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Technoference in infant feeding: the impact of maternal digital media use during breastfeeding on maternal attention and mother-infant interactions

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Introduction: Parents' sensitivity and responsiveness to their infants may be affected by the widespread availability and use of mobile devices. The present study examined the impact of maternal digital media use on maternal attention and the quality of mother-infant interaction during breastfeeding.

Methods: Mothers and infants ($n = 25$ dyads) participated in a within-subject experiment. Mothers breastfed their infants under one experimental and one control condition, counterbalanced across two laboratory visits. During the Digital Media condition, mothers watched a television show on a tablet. During the Control condition, mothers listened to classical music at ambient levels. Video records were later coded to assess maternal attention to the infant, tablet, or elsewhere and evaluate the quality of mother-infant interaction.

Results: There were more disruptions in maternal attention to the infant during the Digital Media ($M = 3.7$, $S.E. = 0.2$ per minute) vs. Control condition ($M = 1.7$, $S.E. = 0.2$ per minute, $p < 0.001$). The proportion of the meal duration mothers spent focused on their infant was significantly lower during the Digital Media ($M = 52.5\%$, $S.E. = 3.9$) vs. Control condition ($M = 83.9\%$, $S.E. = 4.0\%$, $p < 0.001$). Lower maternal attention to the infant was associated with lower maternal sensitivity to cues ($p = 0.03$) and cognitive growth fostering ($p = 0.002$), as well as lower infant clarity of cues ($p = 0.001$). Lower maternal attention was also associated with less socioemotional growth fostering ($p < 0.001$) and lower infant responsiveness to the mother ($p < 0.001$) regardless of whether digital media was present or absent, but during the Digital Media condition, mothers engaged in more socioemotional growth fostering ($p = 0.004$) and infants were more responsive to mothers ($p = 0.03$).

Discussion: The presence of digital media during infant feeding led to more interruptions to mothers' attention to their infants and the time mothers spent focused on digital media displaced time spent focused on their infants. The degree to which mothers were attentive to their infants vs. digital media was a more important predictor of most aspects of interaction quality than the mere presence of digital media.

KEYWORDS

digital media, technology use, technoference, mother-infant interactions, breastfeeding, infant feeding, attention, parent's personal technologies

1 Introduction

Caregiver responsiveness supports healthy development during infancy (Eshel et al., 2006). During responsive caregiver-infant interactions, caregivers recognize and contingently respond to infants' cues in predictable, developmentally appropriate ways that support behavioral regulation, socioemotional and cognitive growth, and autonomy. A caregiver's ability to sensitively respond to infant cues and needs is an important support for their infant's developing abilities to self-regulate and navigate discomforts. Over time, caregiver responsiveness helps children learn to regulate cognitions, emotions, and behaviors to accomplish their goals and adapt to the cognitive and social demands of specific situations (Berger et al., 2007).

During early infancy, feeding is a central form of caregiver-infant interaction because caregivers spend a significant portion of each day feeding their infants. Caregiver sensitivity and responsiveness during early feeding interactions support infants' abilities to self-regulate intake in response to physiological needs, which is an important foundation for the development of healthy eating behaviors and the prevention of rapid weight gain and obesity (Black and Aboud, 2011). Thus, promoting responsive caregiving behaviors—especially during early feeding interactions—is a key target for prevention and intervention efforts.

The responsiveness of today's parents may be affected by the widespread availability and use of personal technologies, such as smartphones and other mobile devices. It is estimated that 96% of U.S. adults own a mobile device, and parents engage with their mobile devices more than 60 times per day (Pew Research Center, 2024; Yuan et al., 2019). Technology and digital media use during infant feeding are common (Coyne et al., 2022), with 78% of mothers reporting they engage with a technological distractor (e.g., television, mobile device) during one or more feedings per day (Golen R. P. and Ventura A. K., 2015) and over one-third of mothers reporting they often or always watch television or use a mobile device while feeding their infant (Ventura et al., 2020). Caregivers of young infants may be particularly vulnerable to habitual technology use during interactions with their infants because the first few months postpartum are primarily dedicated to infant feeding and care, reducing caregivers' time and energy for self-care or other interests (Ventura et al., 2020).

While there are potential benefits of technology and digital media use for mothers, such as social connection, quick access to advice and information, and reduced feelings of stress and boredom (Coyne et al., 2022; Baker and Yang, 2018; McDaniel et al., 2012; Radesky et al., 2016; Wolfers, 2021), these benefits may come with a cost of disruptions to mothers' attention and, subsequently, mother-infant interactions. In particular, today's technologies are especially absorptive because they are always available, considered an "extension of the self," and capture and sustain users' attention through mechanisms such as notifications and autoplay (Campbell, 2008; Bayer et al., 2015). In addition, parents report that consumption of digital media on mobile devices (e.g., streaming television shows, engaging with social media) is typically more personal and interactive—and thus more immersive and absorptive—than non-technological forms of distraction (Radesky et al., 2016). Indeed, previous research

illustrates that mothers who use technology and digital media during mealtime interactions with young children exhibit lower sensitivity and responsiveness to their infants' feeding and social cues (Golen R. P. and Ventura A. K., 2015; Ventura et al., 2023; Vanden Abeele et al., 2020; Ochoa et al., 2021; Tharner et al., 2022). Observational research employing covert observations of families in public settings (e.g., playgrounds and restaurants) illustrates parent device use is common and that parents are less responsive to their children's bids for attention and needs when using devices, reducing the quality of parent-child interactions and parent support for children's emotional wellbeing and safety (Elias et al., 2020; Lemish et al., 2020; Radesky et al., 2014; Wolfers et al., 2020). However, to date, most studies examining potential impacts of technological interference—or technofence—in mother-infant interactions are observational, making it unclear whether mothers' technology and digital media use during mealtimes directly decreases sensitivity, responsiveness, and the overall quality of the interaction or whether mothers who are already less sensitive and responsive are more likely to use technology.

We recently investigated the effect of maternal digital media use on the quality of feeding interactions within a laboratory-based experimental study of 25 mothers and their healthy full-term infants <6 months of age (Ventura et al., 2019). Mothers were asked to feed their infants under two conditions: (1) while watching a television show on a small tablet (Digital Media condition) and (2) while listening to classical music at ambient volumes (Control condition). Behavioral coding of video records of these feeding observations illustrated that mothers spent significantly less time engaging their infants in cognitive growth fostering experiences during the Digital Media vs. Control condition, suggesting that maternal digital media use negatively impacted one aspect of the quality of mother-infant feeding interactions. Mothers tended to be less sensitive to infant cues during the Digital Media than the Control condition, but this difference did not reach significance. However, a limitation of this study is that the data were analyzed on the level of condition. Examining individual differences in the extent to which mothers engaged with digital media vs. their infant during experimental feeding conditions may provide additional insights into associations between digital media use and mothers' sensitivity and responsiveness to infant cues. Thus, further research is needed to understand the extent to which mothers engage with technology and whether individual differences in mothers' attention to technology are associated with feeding outcomes.

The present study was a secondary analysis of the abovementioned experimental study (Ventura et al., 2019). We aimed to describe individual differences in how much mothers attended to digital media vs. their infant and the implications of these differences for the quality of feeding interactions. We hypothesized that mothers would spend a lower proportion of the meal duration focused on their infant when digital media was present vs. absent due to more frequent interruptions in maternal attention. We also hypothesized that displacement of attention to the infant with attention to digital media would be associated with lower maternal sensitivity and responsiveness to infant cues and fewer socioemotional and cognitive growth fostering behaviors, leading to overall lower quality interactions when mothers attended to digital media instead of their infant during feeding.

2 Materials and methods

2.1 Participants

Mothers and infants of either biological sex participated in this study ($n = 25$ dyads). Inclusion criteria for mothers were: (1) between 18 and 40 years of age and (2) did not experience any complications during pregnancy or birth that could lead to child feeding issues. Inclusion criteria for infants were: (1) born full-term (>37 weeks); (2) healthy; (3) 32 weeks of age or younger; and (4) not yet introduced to complementary foods and beverages. Recruitment happened primarily at Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) program offices, breastfeeding support groups, local pediatric offices, and social media (e.g., targeted Facebook ads). Potential participants were informed that the study's purpose was to "better understand infant feeding behaviors during typical feeding interactions;" study objectives and hypotheses were not disclosed to potential participants. Participants received a onesie and a book for their infant as compensation for participation. Informed consent was obtained from all participants before the study's start, and the university Institutional Review Board approved all study procedures.

2.2 Experimental design

This study employed a within-subject design, wherein each dyad served as its own control. Participants visited our laboratory on two separate days, separated by an average of 2.4 ± 1.8 days. Visits were scheduled for the same time each day to control for diurnal variations in intake and behavior. At each visit, mothers were asked to breastfeed their infants under one experimental or one control condition; conditions were counterbalanced across the two visit days.

- 1) During the Digital Media condition, mothers were asked to watch a 22-min-long television show on a small tablet (Apple iPad Air [Apple Inc., Cupertino, CA]) provided by the researchers. Mothers chose a sitcom from a list of pre-selected and pre-screened sitcom episodes free of commercials, violence, sexual content, and references to infants and feeding practices. If the feeding continued past the 22-min-long episode, a second episode of the selected show would autoplay immediately following the first. Mothers were allowed to hold the tablet or place it on a small table located in front of the feeding chair. When mothers were done feeding, they informed the research assistant, who then turned off the tablet.
- 2) During the Control condition, mothers were asked to listen to Rachmaninoff's Second Symphony based on previous research illustrating that classical music is preferred to silence to prevent discomfort or boredom (Blass et al., 2006). The research assistant set the volume to 40 decibels, which is considered an ambient sound level (Mehta et al., 2012). Any other potential technological or non-technological distractions were removed from the room. When mothers

were done feeding, they informed the research assistant, who then turned off the music.

We elected to have mothers stream a television show on a mobile device because previous research suggests this is a common form of technology and digital media use during infant feeding (Golen R. P. and Ventura A. K., 2015; Ventura et al., 2020; Ventura and Teitelbaum, 2017); thus, this condition was deemed to be representative of one common way mothers report using technology and digital media during infant feeding. In addition, streaming a television show on a mobile device allowed for some standardization of mothers' exposure to digital media because a research assistant started the television show at the beginning of the feeding and the show ran for the entire duration of the feeding. Thus, duration of exposure was not dependent upon the mother deciding when to initiate or terminate use.

2.3 Protocol and measures

During the 3 days before the first visit, mothers were asked to keep a daily record of when and what their infants ate. Within these feeding diaries, mothers were also asked to indicate what else, if anything, they were doing while feeding their infants to provide the experimenters with a sense of the infant's normal feeding patterns and the mothers' typical level of technology use during feeding.

2.3.1 Feeding observations

Mother-infant dyads were observed during breastfeeding to control for effects of feeding mode (directly from the breast vs. from a bottle) and milk type (breast milk vs. formula) on feeding interactions. The feeding interaction was recorded with a Canon VIXIA HF M41 Full HD Camcorder (Canon, New York, USA). The camera was placed approximately 10 feet away from the dyad, ensuring both mothers' and infants' faces were visible. The research assistant waited behind a partition to minimize their influence on the interaction.

2.3.2 Objective assessment of maternal attention and the quality of mother-infant interactions

Two trained coders unaware of the study aims, research questions, and hypotheses rated maternal attention using a frame-by-frame behavioral coding approach within Noldus Observer XT 16.0 software (Observer XT; Noldus Information Tech, Heerlen, the Netherlands). Coders identified three mutually exclusive attention states, with codes capturing both the frequency and duration of each attention state:

- 1) Maternal attention to the infant, defined as the mother looking at the infant
- 2) Maternal attention to the tablet, defined as the mother looking at the tablet
- 3) Maternal attention elsewhere, defined as the mother looking elsewhere

Coders mainly attended to the mother's gaze but also used contextual cues to determine the direction of maternal attention. After coding, maternal attention state data was summarized as the total number of bouts for each state and the total duration (in minutes) spent in each state. Maternal attention state data was also summarized as bouts per minute of each state (calculated as total number of bouts/total meal duration) and the proportion of the meal duration spent in each state (calculated as [total duration in state / total meal duration] * 100) to control for variations in meal duration. Bouts per minute represented the extent to which mothers' attention was sustained vs. interrupted during each condition, with greater bouts per minute corresponding to more interruptions to mothers' attention. Coders were trained by a study investigator (AKV) to reach inter-rater and intra-rater reliabilities of Kappa > 0.90. Inter-rater reliability was determined by common coding of 25% of study videos, and intra-rater reliability was determined by double-coding of an additional 25% of study videos. The average Kappa for inter-rater reliability was 0.98, and for intra-rater reliability was 0.97, indicating almost perfect agreement (McHugh, 2012).

A different set of two trained coders unaware of the study aims, research questions, and hypotheses scored the video records using the Nursing Child Assessment Caregiver-Child Interaction Feeding Scale (NCAFS) (Oxford and Findlay, 2015). This scale is validated for assessing the quality of early feeding interactions (breastfeeding, bottle-feeding, or solid food-feeding) for mothers and their infants aged ≤12 months during laboratory- and home-based feeding observations. This scale is comprised of 76 observable behaviors that are organized into six subscales, four of which describe the mother's contributions to the feeding interaction and two of which describe the infant's contribution (Oxford and Findlay, 2015). Maternal subscales include *Sensitivity to Cues* (possible score range = 0–16 with higher scores indicating greater sensitivity to infant cues), *Response to Child's Distress* (possible score range = 0–11 with higher scores indicating greater contingent responsiveness to infant distress), *Social-Emotional Growth Fostering* (possible score range = 0–14 with higher scores indicating greater engagement in behaviors that support infant social-emotional development), and *Cognitive Growth Fostering* (possible score range = 0–9 with higher scores indicating greater engagement in behaviors that support infant cognitive development). Infant subscales include *Clarity of Cues* (score range = 0–15 with higher scores indicating greater clarity of cues) and *Responsiveness to Caregiver* (score range = 0–11 with higher scores indicating greater engagement with and responsiveness to the caregiver). Before coding, raters were trained by a certified NCAFS trainer to reach 90% agreement using the NCAFS training materials (Oxford and Findlay, 2015).

2.3.3 Assessment of maternal demographics

Mothers were asked to complete a family demographic questionnaire at the end of the second visit to assess maternal sociodemographic characteristics and parity.

2.4 Data analysis

Using methods previously described (Golen R. P. and Ventura A. K., 2015; Ventura et al., 2019; Ventura and Teitelbaum, 2017), a qualitative analysis of feeding records was conducted to measure mothers' typical levels of technology use during feeding. These data were then used to determine the proportion of daily feedings during which mothers used technology (= [number of feedings wherein use of a technological device was reported/total number of feedings reported] * 100).

SAS v.9.4 (SAS Institute Inc., North Carolina, USA) was used to conduct all quantitative analyses. *A priori* power analysis conducted using G*Power version 3.1.9.7 (Faul et al., 2007) indicated that the study sample size was sufficient to achieve 80% power for detecting a medium effect at a significance level of $\alpha = 0.05$. Descriptive statistics were calculated to describe sample characteristics, and intraclass correlation (ICC) was used to assess the association between the proportion of the meal duration mothers spent focused on their infants during the Digital Media condition and the Control condition. Mixed linear models using SAS PROC MIXED were used to assess the effects of condition (Digital Media vs. Control), maternal attention to the infant (defined as the proportion of the meal duration the mother spent focused on the infant), and condition by maternal attention interactions on maternal sensitivity to cues, response to distress, social-emotional growth fostering, and cognitive growth fostering and infant clarity of cues and responsiveness to the mother. All models were controlled for infant age and the time elapsed since the infants' last feeding. A *p*-value < 0.05 was used to identify statistical significance of main and interaction effects.

3 Results

3.1 Sample characteristics

Table 1 summarizes sample characteristics. The average age of mothers was 31.2 ± 3.4 years (range = 24.9 to 36.1 years), and the majority (76%, $n = 19$) were primiparous. The majority of mothers in this study reported they held a bachelor's or graduate degree (68%, $n = 17$), 72% ($n = 18$) reported their annual family income level was $\geq \$75,000$, 92% ($n = 23$) were married, and 80% ($n = 20$) identified as non-Hispanic white. The sample consisted of 14 female infants (56%) with an average age of 19.3 ± 6.4 weeks (range = 6.2 to 32.0 weeks). Most infants were exclusively breastfed (92%, $n = 23$), while the remaining two participants were fed breast milk and formula. The average proportion of typical feedings during which mothers reported using technology was $23\% \pm 17\%$ of daily feedings (range = 0–83.3%).

3.2 Associations between technology use and maternal attention during mother-infant feeding interactions

Total meal duration ranged from 2.7 to 31.8 min and did not differ between the Control ($M = 14.0$, $S.E. = 1.3$ min) and Digital

TABLE 1 Sample characteristics ($n = 25$).

Mother characteristics	
Age, mean (SD) years	31.2 (3.4)
Parity, % (n) primiparous	76.0 (19)
Marital status, % (n) married	92.0 (23)
Education level % (n)	
Some college or vocational degree	32.0 (8)
College or graduate degree	68.0 (17)
Annual family income, % (n)	
\$15,000–\$34,999	4.0 (1)
\$35,000–\$74,999	12.0 (3)
\$75,000 and above	72.0 (18)
Not reported	12.0 (3)
Race/ethnicity, % (n)	
White Alone, non-Hispanic	80.0 (20)
Black or African American, Hispanic	4.0 (1)
Native American Alone, non-Hispanic	4.0 (1)
Asian Alone, non-Hispanic	8.0 (2)
Hispanic White	4.0 (1)
Infant characteristics	
Sex, % (n) female	56.0 (14)
Age, mean (SD) weeks	19.3 (6.4)

Media ($M = 13.9$, $S.E. = 1.3$ min) conditions ($p = 0.86$). There were more interruptions to mothers' attention to their infants during the Digital Media vs. Control conditions, as indicated by significantly greater bouts per minute for time spent looking at the infant during the Digital Media ($M = 3.7$, $S.E. = 0.2$) vs. Control ($M = 1.7$, $S.E. = 0.2$) condition ($p < 0.001$). This difference between the Digital Media and Control conditions for the number of interruptions to mothers' attention to their infants is illustrated in Figure 1, which presents a data visualization for one representative dyad.

Table 2 shows the proportion of the meal duration mothers spent focused on the infant, tablet, or somewhere else in the room during both conditions. The proportion of the meal duration mothers spent focused on their infant was significantly lower during the Digital Media vs. Control condition; on average, mothers spent 52.5% ($S.E. = 3.9$) of the meal duration focused on their infant during the Digital Media condition, compared to 83.9% ($S.E. = 4.0$) of the meal duration focused on their infant during the Control condition ($p < 0.001$). However, as illustrated in Figure 2, it is notable that there was wide inter-individual variability in mothers' attentiveness to their infants during the Digital Media condition. There was a moderate association between the proportion of the meal duration mothers spent focused on their infants during the Digital Media condition and the Control condition ($ICC = 0.59$).

3.3 Associations between technology use, maternal attention to the infant, and the quality of mother-infant feeding interactions

Mixed linear models were used to examine effects of condition and maternal attention to the infant on maternal sensitivity to infant cues, responsiveness to infant distress, socioemotional growth fostering, and cognitive growth fostering, and infant clarity of cues and responsiveness to caregiver. Models with independent and interactive effects of condition and maternal attention to the infant were tested, but the interactions between condition and maternal attention to the infant were not significant in any model. Thus, models with independent effects of condition and maternal attention to the infant were retained for analysis.

No effect of condition was seen for sensitivity to infant cues ($p = 0.31$), but lower maternal attention to the infant was associated with lower sensitivity to cues across both conditions ($p = 0.03$; Figure 3). No effects of condition ($p = 0.64$) or maternal attention to the infant ($p = 0.36$) were seen for responsiveness to infant distress (Figure 4). Effects of both condition ($p = 0.004$) and maternal attention to the infant ($p < 0.001$) were seen for socioemotional growth fostering (Figure 5), with mothers engaging in greater socioemotional growth fostering during the Digital Media vs. Control condition, but the lower the mother's attentiveness to the infant, the less the mother engaged their infant in socioemotional growth fostering experiences. No effect of condition was seen for cognitive growth fostering ($p = 0.27$), but there was an effect of maternal attention to the infant, with lower maternal attention to the infant associated with less engagement of the infant in cognitive growth fostering experiences ($p = 0.002$; Figure 6).

With respect to infant contributions to the feeding interaction, no effect of condition was seen for infant clarity of cues ($p = 0.06$), but there was an effect of maternal attention to the infant, with lower maternal attention associated with lower infant clarity of cues ($p = 0.001$; Figure 7). Effects of both condition ($p = 0.03$) and maternal attention to the infant ($p < 0.001$; Figure 8) were seen for infant responsiveness to the caregiver, with infants showing greater responsiveness to their mothers during the Digital Media compared to the Control condition but lower maternal attention to the infant was associated with lower child responsiveness.

4 Discussion

The present study examined the impacts of maternal digital media use on mothers' attention to their infants and the quality of mother-infant interactions during infant feeding. We hypothesized there would be more frequent interruptions in mothers' attention to their infants during the Digital Media condition compared to the Control condition, leading to a lower proportion of the meal duration spent focused on the infant. Furthermore, we hypothesized that the displacement of mothers' attention to their infants by attention to digital media would be associated with lower



FIGURE 1
Data visualization of attention states. The X-axis provides the timeline for the meal duration in minutes, starting at 0:00 and continuing until the meal concludes. The Y-axis shows the two feeding conditions: Control (top row) vs. Digital Media (bottom row). The colored bars show where the mother’s attention was focused (tablet, infant, other) and the duration of focused attention. Comparison of the two feeding observations illustrate there were more disruptions to maternal attention to the infant during the Digital Media compared to Control condition.

TABLE 2 Proportion of observation duration mothers spent in each attention state.

	Digital media condition		Control condition		F-value	P-value
	Mean (S.E.)	Range	Mean (S.E.)	Range		
Tablet	42.7 (3.2)	5.6–83.4	0	0	-	-
Infant	52.5 (3.9)	12.5–91.7	83.9 (4.0)	29.7–99.5	64.12	<0.001
Other	4.4 (2.4)	0.3–24.3	16.5 (2.5)	0.5–70.3	12.06	0.0025

Models controlled for infant age and time since last feeding.

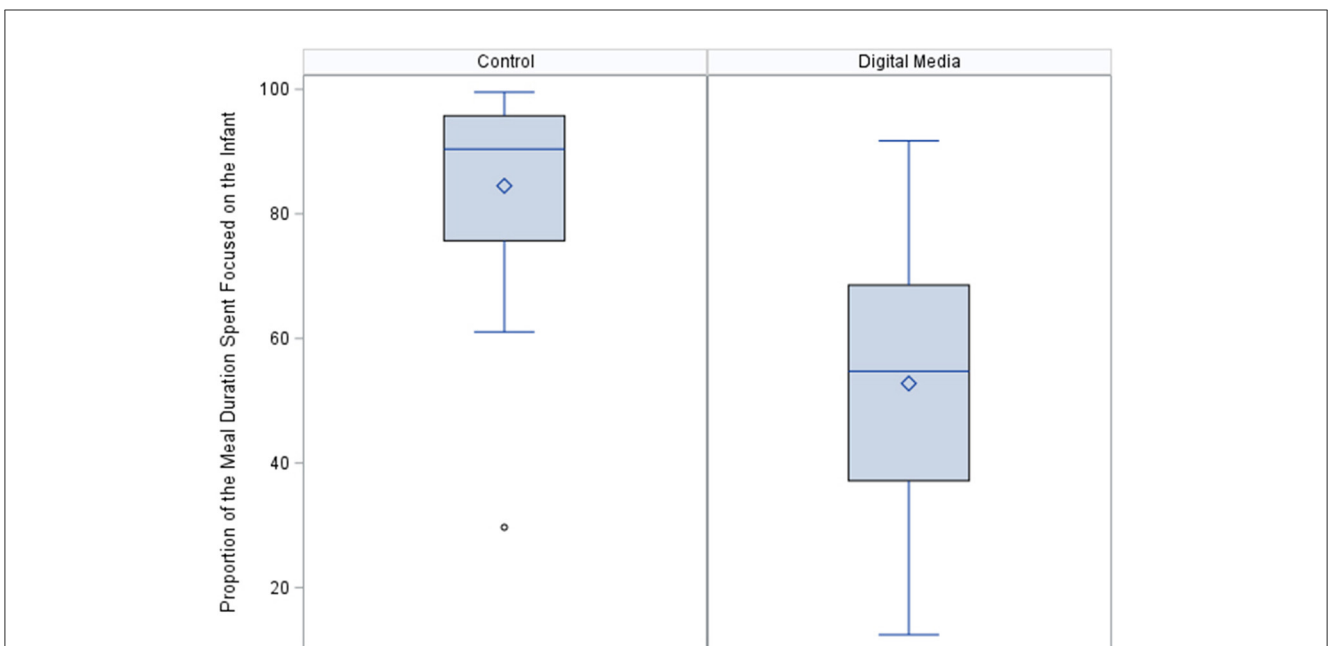


FIGURE 2
Box Plots Illustrating Inter-Individual Variability in Maternal Attention to Infant During the Control vs. Digital Media Conditions. The proportion of the meal duration mothers spent focused on their infants was significantly lower during the Digital Media vs. Control condition ($p < 0.001$).

maternal sensitivity and responsiveness, fewer socioemotional and cognitive growth fostering behaviors, and diminished quality of mother-infant interactions.

In line with these hypotheses, we found that attention shifts were significantly greater during the Digital Media vs. Control condition due to more interruptions in mothers’ attention to their infants when digital media was present. The proportion of time mothers spent attending to their infants was significantly lower during the Digital Media than during

the Control condition, illustrating that time spent attending to digital media directly displaced time focused on the infant. When both condition and maternal attention to the infant were examined as predictors of interaction quality, lower maternal attention to the infant was a more important predictor of some aspects of interaction quality than the mere presence of digital media. This was evidenced by findings that lower maternal attention to the infant, but not condition, was associated with lower maternal sensitivity to cues, cognitive growth

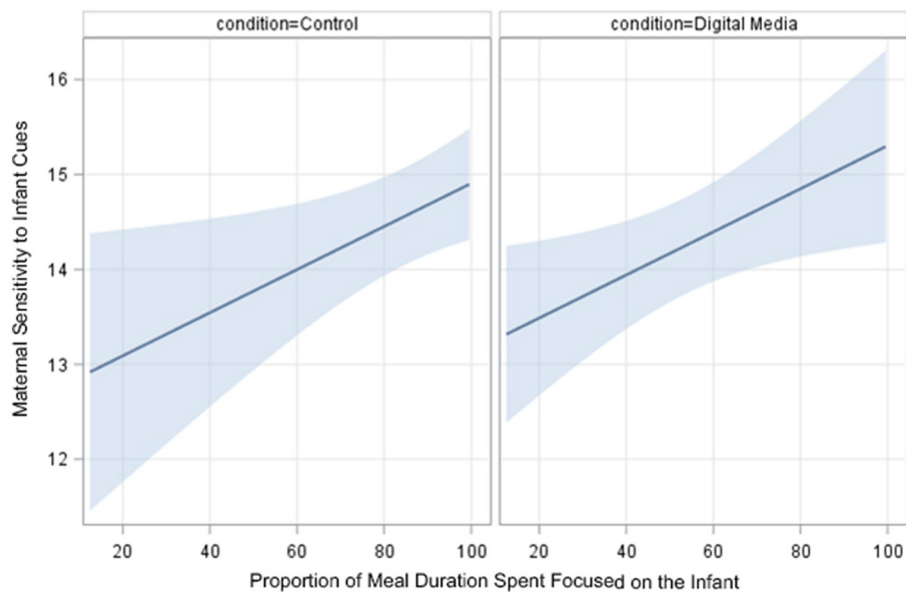


FIGURE 3

Effects of condition and maternal attention on maternal sensitivity to infant cues. No effect of condition was seen for sensitivity to infant cues ($p = 0.31$), but lower maternal attention to the infant was associated with lower sensitivity to cues ($p = 0.03$).

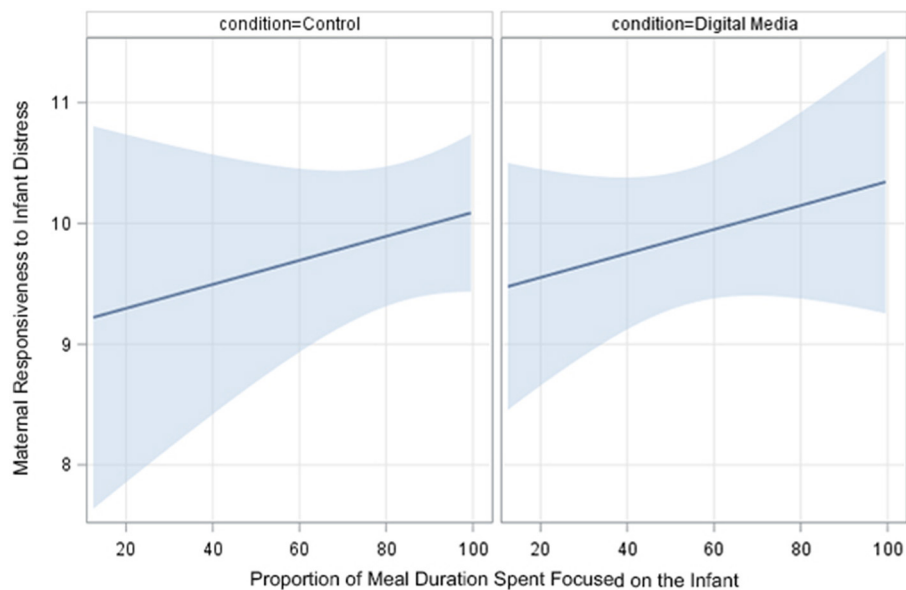


FIGURE 4

Effects of condition and maternal attention on maternal responsiveness to infant distress. No effects of condition ($p = 0.64$) or maternal attention to the infant ($p = 0.36$) were seen for responsiveness to infant distress.

fostering, and infant clarity of cues across both conditions. Lower maternal attentiveness to the infant was also associated with less socioemotional growth fostering and lower infant responsiveness to the mother, regardless of whether digital media was present or absent, but during the Digital Media condition, mothers engaged more in socioemotional growth fostering and infants were more responsive to their mothers than during the Control condition.

Our finding that the presence of digital media during infant feeding interactions led to more interruptions in maternal attention to the infant than when digital media was absent supports the idea that technoferece may occur when technology and digital media are used during caregiver-child interactions (McDaniel and Radesky, 2018a,b; McDaniel and Coyne, 2016). In addition, our results indicated that time spent focusing on digital media directly displaced time spent focusing on the infant,

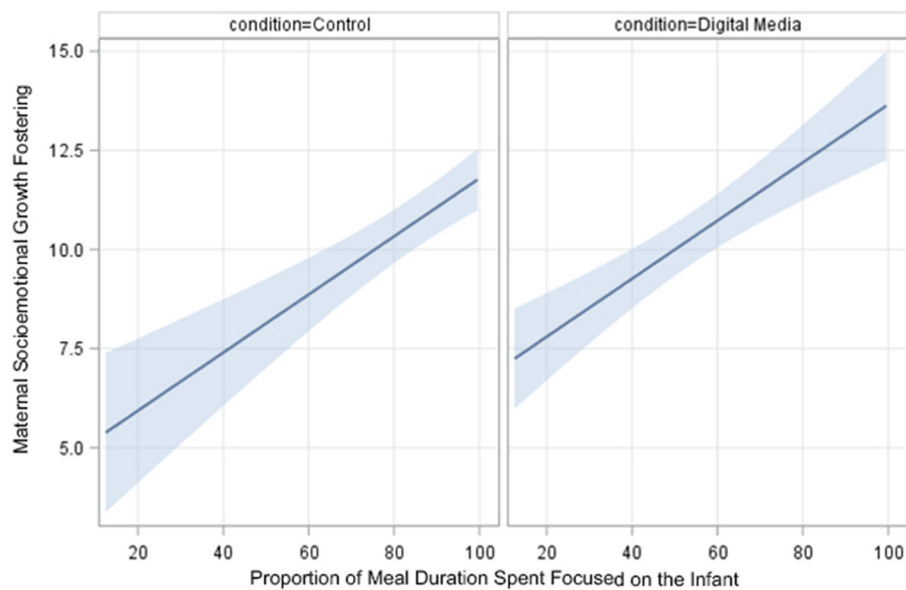


FIGURE 5

Effects of condition and maternal attention on maternal socioemotional growth fostering. Effects of both condition ($p = 0.004$) and maternal attention to the infant ($p < 0.001$) were seen for socioemotional growth fostering. Mothers engaged in significantly more socioemotional growth fostering during the Digital Media compared to Control condition. Lower maternal attention to the infant was associated with less socioemotional growth fostering experiences.

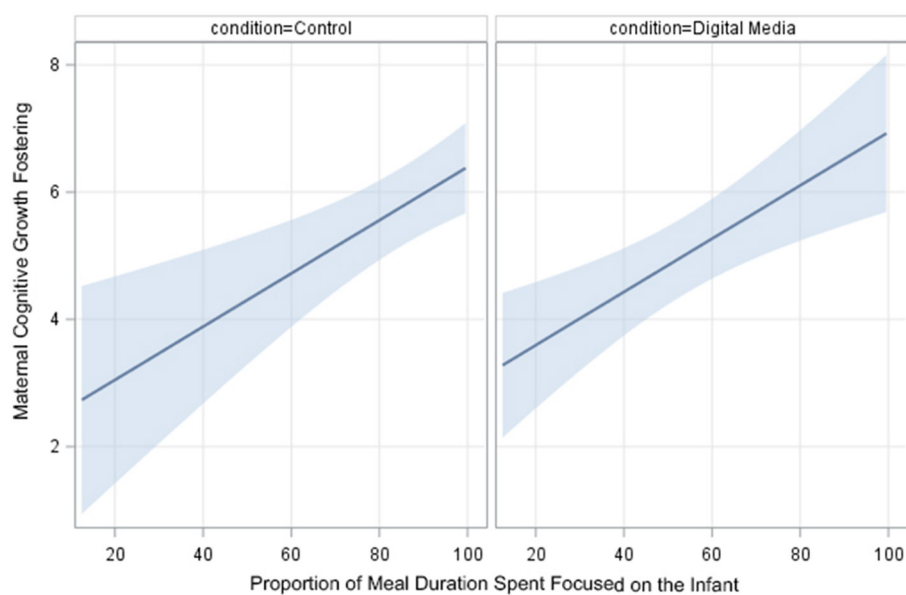


FIGURE 6

Effects of condition and maternal attention on maternal cognitive growth fostering. No effect of condition was seen for cognitive growth fostering ($p = 0.27$), but lower maternal attention to the infant was associated with less engagement of the infant in cognitive growth fostering experiences ($p = 0.002$).

which is consistent with findings from a recent experiment that used eye-tracking glasses to assess maternal gaze patterns objectively and illustrated that mothers spent more time focused on their smartphone than on their infants when asked to use their smartphone during breastfeeding (Nomkin and Gordon, 2021).

The potential implications of technoferece and displacement of maternal attention can be understood within the context of the Barnard Model (Oxford and Findlay, 2015), which emphasizes that components of high-quality feeding interactions are caregivers' abilities to attend to infants' hunger, satiation, engagement, and disengagement cues and contingently respond to these cues in

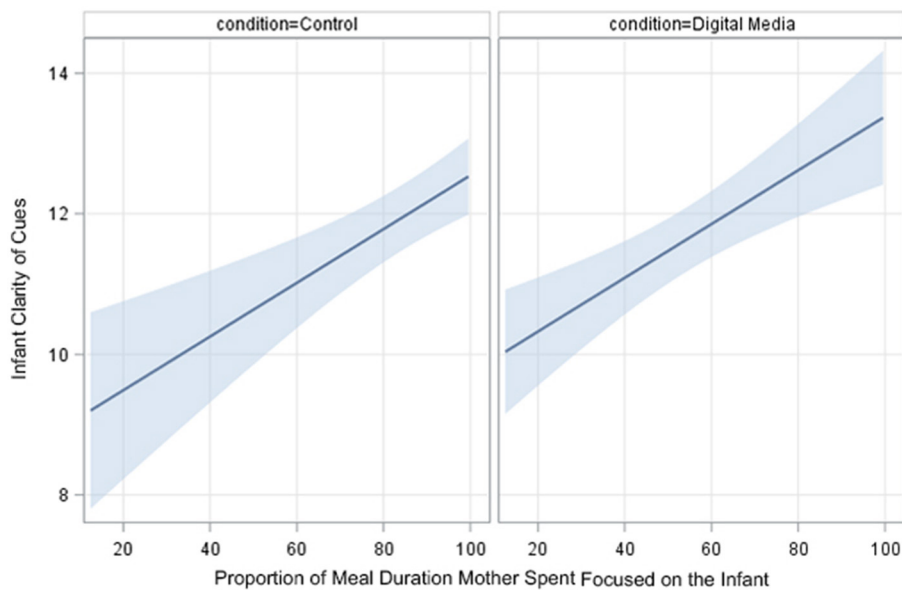


FIGURE 7

Effects of condition and maternal attention on infant clarity of cues. No effect of condition was seen for infant clarity of cues ($p = 0.06$), but lower maternal attention to the infant was associated with lower clarity of cues ($p = 0.001$).

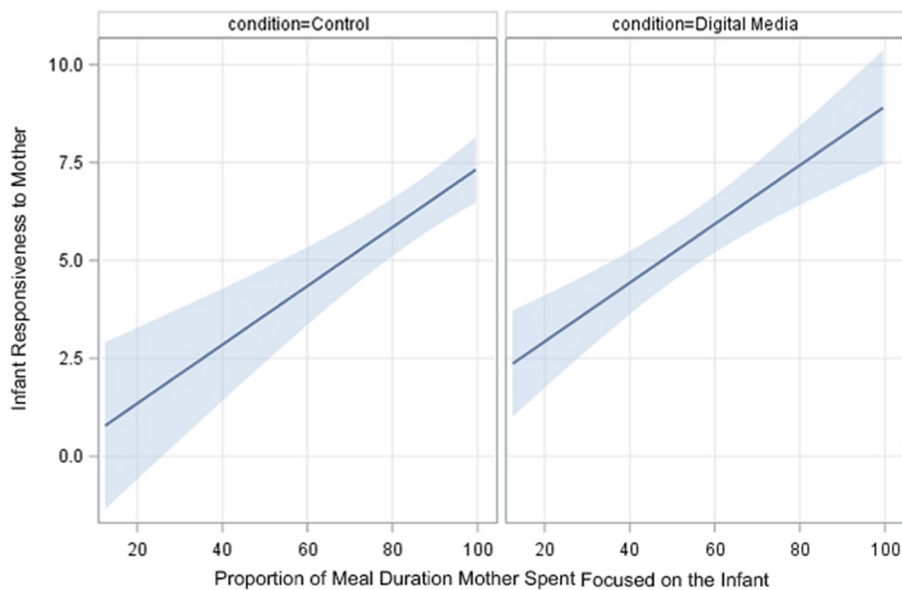


FIGURE 8

Effects of condition and maternal attention on infant responsiveness to caregiver. Effects of both condition ($p = 0.02$) and maternal attention to the infant ($p < 0.001$) were seen for infant responsiveness to the caregiver. Infants showed greater responsiveness to their mothers during the Digital Media compared to Control condition. Lower maternal attention to the infant was associated with lower infant responsiveness to the mother.

developmentally appropriate ways. Also important is the dyad's ability to adapt and engage in mutual regulation. Thus, lowered attentiveness due to technology and digital media use may lead caregivers to miss opportunities to recognize and respond to infant cues, engage their infant in socioemotional and cognitive growth fostering experiences, and create feeding environments supportive of healthy infant growth and development.

Indeed, lower maternal attention to the infant was associated with lower sensitivity to infant cues, socioemotional growth fostering, and cognitive growth fostering, suggesting the extent to which mothers engage with digital media, and not just the mere presence of digital media, may reduce their sensitivity to infant cues and their likelihood of engaging their infants in socioemotional and cognitive growth fostering experiences during feeding interactions.

These findings are consistent with previous observational research illustrating maternal technology and digital media use during infant feeding and care interactions is associated with greater use of non-responsive feeding practices (e.g., lack of involvement in feeding), less joint attention, and lower sensitivity and responsiveness to children's cues (Golen R. P. and Ventura A. K., 2015; Ventura et al., 2020; Golen R. B. and Ventura A. K., 2015; Ventura et al., 2023; Vanden Abeele et al., 2020; Ochoa et al., 2021; Tharner et al., 2022; Ventura and Teitelbaum, 2017; Vik et al., 2021). Previous experimental studies similarly illustrate that mothers' technology and digital media use decreases attentiveness, sensitivity, and responsiveness to their children (Nomkin and Gordon, 2021; Konrad et al., 2021; Krapf-Bar et al., 2022). However, we did not see associations between maternal attention and responsiveness to infant distress (e.g., crying), possibly because infant distress is a potent stimulus for mothers (Bell and Ainsworth, 1973). Thus, mothers' responsiveness to these potent cues may be less affected by the presence of technological distractions or low general attentiveness.

Of note, during the Digital Media condition, we observed wide variability in mothers' attentiveness to the tablet, with some mothers attending to the tablet for ~6% of the meal duration and others attending for ~83%. Thus, some mothers were more impacted by the presence of digital media than others. Previous research highlights several possible reasons for individual differences in mothers' reactivity to the presence of technology. For example, mothers may have differing views on engagement with technology and digital media, with some more relaxed and others more concerned about when and how they use technology and digital media in the presence of their children (Radesky et al., 2016; Oduor et al., 2016). In addition, some mothers may engage with technology and digital media more frequently because they experience benefits of technology and digital media use, such as feelings of social support from the family and friends they interact with online (McDaniel et al., 2012). However, technology and digital media use may also serve as a coping mechanism, as suggested by findings that parents who feel stressed by difficult interactions with their children report using technology to withdraw and cope (McDaniel and Radesky, 2020). Furthermore, mothers experiencing more depressive symptoms report more problematic device usage and greater perceptions of technofence during parenting compared to mothers experiencing fewer depressive symptoms (Newsham et al., 2020). Thus, not all mothers are similarly impacted by the presence of technology or are at risk for technology-induced disruptions in their interactions with their infant, and variability in mothers' absorption with digital media likely reflects variability in mothers' motivations and perceived benefits from engaging with technology and, thus, willingness to engage with it during feedings. These findings support the possibility that targeted interventions aimed at mothers at greater risk for having their mother-infant interactions negatively impacted by technology and digital media are needed to support infants' socioemotional and cognitive growth.

We also noted associations between maternal attention and infant contributions to the feeding interaction, with lower maternal attention to the infant associated with lower infant clarity of cues and responsiveness to the caregiver. Associations between maternal attention to the infant and infant clarity of cues and

responsiveness could represent learned responses on the part of the infant, wherein infants who have learned their mothers are not attentive communicate less and are less responsive to their mothers during mealtime interactions. This interpretation aligns with prior research suggesting that maternal attentiveness shapes infant communicative behaviors (Ainsworth et al., 1991) and is consistent with transactional models of parent-infant interaction, which propose that infants adapt their behaviors in response to repeated patterns of caregiving (Sameroff, 2009). On the other hand, these findings may also represent a learned response on the part of the mother, such that mothers who find their infants' signals unclear or find that their infants do not respond to them are likely to be less engaged during feeding interactions (Goldberg, 1978).

It was also notable that mothers engaged their infants in more socioemotional growth fostering, and infants showed greater responsiveness to their mothers during the Digital Media compared to the Control condition. Previous research suggests that infants' greater responsiveness could be adaptive on the part of the infant (Ventura et al., 2023; Radesky et al., 2014; Ventura et al., 2019; Myruski et al., 2018), meaning that infants responded to the presence of digital media by trying to get their mothers to be more engaged in the interaction. For example, toddlers of mothers who used television or mobile devices during family mealtime interactions showed greater strength of early and subtle satiation cues compared to children of mothers who did not use television or mobile devices (Ventura et al., 2023), which aligns with other observational research illustrating that children responded to parent device use during family mealtime interactions by amplifying their bids for attention (Radesky et al., 2014). Furthermore, an experimental study of 7–24-month-olds found that infants increased the frequency of their social bids for attention when mothers disconnected from a play interaction to engage with a mobile device (Myruski et al., 2018). Similarly, mothers' increases in socioemotional growth fostering during the digital media compared to control condition may have been responsive to infant behaviors or an adaptive response to the presence of digital media (e.g., Coyne et al., 2022). Of note, the NCAFS socioemotional growth fostering subscale includes items that assess whether the mother changes her facial expression, smiles, and laughs during the feeding; thus, it is possible that use of enjoyable digital media elicited these behaviors, which could explain higher socioemotional growth fostering scores during the Digital Media vs. the Control condition. Additional experimental and longitudinal research is needed to understand possible learned and adaptive responses to technology and digital media use during infant feeding interactions and the long-term implications of these responses for infant development.

Study limitations may limit the generalizability of our findings, but also provide possible avenues for future research. Our sample was small, predominantly white, and limited to breastfeeding mothers. In addition, this study occurred within a controlled laboratory environment, not a naturalistic home environment. Exposure to digital media was dictated by our study design but was not typical for some dyads. A strength of this approach is that it allowed us to examine causal impacts of digital media on mother and infant behaviors. However, digital media use during feeding may have been more familiar and comfortable for mothers with typically high use and less familiar and comfortable for mothers

with typically low use, which may have differentially impacted the effects of digital media use on mother and infant behaviors. Within a previous study (Ventura et al., 2019), we did not find that mothers' typical technology and digital media use moderated effects of the digital media condition on mothers' behaviors, but further research with larger, more diverse samples, conducted in home environments, and with additional consideration of typical technology and digital media use is warranted. Video coders were unaware of study research questions, aims, and hypotheses, but it was not possible to mask the experimental conditions to which mothers were exposed; thus, coders may have been biased by their own views on technology and digital media use and how it might influence mother-infant interactions. Within the present study, mothers were asked to watch a television show on a mobile device; this condition was selected because mothers most frequently report watching television during infant feeding (Golen R. P. and Ventura A. K., 2015; Ventura et al., 2020; Ventura and Teitelbaum, 2017), but mothers also frequently text and use mobile apps on smartphones during feeding (Ventura et al., 2020). Texting and use of mobile apps may be more interactive and immersive experiences than watching a television show on a mobile device; thus, further research is needed to examine whether the present study's findings generalize to other types of digital media and mobile device use. Further research examining the implications of different types of mobile device use will provide additional insights regarding the potential impact of maternal technology and digital media use during infant feeding interactions. Finally, this study was cross-sectional and thus can only demonstrate the short-term effects of maternal digital media use on maternal attention and mother-infant feeding interactions. Longitudinal research is needed to understand potential long-term effects on infant development.

In conclusion, the present study demonstrated that maternal digital media use during infant feeding was associated with significant disruptions in maternal attention and lower maternal attention was associated with lower sensitivity to infant cues and reduced engagement in socioemotional and cognitive growth-fostering behaviors. For most dimensions of mother-infant interaction quality, displacement of maternal attention onto digital media was a stronger predictor of interaction quality than the mere presence of digital media. Given the variability in mothers' attentiveness to digital media, future research should explore individual differences and underlying factors contributing to resilience or susceptibility to technological distractions. Additionally, targeted interventions may be necessary to support mothers more adversely affected by digital media use, enhance the quality of mother-infant interactions, and promote infants' socioemotional and cognitive growth. Further studies with larger, more diverse samples and in naturalistic settings are needed to generalize these findings and examine the long-term developmental impacts of maternal digital media use during infant feeding.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by California Polytechnic State University Institutional Review Board (IRB). The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation in this study was provided by the participants (for mothers) and by the participants' legal guardians/next of kin (for infants).

Author contributions

EM: Formal analysis, Investigation, Writing – original draft, Writing – review & editing. TR: Formal analysis, Investigation, Writing – original draft, Writing – review & editing. AV: Conceptualization, Formal analysis, Funding acquisition, Investigation, Methodology, Supervision, Writing – original draft, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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