SHORT REPORT

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Digital disruption? Maternal mobile device use is related to infant social-emotional functioning

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Abstract

Mobile device use has become increasingly prevalent, yet its impact on infant development remains largely unknown. When parents use mobile devices in front of infants, the parent is physically present but most likely distracted and unresponsive. Research using the classic Still Face Paradigm (SFP) suggests that parental withdrawal and unresponsiveness may have negative consequences for children's social-emotional development. In the present study, 50 infants aged 7.20 to 23.60 months ($M = 15.40$, $SD = 4.74$) and their mothers completed a modified SFP. The SFP consisted of three phases: free play (FP; parent and infant play and interact), still face (SF; parent withdraws attention and becomes unresponsive), and reunion (RU; parent resumes normal interaction). The modified SFP incorporated mobile device use in the SF phase. Parents reported on their typical mobile device use and infant temperament. Consistent with the standard SFP, infants showed more negative affect and less positive affect during SF versus FP. Infants also showed more toy engagement and more engagement with mother during FP versus SF and RU. Infants showed the most social bids during SF and more room exploration in SF than RU. More frequent reported mobile device use was associated with less room exploration and positive affect during SF, and less recovery (i.e., engagement with mother, room exploration positive affect) during RU, even when controlling for individual differences in temperament. Findings suggest that the SFP represents a promising theoretical framework for understanding the impact of parent's mobile device use on infant social-emotional functioning and parent–infant interactions.

RESEARCH HIGHLIGHTS

- The traditional Still Face Paradigm (SFP) was modified to include mobile device use, mimicking typical disruptions in parent–infant interactions that may occur in daily life.
- Patterns of child behavior during the modified SFP mirrored those of the traditional version, with infants showing the most distress when mothers were disengaged.
- Greater habitual self-reported maternal mobile device use was associated with less infant recovery upon reunion.

- Findings provide support for the use of this modified paradigm as a framework for understanding the impact of parent's mobile device use on infant social-emotional functioning and parent–infant interactions.

1 | INTRODUCTION

The exponential increase in mobile device use has transformed not only how we communicate remotely, but also how we engage in

face-to-face interactions. Greater mobile device use in adults has been associated with mental health problems, including anxiety (Reid & Reid, 2007; Sapacz, Rockman, & Clark, 2016). However, little is known about the impact of device use on parent–infant interactions. Frequent use of mobile devices during these interactions may decrease the quality of the social exchange by limiting opportunities for the in-the-moment emotional feedback essential for emotion regulation development (Field, 1994).

Infant behavior during dyadic interactions can be assessed using the Still Face Paradigm (SFP; Braungart-Rieker et al., 2014; Fuertes, Santos, Beeghly, & Tronick, 2006; Montirosso, Casini et al., 2015; Montirosso, Provenzi et al., 2015; Provenzi, Borgatti, Menozzi, & Montirosso, 2015; Tronick, Als, Adamson, Wise, & Brazelton, 1978), a classic laboratory behavioral task that examines infant responses to social cues by a parent, consisting of three phases: Free Play (FP), Still Face (SF), and Reunion (RU). The FP phase serves as a baseline for parent–infant play, while the SF phase disrupts this interaction by making the parent cease initiating or responding to social cues, while maintaining eye gaze. Infant behavior during the SF phase is characterized by decreased positive affect and gaze, and increased negative affect (Mesman, van IJzendoorn, & Bakermans-Kranenburg, 2009). Maternal regulation of infant emotion is absent during this phase, and when bids for emotional reciprocation are not returned, the infant tends to respond with distress and confusion (Montirosso, Casini et al., 2015; Montirosso, Provenzi et al., 2015; Provenzi et al., 2015; Trevarthen, 1977). Finally, the RU phase provides an opportunity to repair subsequent mismatches in dyadic behavior by resuming interactive play. The current study created a modified version of the classic SFP by employing a novel SF phase that introduced an ecologically valid mechanism (mobile device use) that *in effect* may typically make parents unavailable to infants in daily life.

Infant behavior during the SFP is related to broader patterns of emotional and social well-being, with greater positive affect and social bids during the SF phase predicting secure attachment (Braungart-Rieker et al., 2014; Fuertes et al., 2006; Kiser, Bates, Maslin, & Bayles, 1986; Tronick, Ricks, & Cohn, 1982). In addition, infant individual differences are related to their behavior during the SFP. For example, infants with greater parent-rated temperamental negative affectivity showed reduced self-comforting during SF, potentially blunting regulation and recovery during RU (Braungart-Rieker, Garwood, Powers, & Notaro, 1998; Mesman et al., 2009). In addition, Rothbart, Ziaie, and O'Boyle (1992) found that self-regulatory behaviors during the task were related to infant temperament. For example, activity level was negatively related to oral self-soothing, fear scores were positively related to inhibited reach and negatively related to approach, and attention disengagement was negatively related to distress and positively related to positive affect.

A large body of research has also established the SFP as an analog for dyadic interactions between a depressed mother and her child (Field, 1994; Field et al., 2007). In one study, the SF phase elicited less distress in infants of depressed mothers compared to controls (Field et al., 2007), potentially since this lack of emotional responsiveness tends to be more habitual in day-to-day interactions for infants of depressed mothers.

Several studies have modified components of the classic SFP. In one study, modifications included mothers wearing masks while maintaining eye contact and vocal interactions with their children, or drinking from a bottle while maintaining eye contact and a neutral, unresponsive face. Infants only displayed negative affect in response to the traditional still face but not to the modified versions (Legerstee & Markova, 2007), suggesting that infants may have interpreted the mothers' unresponsiveness differently when tied to a novel behavior. In another study using a modified SF phase in which mothers played with another infant, 6-month-old infants responded with heightened sadness and interest that exceeded that of the traditional SFP (Hart, Carrington, Tronick, & Carroll, 2004). A third study modified the traditional SFP for use with toddlers by using the same three phases, but placing them in the middle of a longer mother–child free play session (Weinberg, Beeghly, Olson, & Tronick, 2008). Toddlers showed similar response patterns as infants, including the classic still face effect, but also exhibited a wider array of responses, including vocalizations that expressed an effort to understand the reason for the mother's unresponsiveness. Thus, Weinberg and colleagues (2008) demonstrated that the SFP can be used to examine behavior across a wider age range than previously examined.

Similar to the key components of the classic SFP, parent mobile device use in front of infants causes the parents to be physically present but putatively distracted and unresponsive. While mobile device use is pervasive, only two studies to date have investigated how engagement with devices may interfere with parent–child interactions. One study found that during a structured interaction task, maternal mobile device use was common and associated with fewer mother–child interactions (Radesky et al., 2015). In a descriptive observational study, Radesky and colleagues (2014) found that parents who were deeply absorbed in mobile device use during meal times tended to respond to child bids for attention in insensitive or aggressive ways. However, no study to date has examined how infant social and emotional behavior is influenced by parental device use during dyadic interactions.

The first aim of the current study is to establish whether a modified SFP that incorporates maternal mobile device use could serve as an analog to the original SFP, probing the impact of distracted or unresponsive parents on child socioemotional behavior. Specifically, given that mobile device use may mimic the social and emotional disengagement present in the classic SFP, we predict that there will be greater negative affect, and less positive affect, during the SF phase, compared to the FP and RU phases. Also, we predict that dyadic interaction will resume upon the RU phase, with infants showing more engagement with mother in the RU phase compared to the SF phase. Second, we aim to examine whether or not maternal device use habits predict individual differences in infant behavior during the SFP. Specifically, based on research using the SFP with infants and depressed mothers (Field et al., 2007), we hypothesize that habitual device use will be associated with less negative responses from infants in the SF phase. That is, mothers who frequently use devices, particularly in front of their family and infants, may habitually show a lack of emotional responsiveness during interactions, making their infant more accustomed to such disruptions and thus

eliciting less distress. Third, based on previous studies suggesting that temperament may make infants more sensitive to the still face disruption (Braungart-Rieker et al., 1998), we predicted that infants high in negative affect would show greater disruption during the SF and less re-engagement during the RU.

2 | METHOD

2.1 | Participants

Fifty infants (25 female) ages 7.20 to 23.60 months (M = 15.40, SD = 4.74)[1] participated in a modified SFP with their mothers. Forty-five (90.0%) parents reported their infant's ethnicity as White/Non-Hispanic, three (6.0 %) reported Hispanic, three (6.0 %) reported Asian/Pacific Islander, one (2.0 %) reported African-American, and one (2.0 %) reported Native American. All infants were born within 2 weeks of their due date, reported no major health complications, and were within normal birthweight ranges (M = 7.53 lb, SD = 1.14).

2.2 | Materials

2.2.1 | The modified SFP

Infants and their mothers participated in a modified SFP (Tronick et al., 1978), which consisted of three phases: a free play phase (FP; 5 minutes), during which mother and infant interacted as they naturally would during play time; a still face phase (SF; 2 minutes), during which an alarm signaled the mother to pick up a mobile device (iPod touch), interact only with the device, withdraw attention from their infant, become unresponsive, and allow their infant to play on their own; and a reunion phase (RU; 1 minute; signaled by a knock on a window), during which the mothers stopped using the device and resumed interacting with their infant as they did during FP. This modified SFP altered the protocol of the original SFP by instructing mothers to use a mobile device during SF, allowing infants to move around freely instead of confining them to a high chair, and allowing infants to have access to toys throughout the task. We also varied the durations for each of the three SFP phases. A key difference between the modified SFP and the original SFP is that we did not require mothers to maintain eye contact while avoiding any communication with infants, which was a feature present in the original SFP. These modifications were intended to increase the ecological validity of the SFP by including features that more closely mimicked scenarios that may arise in everyday life.

2.2.2 | Behavioral coding

The SFP was video-recorded and scored by three reliable raters. Reliability was computed across 20% of participants using Cohen's kappa, and ranged from .71 to .98 (M = .85, SD = .03). Presence or absence of each behavior (0, 1) was coded in 15 second epochs. Average scores were computed (number of epochs each behavior was performed divided by total number of behaviors) for each phase (FP, SF, RU) to account for individual differences between children who showed generally higher and lower behavioral frequencies overall. Behaviors performed by at least 25% of infants in at least one phase were selected for analyses (negative affect, positive affect, toy engagement, engagement with mother, social bid, room exploration; Table 1).[2]

2.2.3 | Questionnaires

Parents self-reported their mobile device use including habitual device use frequency per day [(1) less than 30 min; (2) 1 hour; (3) 1–3 hours; (4) 3–5 hours], use in front of family, and use in front of infant [(1) do not use in presence; (2) less than 30 min; (3) 1 hour; (4) 1–3 hours; (5) 3–5 hours], as well as the total number of communication types used (e. g. texting, email, etc.).

Participants also completed the Revised Infant Behavior Questionnaire Short Form [IBQ-R; (Putnam, Helbig, Gartstein, Rothbart, & Leerkes, 2014); n = 11] or the Toddler Behavior Assessment Questionnaire [TBAQ; (Goldsmith, 1996); n = 39]. The IBQ-R is a parent-report measure of infant temperament for ages 4–12 months and consists of 91 items about infant behaviors in the past week on a 7-point Likert-type scale. The TBAQ is a parent-report measure of infant temperament for ages 12–24 months and consists of 110 items about infant behaviors in the past month on a 7-point Likert-type scale. To examine temperament across the entire age range of the current sample, within-questionnaire z-scores were computed and IBQ-R and TBAQ subscales were combined. Independent samples t tests found no significant differences in temperament (z-scores) between

TABLE 1 Coding scheme for infant behaviors during the still face paradigm

Infant behavior	Description
Negative affect	Negative expressions or vocalizations; infant protesting, or withdrawn. Must display negative facial expressions.
Positive affect	Displaying facial expressions of joy particularly smiles or vocalizations with a positive tone.
Engagement with toy or other object	Playing with the toys provided or in room or playing with non-toy objects, such as the chair.
Engagement with mother	Playing with or engaging with the parent (except if parent is ignoring infant for the still face phase, then it is a social bid).
Social bid	Making an attempt to get the attention of the parent physically or vocally, either in a negative way or positive or neutral way.
Room exploration	Playing with objects around the room or exploring the room in an attention-seeking manner or in a manner designed to not engage the caregiver.

TABLE 2 Descriptive statistics for SFP behaviors

Behavior	Min	Max	Mean (SD)
Free play phase			
Negative affect	.00	.80	.07 (.16)
Positive affect	.00	1.00	.29 (.25)
Toy engagement	.15	1.00	.92 (.15)
Engagement with mother	.00	1.00	.68 (.26)
Room exploration	.00	.95	.44 (.29)
Still face phase			
Negative affect	.00	.78	.17 (.24)
Positive affect	.00	.57	.06 (.12)
Toy engagement	.20	1.00	.82 (.22)
Social bid	.00	1.00	.26 (.27)
Room exploration	.00	1.00	.50 (.31)
Reunion phase			
Negative affect	.00	1.00	.10 (.20)
Positive affect	.00	1.00	.21 (.27)
Toy engagement	.00	1.00	.70 (.41)
Engagement with mother	.00	1.00	.63 (.38)
Room exploration	.00	1.00	.32 (.37)

infants whose parents completed the infant (IBQ) or toddler (TBAQ) version of the questionnaire (ps > .10). Subscales represented on both versions of the questionnaire that captured characteristics relevant to behavior during the SFP were examined: activity level, approach/interest, attentional control (duration and orienting from IBQ-R and appropriate attentional allocation from TBAQ), and negative affectivity (higher order subscale consisting of fear, sadness, distress to limitation, and falling reactivity).

2.3 | Procedure

This study was approved by the institutional review board of the Pennsylvania State University. Parents and infants participated in either one (2.5 hour duration) or two (to prevent infant fatigue; 1.5 hour duration) lab visits, as part of a larger study. Following informed consent, parents completed questionnaires reporting their infant's temperament and demographics. Participants then completed the modified SFP task with their infant (approximately 8 minutes). The modified SFP task was video-recorded to allow for observation of infant behaviors. Participants were compensated with $50 and infants received a T-shirt with the lab logo.

3 | RESULTS

3.1 | Descriptive statistics

Descriptive statistics for infant behavior during the SFP, maternal device use, and infant temperament are presented in Tables 2–4.

Pearson correlations were conducted to examine associations between infant age and sex relative to other study variables. Infant age was normally distributed, and there were an even number of males and females in the sample. There were no differences between males and females in child temperament (ps > .10), maternal mobile device use habits (ps > .10), or infant behaviors during the SFP (ps > .10). Older infants showed more engagement with mother during FP ($r = .46$, $p = .001$), and infant age was positively correlated with attentional control ($r = .34$, $p = .02$) and approach/interest ($r = .42$, $p = .003$). Infant age was not significantly correlated with maternal mobile device use (ps > .10). Although there were only limited relations between infant age and other measures, due to the wide age range of the sample, age was included as a covariate in subsequent analyses to control for the potential influence of developmental stage on observed behaviors (e.g., greater mobility, verbal skills in older infants).

3.2 | Analytic plan

First, as a manipulation check, we examined within-subject differences in behaviors across the three phases of the SFP to confirm that the parameters of the task elicited varying levels of child behaviors. Second, a series of regressions were conducted to examine the main research question regarding the relationship between maternal device use and infant behavior in the SFP.

TABLE 3 Descriptive statistics for maternal device use

Maternal device use	Min	Max	Mean (SD)
How often do you use your device(s)?	1	5	2.74 (.97)
Do you use your device(s) in the presence of family members? If so, how often?	2	5	2.92 (.80)
Do you use your device(s) in the presence of your baby? If so, how often?	2	4	2.54 (.68)
Communication types	8	14	10.34 (1.24)

Note. Response scale for device use frequency (per day) = (1) less than 30 min; (2) 1 hour; (3) 1–3 hours; (4) 3–5 hours; (5) more than 5 hours.
Response scale for use in front of family and baby (per day) = (1) do not use in presence; (2) less than 30 min; (3) 1 hour; (4) 1–3 hours; (5) 3–5 hours.

TABLE 4 Descriptive Statistics for Temperament Questionnaire Subscales

Temperament Questionnaire Subscale	Measure used	N	Min	Max	Mean (SD)
Attentional control	z-Score	50	−1.87	1.80	–
	IBQ	11	2.25	5.27	3.49 (0.99)
	TBAQ	39	2.13	5.31	3.77(0.88)
Activity level	z-Score	50	−2.10	2.49	–
	IBQ	11	3.93	5.67	4.67 (0.62)
	TBAQ	39	2.67	6.10	4.24 (0.75)
Approach/interest	z-Score	50	−1.94	1.68	–
	IBQ	11	3.70	6.75	5.27(1.03)
	TBAQ	39	1.60	5.00	3.42(0.94)
Negative affectivity	z-Score	50	−1.71	3.06	–
	IBQ	11	3.26	4.56	3.93(0.44)
	TBAQ	39	2.16	5.03	3.26(0.66)

3.3 | Infant behavior during still face paradigm

To examine differences across the phases of the SFP, repeated-measures ANCOVAs were conducted separately for each behavior (negative affect, positive affect, toy engagement, engagement with mother, social bids, room exploration) with age in months as a co-variate, and Phase (FP, SF, RU) as a within-subjects factor (Figure 1). Bonferroni correction was used to control for multiple comparisons in post-hoc paired-samples t tests (adjusted p = .017).

Affect: Mirroring the effects of the traditional SFP, infants showed more negative affect during SF versus FP, [$t(49)$ = 2.98, p = .004; $F(2, 96)$ = 5.67, p = .005, η_p^2 = .11]. In contrast, infants showed less positive affect during SF versus FP [$t(49)$ = −7.14, p < .001] and RU [$t(49)$ = −3.85, p < .001; $F(2, 96)$ = 23.11, p < .001, η_p^2 = .33]. Positive affect was also greater during FP in comparison to RU [$t(49)$ = 2.64, p = .011].

Toy engagement: Infants showed more toy engagement in FP compared to SF [$t(49)$ = 3.37, p = .001] and RU [$t(49)$ = 2.16, p < .001; $F(2, 96)$ = 11.25, p < .001, η_p^2 = .19].

Social behaviors: Infants also showed less engagement with mother during SF compared to FP [$t(49)$ = −17.64, p < .001] and RU [$t(49)$ = −11.37, p < .001; $F(2, 96)$ = 117.83, p < .001, η_p^2 = .71]. Social bids were used more in SF compared to FP [$t(49)$ = 6.76, p < .001] and RU [$t(49)$ = 5.51, p < .001; $F(2, 98)$ = 37.70, p < .001, η_p^2 = .44].

Exploration: Finally, infants explored the room less in RU compared to SF [$t(49)$ = −3.50, p = .001; $F(2, 98)$ = 6.89, p = .002, η_p^2 = .13].

3.4 | Infant temperament and behavior during still face paradigm

To identify covariates for regression analyses, infant temperament was examined in relation to mobile device use and child behavior during the SFP. Pearson correlations revealed that infants with greater parent-reported negative affectivity showed less engagement with mother during FP (r = −.31, p = .03), and less room exploration during RU (r = −.30, p = .03). Infants with greater parent-reported activity

level expressed more negative affect during SF (r = .29, p = .04). Infants with greater approach/interest engaged in more room exploration during SF (r = .32, p = .03).

3.5 | Maternal mobile device use and infant behavior during still face paradigm

Associations between self-report of maternal mobile device use and behavior during the SFP were examined using linear regressions as follows: 1st step = age, sex, and infant temperament variables (negative affectivity, activity level, approach/interest); 2nd step = maternal device use (separately for mobile device use variable: overall habitual use, use in front of family, use in front of infant); DV = infant behavior during SFP, separately for each phase. Infant temperamental variables were included as covariates since they correlated with infant behavior. The Benjamini-Hochberg correction (Benjamini & Hochberg, 1995) was applied to correct for multiple comparisons for each phase.[3] This procedure, which involves ranking p-values and accounts for the number of tests conducted, was applied separately to each family of regressions (i.e., separately for each SFP phase), since this correction approach assumes independence of samples. All p-values reported below are raw, and were significant using a false discovery rate criterion of 0.25 which is recommended for research questions that are a first, relatively exploratory step (Benjamini & Hochberg, 1995). Based on these parameters, raw p-values less than approximately .085 were considered significant.

3.5.1 | Free play phase

Maternal mobile device use did not significantly predict infant behavior during the SFP (ps > .10).

3.5.2 | Still face phase

Greater habitual device use was associated with less room exploration [β = −.39, $t(49)$ = −2.70, p = .01; Figure 2], and more frequent device

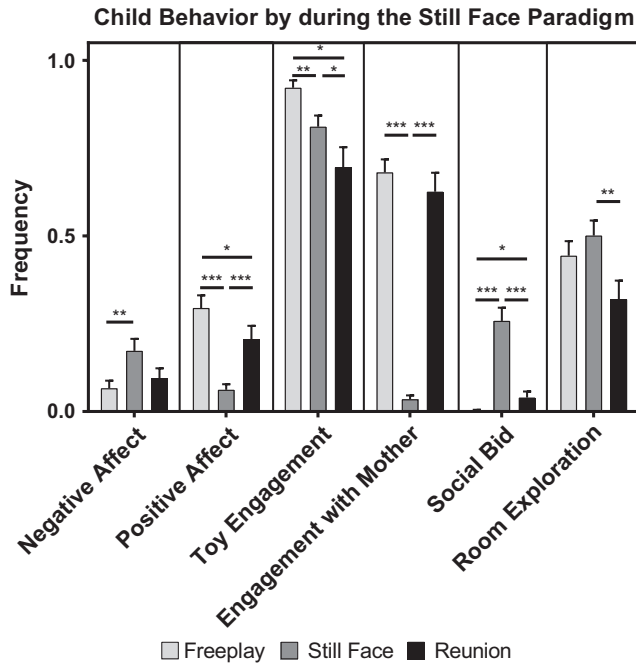**Child Behavior by during the Still Face Paradigm**

FIGURE 1 Infant behavior significantly differed across the three phases of the still face paradigm. Notably, the still face phase elicited greater negative affect, but less positive affect
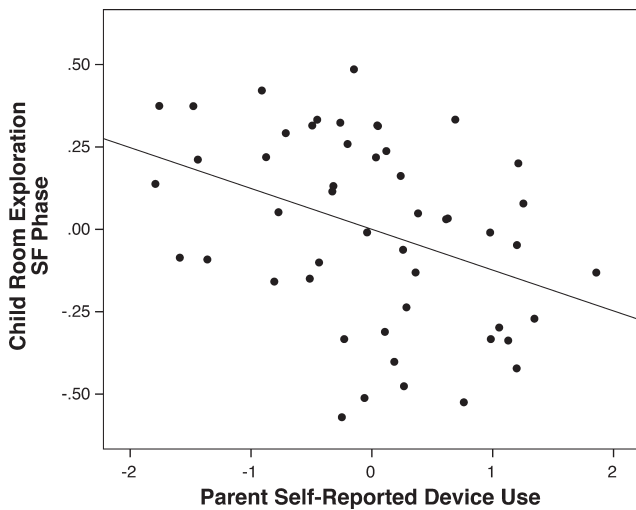

FIGURE 2 Greater parental device use predicts less infant room exploration during the still face phase, while controlling for infant temperament

use in front of infant was associated with less positive affect [β = −.35, t(49) = −2.37, p = .022].

3.5.3 | Reunion phase

Greater habitual device use [β = −.38, t(49) = −2.55, p = .014], and more specifically greater use in front of infant [β = −.29, t(49) = −2.05, p = .047], was associated with less room exploration. Greater habitual device use [β = −.30, t(49) = −1.96, p = .057], as well as use in front of infant [β = −.29, t(49) = −1.95, p = .057], was marginally associated

with less positive affect. Greater habitual device use [β = −.36, t(49) = −2.54, p = .015; Figure 3], more use in front of family [β = −.25, t(49) = −1.79, p = .081], as well as more use in front of infant [β = −.28, t(49) = −2.03, p = .048], was associated with less engagement with mother during this phase.

4 | DISCUSSION

Since infants tend to respond to maternal unresponsiveness during the SF phase with distress (Trevarthen, 1977), the SF phase is characterized by a decrease in positive affect and an increase in negative affect (Mesman et al., 2009). Consistent with the extant literature, the modified SFP using a mobile device in the current study produced robust differential patterns of infant behavior between the three phases. Infants expressed increased negative affect in the SF versus FP, as well as decreased positive affect and engagement with mother in SF versus both FP and RU. Infants also increased social bids during the SF in an attempt to obtain their caregiver's attention. Infants displayed more toy engagement during FP versus the other phases, likely due to the fact that infants were adjusting to the new environment and parents aided in toy engagement when they were available to interact, whereas during RU infants were preoccupied with re-engaging with the parent and they lacked scaffolding for play during SF. Finally, infants explored the room less in RU compared to SF, possibly because they were more focused on reuniting with their mother following the SF phase. In fact, as predicted, infant engagement with mother increased significantly between the SF and RU phases. Two-way engagement was greater in FP and RU when the rules of the task allowed for it, whereas social bids were greater when the parent was unavailable during SF. These observed patterns illustrate that the modified SFP may act as a potentially analogous paradigm to the original SFP and can be used to understand the implications of maternal device use on infant social-emotional functioning.

Results of the current study also indicated that individual differences in infant temperament contribute to behavior during the SFP phases. Infants with higher parent-reported temperamental negative affectivity engaged less with their caregiver during FP. During RU, infants with higher negative affectivity displayed less room exploration, indicating less recovery. This is consistent with findings that infants high in negative affectivity showed less emotion regulation during SF, blunting recovery during RU (Braungart-Rieker et al., 1998; Mesman et al., 2009). During SF, infants with greater activity level scores showed more negative affect. It is possible that it is more challenging for more active infants to deal with their nonresponsive parent, resulting in increased negative affect. Finally, infants with greater approach/interest scores showed more room exploration during SF. Increased approach and interest scores may be related to decreased fear (Buss, 2011; Rothbart et al., 1992) and increased curiosity about the environment, resulting in increased room exploration.

An important goal of the current study was to examine the impact of maternal device use on infant emotion regulation and parent–infant interactions. Although previous research suggests that physical
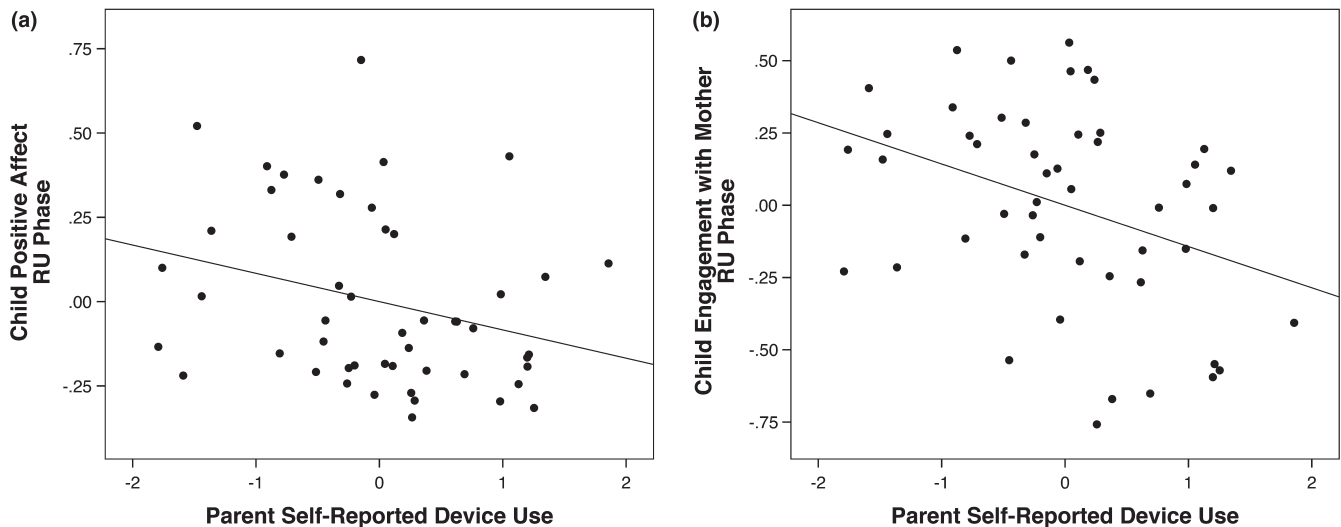
FIGURE 3 Greater parent device use was associated with less infant positive affect (left) and engagement with mother (right) during the reunion phase, while controlling for temperament, suggesting reduced recovery following disruption in parent–infant interaction

and emotional unavailability may decrease the quality of the social exchange (Field, 1994), no study has examined the effect of maternal device use on infant behavior and emotion regulation. The results of the current study suggest that greater maternal mobile use is associated with behavior patterns across the SFP phases, even when infant temperamental traits are taken into account. Contrary to predictions, infants of mothers who frequently used devices did not show less negative affect, or more positive affect, during the SF phase. We did note decreased room exploration during SF and RU as a function of greater habitual use, indicating that these infants were not unaffected by the disruption. These findings may suggest that parental habitual device use may be associated with an infant's ability to adjust to their environment and highlight the need for future research in this area.

Importantly, during RU, greater habitual device use was associated with less positive affect, less engagement with mother, and less room exploration. The RU phase is crucial in that it provides an opportunity for the parent and infant to reconnect. However, the current study showed that with greater habitual device use, the reunion between mother and infant was not as successful. Consistent with previous research showing that greater parental mobile device use was related to less interaction with children (Radesky et al., 2015), and insensitive or aggressive parent responses to social bids (Radesky et al., 2014), the current findings suggest that frequent habitual device use may reduce the successful repair of interactions following disruptions. These results highlight the importance of research surrounding parental device use and its impact on both infant emotional regulation development and the quality of social exchange in parent–infant interactions. The modified SFP represents a promising theoretical framework for this research.

Although the results from the current study confirm the findings that parental mobile device use is associated with infant social-emotional functioning and parent–infant interactions, some limitations should be noted. First, the age range included in the current study was relatively wide, encompassing developmental stages with varying levels of mobility, language ability, and understanding of others'

intentions. For these reasons, age was included as a covariate in all main analyses. Age did not significantly alter the pattern of results when examining either infant behaviors across stages or relations between maternal device use and infant behavior. Although the current findings represent a crucial starting point and previous studies have illustrated that the SFP can be used across a wide age range (Weinberg et al., 2008), future studies must investigate smaller age ranges and/or track changes longitudinally across early childhood to more concretely understand when and how maternal device use impacts social-emotional development. Also, the current study lacked a comparison group or comparison condition exposed to the classic SFP at the same age. Future studies should aim to address this gap to establish if the two versions elicit similar patterns of behavior in the same child.

In addition, contrary to the classic SFP, in the modified SFP with a mobile device, toys were freely available, infant mobility was not restricted, and mothers were not instructed to maintain eye contact during SF. Importantly, these variations included in the modified SFP more closely resemble real-life parent–child interactions involving disruptions in social-emotional communication, thus increasing the ecological validity of this paradigm. Due to these differences, the current SF may have elicited overall lower levels of negative affect versus other behaviors as compared to the classic SF (Braungart-Rieker et al., 2014; Fuertes et al., 2006; Montirosso, Casini et al., 2015; Montirosso, Provenzi et al., 2015; Provenzi et al., 2015). This difference in negative affect frequency could also be due to differences in coding methods used (e.g., 30 second epochs versus second-by-second microanalysis). It also may be that infants are more accustomed to disruptions due to mobile device use and thus were not as distressed as they would be by the classic SFP. These subtle, low-level expressions of negative affect might be common among children whose parents habitually and frequently use mobile devices, and future research should examine their function, such as serving to re-engage the parent or express distress.

An additional limitation is that the response scale for parental mobile device use only went from (1) less than 30 minutes per day to (5)

greater than 5 hours per day for three contexts: general device use frequency, use in front of family, and use in front of their infant. Future research should track device use in real time or complete in-home behavioral observations to observe how often parents use their device and how the infant reacts. This would provide a better understanding of how parent device use and how familiarity with a device may impact an infant's responses. It would also be beneficial to track infant social-emotional functioning over time to determine whether device use has a long-term impact on emotion regulation development.

Finally, it is important to note that the durations of the three phases were altered from the original SFP. Similar to previous studies (Weinberg et al., 2008), an extended free play phase was included to allow dyads enough time to adjust to the room in which they had the freedom to move at will, in contrast to the classic SFP. However, the most notable shortcoming of the current SFP design was that the reunion phase was only 1 minute long. Despite this short time-period, infants exhibited patterns of behavior suggesting dyadic interaction repair (e.g., increase in engagement with mother), as well as significant individual differences in recovery behaviors, which related to mobile device use habits. This suggests that, while this short RU phase may not be ideal, it was sufficient to detect notable patterns of infant behavior and lays the groundwork for subsequent investigations. Future studies should extend this phase to observe recovery over a longer period, and track individual differences in recovery trajectories in relation to patterns of daily device use.

The modified SFP used in the current study may represent a fruitful method for examining the use of digital devices in parent–child relationships in a controlled, yet ecologically valid manner. Taken together, results suggest that parental device use influences the quality of parent–infant interactions, and highlight the need for continued research on the role of technology in infant social-emotional development.

ENDNOTES

[1] The current sample was a subsample taken from a larger study examining broader patterns of socioemotional functioning in the first 2 years of life (LoBue, Buss, Taber-Thomas, & Pérez-Edgar, 2017; Morales et al., 2017; Pérez-Edgar, Morales, LoBue, Taber-Thomas, Allen, Brown, & Buss, in press).

[2] The distributions for some of the observed behaviors were significantly positively or negatively skewed. However, these skewed behaviors would be expected to be used either extremely frequently or infrequently due to the nature of the paradigm (e.g., task parameters would not be expected to elicit social bids from children during free play or reunion). These skewed behaviors were included in the repeated-measures analyses only, in order to track differences in behavior frequency across the three phases.

[3] Bonferroni correction for multiple comparisons was used in the analyses of covariance reported above, since Benjamini-Hochberg is not recommended for within-subject tests (Benjamini & Hochberg, 1995).

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