony used a coding software: INTERACT (Mangold International, 2017; described below). Coders had received training through online demonstrations and technical support and had coded several practice videos. The second coder for these behaviours (who had not previously coded maternal sensitivity) was naïve to the hypotheses of the current study. In order to prevent coder drift, coders ensured that both infant and maternal behaviours were clearly operationally defined and updated if needed, and that these definitions were regularly reviewed together.

Coding Process. Both infant stress behaviours and mother-infant behavioural synchrony (each described below) were video-coded micro-analytically in 1-s intervals throughout each of the three phases of the *cell phone engagement protocol*. The free-play phase was coded for 120 seconds; "Deception Texting" was coded for the first 60 seconds after the first text was received (this was deemed sufficient to provide a "snapshot" of how a mother naturally reacts to receiving a text from an unknown number); "Explicit Texting" was coded for the full 150 seconds (Phase 2 total duration = 210 seconds); the reunion phase was coded for 120 seconds.

To code the videos, the researchers programmed the INTERACT software to display columns of infant and maternal behavioural categories, and to display rows of pre-defined one-second intervals. Videos were typically played at normal speed, with the option to increase or decrease play speed as desired while coding. Both coders first coded only the infant behaviours as they watched a video, and then watched the video a second time to code only mothers' behaviours.

Videos were re-watched a third time for only the still-face phase, to confirm that maternal divided attention/"technoference" had taken place. This was to ensure that infants had undergone the experimental "still-face" effect which was central to answering the objectives of this study. To objectively determine whether mothers became distracted by text messages during the still-face phase, "technoference" in this study was defined as "the mother looks at their phone, AppleWatch, or laptop, and appears to read at least one message on the given screen".

Infant Stress. Infant stress behaviours were selected with consideration of their visibility via a laptop camera (with some definitions modified to fit the scope of the current study) from among the behaviours listed in the revised version of the Infant Caregiver Engagement Phases (ICEP-R) (Reck et al., 2009) and from the NCAST Caregiver/Parent-Child Interaction (PCI) Teaching and Feeding Manuals (Oxford & Findlay, 2013, 2015). Table 2 lists the stress behaviours that were coded in the current study (see Appendix H for full definitions of the behaviours). Importantly, for Pulling Away, it was decided that "turning away" of the infant's head would be coded as a stress behaviour only if it was *clearly* turned due to stress, and only the *initial* turn would be coded as such (unless they continued to exhibit stress while their head was turned). This is because their head may have stayed turned away due to other reasons such as interest or something drawing their attention. Indeed, based on observations made during viewing of the videos, infants often did not seem excessively stressed when they remained in the new positions upon turning their heads away. In addition, “self-comforting by sucking” and “self-comforting with soother” were combined into one category of “self-comforting” prior to statistical analyses, as there was only a small proportion of infants (*n* = 13) who used a soother during the interactions. Keeping this separate category would have hampered the ability to run an analysis due to an inflation of zeroes in the distribution of “self-comforting with soother” behaviour proportions.

To code videos for stress using INTERACT, coders entered “yes” if they had observed one or more of the three stress behaviours, left a blank entry if they had not (i.e., “null”), entered “missing” if it could not be determined whether the behaviour had occurred or not (e.g., infant went off-screen), or entered “interrupted” if another person was speaking during a given time interval. The dichotomized scoring scheme (whether a behaviour was observed or not) is beneficial for reducing coding variability, as compared to more nuanced scoring scales or those that require interpretation of meaning or function of behaviours (Tryphonopoulos et al., 2016).

Table 2

Infant stress behaviours

Stress Behaviours	**Description**
Negative Facial Expressions	Facial expressions including cry face, grimace face, sadness, anger
Pulling Away	a) Turning head away; or b) Back arching
Self-Comforting by Sucking	a) Infant sucks on their body b) Infant sucks on/brings to their mouth an object c) Infant sucks on/brings to their mouth the mother’s hand or finger
Self-Comforting with Soother	Infant sucks on/brings to their mouth a soother

The proportion of each stress behaviour was calculated per phase for each participant by dividing the time spent exhibiting the behaviour by the total available time per phase (i.e., dividing the total number of "yes" entries for every 1-second time interval by the total number of seconds in that phase). The amount of time spent in an unscorable state per phase ("missing" or "interrupted" observations) was subtracted from the total observations/available time per phase prior to calculating the proportions. The resulting dataset of stress behaviour proportions was then used for statistical analysis.

Mother-Infant Behavioural Synchrony. Behavioural synchrony between mothers and infants was video-coded throughout the three phases of the *cell phone engagement protocol*, using a modified Monadic Phases Scoring System (MPSC; Tronick et al., 1980). In line with the MPSC, synchrony in the current study was defined as the degree to which mothers and infants change their behaviours consistently together across time, without regard for the type of behaviour that either member is showing and without necessarily matching in phase (Cohn & Tronick, 1988a; Feldman et al., 1999). The validity of the MPSC has been demonstrated with respect to other discrete-emotion coding systems (Matias et al., 1989; Weinberg & Tronick, 1994). With respect to interobserver agreement, a kappa of .72 was reported by Cohn & Tronick (1988b), and a higher kappa of .82 was reported by Cohn and Elmore (1988). The ICEP coding system has also demonstrated high reliability, with interrater agreement ≥ 80% and Cohen's kappa ≥ 70%. Indeed, "percentage agreement and kappas were high for the duration measures" (84% to 99%), and "intraclass correlations were high for measures of frequency" (.88 - .90) (Tronick et al., 2005, p. 714). The ICEP-R (Reck et al., 2009) described above is a well-established microanalytic coding system based on the MPSC, as well as Tronick and Weinberg's Infant and Maternal Regulatory Scoring Systems (IRSS & MRSS; Tronick & Weinberg, 1990a, 1990b) and Weinberg and Tronick's research on affective configurations (1994). In the current study, this system served as a complement to the MPSC, as it could be used to assess infant and maternal affect, the dyad's level of engagement, and the quality of engagement (Reck et al., 2009).

Behaviours from the MPSC and ICEP systems were chosen to measure synchrony in this study as they were gross behaviours that could be more easily seen through a single laptop camera. Due to the suboptimal audiovisual quality of the dyadic interaction videos in the current study (as a result of relying on participants' laptop cameras and internet connection), Eye Gaze/Head Orientation and Facial Expression were chosen specifically for both infants and mothers as the behavioural measures of dyadic synchrony (Table 3). These behaviours were deemed clearer to observe and define among the two coders. Moreover, previous studies have also coded only gaze and facial expression to measure synchrony (Busuito et al., 2019; Moore & Calkins, 2004). Eye Gaze and Head Orientation were grouped together as they are conceptually similar expressive behaviours; however, despite Eye Gaze providing a more accurate account of whether a member of the dyad was engaged with the other, gaze was not always visible and therefore Head Orientation served as a proxy for engagement. Coders entered into INTERACT which of the behaviours they had observed for Eye Gaze/Head Orientation and Facial Expression from among those listed in Table 3.

In line with previous research (e.g., Busuito et al., 2019; Moore et al., 1997, 2001), each of these behaviours was combined at each second and then categorized into one of six mutually exclusive sets of behaviour, based on the behavioural descriptions provided by the MPSC and the ICEP (Table 4). In other words, the second-by-second behavioural codes were converted into a numeric score across a 6-point "social engagement continuum" (Busuito et al., 2019, p. 1038),

Table 3

Mother-infant synchrony behaviours

Maternal Behaviours	**Infant Behaviours**
Eye Gaze/Head Orientation:	*Eye Gaze/Head Orientation:*
1. eye gaze towards infant (engaged)	1. eye gaze toward mother (engaged)
2. eye gaze away from infant (disengaged)	2. eye gaze away from mother (disengaged)
3. head toward infant (engaged)	3. head toward mother (engaged)
4. head away from infant (disengaged)	4. head away from mother (disengaged)
5. missing	5. missing
6. interrupted	6. interrupted
Facial Expression:	*Facial Expression:*
1. positive (e.g. smile)	1. positive (e.g. smile)
2. neutral/serious	2. neutral
3. negative	3. negative
4. interrupted	4. interrupted
5. missing	5. missing

for infants and mothers separately, ranging from 1 (*most negatively engaged*) to 6 (*most positively engaged*) (Moore & Calkins, 2004; see Table 4). Therefore, both mothers and infants had a Monadic Phase (numeric score) assigned at each second of each phase. Synchrony during each of the three phases was calculated as the Pearson correlation coefficient between infants' and mothers' "social engagement scores" (p. 1038), reflecting the extent to which the dyads move synchronously between the six "social engagement states" (p. 1038).

Inter-Rater Reliability. In line with the procedures followed by Cohn and Tronick (1987) and Weinberg and Tronick (1994), inter-rater reliability for coding infant stress behaviours and mother-infant behavioural synchrony was defined as both coders scoring the same behavioural code during the same one-second interval. According to Weinberg and

Table 4

Mother and infant Monadic Phases

Monadic Phases	Mother	Infant
1. High negative (most negatively engaged)	**Negative** facial expression Head orientation/gaze **away** from infant	**Negative** facial expression Head orientation/gaze **away** from mother
2.	**Negative** facial expression Head orientation/gaze **toward** infant	**Negative** facial expression Head orientation/gaze **toward** mother
3.	**Neutral** facial expression Head orientation/gaze **away** from infant	**Neutral** facial expression Head orientation/gaze **away** from mother
4.	**Neutral** facial expression Head orientation/gaze **toward** infant	**Neutral** facial expression Head orientation/gaze **toward** mother
5.	**Positive** facial expression Head orientation/gaze **away** from infant	**Positive** facial expression Head orientation/gaze **away** from mother
6. High positive (most positively engaged)	**Positive** facial expression Head orientation/gaze **toward** infant	**Positive** facial expression Head orientation/gaze **toward** mother

Tronick (1994), “this is an extremely stringent criterion requiring agreement by category and time” (p. 1506). To assess IRR in the current study, videos were randomly selected to be double-coded until agreement was at least 80% and/or resulted in an unweighted Cohen’s kappa (κ) from .60 to .80 between two videos for all seven behaviours (three infant stress behaviours and four synchrony behaviours [Infant Eye Gaze/Head Orientation, Infant Facial Expression, Caregiver Eye Gaze/Head Orientation, Caregiver Facial Expression]). Percent agreement was calculated initially for all behaviours to get a general sense of observer agreement. Next, Cohen's kappa was calculated for each of the seven behaviours to provide a more accurate assessment of agreement by correcting for chance agreement. Because of the micro-coding approach used in this study, achieving rater agreement between two videos was deemed sufficient as this would require agreement between coders on 6,300 observations (450 rows/seconds x 7 columns/behaviours x 2 videos).

The first reliably coded video had an overall percent agreement of 89%, with substantial agreement between coders for Negative Facial Expressions ($\kappa = 0.69$), Self-Comforting by Sucking ($\kappa = 0.62$), Infant Gaze/Head Orientation ($\kappa = 0.66$), Infant Facial Expression ($\kappa = 0.62$) and Caregiver Facial Expression ($\kappa = 0.76$), and nearly perfect agreement for Caregiver Gaze/Head Orientation ($\kappa = 0.83$) and Pulling Away (% agreement = 98%). The second video for which IRR was achieved had an overall percent agreement of 88%. Coders reliably identified Negative Facial Expressions ($\kappa = 0.63$) and Self-Comforting by Sucking ($\kappa = 0.74$) with substantial agreement, and Self-Comforting with Soother with nearly perfect agreement ($\kappa = 0.91$). Coders rated all synchrony behaviours with substantial agreement: Infant Gaze/Head Orientation ($\kappa = 0.65$), Infant Facial Expression ($\kappa = 0.65$), Caregiver Gaze/Head Orientation ($\kappa = 0.71$), and Caregiver Facial Expressions ($\kappa = 0.71$). See Appendix I for a full description of the inter-rater reliability process.

Missing Data

Twenty-one dyads in the current sample were missing behavioural codes for one or more infant stress categories for one or more phases, *and/or* missing behavioural codes for one or more dyadic synchrony categories for one or more phases. Reasons why some phases could not be coded included participants joining sessions on their cell phone, video loss, protocol not being followed, infant fussiness, biasing from the experimenters, and text messages not being received by the participant. Reasons why certain stress and synchrony categories could not be coded included being unable to see infants' facial expressions or positioning, video blurriness, and infant fussiness. More specifically, 15 out of the 21 dyads were missing behavioural data for one or more *infant stress* categories, for one or more phases. Therefore, the analytic sample size differed across phases for each stress behaviour (see Table 5). Ten dyads were missing behavioural codes for one or more *synchron*y behaviours (Infant Facial Expression, Caregiver Facial Expression, or both) across *all three phases*, so these dyads were excluded from statistical analyses pertaining to synchrony. For the remaining 98 participants, synchrony data were sometimes missing for one or two phases, resulting in a different analytic sample size for each phase for synchrony (see Table 6). Consequently, the number of observations used to calculate synchrony scores (Pearson correlations) differed.

Based on the definition of "technoference" outlined above, it was determined that for 12 dyads the mother had not engaged with their cell phone, Applewatch, or laptop during the still-face phase (thus technoference did not occur). These dyads were therefore assigned "N/A" for Phase 2 in all statistical analyses, as they did not undergo the intended experimental stressor. The removal of these 12 mothers from Phase 2 also accounts for the reduced sample sizes for Phase 2 displayed in Tables 5 and 6. Although some mothers were only distracted during Explicit Texting and not Deception Texting (n = 72), or during Deception Texting and not Explicit Texting (n = 1), they were still considered to have undergone technoference in Phase 2 as it includes both Deception Texting and Explicit Texting portions. For further specificity, the

Explicit Texting portion was analyzed separately during post-hoc analyses to confirm that the lack of technoference during the Deception Texting portion did not skew results.

Data Analysis Plan

Normality was assessed by visually inspecting histograms. For analyses that involved non-normal distributions of data (i.e., data for all stress behaviours were positively skewed), a beta-binomial model was applied. A significance threshold of $p < .05$ was set for statistical tests. Analyses were conducted in R version 4.4.2 (Posit Team, 2024).

Data Cleaning

As mentioned above, 12 dyads did not experience technoference (as defined in the current study) during Phase 2, neither naturally (during Deception Texting) nor when they were informed they would be receiving text messages (Explicit Texting). This group of dyads were removed from the analyses below as these infants did not undergo the experimental stressor.

Objective 1 – Hypothesis 1 a and b

To examine infants' patterns of behavioural stress when mothers become engaged with a cell phone after first playing with their child (i.e., are moving across the three phases of the *cell phone engagement protocol*), we used a multilevel/hierarchical Generalized Linear Mixed Model or Beta-Binomial Model (BMM) to model the three infant stress behaviours in this study. This model was chosen due to the non-normal distribution of infant stress behaviour proportions (high positive skew) and the phase observations being nested within the participant (repeated measures). The proportion of infant stress behaviours was the dependent variable (DV) and phase of the *cell phone engagement protocol* was the independent variable (IV). The beta distribution within the BBM is a flexible probability distribution that can take a positively skewed shape to capture the skewness in the data. Furthermore, the beta distribution works with proportions since it is defined on the interval [0,1], meaning the probabilities are bounded by 0 and 1 (while other models are unbounded). The BBM is also better able to handle missing data compared to a model such as an ANOVA (Yu et al., 2022). Thus, the BBM was chosen to examine the patterns of infants' Negative Facial Expressions, Self-Comforting, and Pulling Away across the three phases of the *cell phone engagement protocol*.

Objective 1 – Hypothesis 1c

To test whether mothers' general level of sensitivity affects these stress patterns, a non-hierarchical BBM was used to model the relationship between mothers' general level of sensitivity (IV) and the proportion of each infant stress behaviour (DV), when mothers' attention was directed to a device (Phase 2).

Objective 2

A General Linear Mixed Model (GLMM), also known as a Hierarchical Linear Model (HLM) or Multilevel Model (MLM) for Repeated Measures, was used to model the level of mother-infant synchrony (DV) across each phase (IV; **Hypothesis 2a**), as well as the relationship between mothers' general level of sensitivity (IV), and level of behavioural synchrony (DV) across the three phases (**Hypothesis 2b**). A standard HLM approach was chosen because the outcome variable (synchrony) was normally distributed, and this model is also better able to handle missing data as compared to a Repeated Measures ANOVA.

Objective 3

To examine the relationship between mothers' attachment-related anxiety (IV) and mother-infant behavioural synchrony (DV) in Phase 2 only (**Hypothesis 3a**), a simple Linear Model was used as there was no nesting within participants and the residuals were normally distributed. A Beta-Binomial Model was used to examine the relationship between mothers' attachment-related anxiety (IV) and proportion of infant stress behaviours (DV) for **Hypothesis 3b**.

Post-hoc Analyses

Technoference during Phase 2 (Explicit Texting + Deception Texting). As mentioned above, 12 mothers did *not* get distracted by text messages (and thus their infants did not undergo the experimental stressor). Post-hoc analyses were conducted to examine whether there were behavioural differences between this group and the rest of the mothers who *did* get distracted (n = 87 for codable stress behaviours, and n = 78 for codable synchrony behaviours during Phase 2). In other words, the aim was to determine whether mothers who did not tend to get distracted by their mobile devices would behave differently with their infants than those who did.

To determine whether *infant stress* behaviours would be significantly different between the non-distracted versus distracted groups of mothers, a generalized linear model was conducted (given the non-normal distribution of stress behaviours). To determine whether there would be a significant difference in the *level of synchrony* between the two groups of dyads, an independent samples t-test was conducted. Further analyses were conducted to examine differences in maternal sensitivity and attachment anxiety between the 12 non-distracted mothers and the rest of the mothers (n = 87) for whom sensitivity and attachment anxiety were codable during Phase 2.

Technoference during only Deception Texting. It was determined that 16 mothers *did* get distracted by text messages during Deception Texting (when they did not know text messages would be arriving). It was thus noteworthy to examine whether these mothers behaved differently than those who did not naturally get distracted by their mobile phones. Post-hoc analyses were conducted to determine whether infant stress and synchrony behaviours during

Deception Texting differed between dyads with distracted vs. non-distracted mothers. Specifically, infant stress behaviours for those 16 distracted dyads were compared to the other 87 non-distracted dyads (for whom *stress* was codable in Deception Texting). Because synchrony was only codable for 13 of these 16 dyads in Phase 2, synchrony behaviours for those 13 dyads were compared to 81 other dyads (for whom *synchrony* was codable during Deception Texting). Further analyses were conducted to examine differences in maternal sensitivity and attachment anxiety between the 16 distracted mothers and the rest of the mothers (n = 87) for whom sensitivity and attachment anxiety were codable during the Deception Texting phase.

Explicit Texting only to represent Phase 2. When re-watching Phase 2 of each video to determine whether technoference had occurred, it was observed that most mothers did *not* get distracted during the Deception Texting phase (i.e., when they did not know that the researchers would be texting them). It was thus possible that the one minute of Deception Texting in Phase 2 would be skewing results toward decreased stress behaviours and increased synchrony (given that most mothers' attention was not divided during Deception Texting). Therefore, analyses for Hypotheses 1-3 were run with only the Explicit Texting portion for Phase 2 to determine whether this would generate a notably different pattern of results. If notable differences were to be found, those results would be reported and interpreted in comparison to those that included both Deception Texting and Explicit Texting for Phase 2.

Biasing instructions before Reunion. As noted in Appendix F, there were 9 mothers who received responses from the experimenters prior to the Reunion phase which may have biased their natural behaviour throughout that phase (i.e., may have impacted whether they continued texting or not). Specifically, the researchers had erroneously instructed these mothers that they could stop responding to texts during Reunion, rather than stating "it's up to you".

Eight of these mothers followed those biasing instructions and did not text during Reunion. Therefore, analyses for Hypothesis 1 a) and b), and Hypothesis 2 a) and b), were run without the Reunion phase for this group of 8 mothers, to determine whether the potentially biasing instructions might have resulted in any notable differences with respect to infant stress and synchrony during Reunion. If a notably different pattern of results had been found, the infant stress and synchrony data during Reunion would have been removed for those 8 dyads and the analyses would have been re-run in order to report the updated results.

Partial data. As noted in the Missing Data section above, twenty-one dyads were missing behavioural codes for one or more categories for one or more phases. An independent samples t-test was conducted to determine whether there was a significant difference in level of sensitivity and attachment-related anxiety between mothers with partial data (n = 21) and those with full data (n = 87).

Chapter 3: Results

Infant behavioural stress patterns (Hypothesis 1 a and b)

The relationship between phase and each infant stress behaviour (Pulling Away, Negative Facial Expression, Self-Comforting) was modelled using the Beta-Binomial Hierarchical Model (Table 7). Because this model performs a logistic regression, coefficients were transformed to Odds Ratios (OR). For Pulling Away behaviours, the difference between Phase 2 and Phase 1 was statistically significant (p = .001), with Pulling Away behaviours being twice as likely to be observed in Phase 2 compared to Phase 1, OR = 2.03, 95% CI [1.32, 3.11]. Although Pulling Away was almost one and a half times more likely to be observed in Phase 3 versus Phase 1, this difference was not significant, OR = 1.40, 95% CI [0.89, 2.20], p = .142. Similarly, the odds of observing Pulling Away were approximately one and a half times more likely in Phase 2 versus Phase 3, but this difference was not significant, OR = 1.45, 95% CI [0.95, 2.20], p = .082. A predicted probability plot was created to visualize how the predicted probability of observing Pulling Away (y-axis) changed across the 3 phases (x-axis) (see Appendix K). The plot shows that Pulling Away is most likely to be observed in Phase 2, but the probability of observing Pulling Away in any given timeframe in that phase is still only about 3% (and is low in *all* of the phases).

For Negative Facial Expressions, the difference between Phase 2 and Phase 1 was statistically significant (p < .001), with Negative Facial Expressions approximately twice as likely to be observed in Phase 2 compared to Phase 1, OR = 2.07, 95% CI [1.39, 3.07]. The odds of observing Negative Facial Expressions were also approximately 1.5 times higher in Phase 2 compared to Phase 3, and this difference was significant, OR = 1.63, 95% CI [1.11, 2.41], p = .013. Although Negative Facial Expressions were 1.27 times more likely to be observed in Phase

Table 5

Descriptive statistics for infant stress behaviours across each phase

	Free-Play (Phase 1)				Still-Face (Phase 2)				Reunion (Phase 3)			
Variable	*N*	*M (SD)*	*Median*	*IQR*	*N*	*M (SD)*	*Median*	*IQR*	*N*	*M (SD)*	*Median*	*IQR*
Pulling Away	106	0.01(0.03)	0.00	0.008	86	0.03(0.05)	0.00	0.043	104	0.02(0.06)	0.00	0.025
Negative Facial Expressions	98	0.06(0.11)	0.01	0.046	78	0.11(0.16)	0.04	0.140	94	0.08(0.18)	0.00	0.080
Self-Comforting	106	0.20(0.27)	0.04	0.354	86	0.21(0.25)	0.12	0.319	105	0.19(0.26)	0.07	0.330

3 versus Phase 1, this difference was not significant, OR = 1.27, 95% CI [0.85, 1.89], *p* = .251. As above, a predicted probability plot was created to visualize how the predicted probability of observing Negative Facial Expressions changed across the 3 phases (see Appendix K). The plot demonstrates that Negative Facial Expressions are most likely to be observed in Phase 2, with approximately 12% likelihood of observing them (which is about 4 times higher than the probability of observing Pulling Away behaviours in Phase 2).

Table 7

Statistical analyses for infant stress behaviours across phase

Behaviour	Odds Ratio	95% CI	p-value
Pulling Away			
Phase 1 vs. 2	2.03	1.32, 3.11	.001***
Phase 1 vs. 3	1.40	0.89, 2.20	.142
Phase 3 vs. 2	1.45	0.95, 2.20	.082
Negative Facial Expressions			
Phase 1 vs. 2	2.07	1.39, 3.07	<.001***
Phase 1 vs. 3	1.27	0.85, 1.89	.251
Phase 3 vs. 2	1.63	1.11, 2.41	.013*
Self-Comforting			
Phase 1 vs. 2	1.64	1.13, 2.38	.010**
Phase 1 vs. 3	1.13	0.78, 1.64	.502
Phase 3 vs. 2	1.44	1.00, 2.09	.052

For Self-Comforting behaviours, the difference between Phase 2 and Phase 1 was statistically significant (*p* = .01), with Self-Comforting behaviours approximately one and a half times as likely to be observed in Phase 2 compared to Phase 1, OR = 1.64, 95% CI [1.13, 2.38]. Although Self-Comforting was also approximately one and a half times as likely to be observed in Phase 2 versus Phase 3, this difference was not significant, OR = 1.44, 95% CI [1.00, 2.09], *p* = .052. Self-Comforting was almost equally as likely to occur in Phase 3 and Phase 1 and this difference was also not significant, OR = 1.13, 95% CI [0.78, 1.64], *p* = .502. A predicted probability plot was also created to visualize how the predicted probability of observing Self-Comforting changed across the 3 phases (see Appendix K). As with Pulling Away and Negative Facial Expressions, the plot shows that Self-Comforting behaviours were most likely to be observed in Phase 2, with approximately 26% chance of observing them (more than double the probability of observing Negative Facial Expressions and almost 10 times the probability of observing Pulling Away behaviours in Phase 2). Overall, Self-Comforting behaviours were more likely to be observed in all phases as compared to Pulling Away behaviours and Negative Facial Expressions. In sum, the odds of observing each of the stress behaviours increased significantly during the still-face phase when mothers were distracted by their mobile phone, and infants continued to display some stress behaviours after re-engaging with their mother. This pattern is similar to that observed in the original Face-to-Face Still-Face experiments, supporting previous findings that mobile device use can be analogous to the “still-face”.

Maternal sensitivity and infant stress patterns (Hypothesis 1c)

Maternal sensitivity scores ranged from -0.47 to 0.87 in the sample of 108 participants. The mean sensitivity score was 0.30 and the median score was 0.34, suggesting that most mothers were not highly sensitive. However, about 37% did have high sensitivity scores at or above 0.5.

The relationship between maternal sensitivity and each infant stress behaviour during Phase 2 was modelled using a standard Beta-Binomial Model (Table 8). A one-tailed statistical test was used to determine whether infants of mothers who are generally more sensitive would demonstrate lower observed signs of stress (as this hypothesis specified one direction of a relationship). With regard to Pulling Away, results of the beta-binomial regression showed that there was a significant decrease in the odds of observing Pulling Away behaviours as maternal sensitivity increased, OR = 0.41, 95% CI [0.19, 0.87], p = .010. In other words, for every 1 unit increase in maternal sensitivity, the odds of observing Pulling Away decreased by about 59%. The beta-binomial regression also revealed a significant decrease in the odds of observing Negative Facial Expressions as maternal sensitivity increased, OR = 0.39, 95% CI [0.19, 0.78], p = .004. Specifically, for every 1 unit increase in maternal sensitivity, Negative Facial

Table 8

Statistical analyses for infant stress behaviours in relation to maternal sensitivity in Phase 2

Behaviour	Odds Ratio (per 1 unit increase in maternal sensitivity)	95% CI	p-value
Pulling Away	0.41	0.19, 0.87	.010**
Negative Facial Expressions	0.39	0.19, 0.78	.004**
Self-Comforting	1.96	1.01, 3.79	.023*

Expressions were about 61% less likely to be observed. In contrast, there was a significant *increase* in the odds of observing Self-Comforting behaviours as maternal sensitivity increased, OR = 1.96, 95% CI [1.01, 3.79], p = .023. In other words, for every 1 unit increase in maternal sensitivity, Self-Comforting was almost twice as likely to be observed. Predicted probability plots for each stress behaviour as a function of maternal sensitivity demonstrate similar trends (see Appendix L).

Dyadic behavioural synchrony patterns (Hypothesis 2a)

Synchrony scores ranged from -0.26 to 0.69 in the free-play phase, from -0.21 to 0.90 in the still-face phase, and from -0.35 to 0.73 in the reunion phase. A histogram of the synchrony scores indicated that scores were normally distributed, with the greatest frequency of scores between 0 and 0.40. A total of 29 dyads had negative synchrony scores (about 34% of the analytic sample): 14 in the free-play phase, 18 in the reunion phase, and only 5 in the still-face phase. Negative scores indicated that the dyads' eye gaze/head orientation and facial expressions changed in opposite directions. However, over half of these (19 dyads) had negative synchrony scores of a small magnitude (below 0.10), suggesting low levels of synchrony. Overall, most dyads were synchronized in the same direction (positive synchrony scores), meaning the mother's and infant's affective behaviours moved in the same direction throughout the interaction (e.g., as infants engaged more positively, mothers engaged more positively; Moore et al., 2016). However, mean synchrony scores were generally low across phases (i.e., correlation values were small in magnitude; Table 6). Only about 10% of dyads had high synchrony scores above 0.6.

Table 6

Descriptive statistics for mother-infant behavioural synchrony across each phase

	Free-Play (Phase 1)				**Still-Face (Phase 2)**				**Reunion (Phase 3)**			
Variable	N	M (SD)	Median	IQR	N	M (SD)	Median	IQR	N	M (SD)	Median	IQR
Mother-infant behavioural synchrony	95	**0.17**(0.19)	0.13	0.24	81	**0.27**(0.19)	0.26	0.19	96	**0.23**(0.25)	0.20	0.38

A General Linear Mixed Model approach was used to conduct a Linear Mixed Effects Regression (LMER) to determine the relationship between synchrony (outcome) and phase (predictor). Results showed that when moving from Phase 2 to Phase 1, the mean level of synchrony decreased by 0.10, 95% CI [-0.16, -0.04], and when moving from Phase 2 to Phase 3, the mean level of synchrony decreased by 0.04, 95% CI [-0.10, 0.02] (see Table 6). However, as synchrony is a correlation value, these changes are considered quite small. Thus, it can be concluded that there was no meaningful change in the level of synchrony between phases.

Maternal sensitivity and synchrony (Hypothesis 2b)

A Linear Mixed Effects Regression (LMER) was also conducted to determine the relationship between the level of synchrony (outcome) across all phases and maternal sensitivity (predictor). Maternal sensitivity did not statistically significantly predict synchrony across phases (b = 0.002, 95% CI [-0.073, 0.076], $R^2 < .001$). In other words, as maternal sensitivity increased by 1 point (a substantial change based on the sensitivity scale), the expected difference in synchrony was essentially zero (i.e., a 0.002 increase in synchrony).

Maternal attachment-related anxiety and synchrony (Hypothesis 3a)

Attachment-related anxiety scores for mothers (average of the 18 item scores) ranged from 1 to 4.67, with a mean of 2.13 and a median of 1.78. A histogram of attachment anxiety scores showed that scores were positively skewed (i.e., most mothers had low attachment-related anxiety), which is also supported by the low average and median scores.

A simple Linear Model was conducted to determine the relationship between level of synchrony (outcome) and maternal attachment-related anxiety (predictor) during Phase 2. Findings revealed that maternal attachment anxiety did not significantly predict synchrony, $R^2 < 0.01$, $t(76) = 0.79$, $p = .432$. Specifically, as attachment-related anxiety increased by 1 point, there was a 0.017 increase in synchrony, which is a very small change for a correlation value and thus not meaningful.

Maternal attachment-related anxiety and infant stress (Hypothesis 3b)

The relationship between maternal attachment-related anxiety and each infant stress behaviour (Pulling Away, Self-Comforting, Negative Facial Expressions) during the still-face phase was modelled using a standard Beta-Binomial Model. A one-tailed statistical test was used to determine whether infants of more anxiously attached mothers would exhibit greater stress than those of less anxiously attached mothers (as this hypothesis specified one direction of a relationship).

With regard to Pulling Away, results of the beta-binomial regression (Table 9) showed that there was no significant change in the odds of observing Pulling Away behaviours as maternal attachment-related anxiety increased, OR = 0.93, 95% CI [0.69, 1.25], $p = .316$. There was also no significant difference in the odds of observing Negative Facial Expressions as maternal attachment-related anxiety increased, OR = 0.90, 95% CI [0.68, 1.19], $p = .228$. Similarly, no significant change was found in the odds of observing Self-Comforting as maternal attachment-related anxiety increased, OR = 1.00, 95% CI [0.76, 1.30], $p = .486$. Plots visualizing the predicted probability of all infant stress behaviours as a function of maternal attachment-related anxiety demonstrate similar trends (Appendix M).

Table 9

Statistical analyses for infant stress behaviours in relation to maternal attachment anxiety in Phase 2

Behaviour	Odds Ratio	95% CI	p-value
Pulling Away	0.93	0.69, 1.25	.316
Negative Facial Expressions	0.90	0.68, 1.19	.228
Self-Comforting	1.00	0.76, 1.30	.486

Post-hoc analyses

Technoference during Phase 2 (Explicit Texting + Deception Texting)

Infant stress behaviours were compared between dyads with distracted mothers ($n = 87$) and non-distracted mothers ($n = 12$) in Phase 2 (see Table 10). Given the unequal sample sizes and the small sample size of the non-distracted condition, power was low for this analysis.

Table 10

Descriptive statistics for infant stress behaviours in the distracted vs. non-distracted conditions during Phase 2

	Distracted Condition (*n* = 87)		**Non-distracted Condition (*n* = 12)**	
Variable	M (SD)	Median	M (SD)	Median
Pulling Away	**0.03**(0.05)	0.00	**0.01**(0.02)	0.00
Negative Facial Expressions	**0.11**(0.16)	0.04	**0.09**(0.14)	0.01
Self-Comforting	**0.21**(0.25)	0.12	**0.09**(0.12)	0.06

Results of a generalized linear model (Table 11) indicated that there was no significant difference in the odds of observing Pulling Away behaviours between infants of distracted vs. non-distracted mothers in Phase 2, OR = 0.65, 95% CI [0.26, 1.65], $p = .368$. Although there was an approximately 35% decrease in the odds of observing Pulling Away behaviours in the non-distracted group, this difference was not significant. In descriptive terms, the mean proportion of Pulling Away behaviours in infants was three times less when mothers were not distracted by their cell phones, while the median frequency was zero in both groups (Table 10). With respect to Negative Facial Expressions, there was no significant difference in the odds of observing Negative Facial Expressions between infants of distracted versus non-distracted mothers in Phase 2 (OR = 0.80, 95% CI [0.37, 1.73], $p = .570$), although Negative Facial Expressions were approximately 20% less likely to be observed in the non-distracted group. The mean proportion of Negative Facial Expressions in infants was also approximately 20% lower when mothers were not distracted, and the median proportion of Negative Facial Expressions was four times less (Table 10). In addition, there was no significant difference in the odds of observing Self-Comforting behaviours in infants of distracted versus non-distracted mothers (OR = 0.66, 95% CI [0.32, 1.37], $p = .264$, though it was approximately 34% less likely to observe this behaviour

Table 11

Probability of observing infant stress behaviours in distracted vs. non-distracted dyads in Phase 2

Behaviour	Odds Ratio	95% CI	p-value
Pulling Away			
Distracted vs. Non-distracted	0.65	0.26, 1.65	.368
Negative Facial Expressions			
Distracted vs. Non-distracted	0.80	0.37, 1.73	.570
Self-Comforting			
Distracted vs. Non-distracted	0.66	0.32, 1.37	.264

in infants of non-distracted mothers. Similarly, the mean proportion of Self-Comforting behaviours in infants was approximately two and a half times reduced when mothers were not distracted by their cell phones, and the median proportion of Self-Comforting was approximately halved (Table 10).

Regarding synchrony, results of an independent samples t-test revealed that there was no significant difference in synchrony between dyads with distracted mothers (n = 78) vs. non-distracted mothers (n = 12) during Phase 2, $t(88) = 0.017$, $p = 0.987$. Indeed, the mean synchrony in the distracted group and non-distracted group was the same (0.27), and the median in both groups was also equivalent (0.26). As for stress behaviours above, power was low for this analysis given the unequal sample sizes and the small sample size of the non-distracted condition.

Further exploratory analyses were conducted to determine whether maternal sensitivity and attachment-related anxiety differed significantly between distracted and non-distracted mothers. Results of an independent samples t-test showed that there was no significant difference in maternal sensitivity between the distracted (n = 87) and non-distracted (n = 12) mothers during Phase 2, $t(17) = -2.025$, $p = 0.059$. Similarly, no significant difference was found between these groups of mothers with respect to their attachment-related anxiety, $t(26) = 1.208$, p = 0.238.

Technoference during only Deception Texting

During the Deception Texting portion of the still-face phase, when mothers did not know they were being sent texts by the researchers, 16 mothers out of the 103 for whom this data was available still became distracted by their mobile phones. In other words, technoference occurred naturally for approximately 15.5% of mothers. Moreover, all but one of the 16 mothers continued to be distracted by their mobile phone during the Explicit Texting phase (when they were aware that the researchers were sending them text messages). Therefore, proportions of infant stress behaviours during the Deception Texting portion of Phase 2 were also compared between dyads with distracted mothers (n = 16) versus non-distracted mothers (n = 87) (see Table 12). As above, power was low for this analysis given the unequal sample sizes and the small sample size of the distracted condition.

Results of a generalized linear model (Table 13) indicated that there was no significant difference in the odds of observing Pulling Away behaviours in infants of mothers who were distracted versus non-distracted during Deception Texting only, OR = 0.87, 95% CI [0.43, 1.74], $p = .693$. However, there was still a 13% decrease in the odds of observing Pulling Away in the non-distracted group. In descriptive terms, there was only a 0.01 difference in mean proportion of Pulling Away behaviours when mothers were and were not distracted by their mobile phones. Although the average proportion of Negative Facial Expressions in infants was approximately 1.5 times higher when mothers were not distracted during Deception Texting (Table 12), there

Table 12

Descriptive statistics for infant stress behaviours in the distracted vs. non-distracted conditions for the Deception Texting portion of Phase 2

	Distracted Condition (*n* = 16)		**Non-distracted Condition (*n* = 87)**	
Variable	M (SD)	Median	M (SD)	Median
Pulling Away	**0.02**(0.02)	0.00	**0.03**(0.05)	0.00
Negative Facial Expressions	**0.07**(0.12)	0.04	**0.11**(0.16)	0.02
Self-Comforting	**0.25**(0.25)	0.20	**0.19**(0.23)	0.08

was no significant difference in the odds of seeing Negative Facial Expressions in infants of distracted versus non-distracted mothers during the Deception Texting phase, OR = 0.96, 95% CI [0.48, 1.95], p = .919. In addition, the odds of observing Self-Comforting behaviours in infants of distracted versus non-distracted mothers were not significantly different, OR = 0.66, 95% CI [0.35, 1.23], p = .187. However, there was a 34% decrease in the odds of seeing Self-Comforting behaviours in infants of non-distracted mothers, and the mean proportion of Self-Comforting was about 1.3 times lower when mothers were not distracted.

Regarding synchrony, the mean synchrony score was 0.27 in the distracted group (median of 0.24), and also 0.27 in the non-distracted group (median of 0.27). Results of an independent samples t-test revealed that there was no significant difference in synchrony between the distracted (n = 13) vs. non-distracted (n = 81) dyads during the Deception Texting phase only, $t(20) = -0.006$, p = .996. For the same reasons described for stress behaviours above, power was low for this analysis.

Further exploratory analyses were conducted to determine whether maternal sensitivity and attachment-related anxiety differed significantly during the Deception Texting phase between the 16 distracted versus the 87 non-distracted mothers. Results of an independent

Table 13

Statistical analyses for infant stress behaviours for distracted vs. non-distracted dyads during Deception Texting

Behaviour	Odds Ratio	95% CI	p-value
Pulling Away			
Distracted vs. Non-distracted	0.87	0.43, 1.75	.693
Negative Facial Expressions			
Distracted vs. Non-distracted	0.96	0.48, 1.95	.919
Self-Comforting			
Distracted vs. Non-distracted	0.66	0.35, 1.23	.187

samples t-test showed that there was no significant difference in maternal sensitivity between these two groups, $t(24) = 1.540$, $p = 0.136$. Similarly, no significant difference was found between these groups of mothers with respect to their attachment-related anxiety, $t(21) = -0.887$, $p = .385$.

Explicit Texting only to represent Phase 2

Statistical analyses for Hypotheses 1 to 3 were conducted again, but with only Explicit Texting representing Phase 2. For **Hypothesis 1 and b**, the same pattern of results was found except that the odds of observing Self-Comforting behaviours no longer increased significantly when moving from free-play to still-face, OR = 1.46, 95% CI [0.99, 2.16], $p = .055$. The odds now increased by 46% in Phase 2 instead of by 64%. For **Hypothesis 1c**, maternal sensitivity no longer significantly predicted Self-Comforting behaviours, OR = 1.71, 95% CI [0.84, 3.44], $p = 0.068$. However, the odds of observing Self-Comforting still increased by 71% for every 1 unit increase in maternal sensitivity (rather than by 96%).

For **Hypothesis 2a**, a GLMM one-tailed statistical test was used to determine whether level of synchrony would now change in the predicted direction between phases (i.e., would be lowest in Phase 2). Results showed that when moving from Phase 2 to Phase 1, level of synchrony decreased by 0.029, 90% CI [-0.084, 0.026], but this difference was minimal (Table 14). When moving from Phase 2 to Phase 3, level of synchrony *increased* by 0.034, 90% CI [-0.021, 0.089]. The change from Phase 2 to Phase 3 was now in the predicted direction but was still not significant (i.e., the 90% CI includes zero, indicating that random chance could account for the observed effect). Ultimately, as synchrony is a correlation value, these changes are considered quite small and it can be concluded that there was no meaningful change in synchrony between phases.

Regarding **Hypothesis 2b**, maternal sensitivity still did not statistically significantly predict synchrony when the Deception Texting portion of Phase 2 was removed (b = .044, 95% CI [-0.031, 0.119], $R^2 = .006$). In other words, findings suggested that as maternal sensitivity increased by 1 point, the difference in level of synchrony was essentially zero (a .044 increase in synchrony).

For **Hypothesis 3a**, when post-hoc analyses were conducted with the Explicit Texting portion of Phase 2 only, there was a 0.005 *decrease* in synchrony as maternal attachment-related anxiety increased by 1 point (as compared to a 0.017 *increase* when Phase 2 was analyzed in full). However, there was still essentially no meaningful difference, and maternal attachment anxiety was not found to significantly predict synchrony, $R^2 < 0.01$, $t(74) = -0.18$, $p = .857$.

Post-hoc analyses for **Hypothesis 3b** examined the relationship between maternal attachment-related anxiety and the odds of observing each infant stress behaviour during only the Explicit Texting portion of Phase 2. The pattern of results was not found to be notably different

Table 14

Comparison of behavioural synchrony means with and without Deception Texting in Phase 2

Variable	Free-Play (Phase 1) M (SD)	Deception Texting + Explicit Texting (Phase 2) M (SD)	Explicit Texting Only (Phase 2) M (SD)	Reunion (Phase 3) M (SD)
Mother-infant behavioural synchrony	0.17(0.19)	0.27(0.19)	**0.20(0.23)**	0.23(0.25)

than those generated by earlier analyses that included both Deception Texting and Explicit Texting portions in Phase 2.

Biasing instructions before Reunion

Statistical analyses for **Hypothesis 1 a)** and **b),** and **Hypothesis 2 a)** and **b)** were conducted without Reunion phase data for the 8 mothers who had received potentially biasing instructions. The same pattern of results was found across hypotheses, except that the difference between the odds of observing Self-Comforting in Phase 2 versus 3 was now statistically significant, OR = 1.46, 95% CI [1.00, 2.12], p = .049. However, the odds of observing Self-Comforting in Phase 2 versus 3 only increased by 2% (i.e., a 46% increase versus a 44% increase in the original sample). Given that this is only a 2% difference in odds, and that it pertained to only one stress behaviour and between one set of phases, the original results that included these 8 mothers were reported.

Partial data

Results of an independent samples t-test showed that level of sensitivity was significantly higher in the mothers with full data available than those with partial data, $t(106) = 1.993$, p =

0.049. However, no significant difference was found between these groups of mothers with respect to their attachment-related anxiety, $t(27) = -1.328$, $p = 0.195$.

Chapter 4: Discussion

With the rising prevalence of mobile technology in developmental contexts, researchers have shown that mothers' engagement with mobile phones interferes with their interactions with their infants. As such, the present study aimed to replicate and extend previous work that had demonstrated the effects of the smartphone-adapted Face-to-Face Still-Face (e.g., Tidemann & Melinder, 2022) by investigating patterns of infant stress behaviours and mother-infant behavioural synchrony, as well as the role of mothers' attachment-related anxiety, in the context of maternal divided attention. First, this study sought to describe the impact of mothers' use of a mobile phone in their child's presence by examining changes in proportions of infant stress behaviours (i.e., negative facial expressions, pulling away behaviours, and self-comforting) across the three phases of the *cell phone engagement protocol*. In addition, given existing findings on the importance of maternal sensitivity in helping infants regulate stress (e.g., Beeghly et al., 2010), the effect of maternal sensitivity on infant stress patterns was also examined. Second, the study aimed to expand the still-face literature as it relates to the infant stress response by assessing changes in mother-infant behavioural synchrony when mothers become engaged with a cell phone while caring for their young infants. As maternal sensitivity is a key component of mother-infant synchrony (e.g., Dollberg et al., 2010), its role in predicting level of synchrony was also examined. Third, this study is the first to explore the impact of maternal attachment style, specifically attachment-related anxiety, on both infant stress and dyadic behavioural synchrony, while mothers were focused on their smartphones during childcare. By analyzing the impact of technoference on not only infant stress but also on dyadic synchrony, as well as maternal factors, the study adds to our current understanding of young infants' emotion regulation and more broadly, mother-infant dynamics in modern-day divided attention contexts.

Significant findings emerged when studying infant stress patterns during the *cell phone engagement protocol*. Specifically, the odds of observing each stress behaviour increased significantly during the still-face phase after the dyad first interacted as usual. However, mother-infant synchrony did not change meaningfully between phases; that is, the level of synchrony was not significantly different when moving from free-play to still-face and then to reunion. Moreover, mother-infant synchrony was not associated with maternal sensitivity across phases. In addition, maternal attachment anxiety was not found to be meaningfully associated with the odds of observing infant stress behaviours or with the level of dyadic synchrony. This lack of support for hypothesized associations calls into question the validity of several components of the study, including: the virtual and highly naturalistic set-up of the current study, the extent of technoference during the still-face phase, how synchrony was defined and measured, and the diversity of the sample. Post-hoc analyses were conducted to further clarify the effects of technoference on mother-infant interactions, and to rule out the effects of biasing instructions given to a small portion of participants before the final phase of the *cell phone engagement protocol*.

Infant behavioural stress patterns

In line with our hypothesis, having a mother become distracted by their mobile phone in their child's presence was found to be stressful for the infant, much like in the original Face-to-Face Still-Face experiments. Specifically, the odds of observing each of the stress behaviours increased significantly during the still-face phase when mothers were distracted by text messages, after having first played as usual with their infants. These findings provide support for mobile device use being analogous to the "still-face", and highlight infants' potential distress due to technoference, consistent with previous studies (e.g., Myruski et al., 2018; Nazzari et al., 2025; Stockdale et al., 2020).

Contrary to expectations, a "carryover effect" was not observed for any of the stress behaviours, as no significant difference was found between free-play and reunion with respect to the odds of observing each behaviour (i.e., the odds remained similar to baseline levels). That is, the effects of the still-face did not persist into the reunion phase, suggesting infants were able to regulate well. This is inconsistent with research showing a partial carry-over effect of negative affect (Li et al., 2019; Mesman et al., 2009; Swider-Cios et al., 2024; Weinberg & Tronick, 1996) and behaviours analogous to pulling away (e.g., Gunning et al., 2013; Nazarri et al., 2025; Stockdale et al., 2020; Weinberg & Tronick, 1996), but is in line with research where self-comforting behaviours did not carry over into reunion (Stockdale et al., 2020). As discussed in more detail below, most infants in this study were likely not very stressed (probabilities and proportions of stress behaviours were low), potentially due to technoference lasting only a short time. Consequently, infants likely did not experience sufficient stress to carry over into the reunion phase, as their mothers may have stayed engaged or re-engaged quickly with their infants within the still-face phase.

In line with the lack of carryover of stress behaviours into the reunion phase, there was a significant decrease in the odds of observing negative facial expressions when moving from the still-face episode to reunion, demonstrating a partial recovery. However, this finding is inconsistent with prior research showing no recovery regarding negative affect (Li et al., 2019; Nazarri et al., 2025; Stockdale et al., 2020). Similar to above, infants likely recovered quickly in the current study as they were not highly stressed to begin with. A partial recovery also appears to have occurred for self-comforting and pulling away behaviours (a 30% and 31% decrease in odds, respectively) when moving from the still-face phase to reunion, although these differences did not reach statistical significance. This suggests that most infants continue to pull away and self-comfort once the mother re-engages, and reflect the idea that arousal does not immediately decrease once a stressor ends (Tronick, 1989). There is also a possibility that recovery takes place in the second part of reunion and that the episode duration is not sufficient for the infant to recover fully (Mesman et al., 2009). However, infants may eventually resume other-oriented strategies when re-engaging with their mother in the third phase, and move toward baseline levels (as suggested by the decrease in odds of observing these behaviours). Indeed, self-comforting has been found to decrease significantly when moving from a modified still-face episode to reunion (Nazarri et al., 2025). Furthermore, it is possible that mothers re-engaging infants with toys during reunion prompted infants to play with and touch the toys versus continuing to suck or pull away at the level they did during the still-face phase. Moreover, infant age may play a role in recovery; for example, 3 month-old infants demonstrated increases in self-comforting from still-face to reunion, but demonstrated decreases in self-comforting when they were 5 and 7 months old (Braungart-Rieker et al., 2014).

Overall, the current results support the distressing nature of the still-face episode, as the odds of infants demonstrating stress behaviours were significantly higher when mothers directed their attention to their mobile device, as compared to interacting with their infants as usual, but infants' stress did not appear to stay elevated when their mothers re-directed their attention to their infants.

In light of these findings, it is worth noting that all three stress behaviours were found to have a relatively low probability of occurring, although self-comforting was most likely to be observed in all phases (Appendix K). This suggests that infants were not very stressed overall during the experimental protocol, but still preferred coping via self-comforting, which aligns with the theory that when mothers are not available to co-regulate, infants turn to self-soothing (Tronick, 1989). It should be noted, however, that negative facial expressions were harder to assess due to poor video quality, versus broader, more visible behaviours such as back-arching (pulling away) or sucking on a finger (self-comforting), leading to potential observation bias for those behaviours and resulting in their appearing less frequently.

Mean proportions of each stress behaviour were also low, which tends to be in line with traditional still-face studies (e.g., Ginnell et al., 2022; Montirosso et al., 2015; Provenzi et al., 2015; Weinberg & Tronick, 1994, 1996; Weinberg, 1989). However, compared to the current study, negative affect during still-face and reunion phases was relatively higher in the studies by Ginnell et al. and Montirosso et al., and in Provenzi et al.'s study for infants who did not exhibit Respiratory Sinus Arrhythmia suppression. Similarly, some smartphone-adapted FFSF studies (e.g., Bimm [Khourochvili] et al., 2018; Nazzari et al., 2025; Stockdale et al., 2020; Tidemann & Melinder, 2022) have shown relatively higher levels of some stress behaviours during the still-face condition than those found in the current study, likely due to longer technoference and/or instructions given to mothers to not interact with the infants.

The low proportions of stress behaviours in our study may be accounted for by several factors. First, mothers were asked by the researchers to play with their infants during the first and last phase, likely resulting in less stress being exhibited by infants during those phases. They were also permitted to use toys and pacifiers during play, unlike in many other smartphone-adapted still-face studies. Second, this study consisted of a highly naturalistic set-up, whereby mothers were not instructed to have their phones on loud and may not have noticed incoming messages. Even during Explicit Texting, mothers were told it was up to them if they would like to respond, potentially arousing suspicion that they should not. Mothers were also permitted to take infants out of their seats and to create a comfortable set up if they expressed a desire to do so, as long as infants were visible on screen, which could have further reduced infant stress. Third, very few mothers engaged with their smartphone for the entire 2.5 minutes of the Explicit Texting phase. Many glanced at their phones for only a few seconds without responding, which could itself be a sign of sensitivity. It was ultimately unclear to what extent and for how long technoference lasted. Thus, many mothers in this study did not become fully engrossed with their mobile phones, which may have led infants to experience less stress overall. This notion is supported by literature showing that periodic, short smartphone use interrupts parent–child interaction less than longer-lasting phone use (Abels et al., 2018; Elias et al., 2020; Vanden Abeele et al., 2020; Wolfers et al., 2020). Even when technoference did occur, some infants may also have been habituated to their mothers' phone use and therefore found it to be less stressful. Finally, mothers were aware of two researchers watching their interactions through Zoom, which could have led to social biasing. Indeed, they were often attentive to their infants during the interaction. However, it appears that some level of distraction did take place during the second phase, given the significantly higher odds of observing all three stress behaviours during that phase. Nevertheless, it may be the case that mothers in this study were regulating well in terms of distractibility (i.e., not becoming absorbed with their phones while managing infant care), and their infants were also regulating well (given the current findings of low proportions and probabilities of stress behaviours).

Maternal sensitivity and infant stress patterns

It was expected that more sensitive mothers would be more appropriately and promptly responsive to their infant's cues even while absorbed with a mobile device, and therefore their infants would demonstrate significantly lower observed signs of stress during maternal divided attention (still-face phase). Consistent with this hypothesis, a significant relationship was found between maternal sensitivity and all three infant stress behaviours, though only two were in the predicted direction. Namely, a one-unit increase in sensitivity led to significant decreases in the odds of observing Pulling Away and Negative Facial Expressions. This suggests that infants with sensitive mothers are more regulated, in general, during dyadic interaction. It is also possible that more sensitive mothers did not become as distracted by incoming text messages during the still-face phase and were thus more attentive to their infants. If their infants did become distressed, it is likely that they responded to infant cues in a timelier manner, so infants may not have needed to escalate to more distressing behaviours such as Pulling Away or Negative Facial Expressions. These findings are consistent with the strong association found in the literature between maternal sensitivity and infant stress (e.g., Beeghly et al., 2010, Girod et al., 2024, Mesman et al., 2013).

Though the odds of observing self-comforting moved in the opposite direction of what was expected, this finding is in line with literature showing that maternal sensitivity was associated with greater infant self-soothing during the still-face (Bozicevic et al., 2025; Tarabulsy et al., 2003). That literature also looked at the role of infant temperament in the relation between self-soothing and maternal sensitivity. Specifically, higher maternal sensitivity in frustrating contexts was associated with greater use of self-soothing in highly negative reactive children but with greater communicative behaviours in low reactive children (Bozicevic et al., 2025). In contrast, Tarabulsy et al. (2003) found a stronger positive association between maternal sensitivity and self-soothing for infants perceived as less difficult. They posited that less fussy infants "may be exposed to interactive behaviour where the emphasis is placed on the coping skills that are associated with self-soothing in times of distress" (p. 435). It may be that the temperament of infants in the current sample may have also played a role in these findings. It is also possible that when more sensitive mothers in this study noticed their infants sucking on their hand or an object, and appearing regulated by way of this behaviour, these mothers did not interrupt the self-comforting due to likely being less intrusive in their caregiving (Bretherton, 2013). This is in line with the idea that sensitive mothers may recognize the importance of their children's need to reduce their arousal, and that self-soothing could be an ideal avenue for this (Bozicevic et al., 2025; Kopp, 1982).

However, it is important to note that a one-unit increase in sensitivity scores (which represent the correlation with the prototypical sensitive mother and range from -1 to +1) translates to an extreme shift across the sensitivity scale. Thus, only a very large difference in sensitivity is associated with the significant differences in the odds of observing stress behaviours. Given the range of sensitivity scores in the current study, a one-unit difference would cover almost the full range of scores and would translate to a significant qualitative difference in sensitivity. Therefore, current findings suggest that infants express stress differently when they are with insensitive versus sensitive mothers. When provided with sensitive caregiving, infants seem to use substantially less overt stress cues (negative facial expressions and pulling away), and instead rely on self-comforting to regulate stress.

It may be useful to consider one-unit differences in sensitivity in experiments where mothers are initially divided into groups on opposite ends of the sensitivity scale: those with high sensitivity and those with low sensitivity. As this was not the case in the current sample, it is more sensible to apply the findings to a context of within-mother changes in sensitivity. From an intervention approach, mothers may be supported in making more realistic improvements in sensitivity, such as by intervals of 0.1 in sensitivity scores. From this perspective, current findings may be scaled down by ten, suggesting that when sensitivity increased by 0.1, the odds of observing pulling away behaviours and negative facial expressions decreased by approximately 6% and the odds of observing self-comforting increased by approximately 10%. While these changes may be small, they may lead to meaningful positive changes in infants' arousal and stress regulation in divided attention contexts and move in a direction that is consistent with developmental expectations (e.g., Beeghly et al., 2010, Tarabulsy et al., 2003).

Dyadic behavioural synchrony patterns

Overall, synchrony scores were low throughout all three phases of our *cell phone engagement protocol* (Table 6). This is consistent with the finding that coordination only occurs approximately 30% of the time or less during face-to-face interactions in the first year (Tronick & Cohn, 1989). Notably, fewer dyads were synchronized in opposite directions in the second phase than during phases 1 and 3, respectively. Thus, in the presence of a distractor such as a mobile phone, dyads may be more positively synchronized (i.e., their eye gaze/head orientation and facial expressions are more likely to move in the same direction). Perhaps there is a greater likelihood that infants will also gaze or turn their head toward mobile phones when mothers are engaged with these in front of their infant. Following the findings from infant stress, when mothers are distracted by mobile phones, infants are more likely to look/turn away and to demonstrate less positive affect (which is in line with what mothers would be doing when engaged with their phones).

Contrary to the hypothesis that the behaviours of a mother and their infant would be significantly less synchronized during the still-face phase as compared to typical face-to-face interactions, no meaningful difference in dyadic synchrony was found across the phases of cell phone engagement. This finding does not align with the expectation based on the Mutual

Regulation Model that the interference of a mobile device would lead to different goals in each member of the dyad, and thus result in a *mismatch* that would make it more difficult to achieve a state of synchrony. Some studies that looked at differences in synchrony between baseline and reunion revealed similar results. Moore et al.'s (2016) study of 6-month-old infants who underwent the Face-to-Face Still-Face found that levels of synchrony (measured by affect and gaze) were not significantly different between the normal and reunion episodes. Others' studies also did not identify changes in affect synchrony between baseline and reunion phases (Lotzin et al., 2016; Weinberg et al., 2006).

In the current study, synchrony may not have significantly decreased during the still-face phase, as the very infant behaviours that were used to assess synchrony are known to transform in such a way that aligns with the behaviours mothers exhibit when engaged with their phone (as mentioned above). Specifically, infants are known to look away and adopt less positive expressions when stressed (e.g., Tidemann & Melinder, 2022), and these are the same behaviours a mother would be displaying when using a mobile phone. Thus, both partners likely became disengaged during the still-face, but were more consistently engaged during free-play and reunion, so their synchrony scores may look similar between phases even though the quality of the interaction has changed.

As discussed in detail below, it is also possible that sufficient technoference did not occur during the still-face episode of cell phone engagement, which may account for the lack of significant difference in synchrony between phases. Indeed, if the technoference had lasted longer, mothers would likely have demonstrated extended "eye gaze/head orientation away" and more "neutral" facial expressions, leading to more infant stress and likely decreasing mother-infant synchrony.

In addition, it is a possibility that the specific behaviours chosen to represent dyadic synchrony in the current study (eye gaze/head orientation and facial expression) were not able to sufficiently capture the nuances of mother-infant behaviour (e.g., time-lags to synchrony, leading/following of dyad members). Indeed, in unstructured interactions of toy play, infants between 3 to 11 months have been found to rarely look at their parents' faces (Deák et al., 2014), and gaze following is not the main method used by infants to achieve shared attention with caregivers (Deák et al., 2014; Yu & Smith, 2013).

Moreover, Pearson correlations were used to calculate synchrony scores in the current study. Pearson correlations offer a global synchrony score which assesses temporal covariation but not the changes in the quality of the interaction (e.g., contingency – one partner's behaviour influencing the other's behaviour to occur within a short time frame). Indeed, the correlation considers time-matched values between two time series (caregiver and infant behaviours) and does not account for time lags. Yet realistically, there may be a lag between infant and caregiver behaviours in dyadic interactions (e.g., Northrup & Iverson, 2020; Yu & Smith, 2013). Indeed, Yu and Smith (2013) have found that mothers and infants can lead and follow each other to shared attention within a lag of 5 seconds of the other's gaze. Thus, the use of more multimodal measures, such as time-lagged sequential analysis or event-based measures (focusing on discrete behaviours instead of continuous time series) which consider leader/follower dynamics of synchrony may be more accurate and if used, might have altered the current findings. In the current study, the underlying assumption was that synchrony would decrease during the still-face phase because mothers would not be able to follow the infant's lead due to the mother's distraction by a mobile phone. Thus, sequential or lagged analyses that measured infant-led synchrony specifically could have changed and/or clarified current results.

As discussed in the Introduction, it can be difficult to define and assess synchrony, and current findings point to the need to develop a more nuanced conceptualization and measurement of dyadic synchrony (Moore et al., 2016).

Maternal sensitivity and synchrony

Results were inconsistent with the hypothesis that mothers who are generally more sensitive would display significantly more synchronous behaviours with their infants across all three phases, as compared to mothers who are generally less sensitive. Thus, maternal sensitivity was not found to predict synchrony. As maternal sensitivity increased, synchrony did not appear to be altered in the current study. Although this is counter to current theories in the literature, the particular behaviours chosen to measure synchrony in this study could represent both maternal withdrawal and infant stress during the still-face phase (as described above), which becomes a confounding factor when assessing synchrony. Several other reasons may also account for this unexpected finding. As mentioned above, duration of technoference was unclear in this study, and mothers likely did not become fully engrossed with their mobile phones. It is possible that the level of technoference that *did* occur was not enough to impact level of synchrony between mothers and infants. It is also possible that other factors or pathways are involved in the relationship between maternal sensitivity and dyadic behavioural synchrony (e.g., a child's individual needs, temperament, age). Furthermore, the presence of toys in this study may have helped less sensitive mothers maintain a higher-than-expected level of synchrony as the dyad could focus together on an object (potentially prompting similar direction of gaze/head as well as similar facial expressions). It could also be informative to consider the distribution of synchrony in the current sample (described in the Results above). Given that most dyads in this study were already at a low level of synchrony (scores mostly between 0 to 0.4), there may not have been enough variability in synchrony scores to demonstrate the predicted relationship with maternal sensitivity. This restricted range in synchrony scores means the linear regression may have underestimated the strength of the relationship between sensitivity and synchrony.

Maternal attachment-related anxiety and synchrony

Contrary to hypotheses, maternal attachment-related anxiety did not significantly predict synchrony during the still-face phase. Mothers' attachment anxiety did not appear to prompt the latter to become absorbed with their mobile phone to a point where they were less synchronous. This result is supported by findings from an earlier study that more anxious mothers were more synchronous in gaze and touch than control mothers (Granat et al., 2017). It is possible that mothers higher in attachment anxiety were more hypervigilant (Shaver & Mikulincer, 2002) to moments of mismatch in interactions with their infants, and over-compensated by repairing these more quickly in order to maintain synchrony. Their anxiety may have also prompted them to be hyper-aware of their infants' bids for re-engagement, and thus they put forth more effort to stay engaged. Moreover, infants of anxiously-attached mothers may be used to their anxiety-related behaviours (Kaitz et al., 2010) and have learned to adapt to these, thus maintaining synchrony.

Maternal attachment-related anxiety and infant stress

Contrary to expectations, infants of more anxiously attached mothers did not experience significantly greater stress than those of less anxiously attached mothers in a context of cell phone intrusion. It may be that highly anxious mothers did *not* become more absorbed with their mobile devices and thus less responsive to their infants' needs; therefore, the dyad did not partake in more mismatched exchanges that ultimately lead to more negative affect (as per the Mutual Regulation Model) and higher infant stress. The current finding is supported by Kaitz et al.'s study (2010) which found that more control infants showed negative affect during the still-face than infants of anxious mothers. As noted above, infants of mothers with higher attachment-related anxiety may be used to the inattentiveness produced by the “still face” (i.e., an anxiety-related behaviour) and thus do not demonstrate a notable change in stress behaviours. “As suggested by Field et al. (2007), this kind of behaviour could reflect flattened affect, inhibition, or avoidance on the part of infants who may be stressed, and stressors related to having an affectively disordered mother. These stressors may include routine exposure to their mothers’ anxiety-related behaviour (Murray et al., 2007)” (Kaitz et al., 2010, p. 146). In addition, social desirability bias may have played a role in our study, as mothers were aware they were being watched and recorded playing with their infants during the online session, and thus may have restrained themselves from checking their cell phones despite their anxiety. Moreover, the *cell phone engagement protocol* may have been too brief to adequately capture behaviours related to mothers’ level of attachment-related anxiety with their cell phones. This may be especially true when considering that the researchers announced before each phase that the phase would last only a few minutes, potentially prompting anxious mothers to resist the urge to check their phone during this structured interaction. Finally, attachment-related anxiety scores for the mothers in this sample were generally low (scores were positively skewed and mostly between 1 to 2). Therefore, there may not have been enough variability in attachment anxiety scores to demonstrate the predicted relationship with infant stress behaviours or with synchrony.

Post-hoc analyses

Technoference during Phase 2 (Explicit Texting + Deception Texting)

No significant differences were found in the odds of observing any of the infant stress behaviours between infants of distracted versus non-distracted mothers in Phase 2. Nevertheless, the odds of observing all three stress behaviours were still markedly lower when mothers were not distracted by their mobile phones. In practice, such differences can produce substantial behavioural changes in infants when they are faced with the stressor of their caregivers being engaged with mobile technology in their presence.

There was no significant difference in synchrony levels between dyads with distracted mothers versus non-distracted mothers during Phase 2, and no significant differences in maternal sensitivity and attachment-related anxiety between these groups. These findings may be accounted for by several factors discussed above, including low power in these analyses, insufficient duration of technoference during the still-face phase, lack of variability in attachment anxiety scores, and mothers with higher attachment anxiety possibly compensating by behaving more sensitively.

Technoference during only Deception Texting

With respect to infant stress behaviours, no significant differences were found between the distracted and non-distracted groups of mothers during Deception Texting. However, as above for Phase 2, there were still decreases in some infant stress behaviours when mothers were not distracted, which aligns with the literature and provides further support for current findings that when mothers *are* distracted, their infants tend to display more stress. As above, there was no significant difference in synchrony or attachment-related anxiety between distracted versus non-distracted mothers during Deception Texting. This finding is in contrast to expectations, and may be explained by similar factors as above when Phase 2 was examined in full.

Explicit Texting only to represent Phase 2

When re-running the statistical analyses with only Explicit Texting data to represent Phase 2, all results were the same except those pertaining to Self-Comforting. Contrary to the initial belief that including Deception Texting could be skewing the results toward decreased stress behaviours, the opposite was found for Self-Comforting. The odds of observing these behaviours decreased when Deception Texting was *excluded*, so there was no longer a significant increase in the odds of observing Self-Comforting from the free-play to still-face phase (though there was still a 46% increase). This suggests that a certain level of Self-Comforting was occurring during the one minute of Deception Texting, which makes sense given that 16 dyads still underwent technoference during this time. Their infants may have demonstrated increased Self-Comforting during Deception Texting, and these occurrences of the behaviour were contributing to the statistically significant increase in Self-Comforting when the entirety of Phase 2 was included in analyses. Furthermore, maternal sensitivity no longer significantly predicted Self-Comforting behaviours. This may be because the removal of Deception Texting led to less Self-Comforting behaviours occurring in the second phase (as suggested above), and therefore the 71% increase in odds of Self-Comforting no longer reached statistical significance when maternal sensitivity increased by one unit. The reason that the exclusion of Deception Texting during Phase 2 only affected Self-Comforting behaviours may be because their odds had initially increased by a smaller amount (64%) when moving from Phase 1 to 2, compared to the odds of the other stress behaviours which had each increased by over 100%.

Considering that all other analyses led to a similar pattern of results whether or not Deception Texting was removed from Phase 2, it can be concluded that the presence of Deception Texting did not make a meaningful difference in the level and impact of technoference in Phase 2 with respect to Pulling Away, Negative Facial Expressions, synchrony or attachment anxiety. Moreover, its inclusion in Phase 2 was not found to result in decreased odds of observing stress behaviours or increased synchrony, as initially posited.

Biasing instructions before Reunion

It was determined that the biasing instructions given to 8 mothers (i.e., telling them that they could stop texting during Reunion instead of letting mothers choose to continue texting) only impacted the difference in the odds of observing Self-Comforting behaviours between still-face and reunion, which became significant. It is possible that these 8 mothers were prompted to continue playing with their infants during reunion, as the experimenter's instructions often suggested that they did not need to continue answering messages, and sometimes explicitly mentioned that the mother could just continue playing. This may have led to reduced Self-Comforting in their infants (as their mothers could be more attentive to them), possibly resulting in a greater difference in Self-Comforting between the still-face and reunion phases. However, the difference in odds between Phase 2 and 3 was minimal (only 2% greater) when these mothers were removed from the analyses. In line with the lack of changes observed in the other two stress behaviours, there was likely no meaningful bias produced by the instructions given to these 8 mothers. Moreover, the rest of the results in this study remained the same. Thus, it can be deduced that these 8 dyads appeared to follow the statistical trends that were observed in this study, and did not notably differ from how the rest of the dyads behaved.

Partial data

Mothers with partial data for behavioural categories and phases were found to have a significantly lower level of sensitivity than those with full data available. For approximately half of the mothers with partial data, the reason for the data loss was due the low quality of the video recordings. It is possible that the blurriness of these recorded interactions affected the coding of sensitivity, resulting in lower sensitivity scores for these mothers. In addition, three of the mothers in this group received responses from the experimenters which may have biased these mothers to focus on responding to text messages, thus decreasing their sensitivity toward their infants. For two mothers, data was lost due to their infant's fussiness, which may have made it more difficult for these mothers to be sensitive while managing other demands of the virtual session. Other reasons for data loss, such as joining the session by phone or the infants' face being out of view, may have been random and unrelated to sensitivity.

With respect to attachment-related anxiety, there was no meaningful difference between mothers with partial versus full coding data, suggesting that mothers' level of anxiety in close relationships had no meaningful relation to the reasons that led to the data loss (i.e., video quality, experimenter bias, joining the session by phone, infants being in view of the camera). Though mothers' anxiety may be related to infant temperament, only two infants were fussy in the group with partial data; moreover, their increased fussiness may have been due to the contrived nature of the experiment and not because it was a trait of these infants.

Implications for maternal mobile technology use

The current study aimed to contribute to the limited literature on the effects of maternal technology use on children's social developmental environment. Although the extent and duration of technoference in this study varied between mothers, and a portion of mothers may not have become sufficiently immersed with their mobile phones, there was still a significant increase in the odds of observing infant stress behaviours when mothers were engaged with mobile technology during the second phase (mirroring a "still-face" effect). Thus, for mothers who do undergo a relatively higher degree of technoference in the presence of their young children, it may be useful to consider implementation of early parenting interventions, and the development of regulations and/or policies, that support mothers' mindful use of digital media during infant care. Promoting careful use of smartphones by mothers may be important for encouraging children's developmental milestones (Nazarri et al., 2025). Though there are extant guidelines on children's use of screens and their impact (e.g., Kirkorian et al., 2025), and recommendations have been made to mitigate potential risks of screentime for young children (American Academy of Paediatrics, 2016), there is a paucity of such guidelines for mothers' use of screens in the presence of their young infants. Following current findings, such guidelines should help mothers become more aware of digital distractions during daily family interactions and the subsequent negative repercussions on their children. They can also support mothers in using screens in a way that is "limited, autonomous, skilled, and critically informed" (Morawska et al., 2023, p. 944), and in setting their own limits on media use, for example through the American Academy of Pediatrics' Family Media Use Plan (McDaniel & Radesky, 2018a).

To the best of my knowledge, there are no published interventions designed to support mothers in monitoring their mobile technology use while in the presence of their young infants, though there are multiple interventions aimed at reducing young children's screen time (e.g., Zhang et al., 2022). However, methods from existing attachment-based interventions (e.g., Attachment and Biobehavioral Catch-Up [ABC] [ABC Parenting Institute, 2017]; Circle of Security [Circle of Security International, 2025]) could be enhanced by providing illustrations pertaining to the potential effects of maternal mobile device use. Although sensitivity is partly stable over time (Isabella, 1993), it is also modifiable and influenced by external and environmental factors in important ways (Lindhiem et al., 2011; Nievar et al., 2010). Therefore, though it can be negatively impacted by extensive media use, it may also have the potential to improve through mindful use of technology and targeted parenting interventions. Indeed, factors (such as sensitivity) that facilitate infants' adaptive responses to stressors are essential for timely identification of targeted intervention approaches (Girod et al., 2024). For example, early interventions that promote mothers' sensitivity may reduce the stress experienced by their infants when mothers are distracted by mobile technology.

Interventions could consider an educational component aimed at decreasing smartphone use in mothers, and increasing parents' awareness of the consequences of screen use while parenting (Blachnio, 2024). Clinicians should "ask open-ended questions to understand how and why families use digital media" (Kirkorian et al., 2025, p. 18). Interventions could also target mothers' perceptions of problematic phone use, as these have been associated with enhanced motivation to change their phone-related behaviour. Clinicians could assist mothers with reflecting on their technology use, becoming aware of its repercussions, and supporting change in behaviour if needed. Care should be taken to prevent guilt, anxiety, or rumination about phone usage in parents (McDaniel et al., 2023). Similarly, parent psychological factors (e.g., stress, postpartum depression) should be taken into account when counselling mothers on their phone use. Finally, it is important to use consistent definitions and measures of problematic technology use patterns versus adaptive ones to facilitate comparison across both research (Kirkorian et al., 2025) and interventions.

Importantly, the content and context of smartphone use should also be considered (Kirkorian et al., 2025), as some may be beneficial for enhancing parental sensitivity, for example through the availability of support (Daneback & Plantin, 2008; Jang & Dworkin, 2014; Lupton, 2017). Indeed, communicating with close others can positively influence sensitivity (Wolfers et al., 2020). Although technology can be beneficial for parents, benefits should be weighed against the risks (Radesky et al., 2016), highlighting the complexity of technology use in caregiving contexts (Gutierrez & Ventura, 2021) and the need for professional support.

The development of interventions to address findings in this study would be timely considering a universal increase in caregivers' absorption in virtual reality following the COVID-19 pandemic. Educating parents about their phone use in the presence of their infants is critical as it can also impact their children's future screen use habits (Blachnio, 2024). The lack of current guidelines and policies underscores the need for a widespread discussion about the negative repercussions on infant development when mothers become absorbed by their mobile devices during infant care. Such a discussion could facilitate the development of targeted interventions and guidelines that support the mindful use of mobile technologies for mothers or mothers-to-be who are interested in creating optimal socioemotional contexts for their developing infants.

Limitations and Future Directions

This study was subject to several noteworthy limitations. It included a relatively small sample size (n = 108) that was further reduced for various analyses due to missing data (see **Tables 8** and **9**). In addition, the sample was predominantly European, highly educated (reporting a college/university degree or higher), and with high socioeconomic status (≥$100,000 in household income). Future research should recruit a more diverse sample to improve the generalizability of current findings and to elucidate cultural differences in smartphone use and parent-child relationships. Moreover, given differences in parenting styles across socioeconomic status and culture (Moore et al., 2016), a more heterogenous sample may reveal different findings than those reported here. For example, sensitive caregiving in emotionally challenging situations may be especially difficult for mothers facing socio-economic adversity (Taraban et al., 2024). Further, because the current study sample consisted only of mothers, future studies could include father-infant dyads, or those with a transgender caregiver, to determine how current findings may differ with a more gender-diverse sample. Indeed, fathers have been found to be more unpredictable than mothers (Feldman, 2007c), with infants contributing more to shaping dyadic interactions with their fathers than with their mothers (Moore et al., 2013).

Given that data collection for this study occurred during the COVID-19 pandemic, a *cell phone engagement protocol* was administered virtually, and suffered from technological limitations. The study relied on participants' laptop cameras to record the mother-infant interactions, which posed challenges with the quality of the videos and resulted in sub-optimal angles with which to view mothers and infants. Consequently, many "missing" codes had to be assigned during both stress and synchrony coding. Given the lack of significant findings for dyadic synchrony, eye gaze/head orientation in particular may have been affected by the poor video quality and angles. If this study is replicated, it would be ideal to collect data in person and with two cameras using a split-screen procedure, where one camera is directed at the infant and the other at the caregiver. This would enable more accurate and complete coding of caregiver and infant behaviours and may reveal different results. Having infants and their mothers seated across from a laptop (for the purpose of video recording) also proved to be quite distracting for many infants as it was a novel experience. Indeed, many mothers shared that their infants were less engaged in play than usual because of the presence of the screen. Another challenge stemmed from asking mothers to have their infants placed in a stationary infant seat during the session. Many mothers commented that their infants were not used to sitting in these seats and that they did not usually play with their infants in this way. Moreover, very young infants sometimes had difficulty remaining upright in their seat as their posture was unstable. At times they had to be placed on a flat surface to complete the session. In addition, researchers gave inconsistent instructions about whether or not to start each phase with infants in their infant seats (Appendix F). Although most infants started out in their seats, many expressed discomfort with the seating and some were eventually picked up by their mothers, who had the choice to take them out at any time. However, some mothers may have felt the need to keep them seated because of the researchers' instructions to keep infants in their seats whenever possible. Although freeing infants from their seats was more naturalistic and ecologically valid, allowing infants to move around the room appears to reduce the still-face effect (Myruski et al., 2018). This effect may also be dampened when children are permitted to engage with toys (Myruski et al., 2018) as in the current study. Allowing infants to freely roam in their homes also interfered significantly with behavioural coding in this study, as it was difficult for coders to evaluate infants' eye gaze/head orientation, as well as their facial expressions, while they were constantly on the move. To allow for more accurate comparison between cell phone engagement and the original Face-to-Face Still-Face, as well as more accurate coding of dyadic behaviours, future studies may want to add more environmental and procedural controls. A further limitation of the current protocol was that mothers were clearly aware that the researchers were watching them throughout the interaction, likely resulting in social biasing. This is especially probable as researchers interrupted the protocol several times to provide instructions or prompts for each phase, potentially making mothers more aware of their behaviours.

In terms of the study procedure, this experiment was highly naturalistic, which created several challenges. Firstly, to maintain their natural tendencies with their mobile phones, mothers were not asked to set their notifications on "loud". However, this likely led many mothers to not notice incoming messages from the researchers during the still-face phase, and may have reduced the maternal distraction expected in this phase. Secondly, because mothers were told that it was their choice to respond to text messages or not (in order to observe their "natural" response tendencies), this led to a variety of situations: ignoring the text messages (and their phone) entirely, glancing at their phone for a few seconds, reading a text message but not responding, and reading one or more text messages and responding verbally or by text. Thus, a portion of mothers may not have become sufficiently immersed with their mobile phones to detect the relationships between variables queried in this study. Indeed, the intensity and duration of technoference during the still-face episode of this study was unclear and likely varied. Technoference in this study was further confounded by the presence of two additional screens (laptops and Apple Watches) which were also occasionally sources of technological interruption (e.g., the messages were sometimes read on those screens, and/or the devices would prompt mothers to check their cell phones). Future studies using a smartphone-adapted Face-to-Face Still-Face could consider assessing the duration of technoference while it is occurring in caregiver-infant interactions, to gain a better understanding of how long caregivers are distracted in front of their infants. No known studies to date have reported on the duration of technoference, or noted a specific "cut-off time" for when it is considered to have occurred. Finally, the current experimental design resulted in many procedural violations, which are outlined in Appendix F. Future research could adopt a more controlled procedure to minimize the aforementioned concerns and to enable more direct comparisons between research studies.

In future studies with the Face-to-Face Still-Face, additional maternal and infant factors could be considered to further elucidate the current findings and to consider the potential for confounding bias. For example, mothers' reported smartphone use and habits could be analyzed. For example, Myruski et al (2018) found that mothers with a high level of daily mobile technology use had children who were more reserved and explored less during free-play and reunion, with the reunion phase also found to be less successful. These infants were also more likely to be distressed by maternal disengagement in the smartphone-adapted still-face experiment (Myruski et al., 2018; Stockdale et al., 2020). However, when infants were used to their parent's more habitual smartphone use, they were found to be less affected by the technological disruption (e.g., Ventura et al., 2019; Stockdale et al., 2020). Thus, future work could compare mothers who are highly versus moderately absorbed with their mobile phones with respect to their sensitivity toward their infants, their infants' stress, and their level of mother-infant synchrony. Future studies should also query the level of social support received by caregivers as this could have a significant effect on the latter's ability to be sensitive and synchronous with their infants during the postpartum year. Other confounding variables that were not examined in the current study were parity and marital status. Future research could consider the effect of having older siblings in the home on mothers' level of sensitivity and synchrony with their infant, and on attachment-related anxiety. Studies could also examine the effect of mothers' marital status (e.g., single, married, common-law, divorced) in relation to their sensitivity, synchrony, and attachment style.

In terms of infant factors, the current study did not take into account the quality and duration of infants' sleep prior to attending the Zoom sessions. It was observed by the researchers that several infants struggled to fully participate in the recorded interactions because they were sleepy, which consequently led to greater infant fussiness. Future studies should control for this by ensuring infants have slept adequately prior to the sessions, or by including infant sleep as a variable in the study analyses. It would also be interesting to examine individual variability in infant temperament, as it has been suggested that infants of sensitive mothers who are temperamentally more reactive show heightened distress and longer recovery from the still-face (Girod et al., 2024). Furthermore, infants rated by their caregivers to have higher negative affectivity showed decreased self-comforting during the still-face condition, possibly disrupting their ability to regulate and recover during Reunion (Braungart-Rieker et al., 1998; Mesman et al., 2009; Myruski et al., 2018). Future research could use a standardized questionnaire by which caregivers could report their child's emotional reactions to daily situations (Bozicevic, 2025). Another infant factor that could be of interest is infant attachment style. Using a longitudinal approach, future studies could build on prior research (e.g., Barbosa et al., 2020) to examine whether and how patterns of infant stress behaviours described in this study predict mother-infant attachment at 12 months. Infant age could also be examined as an influential factor by, for example, dividing the study sample into older and younger infants and examining how patterns of stress behaviours may vary by age (as in Stockdale et al., 2020). Infant age could further be considered in terms of attachment behaviours, which are known to change at approximately 6 months (Schaffer, 1966). Future studies could recruit a larger sample of infants in order to perform comparisons of pre- and post-6 months groups of infants regarding infant stress behaviours.

Infant behavioural stress patterns

Although current findings were in line with our hypotheses, it would be interesting for future studies to consider including additional infant stress behaviours to determine whether current results would be replicated, and whether new associations may be detected between infant stress and, respectively, dyadic synchrony and maternal attachment style. For example, self-clasp (e.g., Ginnell et al., 2022), rubbing of the face or holding the ear (Stockdale et al., 2020), gesturing to be picked up (Stockdale et al., 2020), negative vocalizations (Tronick et al., 1980), object exploration (Weinberg & Tronick, 1994), and attempts to touch their mothers (Fogel et al., 1982) could be examined. This would allow us to gain more breadth of understanding of infants' behavioural patterns when exposed to the stress of their mothers' absorption with a smartphone, and to thereby facilitate support for mothers who may be struggling with noticing their infants' stress cues and responding appropriately.

To more accurately assess how infants respond to stressors, technoference studies could consider the use of person-centered approaches (i.e., latent class and profile analysis) to study individual differences in still-face responding (Howard & Hoffman, 2018). This approach could also be valuable when studying dyadic synchrony and attachment-related anxiety during the Face-to-Face Still-Face. To further improve accuracy of findings, the reunion episode could be extended past the typical 2-minute duration to better evaluate the temporal pattern and scope of mothers' behaviours and infants' affective recovery (Green et al., 2025). Future studies may also consider a longitudinal approach to investigate the long-term effects of mobile technology use on infants' socioemotional development.

Dyadic behavioural synchrony

Researchers may consider coding different behaviours to capture synchrony in this context (e.g., Leclère et al., 2014), and using a method of measurement other than Pearson correlations. For example, using time-lagged sequential analysis (versus lag-0 correlations) would allow for the distinction between mother-led or infant-led synchrony (Northrup & Iverson, 2019; Somers et al., 2025), which could enhance our understanding of the bidirectional nature of synchrony and contingent responding (e.g., mothers' responsivity during infant-led synchrony). Whether interactions are parent- versus infant-led can have implications for developmental outcomes and infant attachment and can also inform targeted interventions to support caregivers in their interactions with their infants. In addition, examining other channels of communication may impact observed patterns of synchrony. Indeed, Beebe et al. 2010 found that the different communication modalities assessed at 4 months each had distinct contributions on contingent coordination. For example, the current study did not consider maternal touch, which is a key modality that is frequently neglected in face-to-face studies (Stepakoff & Beebe, 2023) and may have been easier to visualize given the video quality limitations in this study.

When examining the relationship between synchrony and maternal sensitivity, the current analyses considered all synchrony observations across phases, as the purpose was to determine whether there was a relationship, in general, between sensitivity and synchrony in a smartphone-induced still-face context. However, the experimental design could have been used to its fullest by examining the interaction effect of sensitivity and synchrony by phase (for example, determining whether there would be less change in behavioural synchrony from free-play to still-face phases in more sensitive mothers). Alternatively, the relationship between sensitivity and synchrony could be examined during only the still-face phase: if there is no significant change in synchrony as sensitivity increases and both high and low sensitive mothers look the same, it could mean that mobile device use makes more sensitive mothers appear less sensitive.

Maternal attachment style

Use of the Experiences in Close Relationships-Revised scale to measure attachment-related anxiety is not without limitations. Given that it is a self-report measure, the mothers' current state of mind regarding attachment may have affected how they rated their experiences. The questionnaire is also at risk of inaccuracy due to recall bias and participant bias in using rating scales (Parent et al., 2023). With respect to the analyses conducted with attachment style, the experimental design could have been used to its fullest by investigating the interaction effect of attachment style and synchrony, and of attachment style and stress, across phase. A number of confounding variables could also be considered in these analyses in future studies. For example, caregivers' own childhood history, parenting style, level of self-esteem, partner conflict, and emotion regulation, could impact their attachment-related anxiety and the level of synchrony with their infants. In turn, infant's age and temperament (as mentioned above) could also interact with caregivers' attachment-anxiety and synchrony behaviours, and with infants' own stress and synchrony behaviours. Given that most mothers in this study had relatively low attachment-related anxiety, recruiting a larger, more diverse or at-risk sample could increase variability of scores and produce different results from those found in this study. Furthermore, it would be interesting to also examine avoidant attachment style to determine how this may affect mother-infant interactions during technoference.

Post-hoc analyses

Given the low power of the post-hoc analyses (due to a very small sample being compared to a large sample), future studies could compare an equal number of distracted versus non-distracted mothers during Phase 2 of the *cell phone engagement protocol*. Further, the Deception Texting versus Explicit Texting phases could be more fairly compared by coding the same duration of time for each phase (i.e., 2.5 minutes each) versus only one minute for Deception Texting as in the current study. Though inclusion of Deception Texting was deemed as not problematic and allowed for the observation of natural maternal distraction, more analyses could be conducted pertaining to this phase (e.g., how do mothers' reactions to incoming texts relate to their reported level of technology use; to what extent did they become immersed with the texts).

Conclusion

With the increasing prevalence of smartphones in the modern digital era (Pew Research Centre, 2024), the quality of mother-infant interactions is at risk. When "technoference" through smartphones interrupts mother-infant interactions and divides a mother's attention, infants are known to respond with stress. This dissertation aimed to support these findings through examining patterns of infant stress behaviours and mother-infant behavioural synchrony, respectively, across a modified, smartphone-adapted still-face protocol. The role played by maternal sensitivity and mothers' attachment anxiety in each of these behavioural patterns was also examined. When mothers became engaged with their mobile phones in the presence of their infants, the odds of observing infant stress behaviours were found to be significantly greater, and more sensitive mothers were shown to support infants' regulation of stress. These findings add to our current understanding of young infants' stress regulation and the importance of maternal sensitivity in divided attention contexts. These results also point to a need for the development of guidelines, social policies, and targeted interventions aimed at informing caregivers and caregivers-to-be about appropriate technology use while in the presence of their young children. These recommendations are especially timely and critical in our modern digital era that continues to see a rise in technology use among families.

No meaningful change was observed, in this study, in dyadic synchrony during maternal cell phone engagement, with no significant associations found between maternal sensitivity and dyadic synchrony, attachment anxiety and synchrony, or attachment anxiety and infant stress behaviours. These findings call into question the highly naturalistic procedure, virtual collection of data, the duration of technoference, the way synchrony was measured and defined, the distribution of synchrony and anxiety scores in this sample. Future studies should aim to generate more valid and generalizable results by administering the modified Face-to-Face Still-Face in-person with two cameras, recruiting a more diverse sample, ensuring longer technoference, and using more accurate measures of dyadic synchrony. Studies that replicate and extend the current work are important for enhancing our understanding of current issues relating to family wellness in an era of ever-present technology.

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Appendix A: Recruitment Flyer

Appendix B: Informed Consent Form

INFORMED CONSENT FORM

Date:	December 2021
Study Name:	An investigation of caregiver sensitivity across diverse caregiving contexts
Principal Investigator:	Dr. Yvonne Bohr, C.Psych.
Co-Investigators:	Mariami Bimm, Marette Abdelmaseh
Research Assistants:	Jenna Barnhardt, Khadija Bint Misbah, Alaina Thomas, Sierra DiMarco, Sabrina Da Silva, Fernanda De La Mora, Nichaela Garvey
Sponsor:	LaMarsh Centre for Child and Youth Research, York University 4700 Keele Street, Toronto ON M3J 1P3

PURPOSE OF THE RESEARCH: The purpose of our research project is to learn more about caregiver-child relationships in diverse contexts (the term "caregiver", as used throughout this protocol, will refer to a parent or guardian of children). We are particularly interested in understanding the ways in which risk and protective factors relate to infant stress, synchrony between caregiver and infant behaviours, parenting style, attention, early experiences, and child development.

WHAT WILL YOU BE ASKED TO DO: If you agree to participate in this study, you will be asked to complete a series of questionnaires about your demographics, your relationships, your early childhood experiences, and your emotions. These questionnaires should take between 30-45 minutes and will be completed through Qualtrics, a secure data collection platform[1]. Once you have completed the questionnaires, you will be contacted to schedule a virtual meeting with one or two members of the research team through Zoom for Healthcare[1] (a secure, PHIPA compliant 3rd party platform). During this virtual meeting, you and your infant will be asked to complete a series of activities in view of your computer's web camera. You will first be asked to play/interact normally with your child for 4 minutes without toys. You will then be asked to play with a preferred toy with your infant for one minute, and then withhold that toy from your infant for another minute. Next, you will be asked to continue to interact with your child as you typically would at home (with or without toys) for another 6 minutes. In the following phase, you will be asked to interact with your infant while keeping your phone nearby (for the first 2.5 minutes, your phone should be face-down with alerts set at maximum volume; for the last 2.5 minutes, your phone should be face-up). You will then be asked to again play with your infant as you typically would at home, for up to 2 minutes. These interactions with your child will be videorecorded through Zoom for Healthcare and should take between 20 – 25 minutes altogether. Following these interactions, you will be asked two additional questions about mobile technology. Finally, you will complete a "word task" on your own time (15 – 20 minutes), where you will be asked to identify the colour of different words shown on a screen using a platform called Gorilla[1]. In total, participation in this study will require approximately 1- 1.5 hours of your time.

RISKS AND DISCOMFORTS: Some of the items of the questionnaires may feel difficult or upsetting. For example, some questions will relate to painful early childhood experiences. If any items are difficult for you to answer, you may skip them. The research team will be available to help you if you feel uncomfortable or start to feel upset while answering these questionnaires. The tasks you complete with your infant are designed to help us understand your relationship, but some of them may be difficult or uncomfortable to complete (e.g. withholding a toy). If at any point these tasks become too difficult for you or your infant, you may discontinue the task and provide comfort to your infant. If you feel discomfort during or after participating in this project, the research team will be available to answer any questions you may have. In addition, we can connect you with online and community resources that may be helpful to you (please click here to access a compiled list of resources). You can also stop participating in the study at any point because participation is voluntary.

BENEFITS OF THE RESEARCH AND BENEFITS TO YOU: This study will contribute to the current knowledge base about child development and may help us better understand how to modify existing services for caregivers and their children. As a token of appreciation for your time, you will be paid $20 for your time and your name will be entered into a raffle to win a prize (e.g. 1 of 4 prizes such as a developmentally appropriate play kits, Montessori toy, or spa gift card valued at approximately $150-200CAD).
You will also be offered various psychoeducational resources as desired, such as manuals about parenting and child development, and/or a parenting seminar led by our research team that will include a Q & A session.

VOLUNTARY PARTICIPATION: Your participation in the study is completely voluntary and you may choose to stop participating at any time with no consequence whatsoever. You are not required to agree to participate in this study. If you do not agree to take part in the study, this will have no impact on your participation in any of the programs offered by the agency you were recruited from (if applicable). Furthermore, your decision not to participate in the study will have no influence on the nature of your relationship with York University or the agency you were recruited from (if applicable), either now, or in the future. If you do agree to take part in the study, then you will be free to request that any specific question or information you provide be removed from our research.

WITHDRAWAL FROM THE STUDY: You have the right not to answer any particular questions, if you so decide. You can also stop participating in the study at any time, for any reason, if you so decide. Participants are eligible to receive the compensation offered even if they withdraw from the study without completion of the assessment activities and questionnaires. Your decision to stop participating or to refuse to answer particular questions, will not affect your relationship with agency you were recruited from (if applicable), the researchers, York University, or any other group associated with this project. In the event that you decide to withdraw from the study, all data generated as a consequence of your participation shall be immediately destroyed.

CONFIDENTIALITY: All information you supply during the research will be held in confidence, except in cases where the research team suspects that you or your child may be in imminent danger (e.g. suspected child abuse), in which case we are bound by law to contact the appropriate authorities. If you have any questions about limits to confidentiality, please contact us.

Unless you specifically indicate your consent, your name will not appear in any report or publication of the research. Data will not be shared with anyone, and confidentiality will be provided to the fullest extent possible by law. Data will be collected and analyzed from questionnaires, the "word task", and videotaped sessions. Only the principal investigator, co-investigators, and research assistants will have access to this information. Questionnaires will be completed using Qualtrics[1] and the "word task" will be completed using Gorilla[1]. These are both secure 3rd party platforms, and the data you provide through them will only be linked your participant ID number. Zoom for Healthcare[1] will be used to collect video data. This platform has security safeguards and advanced settings to protect against sessions being eavesdropped on or tampered with, but there is always risk for virtual platforms to be hacked or compromised. Recordings of online sessions will be saved in a password protected file on encrypted USB drives, not the cloud-based service. Videos may then be uploaded to secure servers (i.e. OneDrive) with the correct safeguards in place.
Once videos have been analyzed, all resulting data will only be linked to participant ID numbers. The videos will be retained for five years following data collection, and will be destroyed immediately afterward, unless you provide permission to have your data used for additional studies. The information collected in this study will be presented in the form of doctoral research and/or scientific publication(s). These will describe the results of the study, implications, and recommendations for future researchers and clinicians involved in work with caregivers and their children.

QUESTIONS ABOUT THE RESEARCH? If you have questions about the research in general or about your role in the study, please feel free to contact Dr. Bohr at 416-736-2100 ext. 40561, bohry@yorku.ca, at the LaMarsh Centre for Child and Youth Research. This research has been reviewed and approved by the Human Participants Review Sub-Committee, York University's Ethics Review Board and conforms to the standards of the Canadian Tri-Council Research Ethics guidelines. If you have any ethical concerns, questions about this process, or about your rights as a participant in the study, please contact either the Graduate Psychology Program office (telephone 416-736-5115 ext. 66225) or the Senior Manager and Policy Advisor for the Office of Research Ethics, 5th Floor, York Research Tower, York University (telephone 416-736-5914 or e-mail ore@yorku.ca).

1. This study will use Zoom for Healthcare to conduct virtual sessions and Qualtrics/Gorilla to collect survey data. These are all externally hosted cloud-based services. When information is transmitted over the internet, privacy cannot be guaranteed. There is always a risk your responses may be intercepted by a third party (e.g., government agencies, hackers). Furthermore, while York University researchers will not collect or use IP addresses or other information which could link your participant ID to your computer or electronic devices without informing you, there is a small risk with any platform that data collected on external servers may fall outside the control of the research team. Please contact Yvonne Bohr (bohry@yorku.ca) for further information.
Video recordings will be saved onto an encrypted and password protected USB key, not the cloud-based services. Please note that it is the expectation that participants agree not to make any unauthorized recordings of the content of a meeting / data collection session.

Legal Rights and Signatures:

I___________________________________, consent to participate in the research study "An investigation of caregiver sensitivity across diverse caregiving contexts" conducted by the Infant Mental Health Lab of the LaMarsh Centre for Child and Youth Research at York University. I have understood the nature of this project and wish to participate. I am not waiving any of my legal rights by signing this form. My signature below indicates my consent.

Signature____ **Date**_____________________

(Participant)

Signature____ **Date**_____________________

(Principal Investigator)

Substitute Consent for your Infant

I_____________________________________, consent to for my infant to participate in the research study "An investigation of caregiver sensitivity across diverse caregiving contexts" conducted by the Infant and Child Mental Health Lab (in association with the LaMarsh Centre for Child and Youth Research) at York University. I have understood the nature of this project and wish for my infant to participate. I am not waiving any of my infant's legal rights by signing this form. My signature below indicates my substitute consent for my infant.

Signature____ **Date**_____________________

(Participant)

Signature____ **Date**_____________________

(Principal Investigator)

Audio/Videotape Consent

☐ I ___________________________________, give my consent to be videotaped in an interaction with my child that is no more than 25 minutes in length. I understand that the purpose of the video is strictly for research, to be coded by the research team, and then destroyed 5 years after data collection has ended. My questions have been answered to my satisfaction and I agree to participate in this study. I understand that I can stop taping at any time.

☐ I ___________________________________, give my consent for the viewing of the videotaped tasks for the purpose of (please check to indicate consent): ☐ training and/or ☐ conference presentations.

Signature ____ **Date** ______________
______
(Participant)

Re-Contact for Future Research Consent

Please check the appropriate box below and print your name:

I _____________________________________, give my consent to be contacted in the future for the purpose of (please check to indicate consent): ☐ follow-up to this study and/or ☐ future research studies conducted by the Infant Mental Health Lab of the LaMarsh Centre for Child and Youth Research at York University.

Appendix C: Demographics Questionnaire

Predicting Resilience in Different Caregiving Contexts

DEMOGRAPHICS

In what year were you born? _______________________ Current age? ___________________________

Age of first pregnancy? ___________________________ Child's age? ___________________________

Number of adults in household? __________________ Number of children in household? ____________

Total Annual Household Income? ____

Highest level of education completed? (1) Some High School ______ (2) High School ______

(3) Some College / University ______ (4) College / University ______ (5) Graduate ______ (6) Other ______

Country of birth? ____________________ Years resided in Canada (if not birthplace) ________

Your ethnicity:

- ☐ Aboriginal
- ☐ African
- ☐ South Asian
- ☐ European
- ☐ East Asian/Pacific Islander
- ☐ Middle Eastern
- ☐ Caribbean
- ☐ Latin, Central & South American
- ☐ Other (please specify): _____________________________________

Your partner's ethnicity (if applicable):

- ☐ Aboriginal
- ☐ African
- ☐ South Asian
- ☐ European
- ☐ East Asian/Pacific Islander
- ☐ Middle Eastern
- ☐ Caribbean
- ☐ Latin, Central & South American
- ☐ Other (please specify): _____________________________________

Generational status? By "generational status" I mean, are you the first, second, third, etc. generation of your family to live in this country? ____

Caregiver's parents' country of birth (and province/region) and first language?
____

FAMILY STABILITY

1. What is your marital status?
   (1) Single ______ (2) Married ______ (3) Common Law ______ (4) Separated/Divorced ______

   (5) In a relationship but not living together ______
   (#months in relationship ______ / parent of participant's child: YES ______ NO ______

2. How many residences have you lived in over the last 5 years (i.e. since January 2003)? ________

3. What is your employment status?
   (1) F/T ______ (2) P/T ______ (3) Unemployed (*provide reason)* __________________________
   (4) Length of current employment ___________ (months)

   What is the employment status of other adults living in your household?
   (1) Role of person in household _________________
   (2) F/T ______ (3) P/T ______ (4) Length of current employment ____________ (months)
   (5) Unemployed (*provide reason)* _________________________

4. How easy or comfortable is it for you and your family to live on your current family income?

   (1) Not at all ______ (2) Somewhat ______ (3) Moderately ______ (4) Very ______

CHILD DEVELOPMENTAL HISTORY

1. Is this your biological child? ____
If NO; at what age did the child come under your care? ______________________________

2.) Has your child had any of the following developmental concerns:
☐ Auditory/Visual: ____

☐ Language: ____

☐ Motor: ____

☐ Cognitive: ____

☐ Social/emotional: ____

Appendix D: Zoom Infographic Sent to Caregivers

Appendix E: Text Messages Sent to Caregivers

Text Messages Sent to Caregivers:

List 5 words that you would use to describe your child.

How many text messages did you receive from your friends or family since we signed on for this session today?

Complete the statement: I use my phone mostly to ___________.

When do you usually reply to a text message after you receive it?
- a) Immediately
- b) Within 5 minutes
- c) Within an hour
- d) Within several hours
- e) After a day or more

What is your level of comfort right now?
- a) Very Comfortable
- b) Comfortable
- c) Somewhat Comfortable
- d) Uncomfortable
- e) Extremely Uncomfortable

How much time do you usually spend on interacting with your child alone everyday?
- a) Less than 1 hour
- b) 1-3 hours
- c) 3-6 hours
- d) More than 6 hours

What is your child's favourite activity currently?

What activities do you and your child enjoy doing together?

What do you most often use your phone for?

How often do you keep your phone next to you?
- a) Throughout the whole day and night
- b) All day
- c) Some of the day
- d) Very rarely
- e) Never

Appendix F: Procedural Violations

Note: If an infant was not in their seat while instructions were being given, the researchers sometimes asked mothers to start with their infant in the infant seat. At other times, the researcher mentioned (unprompted) that it would be fine to leave the infant out of the chair (when infants were already seated elsewhere). Similarly, if mothers asked whether their infant could be taken out of their seat, researchers sometimes allowed them to take the infant out right away, but at other times mentioned that it would be ideal to have the infant start in the seat. These are inconsistencies in the instructions as clear rules were lacking for these situations.

Note: The researchers intervened if infants were extremely fussy for approximately 20s and suggested mothers soothe them (if mothers had not already done this).

Note: Earlier videos used a previous version of the protocol which included the line "if any of the questions are unclear to you, send us a reply with the word *question*".

Participant ID	**Procedural Violations**
001 and 003	Used the oldest version of our protocol, which included longer free-play before the *cell phone engagement protocol* began. This version also introduced the Deception Texting (DT) phase by stating "Just continuing to keep your cell phone next to you, you can continue interacting however you'd like for another 2.5 minutes". **For 001:** Before DT, the mother was instructed "have your cell phone right next to you, but face-down, and set your alerts to max volume"; before Explicit Texting (ET), the mother was instructed "have your phone now so that it's face-up, and we'll send some questions to your phone through text message, and it's up to you whether to respond." The mother's phone did not make audible sounds, so she switched to using her husband's cell phone starting from the ET phase. As this was inconsistent with the protocol used for other participants, only the free-play phase and reunion phase were coded. Infant's lower body was not visible for this dyad given their set-up.
001, 003	The protocol included instructions before ET that stated "Feel free to stop anytime if you're uncomfortable. If a question is unclear to you or you don't know how to answer it, you can reply with the word "question" and we'll go back to it later. Please check your phone now".
005	One of the researchers continued texting during the Reunion Phase (which was not part of the protocol), but the mother didn't notice.
006	Before Phase 1, the mother asked if infant has to stay in his chair. The researchers responded that he could start in it, and then it was up to the mother to decide.

008	The mother did not have her phone next to her initially, but was asked to get it after the first 3 minutes of free play. Before Reunion, the mother asked if she should keep the infant in the chair. The researchers responded that she could start, but if she wanted to take him out after she could do that.
010	Before Reunion, the mother asked "Can I take her [infant] out so she's standing on my knees?" The researchers responded that she could if she wanted to.
011	The mother asked before starting Reunion if the researcher would like her to finish answering the text messages. The researcher responded "no, not for this part…I mean, it's up to you actually what you'd like to do, but it's not required". Before ET and Reunion, the infant was already in mother's lap, and we did not intervene to ask her to start the infant in a seat.
009	One of the researchers did not send a text right at the 10-second delay mark during ET (instead waited and sent it later because the participant was still texting at that point). The mother commented that her infant tends to move around a lot and does not enjoy sitting. The mother felt that we would not get the full picture of infant interacting with his toys as he does not tend to sit and play with them very much (he usually moves around with his toys). She noted that the infant is usually in a high chair for only eating. She felt that he would interact differently if she used his more active toys. The researcher encouraged her to grab the ones she would usually use in a sitting context, which she did.
012	The infant completed the session lying down as they did not want to stay in the seat. Before Reunion, the mother asked if she could pick up her infant or had to leave her down. The researcher said to leave her down to start, and then pick her up if she would like to.
016	The mother joined the session on her cell phone, but the researchers still proceeded with the session. However, video was lost during the ET phase as the mother used her cell phone to answer texts. The mother asked before Reunion when we wanted her to finish answering the texts. The researcher responded "we can get back to that later, don't worry about it".
018	At the start of the Reunion phase, the mother asked whether we wanted her to finish the last question. The researcher said "sure you can finish that up and then keep going". However, the mother only texted for 2 seconds from when the timing of the phase began.
020	Before Phase 1, the mother asked if her infant should be kept in the high chair (which she was currently in). The researcher said we could ideally start out that way and then it would be up to the mother.
021	Poor audio quality. The mother interacted with the infant mostly in French (generally understood by one of the coders).

	After the instructions were given, the mother asked "Do I not even need to answer while I'm playing with him you mean?" The researcher said "we'll be sending the messages, and it's up to you to respond or not." The mother could not hear this repeated instruction and asked for it to be repeated again, so the researcher said "you can choose to respond while interacting with baby or you can choose to wait it out."
022	Before Phase 1, the mother asked "Should I keep him there [in the seat]"? The researcher responded "Yeah, we'd like to start with baby there, but then it's up to you".
024	The infant was born prematurely. The mother struggled with the experimental set-up – she laid on her stomach at some points and frequently removed the infant from the infant seat (both were on the floor). The mother appeared tense and the infant was very fussy. Before Phase 1, the infant was standing on the floor in front of the mother, so the researcher asked if infant could be put in the seat to start. The mother took a long break between DT and ET (approximately 9 minutes). One of the researchers missed sending a text during ET (but the mother was not looking at her phone at all).
026	The infant began crying intensely at the start of the texting protocol. The mother mentioned that her infant was teething. The researcher suggested taking the infant out 25 seconds into DT in order to give the infant a break from the seat. DT was continued after the break, with a reminder to the mother to “just keep playing with toys or without toys, whatever, you can just keep playing as you normally would”. Multiple breaks had to be taken. The infant was not able to stay in the seat so we continued with him in the mother’s lap. An older sibling came into the frame several times. After ET instructions were given, while holding her infant, the mother asked "And I can hold him?" The researcher said "yeah you can hold him, and you can respond if you want to and you don't have to respond if you don't want to."
027	Before ET, the mother took the infant out of the chair so she could hear the instructions better (the infant was making noise). The researchers did not ask her to put them back in the seat. The mother held the infant throughout the 2.5 mins of ET. Before Reunion, the mother said “there’s another text that I haven’t finished”. The researcher responded “Oh that’s okay. You can continue if you want, or you can continue playing now, it’s up to you.” The mother finished texting within a few seconds, and then completed the 2 minutes of Reunion.
028	The infant was propped against a pillow for the session. At times, the mother picked him up to readjust him or laid him down. He was still visible the entire time. A few seconds into the ET phase, the mother asked “I just answer them by text I guess?” to which the researcher replied “yup”. The mother asked before Reunion “can I forget about the questions

	on my phone I didn't answer?" The Researcher said "yeah, you can move on now, yeah. No problem".
029	The mother asked before ET, "Answer it to you here or answer it by text?" The researcher said "We're going to be sending texts to your cell phone, and then you would answer on the phone if you want to." (The mother then did answer texts by phone).
030	At one point during the ET phase, the mother asked "Do you want me to answer all these texts right now?" The researcher responded "it is entirely up to you." (The mother then chose to not answer any at all).
038	An older sibling was around during the session and sometimes interrupted. The mother started answering the first text verbally during DT, so one of the researchers intervened to state that she could send her response back as a text if desired ("it's up to you"). The mother then chose to do that. The mother mentioned that text messages were popping up on her laptop, and her smartwatch would also vibrate each time a text was received. The mother later informed the researcher that her family had been recovering from COVID at the time of the session.
039	The mother chose to continue using her cell phone during the Reunion phase.
040	The mother completed the session on their iPhone (tried to use an iPad instead, but it was so delayed that communication was not possible on it). During the ET phase, the mother chose to answer texts on her phone so she had to leave the Zoom app. The mother's phone also fell from its position a few times and siblings entered and left the room several times throughout the session and communicated with the mother.
041	One of the researchers lost Internet connection around the time that DT started. The first "deception text" was thus sent approximately 30 seconds late (free play was extended to approximately 3.5 minutes total).
042	Before Reunion, the mother said "I can't answer [the texts]". The researcher said "that's okay, we're just wrapping up now, so you can play for another 2 minutes".
044	During Reunion, the mother placed the 3-month-old infant down for "tummy time" and his face was not visible. Head orientation was coded but the infant's neck strength may have affected the way they oriented their head.
047	The mother asked at the start of the ET phase, "So you're sending questions to my phone but I don't have to answer them?" The researcher responded "It's up to you. We're just letting you know that we're going to be sending them to your cell phone, and then you can feel free to respond or not respond. You can decide whatever you'd like". The mother then asked whether her responses to those text questions would be needed later; the researcher said, "No. If you do decide to answer that's great, but we don't need them later. So we're just leaving that up to you". The mother ultimately decided not to respond at all. One of the researchers was a bit delayed in sending the 3rd text in this phase; however, the

	mother was not looking at her phone and later said she had not heard or seen the notifications coming in.
049	During DT the mother asked, "Should I be responding to these messages?" but the researcher did not respond. Before starting ET, the researcher asked the mother if she wanted a break because the infant was crying a lot. The mother asked if she could just keep the infant in her lap instead (which she decided to do for the rest of the session). The researcher responded that "we prefer to start in the chair but if you feel like he'd be better like this then that's okay. For this part, if you want to start in the chair so that if you respond to the messages you're able to, that's okay too". The mother said she could respond to messages holding him. Before Reunion, the mother said "I didn't get to many of the messages." The researcher said "That's okay, don't worry about it, you can just continue playing now".
052	The mother decided to take the infant out of chair and he moved around a lot. The infant's face was often not visible. He appeared very tired during the ET phase and often laid against the mother's chest. The mother also commented that the infant was so tired during the Reunion phase.
053	During DT, the mother asked "Am I supposed to answer these I guess?" after she had received the first two anonymous texts. The researchers did not respond at this time. Before starting the ET phase, the mother asked if she should be responding to the messages now while she was with her infant – she was told that it was optional. She stopped responding for a while, but then continued.
058	During Reunion, the researcher voluntarily added "For this part, try to keep her in the chair, but if you feel like she's really not comfortable, you can pick her up and soothe her." After the session, the mother noted that although her phone was on "loud", it did not actually ring when messages came in. She suspected this might have been because they were coming through her laptop (a MacBook) instead.
062	When asked to keep her phone next to her for the interaction, the mother set her phone to "silent" (but later mentioned that she usually has it on "loud"). Near the end of the interaction, the mother took the infant out of the chair as he was becoming distressed. During debriefing, the mother mentioned that they never actually play in the chair which may be why he got quite fussy.
067	The mother noted a "milestone delay" for the infant in the areas of rolling and crawling (not formally noted by a doctor). The infant was also underweight at birth. Before Reunion, the mother asked if she could reply back to us now that the previous phase was done. The researchers asked her to send what she had already typed up and then we could move on. The researchers

	prompted her again to "just hit send" before starting Reunion. However, it appeared that the mother believed she had to continue finishing her responses to the texts that had been sent. Therefore, the researchers mentioned again "You don't have to worry about finishing those now. Don't worry." However, the mother continued texting for another 25 seconds approximately.
070	The mother had another child around during the session, who the researcher suggested be kept occupied with a show. Before the free-play phase, the mother said "5 minutes? I don't think I really have the time ever to sit and just play with him for 5 minutes." The researcher said "it can be with toys or without, even if it's not the exact same in real life, that's just what we ask in this part". The mother asked after receiving the second text during DT whether the texts had come from the researchers. They admitted "yeah, you can feel free to answer or not answer". The mother then started answering those texts verbally. Before the ET phase, the mother asked "So keep him occupied but also reply to text messages?" The researcher said "just whatever you feel like doing…you can text back or not". The mother asked "do I still have to continue playing with him?" The researcher responded "that's up to you…you can feel free to do whatever you'd like". The mother ended up answering all the texts. When her infant started crying intensely during the ET phase, the mother showed him a video on her phone to soothe him.
071	The infant was born prematurely (36 weeks, 5 days). When ET instructions were given, the mother asked "So I need to play with him *and* reply to the messages?" The researchers said it is up to her, and she replied "Ok I won't answer. I'm a good mom". She received all the texts during this phase on her Apple Watch, and would read them out loud but respond verbally.
073	The infant had not slept well the night before, so she was particularly tired. The mother first noticed texts coming in through her smartwatch which vibrated, and that prompted her to look at her phone during the DT phase. Before the ET phase, the mother asked "Am I supposed to be responding to these things?" The researcher said "it's up to you". The mother then said "oh! It was supposed to be during this?" The researcher responded "yeah it's up to you, if you want to respond and when."
075	During DT, the mother asked if the researchers wanted her to answer by talking or through text. The researcher responded "it's up to you what you'd like to do". The mother decided to respond verbally. She asked again at the start of ET if the researchers had a preference for vocal or text responses. One of the researchers responded "It's up to you, but if you'd like to text back you can do that."
076	The mother struggled with the set-up and appeared to have limited space. The researcher re-started the first free-play after 10 seconds in order to fix the set up.

080	The mother asked during ET if the researchers wanted her to look at her phone. She was told that it was entirely up to her.
082	The infant got quite upset during ET. Before Reunion started, the researcher told the mother that she could pick up her infant to soothe her because she was still very upset. Therefore, the mother placed her infant in her lap throughout Reunion. The mother held the infant against her shoulder so the infant's face was not visible.
086	The set-up was not ideal due to spacing in this mother’s home. For the first play phase, the mother’s face periodically went off-screen. After this phase, the researcher asked the mother to readjust her screen, but the mother was still somewhat turned away.
087	The mother picked up her phone after the first "deception" text was sent and asked if she needed to respond. The researchers did not answer. She asked once more, but did not respond to the text. The mother also asked if she had to respond during ET, and was told it was up to her. She held her phone throughout but did not respond to any messages.
088	The researcher’s timer malfunctioned during ET and Reunion phases - ET was 7s too long and Reunion was approximately 35 seconds too long. Before ET, the mother asked “should I just reply in the order that they were texted?”. The researcher responded, “yeah you can do that”.
089	After instructions were given for ET, the mother said "I'll turn on my ringer". She later clarified that her phone had not made sounds out loud despite that, but she would just look at it and see the texts that were being sent by the researchers. The infant was wearing overalls that sometimes covered his mouth.
090	The mother initially logged on using her phone and had difficulty getting her laptop to work (took approximately 20 minutes). During this time, the infant was lying alone, and got a bit fussy over time. The mother also noted that the infant had not managed to nap before the session and was a bit tired. At the end of ET, the mother shared that the text messages from the researchers had not been delivered to her phone.
094	The mother asked if she should keep playing with her infant during ET. The researcher responded “yes, if you’d like, you can just continue like usual”.
098	The infant was extremely active and could not remain seated in their seat. During DT, the mother took the infant out of the seat to play so the infant was not visible at times. After a break, the infant did not settle down and was crawling around the room. The mother did not want to put her infant back in her chair.
099	The infant was physically very small and struggled in the seat during the session (was leaning over, had difficulty supporting their head).
102	The infant was extremely fussy and the protocol had to be restarted more than once until she was comfortable in a certain position. Starting from ET, the infant would not settle at all, so the protocol was not closely

	followed from that point onward – the researcher allowed the mother to focus on holding and soothing the baby.
103	The mother asked before ET "Oh was I supposed to *text* the responses back?" (as she had replied verbally). The researcher said "it's up to you". The mother shared, "I don't usually do screens when I'm with him…I prefer saying them out loud". The researcher said, "Yeah, so it's up to you if you'd even like to respond through text or not."
105	A power outage occurred during the video session, which caused the mother to leave the session while in the midst of DT (the mother later noted that she had not seen or heard text messages due to the settings in her phone). When the mother returned to the session, she asked whether she should turn her phone on loud – the researcher said the mother could put her phone to its original settings before the power outage had occurred. Before Reunion, the mother asked "So do I need to respond to this or no?" The researcher replied, "No, I mean it's up to you".
106	The mother had misread the first text message as "Use 5 words to describe your child*hood*".
107	During DT, the mother noticed a message coming in on her smartwatch and asked "Do I say them out loud?" The researcher did not respond. The mother continued noticing texts on her watch but then used her phone to type some responses, though she never sent any.
113	During DT, the mother asked a question about what to do, but before receiving a response from the researchers, she started responding verbally. During ET, the mother chose to respond by text. At the start of Reunion, she asked, "Am I supposed to text back now?" The researcher responded, "It's entirely up to you". The mother decided to finish responding to the earlier texts during Reunion.
115	During DT, the mother asked, "Should I answer these out loud?" but then proceeded to text using her phone. One of the researchers then messaged the other researcher to inform her that the mother's text response had said, "Should I answer these out loud?" Therefore, one of the researchers responded, "It's up to you."
119	The mother got through answering all texts before the ET time was up (but only 22 seconds remained during this phase after the last text had been answered).
127	The mother decided to phone in her audio, which did not interfere with texting. However, during ET, the mother misunderstood when the researcher suggested she could "exit the phone app" and put her phone on the "normal setting", and instead muted herself. Therefore, there was no audio for ET. The researcher later clarified that she had meant that the mother could go into the "messages" app on her phone for ET. The mother also expressed confusion about whether she could have used other toys versus one toy, so ended up playing with only one toy in all phases before Reunion.
129	Audio was weak at times but can generally hear the mother and infant.

134	The mother asking during a break if she should answer texts by phone or out loud, and the researcher replied “it’s up to you”.
136	During phase 1 of the *cell phone engagement protocol*, the researcher paused her timer to ask the mother to return the infant to the high chair (as the infant’s lower body was not visible). Timing was then resumed.
137	The mother said at the start of the session that she was at her parents’ house.
139	The mother asked, “So just look at my phone?” The researcher said “Yup, so you can feel free to take a look at your phone, text back or not, it’s up to you.” The mother then asked, “No toys for her? Leave her on her own?” The researcher said “It’s up to you, you can continue interacting with her while you send the messages or you can do just the messages, whatever you’d like to do”. Therefore, the researcher may have influenced the mother to respond to texts during ET.
141	The researcher said, “You can continue to play with him while you text” before the ET phase, thus possibly influencing the mother to engage in texting.
142	While instructions were being given for the ET phase, the mother already started looking at her phone and typing. She then clarified, “So I just text back my responses?” The researcher said “Yes.”, which may have biased the mother. The mother also said before Reunion “I haven’t done the final question, is that ok?” The researcher responded, “That’s ok”. The mother the clarified, “Leave it?” The researcher replied, “yeah yeah that’s ok”.
147	The researcher’s keyboard died during DT so the second text message was sent 25s late. Therefore, the next message was also delayed by 25s to accommodate.
148	The mother answered the first 3 texts verbally (she had asked if she should answer out loud but the researchers intentionally did not respond, so she chose to answer out loud). The researcher still waited until the appropriate time-marks to send texts (since no actual texts were received).
152	The session was 15 minutes delayed due to technological issues. The infant was somewhat tired and fussy. The infant’s father was also leaving during the session, causing some distraction during early phases.
154	When ET instructions were given, it appeared that the mother turned on the volume on her phone - it rang from then on, but had not been ringing during the previous phase.
156	The infant was very fussy and cried a lot. He looked away from the screen for most of the session, and had to be taken out of the seat for a large portion of session. At one point he fell asleep for a few seconds. Before Reunion, the mother said there were a couple of questions she did not get to answer, and asked if she should answer those after. The researcher said “Yeah that’s okay, it’s up to you.”
160	During DT, the mother responded to messages verbally. During ET, she used a "voice-to-text" feature to send messages for the rest of the phase.
161	The infant took a short break from the chair between DT and ET.

163	The infant took a short break from the chair between DT and ET. The mother asked before Reunion if the researchers wanted her to finish answering the questions. The researcher replied, “That’s okay, you can just continue playing”.
164	The mother said before Reunion, “I haven’t answered all the questions though.” The researcher said, “That’s okay, you can just continue.”
165	The dyad was at a cottage and did not have a seating option, so the infant was propped against pillows. The infant was not seated the entire time. During the session, the mother commented that the infant might be hungry. The mother also noted that she does not get notifications on her phone (was set to Do Not Disturb), but did get them on her laptop during the session.

Appendix G: Resource List Sent to Caregivers

COMPILED BY:
THE INFANT AND CHILD MENTAL HEALTH LAB

YORK U

RESOURCES TO EXPLORE: CAREGIVER-INFANT INTERACTIONS

Online Resources

- Visit the **Circle of Security International** website to learn about Attachment and Attending to Children's Needs:
  - https://www.circleofsecurityinternational.com/circle-of-security-model/what-is-the-circle-of-security/
- Visit the **CDC Child Development** website for information on Developmental Milestones and a Positive Parenting Tip Sheet
  - https://www.cdc.gov/ncbddd/childdevelopment/positiveparenting/infants.html
- Visit the **Strong Minds, Strong Kids** website for 7 Essential Parenting Strategies and information on how to connect with babies through music
  - https://strongmindsstrongkids.org/Public/Babies/Tips-and-Strategies/Public/Babies/Tips-and-_Strategies.aspx?hkey=0a39b023-8a15-487d-9356-a0838b7b1a8c
- Visit the **Harvard Centre on the Developing Child** website for a video on Building Babies' Brains Through Play
  - https://developingchild.harvard.edu/resources/building-babies-brains-through-play-mini-parenting-master-class/
- Visit the **Toronto Public Health** website for general information on your Baby's First Year
  - https://www.toronto.ca/community-people/children-parenting/pregnancy-and-parenting/parenting/babys-first-year/

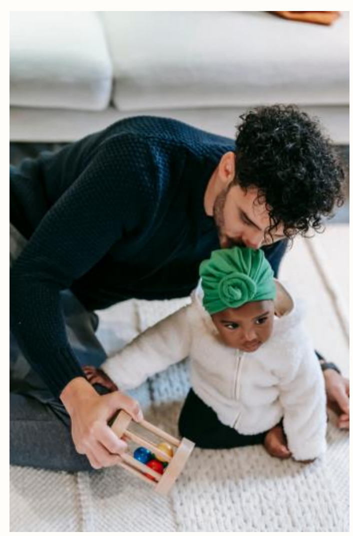
Programs to Check Out

Parents located in Toronto can check out these free parenting programs:

- **Healthy Babies, Healthy Children Program**, offered by Toronto Public Health: https://www.toronto.ca/community-people/children-parenting/pregnancy-and-parenting/pregnancy/during-pregnancy/prenatal-programs/healthy-babies-healthy-children/
- **Babies' Best Start** offered by Strides Toronto (offered in multiple languages): https://stridestoronto.ca/programs/babies-best-start/
- **Infant Mental Health Program**, offered by Strides Toronto: https://stridestoronto.ca/programs/infant-mental-health/

Parents in Ontario can also search for services offered by their local **EarlyON Centre**: https://www.ontario.ca/page/find-earlyon-child-and-family-centre

If you are having trouble locating programs or services, please reach out to us and we will help connect you to resources in your area.



**note*: all websites are hyperlinked for easy access

Appendix H: Descriptions of Infant Stress Behaviours

1) negative facial expression: includes cry face, facial grimace, sadness, anger (Reck et al., 2009)

- ***cry face:*** "face sobers, frown begins to form and deepens as brow knits, eyes close partially as upper cheeks raise and become flushed, lower lip quivers, lip retracts as mouth opens, finally, mouth turns down" (Oxford & Findlay, 2013, p. 37)

- ***facial grimace:*** frown, eye tightening, and/or upper lip raising (Oxford & Findlay, 2013)

- ***missing:*** when the infant's facial expression is not visible (e.g., infant is off-camera, infant's face is turned away, or infant is sucking on something that covers over ¾ of their mouth)

2) pulling away:

- ***turning head away:*** "removing…head away from mother (i.e., withdrawing and increasing distance from mother)" (Oxford & Findlay, 2013, p. 38)
    - only code the *initial* time the infant turns their head away (including up or down, not only to the side) **unless** they are stressed for longer than the first second
    - only code as "turning head away" **if it's clearly due to stress** and not in any other case (e.g., don't code if they turn their head to look at something out of interest)

- ***back arching:*** "hyperextension of the back" (Oxford & Findlay, 2015, p. 43)
    - code every second that the infant's back is arched as a "pulling away" behaviour *even* if not clearly stressed
    - **Note:** make sure "back arching" is not just the infant adjusting their body position

3) self-comforting (Reck et al., 2009):

(1) Instances when the infant sucks on his/her body (e.g., his/her thumb or wrist). There must be skin contact with the mouth and the behaviour must be initiated by infant;

(2) Instances when the infant sucks on or brings to his/her mouth something other than his/her body such as the strap of the chair or his/her clothing. This behaviour must also be initiated by the infant; and

(3) Instances when the infant sucks on or brings to his/her mouth the mother's hand or finger. There must be skin contact but this self-comforting behaviour is scored regardless of who initiated the contact. (p. 6)

Note: Also code soother use by the infant under "self-comforting".

Note: If the infant is sucking on something, but you can see the edges of their mouth, code this accordingly (e.g., positive, neutral, or negative facial expression). However, if > ¾ of their mouth is covered, code facial expression as "missing".

Note: If the infant brings their mouth toward an object to suck on it, also consider this as "self-comforting".

Appendix I: Notes on Achieving IRR for This Study

The process of achieving IRR involved double-coding videos until reliability was achieved for two videos (this resulted in the double-coding of seven videos in total). For the first video, codes were visually compared between coders to gain a general sense of areas of disagreement. For the remaining videos, statistical analyses (percent agreement and Cohen's kappa) were conducted in R version 4.4.2 (Posit Team, 2024) to reveal any discrepancies between coders. Discrepancies were discussed by the two coders and relevant video clips re-watched for all behavioural categories where percent agreement values were under .80; definitions for the behavioural codes were then updated/clarified accordingly.

For the first double-coded video (which included earlier behavioural codes listed in Table 15), it was difficult for both coders to distinguish between an infant's "sad/cry" versus "grimace/frown" facial expression. We discussed focusing on whether the infant is *really* sad and not being influenced by the audio. We decided to add "angry" to the "grimace/frown" code for clarity (see Appendix J for final synchrony definitions). There were often disagreements about when to code a facial expression as "missing", so the definition was made more objective by stating that if most of the lip and one eyebrow was visible, then the facial expression would *not* qualify as "missing". For Pulling Away, it was decided that this category should also include a code for when *only* the infant's arms and legs extended (without back arching). However, after completion of the IRR process it was concluded that it was hard to determine from the videos if the extremities did extend (due to various seating options and movements made by infants) and if this was due to stress. Moreover, no clear definition or visual was found of what would constitute an "extension" of the arms and legs, so this code was ultimately removed. For infants' Head Orientation, it was hard to distinguish when the head was considered "head away from caregiver (disengaged)" versus "caregiver-object directed (engaged)", so more detail was added to these definitions (i.e., if the caregiver [CG] was no longer directly playing with the object they had just shown the infant, and was now just watching the infant play, this would be coded as "head away"). For the first two videos, for the "caregiver-object directed (engaged)" code, it was also difficult to distinguish between an infant/CG looking toward an object or toward the other member (as often the head was technically oriented toward both, and gaze could not be easily coded). "Continued head toward object (engaged)" was also problematic for the first two videos, as it was hard to determine when it was "continued" versus when there was a break in the sequence and the infant returned to it later. It was also decided that the "continued" code could be better conceptualized as a form of disengagement given that the interaction shifted toward an object versus the dyad. Therefore, both the "caregiver-object directed (engaged)" code and the "continued head toward object (engaged)" codes (Table 15) were removed. For the second double-coded video, discrepancies were also revealed with Caregiver Facial Expression, particularly between positive versus neutral/serious expressions for this particular CG. Therefore, these definitions were further clarified, with any slight upturn of the mouth or bright/animated expression being considered "positive".

Before proceeding with double-coding the third video, several more changes were made to the infant and caregiver behavioural categories to increase clarity. First, to improve clarity for Head Orientation of both members, it was decided that Eye Gaze should also be coded, resulting in a new Eye Gaze/Head Orientation category. It was determined that coding of Eye Gaze should be prioritized over Head Orientation if it was visible (as gaze is more specific and frequently used in literature). Second, the Eye Gaze/Head Orientation codes were simplified into being either "toward" or "away" from the other member of the dyad (resulting in the current definitions listed in Appendix J). Third, it was decided that "caregiver-directed head orientation" (Table 15)

Table 15

Initial behavioural synchrony codes

Behaviour	Definition
Infant Head Orientation	
Caregiver-object directed (engaged)	The CG directs the infant toward an object that they are both actively engaged with. **Note:** If the object happens to also be toward the CG, but the infant is clearly looking at object, still code this as "CG-object directed", otherwise code as "head toward". **Note:** Do not code if the CG is just describing/starts playing with an object that the infant is already playing with.
Continued head toward object (engaged)	The infant continues to have their head toward the object the CG has just introduced to them; this occurs within 2s after the dyad was engaged with the object together (do not code if the infant returns to the object later on their own, i.e., there's a break in sequence).
Caregiver-directed head orientation	When the CG is actively directing the infant's head, and it would be very difficult for the infant to turn their head in any other direction; or when the CG is clearly blocking the infant's body from moving.
Infant Facial Expression	
Grimace/frown/angry	Can be one or more of a frown, eye tightening, and/or upper lip raising (NCAST, Oxford & Findlay, 2013, 2015), or an angry expression.
Sad/cry	The infant has a sad or crying facial expression.
Caregiver Head Orientation	
Head away toward object (engaged)	The CG's head is away from the infant, but the CG is clearly looking for an object to engage the infant with.
Caregiver Facial Expression	
Sad	Implies downcast eyes and/or downturned/pursed mouth/lips.
Angry/frown	Can be one or more of a frown, eye tightening, and/or upper lip raising (NCAST, Oxford & Findlay, 2013, 2015), or an angry expression.

would be removed, as it does not clearly indicate the level of engagement between a dyad, and instead could be coded as “missing” as it means the infant did not choose how they would be oriented. Fourth, for Caregiver Head Orientation, “head away toward object (engaged)” was removed and simplified to just “head away from infant”.

When coding the third video following these changes, agreement between coders was still below 80% across all categories. For Eye Gaze/Head Orientation categories, this appeared to be mainly because of subjective differences in perceived *availability* of eye gaze versus head orientation. Thus, “head toward CG (engaged)” and “eye gaze toward CG (engaged)” were equated simply to “toward”, while “head away from CG (disengaged)” and “eye gaze away from CG (disengaged)” were equated to “away” in the R analyses. This was decided because both gaze and head orientation were used as a measure of the same feature, i.e., the infant’s engagement with their caregiver. Coders also clarified that “head /eye gaze toward” would only include the face, upper body, or an object the CG was holding (not their lower body). For facial expressions, it was found to be difficult to distinguish between “neutral” or slightly “positive” expressions, therefore the definition of a “positive” expression was clarified by adding that a slight smile should be accompanied by an open/bright/animated look if unclear, and that facial expressions should be coded literally without being influenced by audio. It was also found that one coder tended to code facial expressions as “missing” more often, so this definition was made more objective to state that if the mouth was not visible (even if the rest of the face was), the expression should be coded as “missing”.

Following these further changes, IRR was achieved for the fourth video that was double-coded (see Table 16), with an overall percent agreement of 89%. The kappa values suggest substantial agreement between the coders when coding Negative Facial Expressions, Self-

Comforting by Sucking, Infant Gaze/Head Orientation, Infant Facial Expression, and Caregiver Facial Expression behaviours, and almost perfect agreement for Caregiver Gaze/Head Orientation. For Pulling Away, κ was not recorded (see Table 16 note), though percent agreement was very high at 98%. Thus, coders reliably identified stress behaviours for infants, and synchrony behaviours for both infants and caregivers.

Table 16

Inter-rater reliability statistics for first reliably coded video

Behaviours	Cohen's kappa (κ)	% Agreement
Stress Behaviours		
Negative Facial Expression	0.69	91%
Self-Comforting by Sucking	0.62	89%
Pulling Away	-[a]	98%
Synchrony Behaviours		
Infant Gaze/Head Orientation	0.66	82%
Infant Facial Expression	0.62	84%
Caregiver Gaze/Head Orientation	0.83	94%
Caregiver Facial Expression	0.76	84%

[a]The kappa value for Pulling Away is not reported as it is not valid given there were only a few instances of Pulling Away occurring during the interaction.

A fifth video was then double-coded with the aim of achieving IRR for a second video. Despite an overall agreement of 82%, there were discrepancies with Negative Facial Expressions, Infant Facial Expression, and Caregiver Facial Expression. One reason was that coders did not align on coding "missing" facial expressions. One coder interpreted hard-to-see Negative Facial Expressions as "null" since she felt they did not appear negative, while the other felt they might have been negative so coded them as "missing". One coder also generally coded more expressions as "missing" because she perceived that she could not clearly see the face, but later felt she had "overcompensated". Another reason for the discrepancies in facial expressions was one coder tended to code more CG facial expressions as "neutral" than the other coder did. We discussed the following changes: (1) erring on the side of "missing" for Negative Facial Expressions if these were not clearly visible; (2) refining the definition of "missing" to state that even if *some* of the side of the mouth and eyes could be seen, then we *could* code facial expression; (3) solidifying when to consider slight positive expressions as "positive" versus "neutral".

The sixth video that was randomly selected for double-coding was quite blurry, so the coders decided to double-code only infant behaviours first to assess whether blurriness would significantly impact agreement. It was decided during coding that a separate column should be added for "self-comforting with soother" as this particular infant had a soother in their mouth for parts of the interaction. After calculating percent agreement, it was determined that the coders were discrepant for Infant Facial Expression. This time the other coder tended to assign more "missing" and "neutral" codes. Following discussion, we concluded that the blurriness of the video would have greatly impeded accurately coding facial expression, so this video was not used for the reliability process.

We then double-coded a seventh video, with IRR results showing a discrepancy only with Infant Facial Expression. Upon further reflection, it was decided that discerning between various infant and CG negative facial expressions was difficult given the suboptimal video quality, and a way to improve accuracy (and consistency) of our coding was to have a single "negative" code for both Infant and Caregiver Facial Expression. Further supporting this change was the fact that when later categorizing synchrony behaviours into Monadic Phases, I would only need to distinguish between "positive", "neutral", or "negative" affect. Therefore, IRR for the seventh video was re-run in R by collapsing the various negative facial expressions into a singular "negative" code. This resulted in IRR being achieved for this video, with an overall percent agreement of 88%. For infant stress behaviours, coders reliably identified Negative Facial Expressions and Self-Comforting by Sucking with substantial agreement, and Self-Comforting with Soother with almost perfect agreement. Coders rated all synchrony behaviours with substantial agreement (Table 17).

Table 17

Inter-rater reliability statistics for second reliably coded video

Behaviours	Cohen's kappa (κ)	% Agreement
Stress Behaviours		
Negative Facial Expression	0.63	81%
Self-Comforting by Sucking	0.74	89%
Self-Comforting with Soother	0.91	99%
Synchrony Behaviours		
Infant Gaze/Head Orientation	0.65	86%
Infant Facial Expression	0.65	80%
Caregiver Gaze/Head Orientation	0.71	97%
Caregiver Facial Expression	0.71	82%

Appendix J: Descriptions of Mother-Infant Synchrony Behaviours

Infant Facial Expression

1) Positive

- ***smiling*: "**facial expression characterized by an upward curving of the corners of the mouth" (Oxford & Findlay, 2013, pg. 35), "crinkly eyes, and raised cheeks" (Reck et al., 2009, p. 3); even a slight upturn of the lips can be coded as long as the eyes are also bright

- ***facial brightening:*** "face bright combined with eyes wide and bright" (Oxford & Findlay, 2015, pg. 42)

- ***excited/animated look***

2) Negative: includes cry face, facial grimace, sadness, anger (Reck et al., 2009)

- ***cry face:*** "face sobers, frown begins to form and deepens as brow knits, eyes close partially as upper cheeks raise and become flushed, lower lip quivers, lip retracts as mouth opens, finally, mouth turns down" (Oxford & Findlay, 2013, p. 37)

- ***facial grimace:*** frown, eye tightening, and/or upper lip raising (Oxford & Findlay, 2013)

3) Neutral: neither a positive nor negative facial expression; includes yawns

4) Missing: when the infant's facial expression is not visible (e.g., infant is off-camera, infant's face is turned away, or infant is sucking on something that covers over ¾ of their mouth); includes sneezes

Infant Eye Gaze

- ***Gaze toward CG (engaged):*** "child looks in the direction of the caregiver's face" (Oxford & Findlay, 2013, p. 35), upper body, or object that the CG is holding (e.g., mobile phone)

- ***Gaze away from CG (disengaged):*** "eyes turned away from caregiver" (Oxford & Findlay, 2013, p. 46), including their face, body part, or object the CG is holding

Infant Head Orientation

1) Head toward CG (engaged): the infant's head is toward the CG but it is unclear if gaze is; also includes when the infant is clearly looking at the same object as the CG while they are both playing with it

2) Head away from CG (disengaged): anytime the infant clearly has their head turned away from the CG

Note: If the CG is actively directing the infant in a certain direction/position, or blocking the infant from moving their body, this is coded as "missing" while it is happening

<u>Caregiver Facial Expression</u>

1) Positive

- ***smiling*: "**facial expression characterized by an upward curving of the corners of the mouth" (Oxford & Findlay, 2013, pg. 35); includes a slight slide; if the smile is very slight, then only code if the rest of the face is open/bright/animated; usually part of a playful interaction

2) Negative:

- ***Sad:*** implies downcast eyes and/or downturned/pursed mouth/lips
- ***Angry/frown***

  Note: If negative faces are made as part of a playful/animated interaction, then code as "positive"

3) Neutral: neither a positive nor negative facial expression; includes serious facial expressions

4) Missing: when the CG's facial expression is not visible (e.g., the CG is off-camera, the CG's face is turned away); not coded as missing if most of the lip and one eyebrow are at least visible

<u>Caregiver eye gaze</u>

- ***Gaze toward infant (engaged):*** the CG is looking at the infant's face, any body parts of the infant, or an object that the infant is holding (this includes if they are clearly playing together); also code if the CG is clearly looking at the infant's lower body (e.g., lifts up the infant's foot and plays with it)

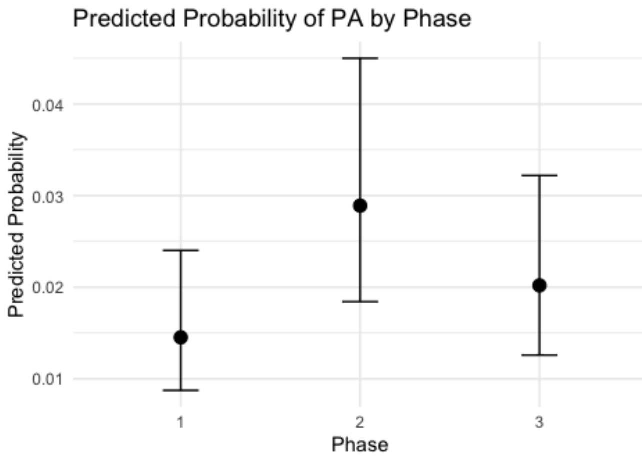
- ***Gaze away from infant (disengaged):*** the CG is looking away from the infant's face, body part, or an object that the infant is holding

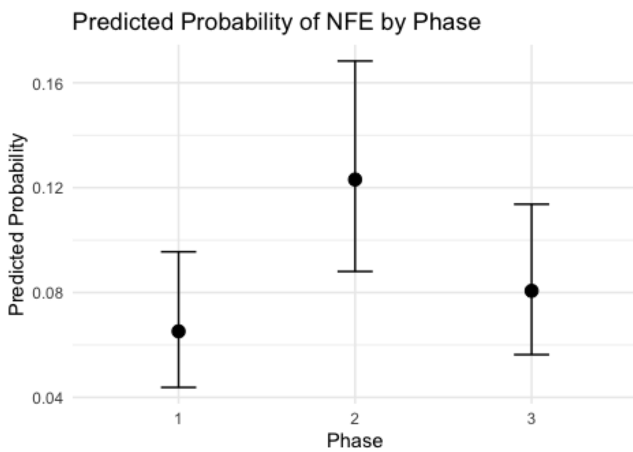
<u>Caregiver head orientation</u>

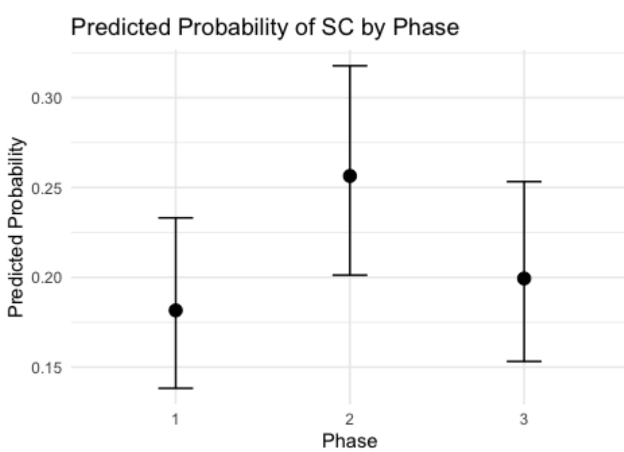
- ***Head towards infant (engaged):*** the CG's head is toward the infant but it is unclear if gaze is; also includes when the CG is clearly looking at the same object as the infant while they are both playing with it (e.g., both reading a book together that is placed between them)

- ***Head away from infant (disengaged):*** anytime the CG clearly has their head turned away from the infant (includes if the CG is moving away to get an object to use with infant, or if the CG shows interest/looks at something the infant is looking at off to the side that they are not playing with together)

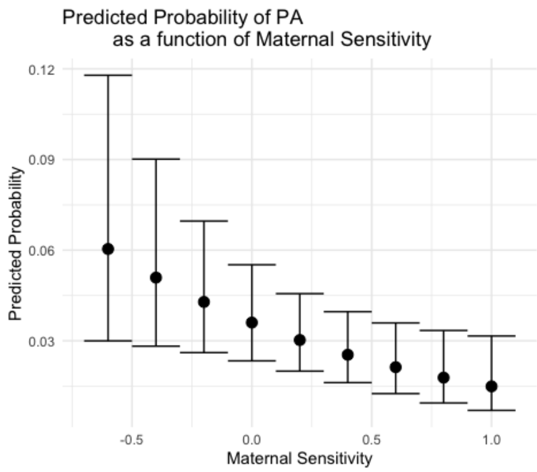
Appendix K: Predicted Probability Plots of Infant Stress Behaviours

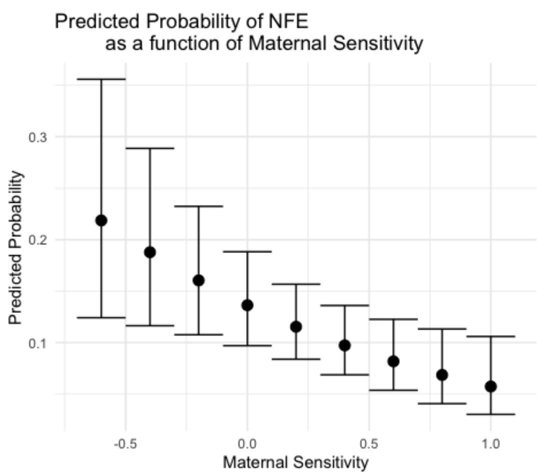


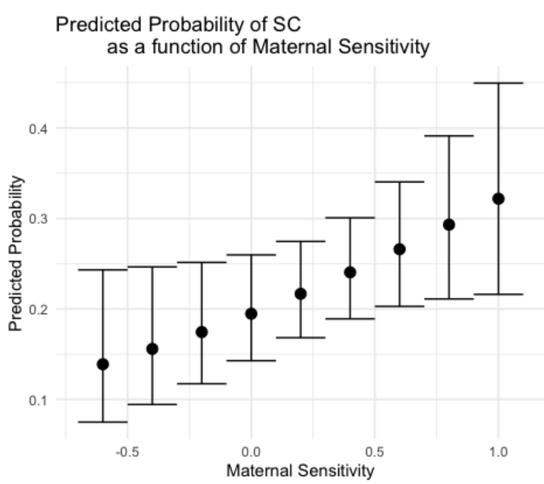




Appendix L: Predicted Probability Plots of Infant Stress Behaviours as a Function of Maternal Sensitivity







Appendix M: Predicted Probability Plots of Infant Stress Behaviours as a Function of Maternal Attachment Anxiety