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The Effect of Maternal Smartphone Distraction on Mother-Child Learning-Based Interaction

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This study assessed the effects of maternal smartphone distraction on mother-child, learning-based interaction. Relying on maternal scaffolding studies and the importance of maternal tutoring, this study determined whether and how a mother being distracted by a smartphone affects three aspects of learning-based interactions: task performance, the child's reactions, and the mother's reactions. The study focuses on five measures: task completion time, number of errors, child input, maternal input, and number of parts assembled by the mother. Seventy-two mothers and their 3- to 6-year-old children (33 girls) participated in this mixed-methods study using both within-subject and between-subject designs. Interrupted and uninterrupted joint mother-child interactions were compared. The findings revealed that maternal smartphone distractions increased task completion time, child's input, and mother's assembly, but decreased mother's input. As mother-child interaction is important for child development, these findings raise developmental concerns caused by maternal smartphone distraction during child tutoring.

Keywords: smartphone distraction, scaffolding, task performance, mother and child input, problem-solving task, experimental study

Smartphones are a significant part of modern life and are used for different purposes (e.g., work, shopping, play) in various public and private settings and for significant proportions of time. Unlike other technologies, smartphones are often in our hands or pockets, enabling us to use them while performing day-to-day activities, such as meeting friends, spending time with spouses, and parenting (Kildare & Middlemiss, 2017; Lederer, Artzi, & Borodkin, 2022; McDaniel, 2019).

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In the last decade, studies have found that parents' smartphone use affects parent-child relationships (Kildare & Middlemiss, 2017; Krapf-Bar, Davidovitch, Rozenblatt-Perkal, & Gueron-Sela, 2022; Lederer et al., 2022). Parents' smartphone use is associated with various negative effects, such as lower parental awareness, sensitivity, and responsiveness to the child; fewer verbal and nonverbal parent-child interactions; parent and child dissatisfaction with the time spent together; and negative reactions by the child (e.g., Konrad et al., 2021; McDaniel & Radesky, 2018; McDaniel, 2019; Myruski, Gulyayeva, Birk, Pérez-Edgar, Buss, & Dennis-Tiwary, 2018).

However, most of these studies relied on observations and parents' self-reports and merely investigated the effect of smartphones on parent-child interactions during free play (e.g., Ewin, Reupert, McLean, & Ewin, 2021; Lederer et al., 2022). Few studies have examined the effects of smartphones in experimental settings. Little is known about the effect of smartphones on parent-child learning-based interactions, despite the importance of these interactions for children's cognitive and emotional development.

This study is a novel attempt to fill this research gap. Relying on studies on maternal scaffolding and the importance of maternal tutoring in learning-based interaction, the present study aims to determine whether and how the mother's distraction with a smartphone affects three aspects of learning-based interactions: task performance, child's reactions, and mother's reactions.

Maternal Smartphone Use and Mother-Child Interaction

Research on the effect of parents' smartphone use on parent-child interaction has mainly examined the extent to which parents' smartphone use affects their attention, sensitivity, and responsiveness toward their child. Studies conducted in both natural settings (e.g., playgrounds, restaurants, waiting rooms for child consultation services) and laboratories found that smartphone use reduces parents' attention, sensitivity, and responsiveness toward the child (Abels, Vanden Abeele, van Telgen, & van Meijl, 2018; Hiniker et al., 2015; Kildare, & Middlemiss, 2017; Krapf-Bar et al., 2022; Lederer et al., 2022; Lemish, Elias, & Floegel, 2020; Morris, Filippetti, & Rigato, 2022; Myruski et al., 2018; Radesky et al., 2014; Wolfers, Kitzmann, Sauer, & Sommer, 2020). Previous findings have revealed that when parents are engaged with their smartphones, children have to make more substantial bids for their attention through multiple modalities and that parents' responses to their children's bids for attention are often disproportionate, impatient, and harsh (Abels et al., 2018; Kildare & Middlemiss, 2017; Lemish et al., 2020; McDaniel, 2021). The degree of decrease in parental attention, sensitivity, and responsiveness was found to be related to the duration (whether the parent was busy with the device for a relatively short or long time) and the frequency of smartphone use in their child's presence (Konrad et al., 2021). The more the parents used the smartphone in the presence of their child, the more significant the decrease was in parental attention, sensitivity, and responsiveness.

Some studies have compared the interference produced by smartphones with that produced by other distractions (e.g., analogous distractions such as reading or writing) to determine whether smartphones interfere with parent-child interaction differently than other distractions (Abels et al., 2018; Ewin et al., 2021; Krapf-Bar, 2022; Lemish et al., 2020). The results often show that the interference produced by smartphones is similar to that of other distractions.

Another aspect of the effect of smartphone use is the satisfaction obtained by parents and children from their interactions and shared time. Studies on this topic have found that smartphone use causes feelings of dissatisfaction in both parents and children, as well as parental feelings of guilt, lower social connection with their children, and worries about their parenting quality (Hiniker et al., 2015; Kildare & Middlemiss, 2017; Kushlev & Dunn, 2019; Steiner-Adair & Barker, 2014).

Studies have also examined the extent to which a parent's use of a smartphone impairs their child's ability to learn from the parent as well as the child's learning and achievements (Kildare & Middlemiss, 2017; McDaniel, 2019). However, most of these studies were based primarily on observation (in homes, public spaces, or a laboratory), parental self-reporting, or a combination of both (Golen & Ventura, 2015; Radesky et al., 2015; Stupica, 2016). To the best of our knowledge, only two studies have experimentally examined the effect of parental smartphone distraction on child learning. Reed, Hirsh-Pasek, and Golinkoff (2017) found a decrease in two-year-old children's word learning when the mother was distracted by a phone call. In contrast, Konrad, Berger-Hanke, Hassel, and Barr (2021) examined 18–20-month-old toddlers' imitation learning—that is, learning how to make a rattle from their parents—under different experimental conditions (no interference, interference before demonstration, single interference between demonstrations, and multiple interferences between demonstrations) and found that technological interference did not disrupt learning. These inconsistent findings highlight the need for further experimental research, as outlined by Krapf-Bar et al. (2022). Therefore, the current study aims to expand existing knowledge on the role of smartphone interference in parent-child learning-based interactions.

Parent-Child Learning-Based Interactions and Maternal Scaffolding

Parent-child learning-based interactions occur regularly throughout child development and represent one of the mechanisms through which human genetic potential is actualized (Bronfenbrenner & Ceci, 1994; Bronfenbrenner & Morris, 2006). Competencies and higher mental abilities necessary for successful functioning within a given society develop through interactions and collaborations between children and more skilled partners, such as caregivers, siblings, or peers (Rogoff, 1990; Vygotsky, 1978). Until they can carry out tasks independently, children rely on their caregivers for assistance. By tailoring interventions to the child's zone of proximal development (Vygotsky, 1978), caregivers help learners increasingly function independently. Therefore, caregivers are said to support, or "scaffold," a child's problem-solving efforts until the child internalizes the skills demonstrated by the caregiver and can perform tasks independently (Mermelshtine, 2017).

Scaffolding (Wood & Middleton, 1975; Wood, Bruner, & Ross, 1976) is defined as the process through which an "expert" partner helps a "novice" partner by increasing or reducing the level of assistance according to the novice partner's performance. This process is based on the premise that the expert partner responds contingently to the novice partner's actions, thereby promoting problem-solving abilities and autonomy in goal-directed activities (Mermelshtine, 2017).

Based on this definition, early studies examined scaffolding in parent-child learning-based interactions and problem-solving tasks (e.g., constructing a three-dimensional wooden structure) by testing the tutors' instruction strategies (Wood et al., 1976). These studies were designed for children to perform a task that was likely beyond their current skills but which could also be achieved with the help of an "expert" partner (Wood & Middleton, 1975; Wood et al., 1976).

These early studies were primarily concerned with describing the scaffolding phenomenon, rather than testing specific hypotheses (Meins, 1997). Their findings suggested that when parents use contingency responses (Wood, Wood, & Middleton, 1978) and adjust their responses to their children's performance, higher dyadic task success is a likely outcome (Conner & Cross, 2003; Meins, 1997).

In contrast, recent scaffolding studies have focused on the association between scaffolding during problem-solving tasks and cognitive outcomes, such as task success, achievement, and executive functioning. For example, Hammond, Müller, Carpendale, Bibok, and Liebermann-Finestone (2012) found that maternal help structuring (such as suggestions when the child is frustrated and not interfering when the child is succeeding) was associated with better executive functioning in children (e.g., higher mental processes that facilitate goal-directed behavior, such as memory, shifting attention, and resisting interference). In a study on mothers and their preschoolers, maternal scaffolding during problem-solving tasks was coded; more scaffolding was associated with better development of children's academic self-regulatory behaviors (Neitzel & Stright, 2003). Notably, a greater transfer of responsibility from mothers to their children was related to higher task persistence and lower disruption.

Several studies have examined the association between scaffolding during problem-solving tasks and socioemotional development, such as cooperation, emotion regulation, and prosocial behavior (Mermelshtine, 2017). For example, maternal contingent responses were associated with more cooperation, better emotion regulation, and less fussing in infancy (Landry, Smith, & Swank, 2006). Furthermore, a longitudinal study on infants revealed how explicit scaffolding, such as encouragement or praise, influences helping behaviors in the child's first year when helping behavior emerges (Dahl, Goeltz, & Brownell, 2022).

In summary, while studies on the association between scaffolding and child development have mainly focused on cognitive aspects, some studies have explored socioemotional aspects (Joussemet & Grolnick, 2022). These studies highlight the importance of mothers' use of contingency responses and the adjustment of their responses to their child's performance in dyadic task success. However, to the best of our knowledge, no scaffolding studies have examined the effect of the distraction of mothers, in general or with smartphones, on mother-child learning-based interaction in a problem-solving task.

Research Goals

This study aims to fill a gap by experimentally investigating the effect of mothers' smartphone distraction on mother-child learning-based interaction during a joint problem-solving task. It seeks to determine the extent to which a mother's distraction from smartphone use affects three aspects of learning-based interaction: task performance, the child's reactions, and the mother's reactions. The study focuses on five measures: task completion time, number of errors, child input, maternal input, and number of parts assembled by the mother. Five hypotheses were proposed:

H1: *Mothers' smartphone distraction will increase task completion time.*

H2: *Mothers' smartphone distraction will increase the number of errors in task completion.*

H3: *Mothers' smartphone distraction will increase child input during task completion.*

H4: *Mothers' smartphone distraction will decrease maternal input during task completion.*

H5: *Mothers' smartphone distraction will increase the number of parts they assemble.*

Method

Participants

Seventy-two dyads of mothers (*M* = 37.55 years, *SD* = 3.69, range: 30–45 years) and their children (33 girls, *M* = 49.29 months, *SD* = 9.30, range: 36–72 months) participated in this study. Participants were Israeli Jews belonging to middle or high socioeconomic status and were recruited in Northern Israel between April 2020 and December 2020 through local community groups and posters displayed at local community centers. Mother-child dyads were eligible to participate if they met the following inclusion criteria: (1) the children were aged between three and six years, (2) the mother used a smartphone daily, (3) the mother reported that the child's development was typical and the child was not diagnosed with any developmental delay, and (4) the task was unfamiliar to the mother and child. The children's age range was selected based on early scaffolding studies (Wood & Middleton, 1975; Wood et al., 1976). In light of previous studies (e.g., Krapf-Bar et al., 2022; Lederer et al., 2022; Myruski et al., 2018), we sampled a homogenous population in the present study to reduce any systematic variation that might have originated from gender or socioeconomic differences.

Data collection was performed in family homes to provide a comfortable and natural setting, at times chosen by the mothers, to ensure a quiet environment and the mother's full attention. Five additional dyads were excluded from the final analysis: two in which the child was too tired to complete all the trials and was later reported as ill, and three that did not meet the inclusion criteria. The required sample size was calculated using G*Power (v.3.1.9.4), assuming a medium effect size (partial $\eta^2 = 0.06$), 95% power to detect an effect, and a correlation of 0.5 between repeated measures. The analysis indicated that a total sample size of 70 was sufficient.

Study Design

The study protocol was approved by the institutional review board of The Max Stern Yezreel Valley College (2020-35 YVC EMEK). This was a mixed study, comprising both within-subject and between-subject designs, to compare interrupted and uninterrupted joint mother-child learning-based interactions. The within-subjects design was based on mothers and children completing three bead-sequencing tasks, one at a time (three trials). The transition from one task to the next occurred when the dyad reported that they had completed the previous task. The between-subjects design was based on a manipulation (smartphone use) performed on the experimental group during the third trial, but not on the control group (see Figure 1).

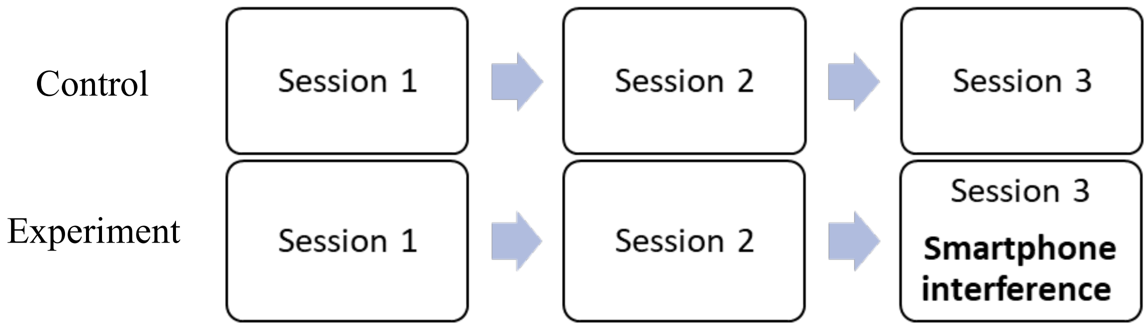

Figure 1. Study design.

Materials and Procedure

A researcher contacted the mothers and explained the research process. For those who expressed a willingness to participate, a visit was scheduled at a time convenient for the family. At the beginning of the meeting, the researcher stated that the purpose of the study was to understand the interactions between mothers and their children during joint play; however, the true purpose of the study was revealed at the end of the meeting after data collection. All mothers signed an informed consent form, and the children provided verbal consent to participate in the study. The mothers and children consented to being videotaped and audiotaped for research purposes.

Mothers were asked to put their smartphones in silent mode and place the device near the researcher "so that it would not distract their attention." Afterward, the mothers and children were introduced to the bead sequencing tasks and told that they would be asked to complete the three tasks. The participants were randomly assigned to the experimental and control groups. They were given the first task and instructed to report when they completed it. After completing each task, the child chose a prize, and the dyad was assigned the next task. In the third task, the manipulation of smartphone interference was performed in the experimental group. Twenty seconds into the task, the researcher handed the mother her smartphone, asked her to open a WhatsApp link sent to her device (via WhatsApp), and complete an online demographic questionnaire. The mother was encouraged to treat this message as she would have when receiving any other message (e.g., an e-mail or WhatsApp message from work). After the third bead sequencing task was completed, the child chose a prize, and the mother was asked to answer a few questions about her smartphone use habits and her perception of the extent to which completing the questionnaire on her smartphone interfered with her interaction with her child. In the control group, there was no interference, and the dyads completed the third task in the same manner that they had completed the previous tasks. In this group, after the third bead sequencing task was completed, the child chose a prize, and the mother was asked a few questions about her smartphone use habits and asked to fill out the online demographic questionnaire sent to her smartphone (via WhatsApp).

In line with the requirements of the institutional ethics committee, the researcher revealed the true purpose of the study to the mothers in both groups after the final questions and questionnaire, answered their questions (if any), and thanked them and their children for their participation. None of the mothers requested that their data not be used after the true purpose of the study was revealed. The entire procedure was videotaped and audiotaped and lasted approximately 25 minutes.

Bead Sequencing Tasks

The bead sequencing tasks were chosen after considering several factors based on the work of Wood et al. (1976). The first consideration was to use unfamiliar games that could arouse interest and pleasure in the children. Second, the tasks should challenge the children in the sense that they would have difficulty solving the tasks on their own and would need their mother's assistance. Third, the tasks should include several components that the mother can teach the child and that the child can learn and develop during the task. Fourth, the tasks should correspond with the cognitive and physical abilities that characterize the age group of the participants; for example, the tasks should only require the child's attention for a short time and not require complex motor skills or physical strength.

Based on these considerations and in consultation with developmental experts, the "Bead Sequencing Set" by "Viga Toys" was selected for use in the study. According to the manufacturer, the set is recommended for children aged three and above. It promotes matching, sequencing, and fine motor skills; encourages creativity; and enhances hand-eye coordination skills. The set included 72 brightly colored wooden beads, 10 patterned wooden panels, 10 round wooden poles, and two cords (the latter were not used in the study), which were all packed in a sturdy wooden tray that doubled as the station that held the dowls upright during playtime (see Figure 2). Of the 10 patterns, three that were identical in their level of difficulty were chosen for this study. At the beginning of each task, the mother and child received a wooden pattern (the patterns were given in fixed order to all the participants). They positioned the patterned panel in a grooved channel on a tray facing a wooden pole (placed upright in a dowl). The task was to place colored beads on a wooden pole in the same sequence as the given pattern. The participants were asked to report to the researchers when they completed the task.

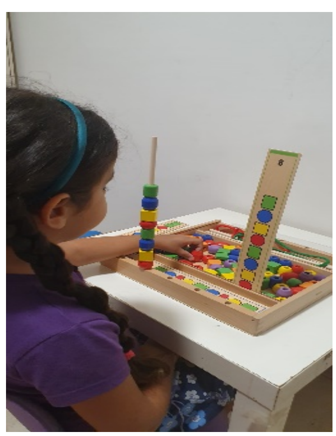

Figure 2. Bead sequencing task.

Mother-Child Learning-Based Interaction Measures

The mother-child learning-based interaction was coded offline from video recordings of each sequencing task by two coders. Coding was based on early scaffolding studies (Wood & Middleton, 1975; Wood et al., 1976) and studies on parent-child interactions during smartphone interference (Lederer et al., 2022). Three aspects of learning-based interaction were coded: task performance, children's reactions, and mothers' reactions.

Task Performance

The mother's and child's performance on each sequencing task was coded using two measures: task completion time and number of errors. Task completion time was the duration of each task, measured in seconds from the moment the task was given until the participants announced that the task was completed. In each task, the mother-child dyads completed a certain pattern. The number of errors was the number of beads that were not placed according to the pattern.

Child's Reactions

The child's reactions to each sequencing task were coded by measuring the child's input, which was the number of utterances produced by the child in each task. An *utterance* was defined as one word or a sequence of words that was preceded and followed by a pause, change in conversational turn, or change in intonation (Rowe, 2012).

Mother's Reactions

The mother's reactions to each sequencing task were coded by two measures: maternal input and the number of parts assembled by the mother. Maternal input was measured as the number of utterances produced by the mother in each task. An *utterance* was defined as one word or a sequence of words that was preceded and followed by a pause, change in conversational turn, or change in intonation (Rowe, 2012). The mother-child learning-based interaction is one in which the mother guides the child to complete the task, but the child actually performs the task (Wood & Middleton, 1975; Wood et al., 1976). The number of parts assembled by the mother was measured as the number of beads placed by the mother on the pole in each task—that is, the number of cases in which the mother performed the task herself instead of guiding the child.

Inter-Coder Reliability

Each coder completed a training video recording before coding the main data and received feedback from an experienced coder. A second recording was provided for further training if inconsistencies were observed in the coding. Eighteen of the video recordings, which comprised 25% of the recordings included in the statistical analyses, were coded by two independent coders to assess inter-coder reliability, which was calculated using two-way mixed consistency and average-measure intraclass correlations (ICCs). The correlation coefficients ranged between .90 and .94.

Statistical Analysis

Group differences in demographic characteristics were analyzed using independent-sample *t*-tests, Pearson's chi-squared test, and Fisher's exact test. The hypotheses were analyzed using a linear mixed model (REML estimation with Satterthwaite degrees of freedom) or generalized linear mixed-model analyses. Models were computed using the GAMLj v.2.6.6 package in jamovi software v.2.3.13, with group (control/experimental) as the between-subjects fixed effect, session as the within-subjects fixed effect, and participants as a random effect (i.e., random intercept). When the software was allowed, the random effect significance was examined using the likelihood ratio test (LRT). Random effects confidence intervals, ICC, and effect size ($R^2_{Marginal}$ and $R^2_{Conditional}$) have been reported when available. $R^2_{Marginal}$ examines the proportion of variance explained by the fixed factors from the sum of all variance components, and $R^2_{Conditional}$ examines the proportion of variance explained by the fixed and random factors from the sum of all variance components.

Significant interactions were followed by simple effects analysis; therefore, rather than examining all possible pairwise comparisons, we examined a small number of comparisons decided upon *a priori*. We examined only the group differences in the first and third sessions and the within-group differences between the third and first sessions for each group separately. Therefore, no multiple-comparison correction was applied.

The fifth hypothesis was also examined using Pearson's chi-squared test, Fisher's exact test, Mann-Whitney U test, and Wilcoxon signed-rank test.

Data points deviating more than 2.5 *SD* from the group mean were considered statistical outliers and were excluded from the statistical analysis. Exclusion was conducted on a case-by-case basis, and no dyad was completely removed from any of the analyses. When conducting nonparametric tests, the Monte Carlo-simulated estimate of the exact *p*-value was reported.

Data Availability

The data and codes necessary to reproduce the analyses presented here are available from the first author, as are the materials necessary to replicate the findings. The analyses were not preregistered.

Results

Cohort Description and Manipulation Check

All participants were Israeli Jews from Northern Israel who belonged to the nation's middle or high socioeconomic class. As shown in Table 1, no group differences were found in the children's age and sex, parents' age, number of working hours, or number of children in the household. All parents in the control group were married, except for one divorced couple and one single mother. Concerning education level, in both groups, roughly 50% of the mothers and fathers had a bachelor's degree, and the remaining 50% of mothers and 30% of fathers had a master's degree or above (maternal education: p = .787; paternal education: p = .844; Fisher-Freeman-Halton exact tests).

Table 1. Cohort Description.

Variable	Control (n = 38) Mean (*SD*)	Experiment (n = 34) Mean (*SD*)	Statistics	*p*
Child's age in months	49.07 (9.52)	49.52 (9.18)	$t_{(70)} = 0.20$	.839
Child's sex	Boys: 47.36% (n = 18) Girls: 52.63% (n = 20)	Boys: 61.76% (n = 21) Girls: 38.23% (n = 13)	χ^2 (1) = 1.49	.245
Mother's age in years	37.02 (3.93)	38.14 (3.36)	$t_{(70)} = 1.29$	.201
Father's age in years	38.86 (5.00)	39.02 (4.58)	$t_{(70)} = 0.14$	.887
Mother's number of working hours	7.93 (1.63)	7.48 (1.92)	$t_{(70)} = -1.06$	.289
Father's number of working hours	8.94 (2.41)	9.35 (0.97)	$t_{(49.83)} = 0.95$	.345
Number of children in the household	2.42 (0.85)	2.44 (0.70)	$t_{(70)} = 0.10$	.914

More than half of the mothers (51.38%, n = 37) reported using a smartphone in their child's presence for an hour or more per day. Additionally, more than half of the mothers (52.77%, n = 38) estimated their smartphone usage to be equal to the usage of other people, whereas one-third of the sample (33.33%, n = 24) estimated it to be lower than that of others; only 13.88% (n = 10) estimated their smartphone usage to be higher than that of others.

Further, to perform the manipulation check, the mothers in the experimental group were asked how disruptive the smartphone was to the completion of the task in the third session. The mean was 5.17 (SD = 1.71) on a scale of 1–7, where 1 indicates *no disruption at all* and 7 indicates *very much*. Thus, the mean indicates a considerable disruption and is significantly different from the scale's 4 indicating *moderate disruption* (one-sample *t*-test; $t_{(33)} = 4.00$, $p < .001$).

Main Analysis

The association between mothers' smartphone distraction and mother-child learning-based interaction was measured using the following: task completion time, number of errors, child input, maternal input, and number of parts assembled by the mother. Table 2 presents the means and standard errors for the five measures.

Table 2. Means and Standard Errors (SE) of the Study's Variables.

Learning-based interaction aspect	**Measure**	**Group**	**Session 1 Mean (*SE*)**	**Session 2 Mean (*SE*)**	**Session 3 Mean (*SE*)**
Task performance	Task-completion time	Control	149.58 (12.22)	159.05 (12.71)	156.91 (12.70)
		Experimental	171.40 (14.31)	137.91 (12.19)	197.54 (16.12)
	Number of errors	Control	6.94 (0.29)	6.02 (0.29)	6.00 (0.29)
		Experimental	6.70 (0.31)	6.05 (0.31)	5.44 (0.31)
Child's reaction	Child's input	Control	17.08 (1.71)	15.48 (1.70)	14.70 (1.73)
		Experimental	13.74 (1.88)	15.86 (1.84)	17.47 (1.86)
Mother's reaction	Mother's input	Control	23.50 (2.99)	20.60 (2.63)	18.80 (2.43)
		Experimental	22.33 (2.98)	17.60 (2.37)	12.25 (1.69)
	Probability of mother's assembly	Control	0.08 (0.07)	0.07 (0.07)	0.01 (0.01)
		Experimental	0.08 (0.07)	0.08 (0.07)	0.23 (0.13)
	Number of beads assembled by the mother	Control	Median = 0 IQR = 0–0 Min-Max = 0–4	Median = 0 IQR = 0–0 Min-Max = 0–4	Median = 0 IQR = 0–0 Min-Max = 0–5
		Experimental	Median = 0 IQR = 0–0 Min-Max = 0–5	Median = 0 IQR = 0–0 Min-Max = 0–5	Median = 0 IQR = 0–2 Min-Max = 0–8

Furthermore, the contributions of the children's age and sex to the models were examined. Age was a significant predictor but did not change the results described below, and sex was not significant in any of the models. Therefore, both were omitted from the analyses to ensure that the models were parsimonious.

H1: Mothers' Smartphone Distraction Will Increase Task Completion Time

The data were analyzed using a Gaussian generalized linear mixed model with a log link function. The random effect ($\sigma^2_{\text{Intercept}}$ = 368.45) could not be tested using the LRT, and the confidence intervals or ICC could not be computed. However, this effect seemed substantially larger than zero. Further, a significant group × session interaction was found ($\chi^2_{(2)}$ = 24.27, p < .001). While no group difference was found at baseline (Z = −1.16, p = .243), a significant difference was found in the third session (Z = −2.00, p =

.045); therefore, the experimental group (*M* = 197.54, *SE* = 16.12) required a significantly longer time to complete the task compared with the control group (*M* = 156.91, *SE* = 12.70). An examination of within-group differences showed that the experimental group (Z = 3.07, $p = .002$) required a significantly longer time to complete the task in the third session than at the baseline (*M* = 171.40, *SE* = 14.31). No within-group differences were observed in the control group (Z = 0.84, $p = .397$).

H2: Mothers' Smartphone Distraction Will Increase the Number of Errors in Task Completion

The data were analyzed using a linear mixed model. The random effect ($\sigma^2_{\text{Intercept}}$ = 1.99; 95% C.I. = 1.32, 2.93; ICC = .59) was significant (LRT = 72.78, $p < .001$). The fixed and random effects explained 62.65% of the variance ($R^2_{\text{Conditional}}$), whereas the fixed effect alone explained 6.88% (R^2_{Marginal}). Contrary to our hypothesis, the group × session interaction was not significant ($F_{(2,140)} = 1.18$, $p = .310$), indicating that the mothers' smartphone distraction did not increase the number of errors in the third session. However, a significant main effect of session was found ($F_{(2,140)} = 17.42$, $p < .001$). As we did not hypothesize this main effect *a priori*, a Holm correction for multiple comparisons was applied to the *p*-value. Post hoc testing showed that the number of errors was lower compared with the baseline (*M* = 6.82, *SE* = .21) in both the second ($t_{(140)} = 4.06$, $p_{\text{holm}} < .001$; *M* = 6.04, *SE* = .21) and third ($t_{(140)} = 5.73$, $p_{\text{holm}} < .001$; *M* = 5.72, *SE* = .21) sessions, indicating that both groups made fewer errors in the second and third sessions compared with the baseline. No difference was found between the second and third sessions ($t_{(140)} = 1.67$, $p_{\text{holm}} = .097$).

H3: Mothers' Smartphone Distraction Will Increase Child Input During Task Completion

The data were analyzed using a linear mixed model. The random effect ($\sigma^2_{\text{Intercept}}$ = 58.98, 95% C.I. = 37.78, 89.10; ICC = .58) was significant (LRT = 55.50, $p < .001$). The fixed and random effects explained 58.70% of the variance ($R^2_{\text{Conditional}}$), whereas the fixed effect alone explained 1.54% (R^2_{Marginal}). There was a significant group × session interaction ($F_{(2,120.08)} = 3.38$, $p = .037$). There were no significant between-group differences at baseline ($t_{(114.07)} = -1.31$, $p = .192$) or in the third session ($t_{(113.62)} = 1.08$, $p = .278$), but within-group differences were found in the experimental group ($t_{(119.57)} = 2.15$, $p = .033$). The children's input was higher in the experimental group in the third session (*M* = 17.48, *SE* = 1.86) than in the first session (*M* = 13.75, *SE* = 1.88). No within-group differences were found in the control group ($t_{(120.39)} = -1.48$, $p = .141$).

H4: Mothers' Smartphone Distraction Will Decrease Maternal Input During Task Completion

Data were analyzed using a negative binomial generalized linear mixed model. The random effect ($\sigma^2_{\text{Intercept}}$ = 0.45) could not be tested with the LRT, but the confidence interval did not include zero (95% C.I. = 0.31, 0.68). There was a significant group × session interaction ($\chi^2_{(2)} = 8.25$, $p = .016$). While no significant group difference was found at baseline (Z = 0.27, $p = .781$), a significant difference was found in the third session (Z = 2.26, $p = .023$); mothers' input was lower in the experimental group (*M* = 12.25, *SE* = 1.69) than in the control group (*M* = 18.80, *SE* = 2.43). An examination of within-group differences showed that in both the experimental (Z = −6.03, $p < .001$) and control (Z = −2.48, $p = .012$) groups, mothers' input significantly decreased in the third session compared with the baseline. Notably, the decline was more substantial in the experimental group than in the control group.

H5: Mothers' Smartphone Distraction Will Increase the Number of Parts They Assemble

The continuous variable of the number of beads assembled by the mother was found to have an excess number of zero values: the mean percentage of zero values from total observations across groups and sessions = 76.18%, *SD* = 7.00%, median = 76.39%. This indicates that the variable was zero-inflated (Martin et al., 2005). Therefore, the hypothesis was tested using several analyses to examine different aspects.

First, in each group, the proportion of mothers who assembled beads (regardless of the number of beads assembled) was compared with the proportion of mothers who did not assemble at baseline and in the third session. While no group difference was found at baseline ($\chi^2_{(1)} = 0.00$, $p > .999$; both groups at 23%), there was a significant difference in the third session ($\chi^2_{(1)} = 4.87$, $p = .049$); the proportion of mothers who assembled beads in the experimental group (35.29%, $n = 12$) was higher than that in the control group (13.15%, $n = 5$). Furthermore, group differences in the proportion of mothers who assembled beads in the third session but not at baseline, and vice versa, were examined; a significant difference ($p = .004$; Fisher's exact test) was found. Seven additional mothers assembled beads in the third session in the experimental group (20.58%, $n = 7$), but only one additional mother did so in the control group (2.63%, $n = 1$). Interestingly, while no mother in the experimental group assembled beads only at baseline (and did not assemble in the third session), five mothers in the control group assembled beads only at baseline (13.15%, $n = 5$).

A probit generalized linear mixed model on the dichotomized variable (assembled/not assembled) was conducted to examine the probability of maternal bead assembly while considering the repeated measures nature of the data. The random effect ($\sigma^2_{\text{Intercept}} = 2.95$, ICC = .74) could not be tested with the LRT, but the confidence interval did not include zero (95% C.I. = 1.13, 7.94). The fixed and random effects explained 75.98% of the variance ($R^2_{\text{Conditional}}$), whereas the fixed effect alone explained 5.02% (R^2_{Marginal}). A significant group × session interaction was found ($\chi^2_{(2)} = 6.00$, $p = .049$). While no group difference was found at the baseline ($Z = 0.06$, $p = .948$), a significant difference was found in the third session ($Z = 2.20$, $p = .027$). The probability of mothers in the experimental group assembling beads (0.23, *SE* = 0.13) was higher than that in the control group (0.01, *SE* = 0.01). On examining within-group differences, no significant change in the probability of mother assembly was found between the baseline and the third session in both the experimental (Z = 1.46, $p = .144$) and control (Z = −1.66, $p = .094$) groups.

Finally, the number of beads assembled by mothers in the two groups was examined. The Mann-Whitney U test indicated that there was no difference in the number of beads assembled by the mothers at baseline in both groups ($U = 645$, Z = −0.01, $p = .991$), but there was a significant difference in the third session ($U = 511.50$, $Z = -2.03$, $p = .044$). A higher number of beads were assembled by the mothers in the experimental group (median = 0, IQR = 0–2, range = 0–8) compared with those in the control group (median = 0, IQR = 0–0, range = 0–5). No within-group differences, examined using the Wilcoxon signed-rank test, were found for the experimental ($Z = -1.31$, $p = .203$) or control ($Z = -1.06$, $p = .373$) groups.

The results of these analyses are presented in Figure 3.

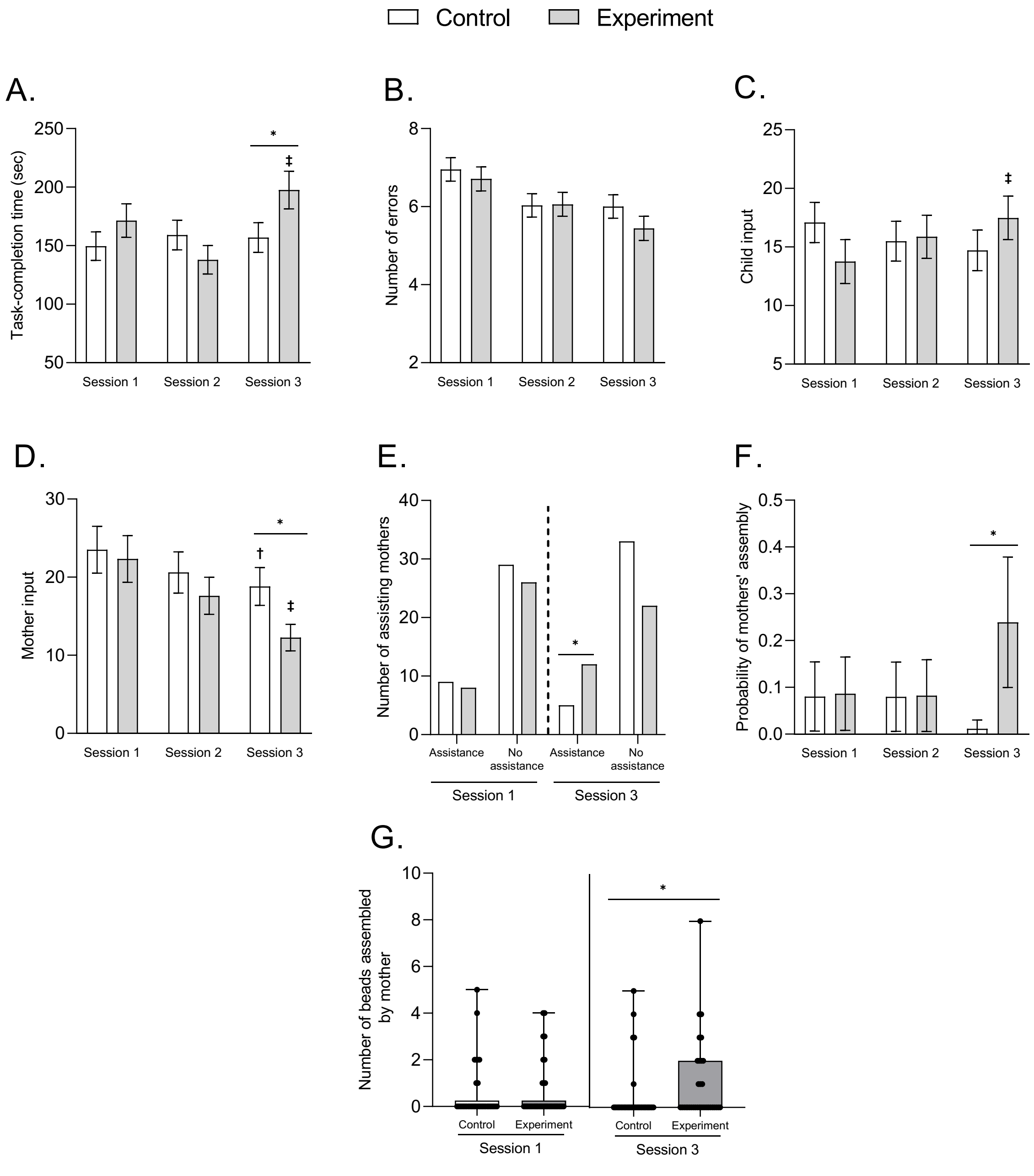

Figure 3. Main analysis.

Note. *p < .05. ‡ indicates a significant difference from baseline in the experiment group (p < .05). † indicates a significant difference from baseline in the control group (p < .05). (A) Children in the experimental group required a longer time to complete the task in the third session compared with those in the control group. (B) No difference in the number of errors between the groups and the sessions. (C) Children in the experimental group gave more input in the third session compared with baseline. (D) Mothers from both groups gave less input in the third session compared with baseline, and mothers in the experimental group gave less input than mothers in the control group. (E) More mothers in the experimental group assembled parts in the third session compared with those in the control group. (F) Mothers in the experimental group had a higher probability of assisting their child in the third session compared with mothers in the control group. (G) In the third session, mothers in the experimental group assembled more parts than mothers in the control group, while no difference was found at baseline.

The results suggest that, as hypothesized, mothers in the experimental group assembled more beads than those in the control group during the third session. This is observed from the higher probability of bead assembly, the greater number of assemblies by mothers, and the increased total number of assembled beads.

Discussion

The present study aimed to empirically examine the effect of mothers' smartphone distraction on mother-child learning-based interaction during a joint problem-solving task. Relying on maternal scaffolding studies and the importance of maternal tutoring in learning-based interactions, this study determined whether and how a mother's distraction with a smartphone affects three aspects of the learning-based interaction: task performance, child's reactions, and mother's reactions.

This study proposed five hypotheses. Hypotheses 1 and 2 predicted that mothers' smartphone distraction would disrupt task performance by increasing task completion time and the number of task errors. The findings confirmed Hypothesis 1, but not Hypothesis 2. Hypothesis 3, which predicted that mothers' smartphone distraction would increase children's reactions, was confirmed. Hypotheses 4 and 5 predicted that a mother's smartphone distraction would disrupt her reactions by decreasing the mother's input and increasing the number of beads assembled by her. Hypotheses 4 and 5 were also confirmed.

These findings indicate that mothers' smartphone distraction interferes with mother-child learning-based interaction during a joint problem-solving task. A comprehensive observation of the findings suggests that when the mother is distracted by her smartphone, her reactivity toward the child and the joint task decrease. The mother's distraction leads to more input from the child, apparently in an attempt to gain her attention. The mother's distraction and the child's repeated bids for attention resulted in an extension of the task completion time. Finally, it can be assumed that it is this dynamic between the mother and the child that causes the mother to assemble more beads herself instead of allowing the child to assemble them on their own. This may explain why the mother's smartphone distraction did not increase the number of errors—the mother still completed the task correctly.

The results of this study and the suggested dynamics are consistent with the findings of previous studies. Reduced maternal attention, sensitivity, and responsiveness toward the child when engaged with smartphones (manifested in the study by reduced mothers' input) is well-documented (e.g., Abels et al., 2018; Lederer et al., 2022; Lemish et al., 2020; Wolfers et al., 2020). Increased assembly by mothers after the distraction can be interpreted as a disproportionate and impatient response to the child's bids for attention, as documented in previous studies (Abels et al., 2018; Lemish et al., 2020; McDaniel, 2021). Another possible explanation is that the increased assembly is an attempt to compensate the child for the time the mother was distracted; it has been observed in studies that after distraction, parents became more attentive to and engaged with their children, sometimes even more than before the distraction occurred (Boles & Roberts, 2008; Hiniker et al., 2015). Children's increased input is consistent with suggestions that mothers' engagement with smartphones and reduced responsiveness result in the children making greater efforts to gain attention (Abels et al., 2018; Kildare & Middlemiss, 2017). Although the effect of mothers' distraction with smartphones on mothers' and children's task performance has not been studied in the past, the findings of the current study are supported by previous studies demonstrating that technoference and mothers' distraction affect children's learning and achievements (McDaniel, 2019; Stupica, 2016).

Analysis of the learning process among the mother-child dyads according to the concept of maternal scaffolding relies on the comparison of the dyads' task performances in the experimental and control groups. The analysis of the control group revealed that while task performance improved, the mothers' input and bead assembly decreased. These changes suggest that the mothers adjusted their responses to the children's performance and used contingent responses that allowed the children to learn and improve. This dynamic can also be observed in the first two tasks in the experimental group and is consistent with previous studies on maternal scaffolding that highlight the importance of contingency and mothers adjusting responses to task success (Conner & Cross, 2003; Meins, 1997; Mermelshtine, 2017). By tailoring maternal responses to the child's zone of proximal development (Vygotsky, 1978), mothers enhance the child's learning and independence (Mermelshtine, 2017), and the distraction of mothers via smartphone use interrupts this dynamic.

When the mothers were distracted by smartphones, an impairment in task performance was observed. The mother's distraction apparently changed her maternal scaffolding pattern, and her responses became less contingent (because the mother's input decreased substantially, although the child's input increased substantially). This change was also apparent in the increase in the mothers' assembly and the finding that more mothers assembled beads after distraction compared with the tasks before. Expressly, the mothers who did not exhibit scaffolding by assembling beads in tasks one and two changed their scaffolding patterns, or assembled, in the third task. To the best of our knowledge, this is the first study to examine the effects of smartphone distraction on mother-child learning-based interaction during a joint problem-solving task. The study found that maternal distraction affected the mothers' reactions and resulted in impaired task performance. The scope of this influence and its possible consequences should be studied further.

This study has several methodological strengths. The controlled setting, randomized group extension, and relatively large sample allowed the researchers to recognize the effects of the distraction of mothers by smartphones on mother-child learning-based interactions. Additionally, the reliance on several measurements assessing different aspects of the interaction (task performance, children's responses, and mothers' responses) allowed for a multidimensional observation of mother-child dynamics.

However, this study has some limitations. The generalizability of the findings may be restricted to the particular smartphone use feature tested in this study (i.e., answering an online questionnaire). This activity resembles the mother's use of her smartphone for texting (such as sending e-mails or SMS); these activities may prevent her from maintaining eye contact with and gesturing to the child, as the act of texting would require her active attention (Konrad et al., 2021). Other smartphone functions (e.g., phone calls, visiting social apps, reading articles) may interfere differently and therefore should be examined in future studies.

Further, generalizability concerns involve the characteristics of the sample. The present sample included only mothers. Given the differences between mother-child and father-child interaction patterns (John, Halliburton, & Humphrey, 2013; Robinson, Stgeorge, & Freeman, 2021) and gender differences in smartphone use (Chen et al., 2017), the effects of smartphone-induced distraction on father-child learning-based interaction should be studied separately. Additionally, all the participants in the present study had middle- or high-socioeconomic statuses. As there may be socioeconomic differences in screen use (Krogh, Egmose, Stuart, Madsen, Haase, & Væver, 2021; Nagata et al., 2022), future studies could study the effects of smartphone-induced behavior across diverse socioeconomic groups.

Future studies could also compare the extent to which smartphone distractions differ from non-technological distractions of mothers (e.g., filling out a questionnaire manually, reading a magazine article, or solving a crossword puzzle). However, in recent years, the performance of these actions, which were previously not done on a smartphone, are being transferred to the device; hence, the relevance of these studies to everyday life in the current context is decreasing. Therefore, it may be more relevant to examine the differences in parental distractions and responsivity to children caused by different actions on the smartphone, as suggested above.

In conclusion, this study demonstrated the negative effects of maternal distraction with a smartphone on mother-child learning-based interaction. Given the importance of this interaction to child development in numerous domains (e.g., cognition and socioemotional regulation), the findings raise developmental concerns due to maternal smartphone distraction during child tutoring. Pediatric health professionals should consider counseling mothers to avoid or reduce their use of smartphones while engaging in joint mother-child learning tasks. Because maternal smartphone use is sometimes automatic, increasing awareness may encourage mothers' self-monitoring behavior around children. Simple strategies, such as turning off notifications, putting the smartphone in another room, or designating technology-free times, can help mothers actively reduce distractions from smartphones when interacting with their children.

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