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Learning on Hold: Cell Phones Sidetrack Parent-Child Interactions

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Although research suggests that responsive interactions are imperative for language development, the advent of mobile technology means that parent-child exchanges are often fraught with unpredictable interruptions. Less clear is how these momentary breaks in responsiveness affect word learning. In this within-subjects design, 38 mothers taught their 2-year-olds (M = 27.15 months) 2 novel words, 1 at a time. One teaching period was interrupted by a cell phone call. Children learned the word when the teaching was not interrupted, but not when it was interrupted. Critically, the number of times each target word was spoken did not differ by condition. This finding supports the literature on responsiveness, offering experimental evidence that interruptions in social interactions can affect learning outcomes.

Keywords: language development, word learning, parent-child interactions, interruptions

We are engaged in a great natural experiment. With the click of a button we talk, text, and share photos. These possibilities lead not only to unprecedented connectivity but also to overwhelming distraction. Despite the sense that we can jointly attend to devices and tasks at hand, laboratory studies suggest otherwise. Only 2% of us multitask without any attentional deficits (Watson & Strayer, 2010). The ubiquitous use of mobile technology also disrupts social rhythms in face-to-face interactions (Radesky et al., 2014). In language development, for example, young children rely on sensitive and responsive caregivers who offer prompt and meaningful input (Tamis-LeMonda, Kuchirko, & Song, 2014). Together, parent-toddler dyads establish shared referents, which facilitate the word-to-world mapping process. By age 2, children are sensitive to the social input that adult speakers offer. At around this time, children's word learning strategies move from relying more on perceptual cues to realizing the importance of cues such as eye gaze and pointing in determining word-to-world reference (Hollich, Hirsh-Pasek, & Golinkoff, 2000; Yurovsky & Frank, 2015). Thus, studying 2-year-olds who are attuned to social information offers a prime test of the consequences for word learning when dyadic exchanges are disrupted.

Word learning occurs in the nexus of social interaction (Tamis-LeMonda et al., 2014; Tomasello, 2003). Longitudinal data revealed that the fluency and connectedness of parent-child interactions at 24 months of age predicted children's language outcomes a year later (Hirsh-Pasek et al., 2015). Bloom and Tinker's (2001) *principle of relevance* suggests that word learning works best when caregivers respond in a temporally contingent manner and expand and elaborate upon children's contributions (Dieterich, Assel, Swank, Smith, & Landry, 2006; Dunham, Dunham, & Curwin, 1993; Goldstein & Schwade, 2009; McGillion et al., 2013; Page, Wilhem, Gamble, & Card, 2010). By contrasting 2-year-olds' word learning following live, Skype, or prerecorded video training sessions, Roseberry, Hirsh-Pasek, and Golinkoff (2014) isolated social contingency as a mechanism that underpins toddlers' acquisition of novel verbs. The Skype condition bridged the live and prerecorded video conditions, preserving the social contingency (as in the live condition) but presented the content through screen media (mirroring the prerecorded condition). Children's performance following Skype training was indistinguishable from those in the live condition, suggesting a powerful role for social contingency during word learning interactions. In this developmental epoch of young toddlerhood (i.e., 18 months to 3 years), meaningful and temporally contingent interactions may be particularly salient, signaling intentionality and pedagogical relevance.

Infants are sensitive not only to caregiver responsiveness that is contingent on their behavior, but also to disruptions in the flow of natural interactions (Bigelow & Best, 2013; Henning & Striano, 2011). In the classic Still-Face studies (for a review, see Mesman, van Ijzendoorn, & Bakersman-Kranenburg, 2009), caregivers begin by interacting naturally with their infants but become suddenly unresponsive for a short period. The session ends with a reunion phase during which caregivers reengage with their babies. Infants as young as 2 months detect these changes in caregivers' behavior (Bigelow & Power, 2014). Developmentally, infants' sensitivity to the social rhythm of back-and-forth exchanges manifests as an appreciation for shared goals in toddlerhood. For example, when a

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child and experimenter play a game together and the experimenter unexpectedly stops participating, preschoolers will attempt to re-engage with their partners to complete the joint activity (Gräfenhain, Behne, Carpenter, & Tomasello, 2009; Warneken, Gräfenhain, & Tomasello, 2012).

The current study builds on past work by asking whether 2-year-olds are sensitive to disruptions within the dynamic flow of a word-learning task. Some research suggests that this will be the case. For example, preschoolers in Breazeal et al.'s (2016) study interacted with two robots that differed in their degree of contingent responsiveness. When asked by an experimenter to name an unfamiliar object, children turned more often to the responsive robot for help. Likewise, mothers with depressive or anxious symptoms provide children with atypical temporal contingency patterns (Beebe et al., 2008, 2011). These children are at a higher risk for language delays (Sohr-Preston & Scaramella, 2006). Interruptions offer a test of social contingency by experimentally manipulating the back-and-forth exchanges of parents and children. Given that the social nature of language development occurs within the dyad (Tomasello, 2008), the present study examines this question *within* the dyadic flow of a conversation. Although this line of inquiry has its roots in the distraction literature, the experimental manipulations used in previous studies disrupted individual *children* rather than dyadic interactions (Dixon et al., 2012; Newman, 2011; Wyss, Kannass, & Haden, 2012). For example, Dixon and Salley (2010) utilized interruptions in their investigation of environmental distractions during a novel word learning task and found that word learning was impaired relative to baseline performance. The current study builds upon this foundation. By interrupting the caregiver, the dyad is confronted with a break and the unfolding interaction is momentarily paused. We hypothesized that 2-year-olds would notice the disruption and that it would impact word learning—even if the words were offered to children many times. Alternatively, no difference in word learning may emerge because the two teaching periods will not differ in total teaching time—60 s—allowing mothers to offer the novel words with sufficient frequency to overcome the interruption. Using Roseberry, Hirsh-Pasek, and Golinkoff's (2014) stimuli, we pitted these two hypotheses against one another.

Method

Participants

Forty-four mothers (M_{age} = 35.26 years, age range: 29.53–47.10 years; 19 mothers did not report their age) and their 2-year old typically developing children (22 females; M_{age} = 27.05 months, SD = 2.89) participated. Participants were recruited from a purchased list of area births. Drawn from suburban communities surrounding Philadelphia, PA, the sample was primarily Caucasian (9.10% of families self-identified as Hispanic, Pacific Islander, African American, or multiethnic). Two additional children did not complete the experiment because of fussiness; 3 were excluded because of parental reports of children's hearing or language delays. Four sessions encountered a technical error (e.g., camera failed to record or cell phone failed to connect). Data from seven children were excluded because mothers did not answer an incoming call, failing to follow protocol.

Design and Variables

This study used a within-subjects design to contrast word learning across an interrupted and uninterrupted (control) teaching period. Mothers taught two novel words to their children, one at a time, counterbalanced for order of presentation. Random assignment determined whether the first or second teaching period would be interrupted by a brief (30 second) phone call with the experimenter (see Figure 1). A measure of parents' mobile technology use was collected; mothers self-reported the average number of calls and texts they received and sent each day. A *total cell phone use* variable was calculated as the sum of the number of calls and texts sent and received per day.

The Intermodal Preferential Looking Paradigm (IPLP; Golinkoff, Ma, Song, & Hirsh-Pasek, 2013; Hirsh-Pasek & Golinkoff, 1996) was used to assess children's comprehension of the novel action words. Given that the mother was not the actor in the videos, this was an immediate test of learning and extension as Sesame Street characters performed the actions. Table 1 shows the layout of the videos for each word. Children watched two scenes (presented side-by-side simultaneously) as they heard an instruction to find a particular action. If children learned the new words, they should direct their visual attention more to the matching scene. The dependent measure was the proportion of time that children attended to the matching scene during test trials.

Procedure

Maternal training. Before each session, an experimenter demonstrated each action to mothers in a separate room and labeled them with the novel word. An 18-in gender-neutral doll was the direct object for the verb *blicking* (i.e., a variation on bouncing) and a 6-in silent maraca was used to enact *frepping* (i.e., a variation on shaking). Mothers also received instruction on how to answer the Samsung S125G cell phone set on vibrate; the experimenter told the mothers to expect occasional phone calls from her. Parents were told the purpose of the cell phone, explained as a way for the experimenter to share directions with the mother, such as when it was time to move from one word to the other, and so that the experimenter could call and "chit chat with you, like we're friends in real life."

As caregivers conducted the teaching phase with their children, there was variability across parent-child dyads in the length of each teaching period driven by two sources. First, mothers differed in when they answered the cell phones; some responded after the first ring while others answered the call after several rings. A second source of variability was how quickly mothers adapted to transitions during the actual experiment. Parents differed in when they began teaching after hanging up the cell phone. These differences were reflected in the analysis.

To check that mothers pronounced each word correctly and understood their meanings, the experimenter listened and watched while the mothers practiced each new action in a separate space, correcting any mistakes as necessary. During this time, the child was supervised in the child-friendly waiting room. Mothers and children were reunited in the testing room for the duration of the study.

Salience video. To ensure that a visual preference for one scene at test was not a result of an a priori preference, children first watched a short video seated on their mothers' laps cen-

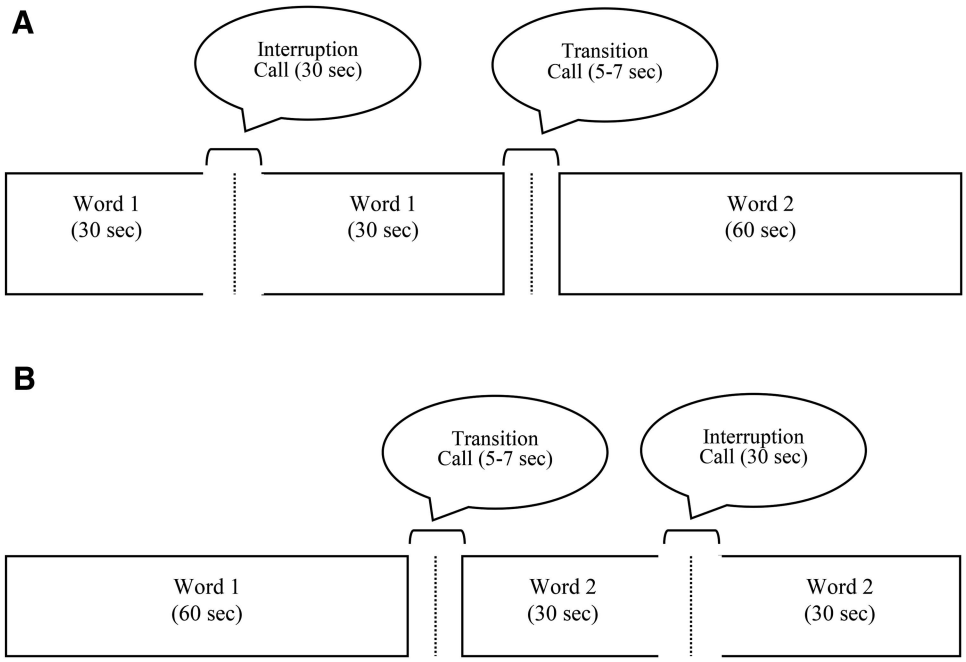

Figure 1. (A) Teaching sequence in interruption-first condition. (B) Teaching sequence in interruption-second condition.

trally located in front of a projected screen that contained the two video clips children would see later at test. Following Roseberry et al. (2014), the video included pairs of video clips with Sesame Street characters. Each scene contained a different action (e.g., Prairie Dawn shaking a box of macaroni or Elmo standing up). These same scenes paired in this same way would become test scenes after training. While these videos played, children heard generic instructions from the surround-sound speakers (e.g., "Look up here!"). Mothers were instructed to close their eyes during the video so that they did not cue the child to look in any particular direction.

Warm-up play. Dyads were given 2.5 min for unstructured block play. Parents were reminded that this free play period was not intended for teaching.

Teaching phase. To initiate the teaching phase, the experimenter called the mother and instructed her to teach *blick* or *frep* (order counterbalanced) after cleaning up the blocks. Mothers were given 60 s to teach the novel word. Parents transitioned to the second word after they received a phone call from the experimenter instructing them to do so. Another 60-s teaching period followed and ended once the experimenter knocked on the door.

Interrupted period. In the middle of one of the teaching periods (after 30 s passed), mothers received a phone call from the experimenter. This phone call served as the experimentally induced interruption and lasted for 30 s. During this interruption, the experimenter chatted with mothers about morning coffee routines; the conversation ended when the experimenter instructed mothers to continue to teach the target word prior to that phone call. Mothers had 30 s more to teach that target word. Critically, total teaching time in this interrupted condition was 60 s, the same as in the control (uninterrupted) condition.

Table 1
Matching (Bolded) and Nonmatching Actions Used in Training and Test. Adapted with Permission from "Skype Me! Socially Contingent Interactions Help Toddlers Learn Language," by S. Roseberry, K. Hirsh-Pasek, R. M. Golinkoff, 2014, Child Development, 85, p. 959. Copyright 2014 by Society for Research in Child Development, Inc.

Novel Word: Frep	**Matching Action**	Nonmatching Action
Training (live, in person)	**Adult moves a maraca in hand from side to side rapidly**	
Test (video stimuli)	**Prairie Dawn moves a box in hand from side to side rapidly**	Elmo places his hand on a block as he stands up
Novel Word: Blick	**Nonmatching Action**	**Matching Action**
Training (live, in person)		**Adult moves doll up and down on knee**
Test (video stimuli)	Cookie Monster's grandmother twists side to side while holding Cookie Monster	**Elmo's dad moves baby Elmo up and down on knee**

Test video. Following the teaching phase, children watched the test video in the same room while seated on their mothers' laps. As during the salience video, mothers closed their eyes during the video. In the test video, each verb was tested via four 6-s trials (verb order counterbalanced). Three-second centering trials presented a laughing baby centrally on the screen before each test trial. For each trial, two scenes exactly like those presented during salience played side-by-side with audio instructions. An overview of the four test trials for each verb is presented in Table 2.

Extension trials. The first two trials were *extension trials*. Children were asked to find the action for one of the novel words taught previously (e.g., "Find blicking!"). Because children were taught the novel action words by the mother with either a doll or a maraca as the direct object, success on this task required that children map and extend the verbs' meaning onto *new* actors and *new* objects. Previous research demonstrated that mapping and extending a novel action word is a difficult task (Imai et al., 2008). Performance on these original extension trials provided a test of "traditional" word learning (e.g., Childers, Heard, Ring, Pai, & Sallquist, 2012).

Mutual exclusivity and recovery trials. To further probe whether children learned the words, we utilized a more stringent test. In a third trial children were asked to find an action requested by a completely unfamiliar word (*glorping*, *wezzling*). As in Trials 1 and 2, the same two scenes played side-by-side. Following the findings from Markman, Wasow, and Hansen (2003), we reasoned that if children mapped the novel word to its action referent, then when presented with a new word, they should not attempt to map it onto the already named action, but rather to the new scene that had not yet been labeled. For example, in Table 1, the "nonmatching" scene now becomes the target on the mutual exclusivity trial (i.e., the scene with Elmo). A final recovery trial asks children to once again find the action representing the original target word.

Using four trials allows for two complementary analyses that examine children's responses on both an extension (traditional) test (Trials 1 and 2), and a stringent test (performance across the extension, mutual exclusivity, and recovery trials). Across the three trial types, a quadratic pattern is hypothesized: children first attend to the target, shift away during the mutual exclusivity trial, and then once again prefer the target scene on the last trial. The stringent approach has yielded mixed results in prior studies (Roseberry, Hirsh-Pasek, & Golinkoff, 2014; Roseberry, Hirsh-Pasek, Parish-Morris, & Golinkoff, 2009) as children often extend the newly learned word, but do not convincingly respond with mutual exclusivity in the use of that newly mastered word.

Coding and reliability. Using Supercoder 5.0 (Hollich, 2008), children's eye gaze data were coded by researchers blind to teaching condition. Looks coded as left, right, center, or away on a frame-by-frame (29.97 frame/s) basis yielded intrarater and interrater reliabilities above 0.95.

Table 2
Order of Test Trials with Accompanying Audio Instructions

Trial	Type	Audio
1	Extension	"Find [blick/frep]ing"
2	Extension	"Find [blick/frep]ing"
3	Mutual Exclusivity	"Now find [glorp/wezzle]ing"
4	Recovery	"Find [blick/frep]ing again"

Results

Maternal Input During Training

To isolate our independent variable (i.e., presence/absence of an interruption), we examined input frequency and time in both the interrupted and uninterrupted teaching conditions. Input frequency was a count of the number of times mothers used the target words. The within-subjects design accommodated variation in maternal labeling behaviors. Indeed, a repeated-measures *t* test affirmed that individual mothers were consistent in their approach across teaching periods, repeating the novel label approximately 24 times in the interrupted teaching condition and approximately 20 times in the uninterrupted teaching condition. This difference was not significant, $t(40) = -1.65$, $p > .05$.

To directly test our hypothesis that interruptions affect word learning, even when controlling for input frequency and time, outliers were removed from all further analyses. Outliers were defined as values with standardized *z* scores greater than 2, following Pruden, Göksun, Roseberry, Hirsh-Pasek, and Golinkoff (2012). Examination of time spent teaching without interruption revealed two outliers; each spent only 27 s in that condition. An additional outlier was identified and removed based on total time in the interrupted condition (only 43 s total). For input frequency, a difference score was calculated to compare target word counts across the two teaching conditions. Higher scores reflect a discrepancy in input, and three outliers were identified and removed because of an exceedingly large difference in target word usage. A sensitivity analysis (Thabane et al., 2013) revealed that the pattern of results was consistent with and without these outliers. After removing outliers, we had a final sample size of 38 dyads.

Salience Trials

Children's a priori preferences for target scenes in the salience phase were analyzed first. The dependent variable used for salience and test trials was the same: the time a child watched what would be the target (after training) during test trials was divided by the total time the child attended to either scene, thus yielding a proportional response for each of the two words learned. Children showed no preference for the *blick* target scene as compared to the distracter scene ($M_{target} = 0.52$), one-sample $t(37) = 0.64$, $p > .05$. There was a preference, however, for the *non*-target scene for *frep* ($M_{target} = 0.45$), $t(37) = -1.99$, $p = .05$. These tests suggest that any preference for target scenes at test cannot be attributed to a priori preferences based on perceptual features such as color or motion.

Did Toddlers Demonstrate Comprehension of Novel Verbs?

The first 2 s of each trial were analyzed following the model of previous work with toddlers using IPLP (e.g., Candan et al., 2012). Tovar, Fein, and Naigles (2015) identified several factors such as stimulus timing and rapid boredom that cause looks during the first

2 s to be a more reliable measure of comprehension than the full window (see Althaus & Mareschal, 2014, for a similar argument). Tovar and colleagues concluded, "Many IPL studies have found that children who understand the linguistic audio find the matching scene early in the test trial, especially when . . . the audio is first presented before the visual stimuli appear" (p. 305). As in their work, the audio instructions (e.g., "Find blicking!") preceded the appearance of the visual scenes. To create a more reliable measure, data from the first two extension test trials for each word were averaged together into a single proportion.

Extension test. Given that each participant learned one word during an uninterrupted teaching period and another during an interrupted teaching period, a 2 (interruption: present, absent) × 2 (sex: male, female) × 2 (order: interrupted first, interrupted second) split-plot ANOVA was conducted. It revealed only a significant effect of the experimental interruption manipulation, F (1, 34) = 6.44, $p < .02$, partial $\eta^2 = 0.16$, meaning that children preferred the target scene—demonstrating comprehension—when the word was taught without interruption ($M = 0.63$) but not when the teaching was interrupted ($M = 0.50$; Figure 2). There was no significant effect of gender, F (1, 34) = 0.20, $p > .05$ or order of interruption, F(1, 34) = 0.18, $p > .05$).

This finding cannot be attributed to differences in input between the two conditions, for which a paired t test revealed no significant difference in labeling frequency across conditions (reported in above discussion of maternal input). Furthermore, dyads spent more time in the interrupted condition ($M = 65.05$ s) than in the uninterrupted condition ($M = 58.37$ s), t (37) = −3.46, $p < .01$.

Did mothers' self-reported cell phone use have a differential effect on children's word learning in interrupted and uninterrupted conditions? No, the number of calls and texts mothers sent and received was not correlated with the proportion of time that children attended to the target scene for either the interrupted, $r = -0.16$, $p > .05$ or uninterrupted, $r = -0.30$, $p > .05$ conditions. Based on a median split, we categorized mothers as either light or heavy cell phone users. An ANOVA with one within-subjects factor (interrupted or uninterrupted teaching) and one between-subjects factor (heavy or light cell phone usage) revealed an effect of interruption, F (1, 35) = 5.38, $p < .03$ and cell usage, F (1, 35) = 5.34, $p < .03$ but no interruption by usage interaction. With total cell phone usage as a covariate, the effect of interruption remains significant, F (1, 35) = 5.05, $p < .04$.

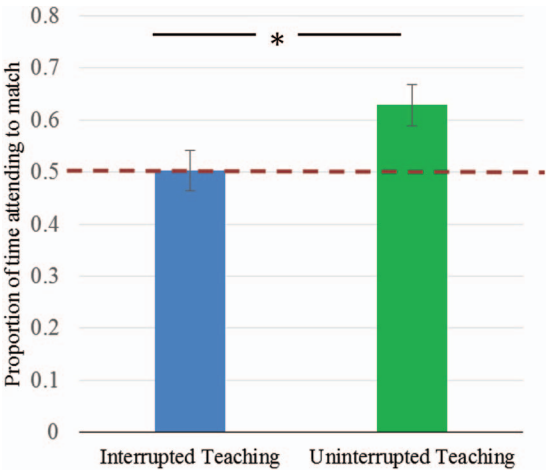

Figure 2. Performance on extension trials by teaching condition. Error bars represent standard errors. Dashed line represents chance performance. * $p < .05$. See the online article for the color version of this figure.

Rigorous test. To test whether children looked away from the target during the mutual exclusivity trial and shifted back to the target scene during the recovery trial, a repeated-measures ANOVA with one factor (trial type) with three levels (extension, mutual exclusivity, recovery) was run. Only data from the uninterrupted condition was analyzed, as we did not expect this quadratic pattern of results for the interrupted condition, in which children did not demonstrate successful word learning on the initial test trials. A repeated-measures ANOVA, which tested for the quadratic pattern, did not reveal a significant effect of trial type; children instead consistently maintained their visual attention on the target scene across trials ($M_{\text{extension}} = 0.66$, $M_{\text{mutual exclusivity}} = 0.65$, $M_{\text{recovery}} = 0.64$). Thus, the results demonstrating learning appeared only in the traditional—not the stringent—analysis.

Behavioral Responses to Interruptions

The interruption call elicited a variety of responses from both mothers and toddlers. We tested whether toddlers' preference for the target scene at test for the *interrupted teaching* word depended on how each partner reacted to the interruption.

Maternal reactions. Some mothers ($N = 13$) acknowledged the incoming interruption before answering the call with language such as, "Hold on, sweetheart, Mama's getting a phone call." Other mothers ($N = 25$) did not preface their disengagement; instead, they shifted their focus from child to phone without any notice. A one-way ANOVA found that children's performance at test for the *interrupted teaching* word did not depend on whether or not mothers acknowledged the incoming interruption, F (1, 36) = 0.08, $p > .05$.

Toddlers' reactions. Toddlers reacted to the interruption either by waiting patiently ($N = 23$) or walking away in order to find an alternative diversion ($N = 12$).[1] The toddlers who eventually walked away waited 12.83 s on average before walking away (range: 1–29 s; $SD = 8.99$). Preference for the target scene at test for the *interrupted teaching* word did not differ between children who waited and those who walked away, F(1, 33) = 0.13, $p > .05$.

Discussion

Extensive research establishes that children learn words in social contexts in which parents and caregivers offer meaningful and prompt responses to their conversational bids. Most studies however, ask whether the presence of these contingencies is key to language success. This research offers a complementary approach by examining what happens when the social rhythms of parent-child interactions are disrupted by a cell phone call. In a within-subject design, parents taught their 2-year-olds two words that had been used successfully in prior studies (Roseberry et al., 2014). In one condition, the teaching was disrupted midstream. In the other

[1] Data for 3 participants was unavailable because of video quality ($N = 1$) or inattention ($N = 2$) prior to interruption that precluded a meaningful reaction.

it was not. Results suggest that in the interrupted condition children did not learn the target words while in the uninterrupted condition they did learn them. Infants and toddlers are thus sensitive to contingent and responsive interactions that pave the way for language learning (Kuhl, 2007; Tamis-LeMonda et al., 2014).

Why is contingent responding so crucial to language growth during toddlerhood? Tomasello (2008) holds that contingent responding in the form of joint attention helps toddlers narrow the referential possibilities when confronted with a novel label, guiding word-to-world mapping. Contingent responsiveness may boost the *referential transparency* of the labeling event, which predicts later language scores (Cartmill et al., 2013). Through joint engagement (Adamson, Bakeman, Deckner, & Nelson, 2012, 2014), caregivers capitalize upon moments when children may be particularly ready to learn words. For example, Goldstein, Schwade, Briesch, and Syal (2010) found that 11-month-old infants only learned novel labels after they produced object-directed vocalizations. Begus, Gliga, and Southgate (2014) presented 16-month-old infants with unfamiliar objects and demonstrated a unique action for each. Sometimes the experimenter's initial teaching *followed* infants' points and sometimes the experimenter redirected infants' attention. When asked to perform the novel action at test, infants were far more successful in the former condition than the latter (see Tomasello & Farrar, 1986, for a similar finding on word learning). With the innovative use of head-mounted video technology, Smith, Yu, and colleagues (Pereira, Smith, & Yu, 2014; Yurovsky, Smith, & Yu, 2013) provided corroborating evidence for this account, revealing that particular views from children's first-person perspective predicted successful word learning.

If contingencies are key to learning language, we speculated that disrupting the temporal and meaningful flow of conversation would be detrimental to word learning. In our auditory analogue of the Still Face procedure, we found just that. Minimally, the work suggests that toddlers are sensitive to interactional rhythms, which are crucial to word learning. Critically, differences in outcome cannot be attributed to the number of times the mothers offered the word during interrupted versus uninterrupted conditions, as these did not differ. Mothers resumed teaching after chatting with the experimenter, suggesting that mothers adapted and switched from "off task" to "on task" with relative ease. Otherwise, we would expect far fewer labels in the interrupted condition, which was not the case. It is worth noting that mothers did not know ahead of time whether the first or second teaching session would be interrupted. Further, the finding cannot be attributed to the type of words used as the very same words had been taught in prior research (Roseberry et al., 2014).

Whether or not the mother momentarily disengaged to respond to a cell phone call was the critical difference between the two teaching conditions. By "breaking" the dyadic exchange, the present study is the first to identify disengagement as antagonistic for word learning. When speakers momentarily withdraw from the exchange, they may violate conversational maxims (Grice, 1975). Eskritt, Whalen, and Lee (2008) demonstrated that children as young as three years are sensitive to pragmatic violations. Further, social contingency fosters a sense of connectedness, through which ostensive cues reinforce a natural pedagogy for learning (Csibra & Gergely, 2009). Disengagement may effectively undermine that shared context. Interestingly, the performance of children whose mothers reported frequent texting and talking was dampened relative to their peers, hinting that patterns of disengagement may have ramifications beyond the scope of this paper. Among adult dyads, for example, interruptions affect our qualitative perceptions of both our interaction partners *and* how interesting we find the shared topic to be (Lopez-Rosenfeld et al.2015). Indeed, it is interesting to ask about the effects of a *joint* interruption—as from a doorbell ringing that draws the attention of both communicative partners, instead of only one. In this case, the dyad maintains a shared referent, even though the focus has shifted. In contrast, a cell phone interruption *breaks* the common ground (Clark, 1996; Tomasello, 2008), as one partner disengages to answer a call that does not include the child. Perhaps a shared disruption changes conversational contingencies in ways that are less disruptive for word learning. That is precisely the focus of our current research. Alternatively, what if the child—instead of parent—is interrupted? The literature on distraction addresses this possibility, with findings in line with our results here. Toddlers' performance on various cognitive tasks suffers when they experience random interruptions, such as when a toy figurine unexpectedly moves (Dixon et al., 2012; Dixon & Salley, 2010).

In this within-subjects design, the two teaching periods differed only in the presence or absence of an interrupting phone call. Mothers' use of the target labels was consistent across conditions, suggesting that frequency of input alone cannot account for our finding. Although the social responsiveness between mother-child dyads was momentarily disrupted by the interruption, the current study cannot tease apart the various causal mechanisms that may be at work. The disruption in timing covaried with changes in eye contact, affect, and even posture as mothers shifted attention to the cell phone. The content changes because when the mother picks up her telephone to speak to an invisible partner, she is no longer talking about the same topic that had been the subject of the conversation with her child. Semantic contingency is as important for learning as is temporal contingency (Kaiser & Roberts, 2013). Further research should examine these correlated changes in affect, eye gaze, and body orientation during interrupted interactions. Relatedly, how dyads reengage after interruptions and whether some developmental periods may be more vulnerable to interruptions remain open empirical questions that will shed light on the mechanisms responsible for our current finding. For example, the interrupted teaching paradigm may also tap into children's task-switching abilities, as children's attention shifts from on- to off-task then back once more when teaching resumes. Further, future research should address whether learning is possible when dyads "reset" following an interruption, by providing a 60-s teaching period in the second half of the interrupted condition.

Another limitation to consider is that although toddlers successfully *extended* the verbs' meaning on test trials that featured different characters with different objects than those used in training, their looking patterns did not reveal the quadratic pattern. On the mutual exclusivity trials, toddlers did not shift their attention away from the target action. Data from Grassmann, Schulze, and Tomasello's (2015) study with 2- to 4-year-olds suggests that young children utilize the mutual exclusivity principle only when the familiar target, which will be "ruled out" as a possible referent, is part of their productive—not only receptive—vocabularies. Unlike other studies in which children are tested on the *same stimuli* used during training, to succeed in this study children needed to generalize the action to a new exemplar of the target. Given that

previous work has found toddlers to be "conservative verb extenders" (Childers, 2011, p. 4), failure to find the quadratic pattern should not overshadow toddlers' successful extension of the novel action words at test.

Despite these limitations, the pattern of results suggests that interruptions may not simply "pause" a dynamically unfolding social exchange; instead, the connectedness may be subtly perturbed with cascading effects on learning. The ubiquitous use of mobile communication makes interruptions an everyday occurrence. Mobile technology randomly interrupts us, without regard for whether individuals are idly standing in line or engaged in a conversation with their 3-year-old about naptime. Consequently, the nature of parent-child interactions is constantly challenged, as dyads navigate these incoming interruptions. Here, we have an ecologically valid example of environments in which meaningful and temporally contingent interactions are unpredictably disrupted. Radesky et al. (2014) reported that of 55 families observed during mealtime with their young child, fully 40 shared the table with their cell phone. If contingent interactions are central to word learning then these data are potentially devastating. Further, it is important not only to demonstrate that word learning is fostered by meaningful and temporally contingent conditions, but also the converse: that word learning is disrupted when these conditions are not available. The findings of this study are the first to complement prior research by suggesting that meaningful and temporally contingent interactions are necessary for word learning and that when they are absent, word learning suffers.

The effects of interruptions on cognitive processing are not restricted to that of word learning. Research on "distracted driving" (Drews, Pasupathi, & Strayer, 2008), for example, has found that the unpredictability of incoming cell phone calls and text messages co-opts drivers' attention. Similar findings from a different medium—that of electronic books—underscore this link between distraction and its cognitive consequences (de Jong & Bus, 2002; Labbo & Kuhn, 2000; Parish-Morris, Mahajan, Hirsh-Pasek, Golinkoff, & Collins, 2013). The sound effects and other auxiliary components of electronic books may interfere with children's attention, thereby disrupting their story comprehension. The literature on distractions suggests children's learning is hampered when attention is coopted by sporadic TV broadcasting (Wyss, Kannass, & Haden, 2012) or overwhelming visual displays in classrooms (Fisher, Godwin, & Seltman, 2014). This study adds to that burgeoning literature. It is the first to experimentally manipulate parent-child interactions via cell phone calls in a laboratory setting. Our findings suggest that not only do children notice interruptions during face-to-face interactions with their parents, but also that these interruptions have cognitive consequences, at least for young word learners. They sidetrack language learning.

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