Associations between maternal technology use, perceptions of infant temperament, and indicators of mother-to-infant attachment quality

Shawnee Alvarez Gutierrez, Alison K. Ventura [*]

California Polytechnic State University, Department of Kinesiology and Public Health, College of Science and Mathematics, One Grand Avenue, San Luis Obispo, CA 93407, United States of America

A B S T R A C T

Background: Previous research suggests parents' use of technological devices, such as TV and mobile devices, within family contexts may decrease the quality of parent-child interactions. During early infancy, mothers report engaging with technological devices during infant feeding and care interactions, however, few studies have explored potential associations between maternal technology use and the quality of mother-to-infant attachment.

Aim: To examine associations between maternal technology use during mother-infant interactions and indicators of mother-to-infant attachment during early infancy.

Study design: Cross-sectional survey.

Methods: Mothers ($n = 332$) of infants aged 2 to 6 months were recruited via MTurk, a crowdsourcing platform, to participate in an online survey. Participants responded to a series of validated questionnaires that assessed maternal technology use during mother-infant interactions (Maternal Distraction Questionnaire), infant temperament (Infant Behavior Questionnaire-Revised Very Short Form), and indicators of mother-to-infant attachment, including quality of attachment, absence of hostility toward motherhood, and pleasure in mother-infant interactions (Maternal Postnatal Attachment Questionnaire).

Results: Greater technology use during mother-infant interactions was significantly associated with greater infant negative affectivity ($\beta = 0.26$, $p < .0001$). Greater technology use was also significantly associated with lower mother-to-infant attachment quality ($\beta = -0.21$, $p = .0001$), and greater hostility toward motherhood ($\beta = -0.39$, $p < .0001$). Associations between technology use and indicators of mother-to-infant attachment were not mediated by infant negative affectivity.

Conclusions: Maternal technology use was associated with greater perceptions of infant negative affectivity and poorer mother-to-infant attachment quality; further research is needed to understand mechanisms underlying these associations.

1. Introduction

In the U.S., ownership and usage of technological devices has increased dramatically over the last decade [1]. In 2019, 96% of Americans reported they owned a mobile phone, 75% owned a desktop or laptop computers, and roughly half of U.S. adults owned either tablet computers or e-reader devices [2]. Moreover, a substantial proportion of American households have multiple devices, with one-third of households reporting ownership of three or more smartphones [3]. The ubiquity of technology ownership coupled with the rapid evolution of social and interactive media has immersed American families in a digital environment. While technology has proven to be critical in communication and connectivity, there is increasing concern that the omnipresence of these devices within family contexts may affect family interactions, especially among parents and young children [4–6].

Recent research illustrates parents frequently engage with technology (e.g., mobile phones) during family interactions. Indeed, previous studies have identified several contexts in which parents engage with their devices, including playtime with their children [7,8], when spending time with their children in a restaurant [9], and during infant feeding [10]. For example, a naturalistic observational study investigated parents' phone use when supervising their child at a playground

and found that parents often use their phone in short bursts, frequently shifting their attention between their device and child [7]. Further, Radesky and colleagues found that 73% of parents engaged with their phones when directly observed in a fast-food restaurant; this engagement ranged from having the device on the table to continuous use throughout meal time [9]. Additionally, 29% of those interacting with their devices were considered "highly absorbed," paying substantially more attention to their mobile phone than to their children [9]. A study by Golen and Ventura [11] illuminated that mothers reported engaging in other activities during over half of bottle-feedings reported in feeding diaries; one third of these feedings involved technological distractions, primarily television. Given the large volume of time dedicated to feeding during early infancy, there may be an increased tendency for mothers to use that time to attend to technological distractions [12]. However, maternal attention to technological distractions may negatively impact the quality of mother-infant interactions by decreasing maternal sensitivity to infant cues and engagement of the infant in cognitive growth fostering, which encompasses the quality and frequency of verbalizations to the infant, as well as permitting the infant to explore his or her environment during interaction [10,13].

Potential impacts of maternal technology use on mother-infant interactions are concerning because maternal sensitivity and responsiveness to infant cues and engagement with the infant are key contributors to the mother's attachment representations to her infant (hereon referred to as mother-to-infant attachment), which describes the cognitive and emotional representations held by the mother about her child and the caregiving relationship [14]. Indicators of mother-to-infant attachment include *absence of hostility toward motherhood*, or acceptance of and lack of resentment for the personal sacrifices and difficulties associated with infant care, and *pleasure in proximity*, or the desire for interaction with the infant [15]. Ultimately, high quality mother-to-infant attachment develops through contingent and reciprocal dyadic behaviors, and helps the mother build an affectionate relationship with her child over time [16]. However, it is possible that frequent interactions with technological distractions during infant feeding and care interactions compromise the emotional connection that mothers feel toward their infants by disrupting sensitivity and responsiveness to infant cues and opportunities for relationship building through interaction. To our knowledge, no studies have empirically examined whether maternal technology use is related to the subjective indicators of mother-to-infant attachment quality.

Because bidirectional associations exist between early rearing environments and infant temperament [17,18], it is also important to consider the possibility that aspects of infant temperament (e.g., greater levels of negative affectivity) could mediate associations between mother's propensity toward technology use and feelings of mother-to-infant attachment [19]. Research with parents of young children illustrates that parents who more frequently engaged with technology during parent-child interactions described their child as being more "difficult," defined as exhibiting more internalizing (i.e., withdrawal) and externalizing (i.e., tantrums) behaviors [20,21]. Parents also report that balancing their attention between their device and their child is difficult and that it leads them to feel like they extract less meaning from time spent with their children [22]. That these perceptions may then affect attachment is suggested by recent research with mothers and infants, wherein mothers' perceptions of difficult infant temperament during early infancy predicted poorer mother-to-infant bonding during the first 9 months of infancy [19]. Taken together, these previous findings suggest research examining associations between maternal technology use and indicators of mother-to-infant attachment should also assess infant temperament (and, in particular, infants' level of negative affectivity), and should explore potential mediating effects of infant temperament on associations between maternal technology use and indicators of mother-to-infant attachment.

It is important to note that technology may provide certain benefits to parents; consideration of these benefits should be balanced with concerns about risks [23]. Parents admit that even brief, intermittent mobile device use provides emotional relief amidst their daily routines [23]. Other studies find that the use of certain types of media (i.e., texting, blogging, social networking) is connected to increased access to information [4,23], the maintenance of family relationships [24], and increased perceived feelings of social support, particularly for new mothers [25]. On the other hand, parents who attempt to "un-plug" express that using their mobile devices around their children induces uneasiness and guilt, and they feel more attuned to their children's needs when they refrain from using their phones [7,23]. These findings illustrate the complexity of technological use within parenting contexts and suggest that maternal technology use might be associated with both benefits and concerns.

To this end, the objective of this cross-sectional, exploratory study was to examine associations between maternal technology use and indicators of mother-to-infant attachment during early infancy. As described above, previous research connects maternal technology use to lower sensitivity and responsiveness to infant cues and less engagement with the infant, which may decrease mother-to-infant attachment quality, but other research connects maternal technology use to positive adaptations to motherhood. Thus, we adopted an exploratory approach to understand how maternal technology use relates to indicators of mother-to-infant attachment, including subjectively reported mother-to-infant attachment quality, absence of hostility toward motherhood, and pleasure in mother-infant interactions [15], during early infancy. In addition, previous research with parents of both infants and older children suggest child temperament (e.g., negative affectivity) may mediate associations between maternal technology use and mother-to-infant attachment quality. Thus, we also explored whether maternal technology use and indicators of mother-to-infant attachment were associated with dimensions of infant temperament, as well as whether infant negative affectivity mediated associations between maternal technology use and mother-to-infant attachment.

2. Methods

2.1. Participants and recruitment

Participants were recruited via Amazon Mechanical Turk (MTurk), a crowdsourcing platform for human subject research, to participate in an online, cross-sectional survey hosted via Qualtrics. MTurk functions as an integrated marketplace that permits a streamlined process for participant recruitment and data collection. Individuals can sign up as "workers" to complete Human Intelligence Tasks, such as online surveys, to receive compensation upon successful and satisfactory completion of each task [26]. Previous research illustrates MTurk is a cost-effective method for obtaining reliable data from diverse samples of families with young children [27–30].

Workers that accessed the task were able to read a brief description of the project. If interested, they were re-directed to screening questions to determine eligibility and, if eligible, the informed consent form. The eligibility requirements were: 1) mothers; 2) over 18 years of age; 3) had an infant between 8 and 24 weeks (2 to 6 months) of age; 4) infant was born term with no feeding disorders or developmental delays; 5) mother read and understood the consent form; 6) mother agreed to participate in the study. Eligible participants who completed the study received a unique verification code that was entered into MTurk to ensure they received compensation for their participation. In order to encourage a greater participant response, workers were compensated $0.50, which is comparable to other tasks of similar survey length [27]. Respondents that did not meet these eligibility requirements were directed to the end of the survey and did not receive compensation. All study procedures were reviewed and approved by the California Polytechnic State University Institutional Review Board.

2.2. Measures

Data collection occurred through Qualtrics (www.qualtrics.com), an online survey platform. Mothers were asked to answer a series of questionnaires pertaining to infant and caregiver characteristics that addressed the following constructs:

2.2.1. Quality control/attention questions

Mothers were presented with two quality control/attention questions to ensure they were completing the survey intentionally and accurately. These questions also facilitated screening of unreliable responses. For the first question, mothers were instructed to "Please select yes" and for the other question mothers were asked to provide a qualitative response to the prompt: "Tell us about being a parent."

2.2.2. Family demographics and health history

This questionnaire assessed infant sex and age; maternal age, parity, marital status, race/ethnicity, and education level; family income level and use of federal assistance programs; and feeding mode (any breastfeeding versus exclusive formula feeding).

2.2.3. Maternal Distraction Questionnaire (MDQ)

The MDQ is a validated, self-report measure that assesses the various activities that mothers may do while interacting with their infants within both feeding and non-feeding (e.g., soothing, play) contexts [31]. The present study focused on the *Technology Engagement* subscale of this questionnaire, which assesses the frequency to which mothers engage with various forms of technology (i.e., watching television, talking or texting on the phone, using the computer) during infant feeding and care interactions. For each subscale item, response options are on a 5-point Likert scale ranging from 1 (Never), 2 (Rarely), 3 (Sometimes), 4 (Often), 5 (Always). Thus, the possible score range is 1–5, with higher technology engagement scores representing more frequent engagement in technological activities during infant feeding and care interactions. In a previous psychometric study, this subscale demonstrated high internal consistency ($\alpha = 0.86$) [31]; within the present study, this subscale also demonstrated high internal consistency ($\alpha = 0.86$).

2.2.4. Infant Behavior Questionnaire-Revised Very Short Form (IBQ-RVS)

This is a widely-used parent-report measure that assesses infant behaviors that are representative of key domains of infant temperament [32,33]. The original IBQ was developed in 1981 and contained 91 items [34]; the IBQ was revised (IBQ-R) to contain 191 items in 2003 in response to new developments infant temperament research. In 2014, short (IBQ-RS; 91 items) and very short (IBQ-RVS; 37 items) forms were created and validated. A key difference between the original IBQ-R and the IBQ-RVS is that the IBQ-RVS does not capture all 14 detailed scales that comprise the IBQ-R, rather measures 3 overarching factors identified in previous research with the IBQ-R and derived from exploratory factor analysis: *Negative Affectivity* (Sadness, Distress to Limitations, Fear, and loading negatively, Falling Reactivity); *Orienting/Regulatory Capacity* (Low Intensity Pleasure, Cuddliness/Affiliation, Duration of Orienting, and Soothability); and *Positive Affectivity/Surgency* (Approach, Vocal Reactivity, High Intensity Pleasure, Smiling and Laughter, Activity Level, and Perceptual Sensitivity). Possible score range is 1–7, with higher scores indicating the infant displays greater levels of negative affectivity, orienting/regulatory capacity, or positive affectivity/surgency, respectively. In a previous psychometric study, the IBQ-RVS subscales demonstrated good internal consistency: negative affectivity, $\alpha = 0.78$; orienting/regulatory capacity, $\alpha = 0.75$; or positive affectivity/surgency, $\alpha = 0.77$ [33]. In addition, the abbreviated subscales derived from the IBQ-RVS were strongly correlated with and had similar levels of internal consistency and validity compared to the corresponding subscales derived from the longer IBQ-R [33]. In the present study, internal consistency for the IBQ-RVS subscales was: negative affectivity, $\alpha = 0.84$; orienting/regulatory capacity, $\alpha = 0.76$; and positive affectivity/surgency, $\alpha = 0.86$.

2.2.5. Maternal Postnatal Attachment Scale (MPAS)

The MPAS is a validated, 19-item questionnaire that assesses the mother's emotional responses toward her infant, particularly during the first year of life [15]. This questionnaire is organized into three subscales, including: *Quality of Attachment* (example item: "I now think of my baby as:" with response options ranging from "very much my own baby" to "not yet really my own baby"), *Absence of Hostility* (example item: "Regarding the things that we have had to give up because of the baby:" with response options ranging from "I find I resent it quite a lot" to "I find I don't resent it at all"), *Pleasure in Interaction* (example item: "I try to involve myself as much as I possibly can playing with the baby:" with response options ranging from "this is true" to "this is untrue"). Possible score range is 1–5, with higher scores representing greater feelings of attachment. In a previous psychometric study, these subscales demonstrated good internal consistency ($\alpha = 0.78$–0.79) [15]. In the present study, internal consistency for subscales was: quality of attachment, $\alpha = 0.78$; absence of hostility, $\alpha = 0.73$; and pleasure in interaction, $\alpha = 0.68$.

2.3. Statistical analysis

Prior to data analysis, data were thoroughly cleaned and assessed for normality. To ensure data were of high quality, data were cleaned using a three-pass approach: 1) respondents were excluded from the sample if their survey was incomplete (<90% of survey completed); 2) remaining respondents were excluded if they incorrectly answered the first quality control question ("Please select yes") or provided an incoherent response for the second quality control question ("Tell us about being a parent"); 3) remaining respondents were excluded if they had invalid responses for write-in questions such as infant birth date or infant weight and length. Of the 820 mothers who responded to our advertisement, 341 were excluded for incomplete surveys and 147 were excluded for incorrect or incoherent quality control or write-in question responses. Because we excluded mothers who completed 90% of the survey or less, missing data was minimal and limited to demographics characteristics (e.g., family income); these missing values were coded as "Not Reported." The final analytical sample was 332 mothers. Mothers who were excluded were not statistically different from mothers who were included for key demographic characteristics, including infant sex ($p = .4602$) and age ($p = .3650$); maternal age ($p = .0600$), parity ($p = .8169$), and education level ($p = .6030$); and family income ($p = .2383$).

All quantitative analyses were conducted using SAS v.9.4 (July 2013; SAS Institute Inc., North Carolina, USA). Descriptive statistics were calculated to summarize sample demographics. Correlation analysis was used to examine bivariate associations among maternal technology use, infant temperament (negative affectivity, orienting/regulatory capacity, or positive affectivity/surgency), and indicators of mother-to-infant attachment (mother-to-infant attachment quality, absence of hostility, and pleasure of interaction). Given significant correlations existed between maternal technology use and negative affectivity, mother-to-infant attachment quality, and absence of hostility, these associations were explored further using multiple linear regression analyses. In particular, separate multiple linear regression analyses (3 total) were used examine whether maternal technology use predicted maternal perceptions of infant negative affectivity, attachment quality, and absence of hostility, respectively. In addition, we explored whether maternal perceptions of infant negative affectivity explained associations between maternal technology use and dimensions of maternal attachment using simple mediation analysis as described by Baron and Kenny [35]. Within this approach, a given predictor (*X*, maternal technology use) is suggested to be associated with an outcome (*Y*, dimensions of maternal attachment) via a mediating variable (*M*, infant negative affectivity). To test for mediation, three regression equations are estimated: 1) regressing *M* on *X*; 2) regressing *Y* on *X*; and 3)

regressing *Y* on both *X* and *M*. Mediation is identified when: 1) *X* is a significant predictor of *M*; 2) *X* is a significant predictor of *Y*; and 3) the association between *X* and *Y* is null when *M* is included as a predictor in the regression model.

All regression models were controlled for relevant sociodemographic characteristics, including infant sex and age; maternal age, parity, marital status, race/ethnicity, and education level; family income level; and feeding mode (any breastfeeding versus exclusive formula feeding). Effect sizes were assessed by calculating Cohen's f^2 for local effect size; effect sizes were interpreted as small ($f^2 \geq 0.02$), medium ($f^2 \geq 0.15$), or large ($f^2 \geq 0.35$) per Cohen's guidelines [36]. A *p*-value < .05 was used as the criterion for statistical significance.

3. Results

3.1. Sample characteristics

Sample characteristics are described in Table 1. Average age for mothers was 31.2 (SD = 4.7) years. Approximately one-third of mothers (31%) were primiparous. Most mothers (67.2%) were married, employed (61.3%), and had some college education or higher (87.1%). In addition, 74.7% of mothers identified themselves as Non-Hispanic White. With respect to socioeconomic status, 75.6% reported a family income level less than $75,000 per year and 59.6% were enrolled in the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC), 76.5% in the Supplemental Nutrition Assistance Program (SNAP), and 68.7% in Medicaid. Slightly less than half (48.9%) of infants were exclusively breastfed.

3.2. Correlations among maternal tech use, infant temperament, and indicators of mother-to-infant attachment

Bivariate correlations between maternal technology use during infant feeding and care interactions, infant temperament, and maternal-to-infant attachment are presented in Table 2. Maternal technology use was significantly and positively correlated with infant negative affectivity (*r* = 0.29, *p* < .0001) indicating greater technology use was associated

Table 1
Sample characteristics (*N* = 332).

Infant characteristics	
Age (months), mean (SD)	3.8 (1.4)
Sex, % (n) Female	53.6 (178)
Mother characteristics	
Age (years), mean (SD)	31.2 (4.7)
Parity, % (n) primiparous	31.0 (103)
Married, % (n)	67.2 (223)
Family income, % (n)	
<$25,000/year	14.2 (47)
$25,000 to <$75,000/year	61.4 (204)
>$75,000/year	23.2 (77)
Not reported	1.2 (4)
Education level, % (n)	
Less than high school	2.4 (8)
High school	10.5 (35)
Some college or associates	47.9 (159)
College or graduate degree	39.2 (130)
Racial/ethnic category, % (n)	
Non-Hispanic White	74.7 (248)
Non-Hispanic Black	9.6 (32)
Hispanic	8.7 (29)
Asian	3.6 (12)
Mixed	2.4 (8)
Not reported	0.9 (3)
Infant feeding	
Current feeding mode, % (n)	
Exclusive breastfeeding	48.9 (161)
Exclusive formula-feeding	26.2 (87)
Mix of breast-and formula-feeding	25.3 (84)

Table 2
Correlations between study variables (N = 332).

	2	3	4	5	6	7
1. Maternal tech use	**0.29**	−0.09	0.00	**−0.31**	**−0.40**	−0.10
2. Infant negative affectivity		**0.15**	**0.37**	**−0.14**	**−0.31**	0.06
3. Infant orienting/regulatory capacity			**0.55**	**0.30**	0.09	**0.17**
4. Infant positive affectivity/surgency				0.09	−0.06	0.05
5. Mother-to-infant attachment quality					**0.68**	**0.20**
6. Maternal absence of hostility						**0.13**
7. Maternal pleasure in interactions						

Note: bolded correlations are significant at *p* < .05.

with greater perceptions of infant negative affectivity. Maternal technology use was significantly and negatively correlated with mother-to-infant attachment quality (*r* = −0.31, *p* < .0001) and absence of hostility toward motherhood (*r* = −0.40, p < .0001), indicating greater technology use was associated with lower perceived mother-to-infant attachment quality and greater feelings of hostility toward motherhood.

3.3. Associations between maternal technology use and infant negative affectivity, mother-to-infant attachment quality, and maternal absence of hostility toward motherhood

Within adjusted multiple regression models that controlled for relevant sociodemographic covariates, there was a positive association between maternal technology use during infant feeding and care interactions and perceived infant negative affectivity (β = 0.26, *p* < .0001, f^2 = 0.09; Table 3). The effect for maternal technology use was small, albeit significant. Each unit increase in maternal technology use was associated with a 0.26 unit increase in perceptions of infant negative affectivity.

Maternal technology use was negatively associated with mother-to-infant attachment quality (β = −0.21, *p* < .0001, f^2 = 0.10; Table 4,

Table 3
Associations between maternal technology use during infant feeding and care interactions and infant negative affectivity (N = 332).

Parameter	Estimate	Standard Error	p-Value
Intercept	2.30	0.32	<0.0001
Infant age	0.01	0.03	0.646
Infant sex, male (reference = female)	−0.03	0.07	0.639
Mother age	0.00	0.01	0.936
Parity, multiparous (reference = primiparous)	−0.05	0.08	0.540
Marital status			
Married	Reference		
Not married	−0.11	0.08	0.184
Not reported	−0.91	0.36	0.013
Family income level			
>$75,000	Reference		
$25,000-75,000	0.06	0.09	0.514
<$25,000	0.05	0.13	0.686
Not reported	0.10	0.32	0.747
Maternal education, high school degree or less	0.00	0.10	0.988
(Reference = some college or college degree)			
Maternal race/ethnicity			
Non-Hispanic white	Reference		
Minority	0.14	0.08	0.091
Not reported	0.41	0.37	0.266
Feeding mode, formula-feeding	−0.06	0.08	0.457
(Reference = any breastfeeding)			
Maternal technology use	0.26	0.05	<0.0001

Table 4

Associations between maternal technology use during infant feeding and care interactions and mother-to-infant attachment quality (N = 332).

Parameter	Model 1			Model 2		
	Estimate	Standard error	p-Value	Estimate	Standard error	p-Value
Intercept	5.01	0.24	<0.0001	5.09	0.26	<0.0001
Infant age	0.02	0.02	0.420	0.02	0.02	0.408
Infant sex, male (reference = female)	0.02	0.05	0.738	0.02	0.05	0.755
Mother age	0.00	0.01	0.673	0.00	0.01	0.671
Parity, multiparous (reference = primiparous)	0.17	0.06	0.006	0.16	0.06	0.007
Marital status						
Married	Reference			Reference		
Not married	0.05	0.06	0.401	0.05	0.06	0.437
Not reported	0.08	0.28	0.762	0.05	0.28	0.853
Family income level						
>$75,000	Reference			Reference		
$25,000-75,000	−0.04	0.07	0.538	−0.04	0.07	0.559
<$25,000	0.02	0.10	0.855	0.02	0.10	0.840
Not reported	−0.07	0.25	0.784	−0.06	0.25	0.796
Maternal education, high school degree or less (Reference = some college or college degree)	−0.12	0.08	0.139	−0.12	0.08	0.140
Maternal race/ethnicity						
Non-Hispanic White	Reference			Reference		
Minority	−0.06	0.06	0.337	−0.06	0.06	0.380
Not reported	−0.24	0.28	0.391	−0.23	0.28	0.420
Feeding mode, formula-feeding (Reference = any breastfeeding)	−0.04	0.06	0.527	−0.04	0.06	0.506
Maternal technology use	−0.21	0.04	<0.0001	−0.20	0.04	<0.0001
Infant negative affectivity				−0.04	0.04	0.413

Note: Multiple linear regression was used to explore the association between maternal technology use and mother-to-infant attachment quality (Model 1), as well as whether infant negative affectivity mediated this association (Model 2). Based on simple mediation analysis (as described by Baron and Kenny [35]), we explored whether the given predictor (X, maternal technology use) was associated with the outcome (Y, mother-to-infant attachment quality) via a mediating variable (M, infant negative affectivity). To test for mediation, we first established a significant association between the mediator (M, infant negative affectivity) and the predictor (X, maternal technology use), then regressed Y on X (Model 1). Finally, we regressed Y on both X and M (Model 2). Mediation would be identified when: 1) X is a significant predictor of M; 2) X is a significant predictor of Y; and 3) the association between X and Y is null when M is included as a predictor in the regression model.

Model 1). The effect for maternal technology use was small but significant, with each unit increase in maternal technology use associated with a 0.21 unit decrease in mother-to-infant attachment quality. Further analysis illustrated that this association remained significant after controlling for infant negative affectivity ($\beta = -0.20$, $p < .0001$, $f^2 = 0.09$; Table 4, Model 2), indicating that infant negative affectivity did not mediate the association between maternal technology use and attachment quality (Fig. 1).

Maternal technology use was significantly and negatively associated with absence of hostility toward motherhood ($\beta = -0.39$, $p < .0001$, f^2 = 0.19; Table 5, Model 1). The effect for maternal technology use was medium and significant, with each unit increase in maternal technology use associated with a 0.39 unit decrease in absence of hostility toward motherhood (i.e., greater feelings of hostility toward motherhood). This association also remained significant after controlling for infant negative affectivity ($\beta = -0.33$, $p < .0001$, $f^2 = 0.13$; Table 5, Model 2), indicating that infant negative affectivity did not mediate the association between maternal technology use and absence of hostility toward motherhood (Fig. 2).
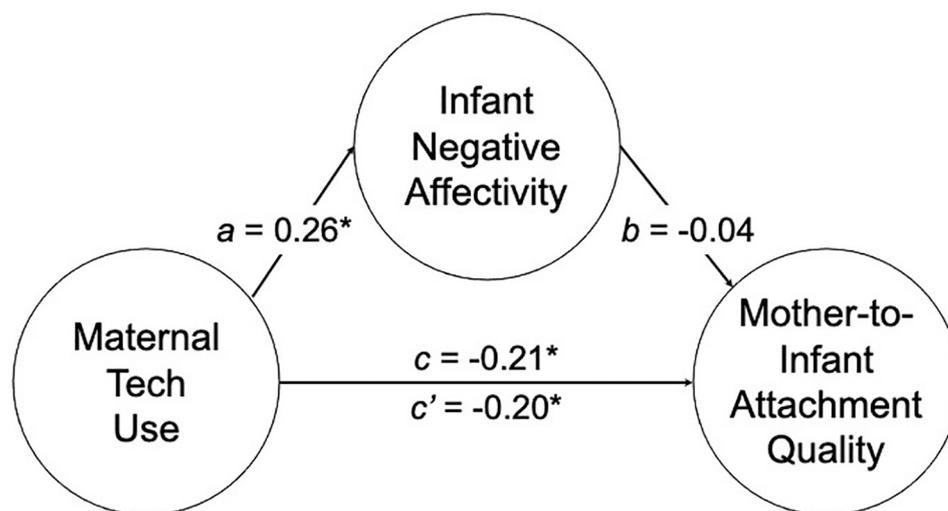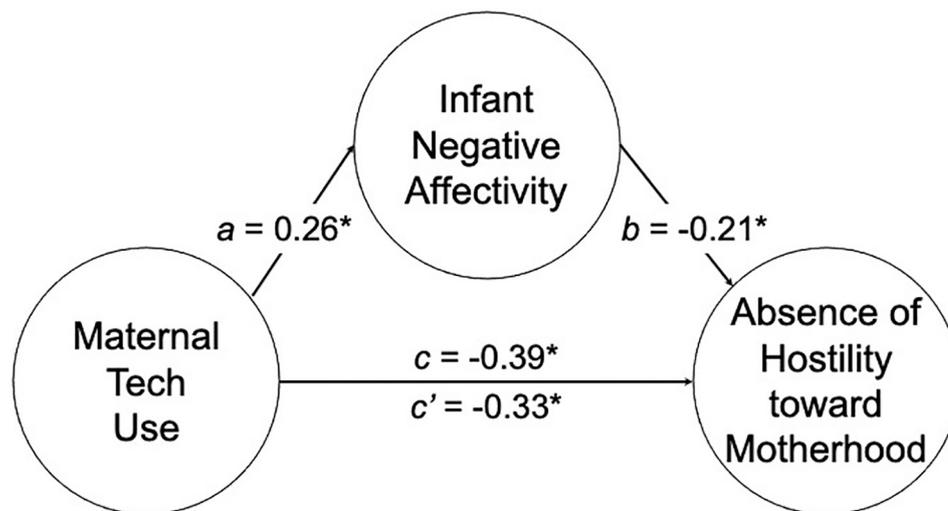

Fig. 1. Simple mediation model testing whether infant negative affectivity mediates the association between maternal technology use and mother-to-infant attachment quality. Based on the approach outlined by Baron and Kenney [35], a is the estimate for the association between the predictor (X, maternal technology use) and the mediator (M, infant negative affectivity). b is the estimate for the association between the mediator and the outcome (Y, mother-to-infant attachment quality) adjusted for the predictor. c is the estimate for the association of the predictor and the outcome. c' the estimate for the association between the predictor and the outcome, adjusted for the mediator. Mediation is identified when: 1) X is a significant predictor of M; 2) X is a significant predictor of Y; and 3) the association between X and Y is null when M is included as a predictor in the regression model. The significance of c' indicates that infant negative affectivity did not mediate the association between maternal technology use and mother-to-infant attachment quality.

*significant at $p < .001$.

Table 5

Associations between maternal technology use during infant feeding and care interactions and maternal absence of hostility (N = 332).

Parameter	Model 1			Model 2		
	Estimate	Standard error	p-Value	Estimate	Standard error	p-Value
Intercept	4.81	0.32	<0.0001	5.30	0.34	<0.00001
Infant age	−0.01	0.03	0.681	−0.01	0.03	0.747
Infant sex, male (reference = female)	−0.06	0.07	0.366	−0.07	0.07	0.308
Mother age	0.00	0.01	0.869	0.00	0.01	0.853
Parity, multiparous (reference = primiparous)	0.17	0.08	0.035	0.16	0.08	0.043
Marital status						
Married	Reference			Reference		
Not married	−0.02	0.08	0.802	−0.04	0.08	0.594
Not reported	0.53	0.37	0.154	0.34	0.37	0.357
Family income level						
>$75,000	Reference			Reference		
$25,000-75,000	0.00	0.09	0.973	0.01	0.09	0.918
<$25,000	0.20	0.13	0.125	0.21	0.13	0.099
Not reported	0.35	0.33	0.298	0.37	0.33	0.259
Maternal education, high school degree or less (Reference = some college or college degree)	−0.12	0.11	0.256	−0.12	0.11	0.249
Maternal race/ethnicity						
Non-Hispanic White	Reference			Reference		
Minority	0.01	0.08	0.877	0.04	0.08	0.609
Not reported	−0.79	0.38	0.037	−0.71	0.37	0.058
Feeding mode, formula-feeding (Reference = any breastfeeding)	0.11	0.08	0.164	0.10	0.08	0.206
Maternal technology use	−0.39	0.05	<0.0001	−0.33	0.05	<0.0001
Infant negative affectivity				−0.21	0.06	0.001

Note: Multiple linear regression was used to explore the association between maternal technology use and maternal absence of hostility (Model 1), as well as whether infant negative affectivity mediated this association (Model 2). Based on simple mediation analysis (as described by Baron and Kenny [35]), we explored whether the given predictor (X, maternal technology use) was associated with the outcome (Y, maternal absence of hostility) via a mediating variable (M, infant negative affectivity). To test for mediation, we first established a significant association between the M and X, then regressed Y on X (Model 1). We then regressed Y on both X and M (Model 2). Mediation would be identified when: 1) X is a significant predictor of M; 2) X is a significant predictor of Y; and 3) the association between X and Y is null when M is included as a predictor in the regression model.

Fig. 2. Simple mediation model testing whether infant negative affectivity mediates the association between maternal technology use and absence of hostility toward motherhood. Based on the approach outlined by Baron and Kenney [35], a is the estimate for the association between the predictor (X, maternal technology use) and the mediator (M, infant negative affectivity). b is the estimate for the association between the mediator and the outcome (Y, absence of hostility toward motherhood) adjusted for the predictor. c is the estimate for the association of the predictor and the outcome. c' the estimate for the association between the predictor and the outcome, adjusted for the mediator. Mediation is identified when: 1) X is a significant predictor of M; 2) X is a significant predictor of Y; and 3) the association between X and Y is null when M is included as a predictor in the regression model. The significance of c' indicates that infant negative affectivity did not mediate the association between maternal technology use and absence of hostility toward motherhood.
*significant at p < .001.

4. Discussion

The purpose of this study was to explore associations between maternal technological use during maternal-infant feeding and care interactions, infant temperament, and indicators of mother-to-infant attachment. To our knowledge, our study is the first to report significant associations between mother's self-reported technology use, perceptions of infant negative affectivity, and lower mother-to-infant attachment quality. Given mobile device usage has become nearly

universal, these results highlight the need for future research to better understand mechanisms underlying these associations and potential long-term implications for the parent-child relationship and child outcomes.

In this study, we found that more frequent technology use during mother-infant interactions was associated with greater perceived temperamental negative affectivity for infants, but not with infant orienting/regulatory capacity or positive affectivity/surgency; this finding aligns with previous research with older children examining parent

technology use and perceptions of child behavior [20,37]. For example, in a study of parents of 3-year-olds, McDaniel and Radesky [20] found that heavy parent technology use during parent-child interactions was associated with greater parent-reported child externalizing (e.g., tantrums, reactivity) and internalizing (e.g., anxiety, withdrawal) behavioral problems. Furthermore, this association was stronger for mothers than fathers [20].

One possible explanation for this association is that parents use technology to alleviate the stress or discomfort associated with difficult parenting interactions. In a subsequent longitudinal study of parents of 0–5-year-olds [21], McDaniel and Radesky further explored associations between parent-reported child externalizing and internalizing behavior and parent technology use, and whether parenting stress mediated this relationship. Parent reports of greater child externalizing behavior and greater levels of parenting stress were both significantly associated with more frequent technology use, with evidence that parenting stress mediated the association between child externalizing behavior and parent technology use [21]. These findings and others [23] suggest parents use technology as a form of stress relief, perhaps explaining why maternal technology use was associated with negative affectivity, but not with other dimensions of infant temperament. However, it is also possible that parents perceive their child to be more difficult during parent-child interactions when using technology, perpetuating both continued technology use as a coping mechanism and perceptions of child behavioral difficulties over time [23].

Thus, another possible explanation for associations between parent technology use and perceptions of child behavior is that parents' use of technology negatively alters their appraisal and perceptions of child behaviors. Previous research illustrates parents distracted by technology exhibit poor recognition of and harsh responses to their children's cues and bids for attention [9,10,13,37,38]. Indeed, a naturalistic mealtime observation revealed that parents absorbed with their mobile devices frequently ignored their child's behavior or reacted negatively by raising their voices or using more physical responses (e.g., pushing hands away) [9]. To our knowledge, few studies have examined bidirectional associations between parent technology use and child behavior during infancy; however, previous research in other domains of parenting illustrates infants perceived as having higher levels of negative affectivity evoke certain parental responses within both feeding and non-feeding interactions, which may lead to less desirable patterns of parent-child interaction (e.g., use of food to soothe the fussy infant) [19,39,40] and lower mother-to-infant bonding [19]. Future experimental and longitudinal research is necessary to better understand the potential bidirectional nature of associations between parent technology use and child temperament and behavioral difficulties.

Despite noted associations between maternal technology use, infant negative affectivity, and some indicators of mother-to-infant attachment (specifically, lower attachment quality and greater hostility toward motherhood), we did not find that infant negative affectivity mediated associations between maternal technology use and mother-to-infant attachment. Traditionally, the term attachment is used to refer to infant outcomes resulting from maternal behavior [14], yet it is important to note that attachment is not unidirectional; rather, behaviors of both infants and caregivers mutually reinforce attachment to one another [41]. As such, research exploring the development of mother-to-infant attachment has primarily focused on how mother-infant interactions contribute to a mother's feelings and perceptions about her child [42]. Findings from the present study suggest other mechanisms, beyond perceptions of infant temperament and behavior, may explain associations between maternal technology use and mother-to-infant attachment quality. These mechanisms may include individual differences in the pattern, frequency, proximity, and quality of maternal-child interactions, all of which influence mothers' attachment representations [42–44]. The proliferation of technology use in family life may lead to a series of interruptions that may ultimately undermine the quality of parents' sensitivity and responsiveness to and engagement with their children [14,45,46]. Thus, one potential explanation for our findings is that maternal technology use displaces time spent engaging with the infant or disrupts the quality interactions via negative impacts on maternal sensitivity and reciprocity [43,47], leading to lower feelings of attachment to the infant and greater feelings of hostility toward the difficult aspects of caring for a young infant.

On the other hand, it is also possible that maternal technology use alerts to the presence of other underlying issues, thus is a symptom of low mother-to-infant attachment and feelings of hostility toward motherhood rather than a cause [37]. For example, in-depth semi-structured and individual interviews conducted by Radesky and colleagues [37] revealed that an already strained parent-child relationship due to other factors (i.e., work-life imbalance), may lead mothers to use technology to alleviate feelings associated with that conflict or feelings of missing out. In addition, parents also report that technology use reminds parents of the vast number of possibilities and obligations available beyond their caregiving roles [37], which could explain associations between technology use and feelings of hostility or resentment toward the personal sacrifices and difficult aspects of infant care that come with early parenthood. In general, more research is needed to understand how mothers' feelings of attachment alter the manner in which she interacts with her infant and what circumstances may negatively affect this process. Therefore, further research is necessary to understand whether parent technology use affects parent-child attachment quality over time or whether low parent-to-child attachment quality facilitates parent technology use during family interactions. In addition, it is unclear why we did not find an association between maternal technology use and the pleasure of interaction subscale of our measure of mother-to-infant attachment; thus, further research is needed to understand these potential differential associations between aspects of mother-to-infant attachment and maternal technology use.

Parents have previously expressed both positive and negative attitudes about technology use and that technology use may afford certain benefits, such as stress relief, especially when used in short bursts to stay connected to social networks (e.g., friends, relatives, neighbors) amidst the demands of parenthood [4,23]. Moreover, mothers have previously reported that using technology is beneficial for managing their family and social lives [23,48,49]. The maintenance of social networks has been identified as an important contributor to successful adjustment to parenthood [50]; thus, the use of technology and social media, outside of face-to-face relationships, may provide mothers with more convenient and efficient platforms to enjoy the benefits of their social ties. These potential benefits of technology use are important and should be preserved. Thus, more research is needed to better understand parents' emotional and cognitive experiences when using technology, as well as to guide recommendations regarding ideal ways to balance parent technology use to maximize benefits while minimizing detriments.

Several limitations of the current study should be noted. First, the cross-sectional nature of this study limits our abilities to determine causality or directionality related to associations between technology use and maternal or child characteristics. Second, the use of self-reported data regarding technology use may have led to reporter bias or underreporting. Third, findings may have been further biased by the technological nature of our recruitment (MTurk) and data collection (Qualtrics online survey platform) methods; it is possible that the study sample was more technologically inclined than a sample recruited and assessed via non-technological methods. Fourth, the sample studied was mothers of 2–6-month-olds who were primarily non-Hispanic White and well-educated; thus, results may not be generalizable to the U.S. population. As such, future studies should aim to recruit a more diverse and representative sample in order to understand cultural and contextual differences in attitudes and behaviors related to technology use during parent-infant interactions. Moreover, the associations found within this study may not be applicable to fathers, so future work should examine whether fathers are more or less perceptive of technology use within the home and how technological interruption is perceived relative to their

parenting.

In conclusion, this study highlighted significant associations between greater maternal technology use, infant negative affectivity, and lower mother-to-infant attachment quality. Given the exploratory and cross-sectional nature of this study, more research is warranted to further understand the nature of these associations and potential explanatory factors. It is important to note that the mother-infant attachment relationship is primarily influenced by the interactions that occur over the course of the child's first year of life [14]; therefore, future investigations should also explore other potential benefits and risks of caregiver technology use during this critical period of growth and development. Future experimental research that expands on these associations would be beneficial in bringing about more reflection on technology use within the home, and how to integrate media and technology into the family dynamic in a way that maximizes benefits and minimizes risks.

CRediT authorship contribution statement

Shawnee Alvarez Guttierez: Conceptualization, Methodology, Investigation, Writing – Original Draft Preparation, Writing – Reviewing and Editing, Visualization.

Alison Ventura: Conceptualization, Methodology, Investigation, Formal Analysis, Data Curation, Writing – Original Draft Preparation, Writing – Reviewing and Editing, Visualization, Supervision, Project Administration, Funding Acquisition.

Declaration of competing interest

The authors have no conflicts of interest to disclose.

Acknowledgements

References

[1] M. Anderson, Mobile Technology and Home Broadband. https://www.pewresearch.org/internet/2019/06/13/mobile-technology-and-home-broadband-2019/, 2019. (Accessed 8 November 2020).

[2] Pew Research Center, Mobile Fact Sheet. https://www.pewresearch.org/internet/fact-sheet/mobile/, 2019. (Accessed 8 November 2020).

[3] K. Olmstead, A third of Americans live in a household with three or more smartphones, Pew Research Center. 25 (2017).

[4] B.T. McDaniel, Parent distraction with phones, reasons for use, and impacts on parenting and child outcomes: a review of the emerging research, Hum Behav Emerg Technol. 1 (2019) 72–80.

[5] G. Newsham, M. Drouin, B.T. McDaniel, Problematic phone use, depression, and technology interference among mothers, Psychology of Popular Media. 9 (2020) 117–124.

[6] E. Oduor, C. Neustaedter, W. Odom, A. Tang, N. Moallem, M. Tory, et al., The Frustrations and Benefits of Mobile Device Usage in the Home when Co-present with Family Members. Proceedings of the 2016 ACM Conference on Designing Interactive Systems - DIS '16, 2016, pp. 1315–1327.

[7] A. Hiniker, K. Sobel, H. Suh, Y.-C. Sung, C.P. Lee, J.A. Kientz, Texting while Parenting. Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems - CHI '15, 2015, pp. 727–736.

[8] B.T. McDaniel, S.M. Coyne, Technology interference in the parenting of young children: implications for mothers' perceptions of coparenting, Soc. Sci. J. 53 (2019) 435–443.

[9] J.S. Radesky, C.J. Kistin, B. Zuckerman, K. Nitzberg, J. Gross, M. Kaplan-Sanoff, et al., Patterns of mobile device use by caregivers and children during meals in fast food restaurants, Pediatrics. 133 (2014) e843–e849.

[10] R.B. Golen, A.K. Ventura, Mindless feeding: is maternal distraction during bottle-feeding associated with overfeeding? Appetite. 91 (2015) 385–392.

[11] R.P. Golen, A.K. Ventura, What are mothers doing while bottle-feeding their infants? Exploring the prevalence of maternal distraction during bottle-feeding interactions, Early Hum. Dev. 91 (2015) 787–791.

[12] A.K. Ventura, S. Teitelbaum, Maternal distraction during breast- and bottle feeding among WIC and non-WIC mothers, J. Nutr. Educ. Behav. 49 (2017) (S169-S76 e1).

[13] A.K. Ventura, J. Levy, S. Sheeper, Maternal digital media use during infant feeding and the quality of feeding interactions, Appetite. 143 (2019) 104415.

[14] M.D.S. Ainsworth, M.C. Blehar, E. Waters, S. Wall, Patterns of Attachment: A Psychological Study of the Strange Situation, Lawrence Erlbaum, Oxford, England, 1978.

[15] J.T. Condon, C.J. Corkindale, The assessment of parent-to-infant attachment: development of a self-report questionnaire instrument, J Reprod Infant Psychol. 16 (1998) 57–76.

[16] M.E. Muller, A questionnaire to measure mother-to-infant attachment, J. Nurs. Meas. 2 (1994) 129–141.

[17] R. Feldman, A.I. Eidelman, Parent-infant synchrony and the social-emotional development of triplets, Dev. Psychol. 40 (2004) 1133–1147.

[18] B.L. Volling, N.L. McElwain, P.C. Notaro, C. Herrera, Parents' emotional availability and infant emotional competence: predictors of parent-infant attachment and emerging self-regulation, J. Fam. Psychol. 16 (2002) 447–465.

[19] L. Takács, F. Smolík, M. Kaźmierczak, S.P. Putnam, Early infant temperament shapes the nature of mother-infant bonding in the first postpartum year, Infant Behav Devel. 58 (2020) 101428.

[20] B.T. McDaniel, J.S. Radesky, Technoference: parent distraction with technology and associations with child behavior problems, Child Dev. 89 (2017) 100–109.

[21] B.T. McDaniel, J.S. Radesky, Technoference: longitudinal associations between parent technology use, parenting stress, and child behavior problems, Pediatr. Res. 84 (2018) 210–218.

[22] K. Kushlev, E.W. Dunn, Smartphones distract parents from cultivating feelings of connection when spending time with their children, J. Soc. Pers. Relat. 36 (2018) 1619–1639.

[23] J.S. Radesky, C. Kistin, S. Eisenberg, J. Gross, G. Block, B. Zuckerman, et al., Parent perspectives on their Mobile technology use: the excitement and exhaustion of parenting while connected, J. Dev. Behav. Pediatr. 37 (2016) 694–701.

[24] L.M. Padilla-Walker, S.M. Coyne, A.M. Fraser, Getting a high-speed family connection: associations between family media use and family connection, Fam. Relat. 61 (2012) 426–440.

[25] B.T. McDaniel, S.M. Coyne, E.K. Holmes, New mothers and media use: associations between blogging, social networking, and maternal well-being, Matern. Child Health J. 16 (2012) 1509–1517.

[26] D.J. Follmer, R.A. Sperling, H.K. Suen, The role of MTurk in education research: advantages, issues, and future directions, Educ. Res. 46 (2017) 329–334.

[27] M. Buhrmester, T. Kwang, S.D. Gosling, Amazon's mechanical Turk: a new source of inexpensive, yet high-quality data? Perspect. Psychol. Sci. 6 (2011) 3–5.

[28] J. Chandler, D. Shapiro, Conducting clinical research using crowdsourced convenience samples, Annu. Rev. Clin. Psychol. 12 (2016).

[29] J. Dworkin, H. Hessel, K. Gliske, J.H. Rudi, A comparison of three online recruitment strategies for engaging parents, Fam. Relat. 65 (2016) 550–561.

[30] M. Tran, L. Cabral, R. Patel, R. Cusack, Online recruitment and testing of infants with mechanical Turk, J. Exp. Child Psychol. 156 (2017) 168–178.

[31] A.K. Ventura, M. Hupp, S.A. Gutierrez, R. Almeida, Development and validation of the maternal distraction questionnaire, Heliyon. 6 (2020), e03276.

[32] M.A. Gartstein, M.K. Rothbart, Studying infant temperament via the revised infant behavior questionnaire, Infant Behav Devel. 26 (2003) 64–86.

[33] S.P. Putnam, A.L. Helbig, M.A. Gartstein, M.K. Rothbart, E. Leerkes, Development and assessment of short and very short forms of the infant behavior questionnaire–revised, J. Pers. Assess. 96 (2014) 445–458.

[34] M.K. Rothbart, Measurement of temperament in infancy, Child Dev. 52 (1981) 569–578.

[35] R.M. Baron, D.A. Kenny, The moderator–mediator variable distinction in social psychological research: conceptual, strategic, and statistical considerations, J. Pers. Soc. Psychol. 51 (1986) 1173.

[36] J.E. Cohen, Statistical Power Analysis for the Behavioral Sciences, Hillsdale, NJ, Lawrence Erlbaum Associates, Inc, 1988.

[37] J.S. Radesky, C. Leung, D. Appugliese, A.L. Miller, J.C. Lumeng, K.L. Rosenblum, Maternal mental representations of the child and mobile phone use during parent-child mealtimes, J. Dev. Behav. Pediatr. 39 (2018) 310–317.

[38] J.S. Radesky, A.L. Miller, K.L. Rosenblum, D. Appugliese, N. Kaciroti, J.C. Lumeng, Maternal mobile device use during a structured parent-child interaction task, Acad. Pediatr. 15 (2015) 238–244.

[39] C.A. Forestell, J.A. Mennella, More than just a pretty face. The relationship between infant's temperament, food acceptance, and mothers' perceptions of their enjoyment of food, Appetite. 58 (2012) 1136–1142.

[40] C.A. Stifter, S. Anzman-Frasca, L.L. Birch, K. Voegtline, Parent use of food to soothe infant/toddler distress and child weight status. An exploratory study, Appetite. 57 (2011) 693–699.

[41] World Health Organization. The importance of caregiver-child interactions for the survival and healthy development of young children: A review, Department of Child and Adolescent Health and Development (CAH), World Health Organization, Geneva, Switzerland, 2004.

[42] Z.S. Mason, R.D. Briggs, E.J. Silver, Maternal attachment feelings mediate between maternal reports of depression, infant social–emotional development, and parenting stress, J Reprod Infant Psychol. 29 (2011) 382–394.

[43] I.M.H. Van, Adult attachment representations, parental responsiveness, and infant attachment: a meta-analysis on the predictive validity of the Adult Attachment Interview, Psychol Bull. 117 (1995) 387–403.

[44] C. Goulet, L. Bell, D. St-Cyr, D. Paul, A. Lang, A concept analysis of parent-infant attachment, J. Adv. Nurs. 28 (1998) 1071–1081.

[45] M.D.S. Ainsworth, S.M. Bell, D.F. Stayton, Infant-mother attachment and social development: socialization as a product of reciprocal responsiveness to signals, in: The Integration of a Child Into a Social World, Cambridge University Press, New York, NY, US, 1974, pp. 99–135.

[46] P. Leigh, M.A. Nievar, L. Nathans, Maternal sensitivity and language in early childhood: a test of the transactional model, Percept. Mot. Skills 113 (2011) 281–299.

[47] D.R. Pederson, K.E. Gleason, G. Moran, S. Bento, Maternal attachment representations, maternal sensitivity, and the infant–mother attachment relationship, Devel Psych. 34 (1998) 925–933.

[48] C.A. Kildare, W. Middlemiss, Impact of parents mobile device use on parent-child interaction: a literature review, Comput. Hum. Behav. 75 (2017) 579–593.

[49] L. Palen, A. Hughes, When home base is not a place: parents' use of mobile telephones, Pers Ubiquitous Comput. 11 (2006) 339–348.

[50] M.K. Bartholomew, S.J. Schoppe-Sullivan, M. Glassman, C.M. Kamp Dush, J. M. Sullivan, New parents' Facebook use at the transition to parenthood, Fam. Relat. 61 (2012) 455–469.