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Learning While Babbling: Prelinguistic Object-Directed Vocalizations Indicate a Readiness to Learn

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Two studies illustrate the functional significance of a new category of prelinguistic vocalizing—object-directed vocalizations (ODVs)—and show that these sounds are connected to learning about words and objects. Experiment 1 tested 12-month-old infants' perceptual learning of objects that elicited ODVs. Fourteen infants' vocalizations were recorded as they explored novel objects. Infants learned visual features of objects that elicited the most ODVs but not of objects that elicited the fewest vocalizations. Experiment 2 assessed the role of ODVs in learning word–object associations. Forty infants aged 11.5 months played with a novel object and received a label either contingently on an ODV or on a look alone. Only infants who received labels in response to an ODV learned the association. Taken together, the findings suggest that infants' ODVs signal a state of attention that facilitates learning.

The developmental trajectory of early word learning is slow and gradual. By 8 months, infants are able to associate a specific phoneme with an object when presented synchronously and in isolation on a screen (Gogate & Bahrick, 1998). By 12 months, infants have approximately 50 words in their receptive vocabulary (Fenson et al., 1994) and are just beginning to utter sounds that have reliable links to the objects around them (Bloom, 2000).

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The first 50 words of the productive vocabulary are acquired gradually, until the rate of word learning dramatically increases at approximately 18 months (the "vocabulary explosion"). Most research on early word learning focuses on the cognitive, perceptual, and social processes that may be responsible for developmental increases in the efficiency of word learning (e.g., Hollich, Hirsh-Pasek, & Golinkoff, 2000; Smith, 2000; but see McMurray, 2007).

Here, we focus on the acquisition of early sound/object correspondences. How do infants begin to associate words with referents? To an unconstrained, unsupervised learner, any word may label any object or object characteristic. In the canonical formulation of the word learning problem (Quine, 1960), a visitor to a foreign land encounters a native who, looking toward a rabbit hopping through a field, says "Gavagai!" To what does *gavagai* refer? It could mean "rabbit," "hopping," or "furry." It could mean "Let's hunt that," or "Death awaits you all with nasty, big, pointy teeth" (Gilliam & Jones, 1975), etc. The utterance "Gavagai," by itself, is too underspecified to refer to anything particular in the world of an unconstrained learner. What kinds of constraints do toddlers use to solve the problem of reference? Toddlers could use external cues, such as object salience (Hollich et al., 2000), pointing, or eye gaze, to disambiguate word–object associations (Akhtar & Tomasello, 2000; Baldwin, 1993). In addition, perceptual and cognitive constraints, such as mutual exclusivity, contrast, the whole object principle, and the shape bias, could be used to constrain the possible mappings between word and world (e.g., Clark, 1983; Golinkoff, Mervis, & Hirsh-Pasek, 1994; Jones & Smith, 2002; Markman, 1987, 1989; Smith, 2000). The constraints that are used by toddlers change over developmental time (for a review, see Hollich et al., 2000). As vocabulary increases, children could use linguistic information to disambiguate words for new object names, properties, and actions (e.g., Bloom, 2000; Diesendruck & Shatz, 1997; Hirsh-Pasek & Golinkoff, 2006; Waxman & Senghas, 1992). Thus, the ontogeny of word learning is thought to be governed by the development of social and cognitive constraints that control how infants process information and form hypotheses about word/referent correspondences. Many of these constraints are thought to emerge in the second year of life (e.g., Golinkoff et al., 1994).

In experiments testing specific constraints that toddlers might use to learn and generalize names for objects, word learning is not typically demonstrated until at least 15–16 months (e.g., Baldwin et al., 1996; Woodward, Markman, & Fitzsimmons, 1994; but see Pruden, Hirsh-Pasek, Golinkoff, & Hennon, 2006; Smith & Yu, 2008 for demonstrations of associative word learning in younger infants). Although children do not consistently learn words in laboratory-based tasks during their first year of life, there are aspects of caregiver–infant interaction in the first year, such as responsiveness to babbling and attentional focus, that reliably predict early language development. For example, the amount of prompt, contingent maternal responding to infant behavior, including prelinguistic vocalizations, is positively related to larger receptive and productive vocabulary size at 13–15 months (Rollins, 2003; Tamis-LeMonda & Bornstein, 2002; Tamis-LeMonda, Bornstein, & Baumwell, 2001). Correlations between maternal responsiveness and infant language development may be due to other aspects of caregiver behavior, such as the amount of speech directed at infants (Hart & Risley, 1995), that then account for individual differences in vocabulary development. However, not all forms of contingent caregiver responses to babbling have equal effects on language. Recent work has shown that contingent social responses to a newly studied type of babbling in 9-month-olds—object-directed vocalizations (ODVs)—has disparate relations to vocabulary size at 15 months, depending on the match between caregiver labeling and the object at which the infant is babbling (Goldstein & Schwade, 2010).

An ODV is defined as a noncry prelinguistic vocalization uttered when the infant is looking at an object that is within reach or is being held. During a play session with their 9-month-old infants, mothers had stable forms of responding to ODVs. Responding to an ODV by labeling the object positively correlated with vocabulary size at 15 months. By contrast, responding to an ODV by saying a word that bore an acoustic resemblance to the babble (e.g., saying "bottle" after the infant uttered "ba") but was not related to the object at hand *negatively* correlated with vocabulary size at 15 months (Goldstein & Schwade, 2010). Thus, mothers who provided object labels to the early vocalizations of their infants may have facilitated later word learning by helping their infants recognize connections between sounds and objects. Mothers who tended to react with words that were similar to their infants' sounds, but unrelated to the object at which the vocalization was directed, may have slowed later word learning because their utterances did not label the objects in the infants' field of view.

What mechanisms might underlie the observed relations between responses to ODVs at 9 months and vocabulary size at 15 months? We hypothesize that ODVs are diagnostic of infant attention. In our view, ODVs indicate that the infant is in a state of focused attention that facilitates learning about the features of objects and about associations between objects and referents. At the same time, ODVs may serve to elicit labeling speech from caregivers. For example, when infants direct a vocalization at a toy or a picture in a book, mothers sometimes respond by labeling the object or picture (e.g., Bruner, 1983; Newson, 1977). The response comes at a moment when the infant is focused on an object, which may facilitate learning of word–object associations. Infants may also use ODVs to increase their attention to an object, in a manner similar to the self-stimulating function of vocalizations in ring doves, dogs, and chicks (see review in Cheng, 1992, 2003). Thus, there may be precursor mechanisms, operating before and during the emergence of receptive and productive vocabulary, that are involved in establishing the ability to learn words in the second year. The robust relations between caregiver responses to early infant behavior and later vocabulary size indicate that such mechanisms have a strong social component.

By eliciting reactions from caregivers, ODVs open a social gateway for learning (a similar process has been found in songbirds, see West, King, & White, 2003; White, King, Cole, & West, 2002). ODVs organize the timing of social feedback so that it occurs when the infant is in a state conducive to learning. Prior research on early vocal learning has shown that contingent social feedback to babbling promotes rapid learning of new vocal forms (Goldstein, King, & West, 2003; Goldstein & Schwade, 2008). For example, 9-month-old infants learned to produce specific phonological patterns based on the statistical regularities in caregivers' speech that was uttered within 2 sec of their babbling (Goldstein & Schwade, 2008). Infants did not learn new vocal forms when caregiver behavior was not contingent on their babbles. Even the earliest stages of noncry vocal communication are influenced by social learning. In a still face paradigm, 5-month-olds showed an extinction burst (a temporary increase) in babbling when social responsiveness was terminated, indicating that they had learned that their prelinguistic vocalizations should obtain social responses. Such early vocal learning was predictive of later language development, as the magnitude of the vocal extinction burst was related to receptive vocabulary size at 13 months (Goldstein, Schwade, & Bornstein, 2009).

We propose that the acquisition of object properties and the development of early object–word associations emerge from the operation of the same kind of learning mechanism that allows infants to learn new phonological structures from caregiver responses to their babbling. Given the existence of specific positive and negative relations between caregiver responses to ODVs and later vocabulary, and the efficacy of social feedback to babbling as a mechanism of vocal learning, we hypothesized that an ODV may serve as a signal of focused infant attention to an object, in much the same way as a furrowed brow (Ruff, 1986). Social reactions to ODVs may provide a bridge between prelinguistic learning about the social consequences of vocalizing and later learning about how sounds can be used to label objects. In addition to learning about the speech patterns of mothers' contingent vocal responses to their vocalizations, infants may also be learning about the objects at which they vocalize. In the experiments below, we assess the role of ODVs as part of a social gateway mediating early learning about objects and words. If ODVs are indicative of focused attention, then perceptual information available during an ODV, as well as information contained in social feedback given contingently on an ODV, are likely to be learned and associated with the object at hand. In Experiment 1, we tested whether the ability to learn object features is heightened during periods of object-directed babbling. If infants are better at perceptual learning while vocalizing, then ODVs might help infants integrate auditory and visual information, which would support word learning. In Experiment 2, we assessed the role of object-directed babbling in forming word–object associations by labeling objects either contingently on an ODV or, in a yoked control group, contingently on a look alone.

EXPERIMENT 1

We hypothesized that ODVs signal a state of focused attention, so that maternal responses to those sounds occur when an infant is in an state optimal for learning the properties of an object. Experiment 1 focused on the role of ODVs in infant attention. We tested whether infants learned more about the visual features of the objects to which they were attending when they produced ODVs. Infants explored a set of novel objects and we recorded which object received the most and the least or no ODVs for each infant. We then tested infants' knowledge of the high- and low-ODV objects' features in a preferential looking task, in which infants were presented with familiar and distorted versions of the objects. We predicted that infants would learn more about the objects that elicited vocalizations than about objects that did not; thus, infants should distinguish between the familiar and distorted versions of the high-ODV objects, but not the low-ODV objects.

Methods

Participants

Fourteen 12-month-old infants (*M* age = 12 months 1 day, range = 11 months 63 days to 12 months 87 days) participated. Two additional infants were tested but excluded from analyses. One parent talked to the infant about the objects during the object examination, and a second infant was excluded due to equipment failure during the preferential looking task. The final sample was balanced for infant gender. Families were recruited through birth announcements printed in the local newspaper and were primarily Caucasian and middle-class socioeconomic status. Parents received an infant t-shirt or bib for their participation.

Apparatus

An initial warm-up phase took place in a 3.7-m × 5.5-m room containing toys and pictureboards. The object exploration and test phases took place in a 3.7-m × 2.4-m testing room containing a table with two chairs on opposite sides of the table. Infants' explorations of the objects were video-taped with a wall-mounted, remotely controlled video camera. Infant vocalizations were recorded by a wireless microphone (Telex FLM-22; Telex Communications, Inc., Burnsville, MN) and transmitter (Telex USR-100) that was carried in denim overalls worn by the infants. The microphone was contained in a pocket in the front of the overalls. The wire and transmitter were concealed in the lining of the overalls and did not impede infants' movement.

During the test phase (a preferential looking task), digital photographs of objects that infants had seen in the exploration phase were paired with photographs of the previously unseen, matched objects. The photographs were presented with Microsoft PowerPoint (2000) on an Apple Powerbook G3 connected to a ceiling-mounted projector (Epson Powerlite 81p; Seiko Epson Corporation, Nagano, Japan). The computer was located in a separate control room. Photos of objects were displayed on the wall of the testing room at 55.9 cm × 48.3 cm, each subtending 19° visual angle. The center-to-center distance between the two photographed objects was 88.9 cm. Infants' looking was recorded with a video camera positioned approximately 162.6 cm from the infant and centered just below the two projected images.

Stimuli

During the object exploration phase, infants were presented with one of two sets of 12 novel objects as shown in Figure 1. The novel objects were made of baked polymer clay, fabric, plastic, or painted wood. Objects varied in size, but most were approximately 3.5 inch × 5 inch (8.9 cm × 12.7 cm). Infants could easily lift, grasp, and manipulate all objects.

Each object in the first set partially matched one object in the second set. The matched objects were the same color, the same general size, and made of the same material. The matched objects' shape, however, was distorted by adding or deleting parts as shown in Figure 1. Shape was changed because infants can detect changes in the shapes of solid objects and because shape correlates with both children's categorization and object names (Baldwin, 1989; Imai, Gentner, & Uchida, 1994; Smith, 2000). Infants were exposed to one of the two sets during the exploration phase, with equal numbers of infants receiving each object set.

Figure 1 Novel objects presented in Experiment 1. Infants saw all 12 objects from one of the two sets during the object exploration period. Matched objects from the unseen set served as the novel, shape-distorted controls during the preferential looking task. The clear container of glitter balls from Set 1 and the green wooden balls from Set 1 were also used in Experiment 2.

Procedure

The procedure was divided into three phases: warm-up, object exploration, and test. In the warm-up phase, infants participated in a 10-min play period with their parents and the experimenter. The warm-up phase allowed the infants to become familiar with the environment and experimenter, making them more likely to vocalize during object exploration. During this time, the infant explored a large playroom containing toys and pictureboards. The exploration and test phases took place in a smaller adjacent testing room and immediately followed the warm-up period. During these phases, infants were seated on their parents' laps at a table across from the experimenter.

During the object exploration phase, the experimenter presented the infant with each of the 12 objects in one set, in a randomly determined order, each for 40 sec. Objects were presented individually. When presenting each object, the experimenter said "This is for you to play with." The experimenter did not otherwise comment on the object. If the infant dropped an object, the experimenter or parent returned it to the table immediately. After 40 sec, the experimenter removed the object and replaced it with a new object, until all 12 objects had been presented. While the infant explored each object, the experimenter timed the trial by looking at a stopwatch concealed under the table; the experimenter did not look at the infant or the object. The experimenter's interactions with the infant were thus limited to giving and retrieving the objects. During object exploration, parents listened to music over sound-attenuating headphones (Peltor model HT79; Aearo Company, Indianapolis, IN). Apart from retrieving dropped objects, parents were asked not to touch or talk about the objects during object exploration and to minimize their interactions with their infants during the study. Parents of infants who were included in the final sample complied with this request.

While the infant explored each object, an observer in the control room counted the number of vocalizations that the infant directed at the object. ODVs were counted when an infant vocalized while looking at an object that he/she was holding or that was within reach. Each syllable (any vocalization containing a vowel) was counted as a separate vocalization (e.g., Goldstein et al., 2003). For example, [dada] was counted as two vocalizations. Vegetative sounds, such as coughs or fusses, were not counted as vocalizations.

After the infant had the opportunity to explore all 12 objects in the set, the object that received the most vocalizations (high vocalization object—HVO) and the object that received the fewest or no vocalizations (low vocalization object—LVO) were determined. If an infant babbled equally often at multiple objects or if several objects received no vocalizations, then objects were selected for the preferential looking task so as to maximize counterbalancing of the objects as the high vocalization and low vocalization items. As object assignment to the two vocalization conditions was infant controlled, exact counterbalancing was not possible (Table 1).

TABLE 1
Directed Vocalizations Elicited by Each Object in Experiment 1

	Object Condition		*Vocalizations*	
Object Description	*High Vocalization*	*Low Vocalization*	*Mean*	*SD*
Blue felt disc with missing wedge	1	0	3.29	4.63
Silver sculpy angled cylinder	1	1	2.43	2.53
Mauve vinyl beanbag	0	1	2.07	2.24
Pink wooden shape	1	0	2.93	3.61
Clear container of glitter balls	2	1	3.57	4.52
Green mesh U-shape	2	1	6.00	7.16
Yellow vinyl hourglass	1	1	4.57	6.21
Red foam block	1	2	4.21	7.50
Orange sculpy star	2	1	4.14	5.14
White and blue-striped bowling pin	0	3	3.29	4.81
Gold spools	1	3	1.14	1.70
Green wooden balls	2	0	4.00	8.36
Overall mean (SD)	1.17 (.72)	1.17 (1.03)		

The test phase began approximately 5 min after the end of the object exploration phase. The test phase consisted of a preferential looking task. During this time, parents wore a baseball cap with a short opaque veil attached to the brim. The cap permitted parents to see their infants seated on their laps but prevented them from seeing the pictures presented on the screen. The experimenter left the room before the onset of the preferential looking task. The task began with an animation in the center of the screen. When the infant looked at the screen, an observer in the control room started the first of four test trials. Each trial presented a photograph of the familiar object (either the HVO or the LVO) paired with its shape-distorted matching object. The four trials were organized into two blocks based on the object (HVO or LVO) that was presented. Each block consisted of two trials (i.e., one block contained two HVO trials, the other block contained two LVO trials). Side of presentation of familiar and novel objects was counterbalanced within each block. Block order was counterbalanced. Infants saw each object pair for 6 sec, with an intertrial interval of 2 sec. During the intertrial interval, an animation was displayed in the center of the screen to bring the infant back to midline.

Coding

We coded the duration of infants' looking and handling for each of the 12 novel objects presented during the exploration phase. One infant's object exploration was not filmed due to experimenter error; infant behavior during object exploration was analyzed for the remaining 13 infants. Looking was coded when the infant looked at the object; handling was coded when the infant touched or held the object. Looking and handling could occur simultaneously or separately. Duration of infant looking and handling were recorded with frame accuracy using custom-designed software (Goldstein & Brodsky, 2006). The frame-by-frame coding was conducted without sound, thus the coders were blinded to the number of vocalizations directed to each object. Infants' object exploration was initially scored by one of four coders. Half of the sessions were re-scored by another coder to assess reliability. Reliability was $r = .94$ for looking and $r = .99$ for handling.

Infant's looks to the stimuli during the preferential looking task were coded frame by frame using SuperCoder software (Hollich, 2005). One of four coders recorded the amount of looking during the preferential looking task. Coders were blinded to the location of the familiar and distorted objects. To assess reliability, 50% of sessions were re-scored by another coder. Intercoder reliability was $r = .94$.

Results

Object-directed vocalizations

Infants produced a mean of 41.3 vocalizations ($SD = 44.8$) during the object exploration period. HVOs elicited a mean of 10.4 vocalizations ($SD = 8.7$, range = 2–32); LVOs elicited a mean of .57 vocalizations ($SD = .94$, range = 0–3). Infants' choice of objects as their HVOs or LVOs did not differ significantly from a uniform distribution in either object condition, HVO $\chi^2(11) = .40$, ns; LVO $\chi^2(11) = .83$, ns. Thus, there was no systematic pattern regarding which objects were HVOs or LVOs across infants (Table 1).

Preferential looking

The magnitude of infants' novelty preference (looking time to novel object – looking time to familiar object) was calculated for the HVO and LVO object pairs in each trial. Preferential looking was analyzed with a two (object: HVO, LVO) × two (trial: 1, 2) repeated measures analysis of variance (ANOVA) on the novelty preference measure. There was a significant Object × Trial interaction, $F(1, 13) = 5.40$, $p = .037$, $\eta_p^2 = .29$ as seen in Figure 2. Neither main effect was significant, Fs $< .97$, ps $> .34$. We examined the two-way interaction with tests of simple main effects within each level of trial. In the first trial, there was a significant main effect of object,

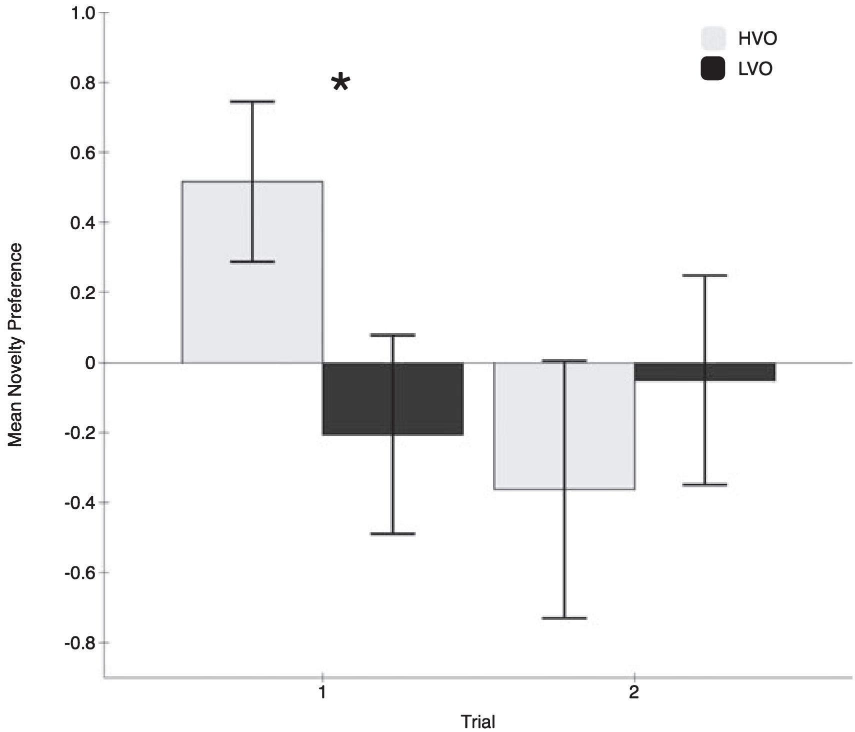

Figure 2 Mean novelty preference (duration of looking at distorted object in pair − looking at familiar object in pair) by object condition and trial in Experiment 1. Error bars represent ± 1 *SE*. *$p < .05$.

$F(1, 13) = 5.52, p = .035, \eta_p^2 = .30$. Infants had a larger preference for the novel object in the high vocalization pair and did not show a preference for either object in the low vocalization pair. In the second trial, infants did not show a significant preference for either object in the HVO or LVO pair, $p = .35$.

To test whether the majority of infants showed a novelty preference in either condition, we conducted separate Wilcoxon signed rank tests for each object condition on looking time during each trial. In the first trial, a significant number of infants ($n = 10$) looked longer at the novel object in the high vocalization pair, $T(+) = 73.5$, $p = .04$, two-tailed. In contrast, infants did not show a systematic preference for either object in the low vocalization pair, Wilcoxon $T(+) = 30.0$, $p = .69$, two-tailed (four infants looked longer at the novel object and nine infants looked longer at the familiar object). In the second trial, infants did not have a significant preference for either object in the HVO or LVO pairs.

As infants varied in the total number of ODVs they produced, we tested whether the observed differences in preferential looking were due to individual differences in infants' vocalization frequency during the object exploration phase. Infants were divided into two groups by a median split (median number of vocalizations = 27.5). The novelty preference scores were analyzed with a mixed two (infant vocalization frequency: high vocalizers, low vocalizers) × two (object: HVO, LVO) × 2 (trial) ANOVA with repeated measures on object and trial. The ANOVA again revealed a significant Object × Trial interaction, $F(1, 13) = 5.40$, $p = .037$, $\eta_p^2 = .29$. In addition, the ANOVA found a significant interaction between infant vocalization frequency and trial, $F(1, 12) = 5.56$, $p = .036$, $\eta_p^2 = .32$. Tests of simple main effects showed, for low vocalizers, a significant effect of trial, $F(1, 6) = 9.34$, $p = .022$, $\eta_p^2 = .61$. These infants significantly decreased looking at the novel object over trials (Trial 1: $M = .36$, $SD = .61$; Trial 2: $M = -.75$, $SD = 1.01$). High vocalizers did not show an effect of trial on novelty preference scores, $p = .49$ (Trial 1: $M = -.05$, $SD = .91$; Trial 2: $M = .34$, $SD = .95$). These infants maintained a similar level of looking at the novel object over both trials. No other main effects or interactions were significant.

Object handling and looking during the exploration period

HVOs and LVOs did not significantly differ in the amount of infant looking during the object exploration phase ($M_{\text{high vocalization}} = 16.7$ sec, $SD = 4.6$; $M_{\text{low vocalization}} = 17.0$ sec, $SD = 7.2$), $t(12) = -.14$, $p = .89$. Infant handling of objects also did not differ significantly ($M_{\text{high vocalization}} = 31.1$ sec, $SD = 13.2$; $M_{\text{low vocalization}} = 24.6$ sec, $SD = 14.0$), $t(12) = 1.58$, $p = .14$. It is possible that a trend toward increased object handling of the HVOs would be significant with a larger infant sample. To explore this trend, we assessed whether handling, rather than vocalizing, during the exploration period could explain the novelty preference in the preferential looking task. We identified the objects that received the highest and lowest durations of handling during exploration and analyzed novelty preference in a two (handling: High, Low) × two (trial) repeated measures ANOVA. There were no significant main effects or interactions, all ps > .29. Thus, handling was not the source of the observed differences in preferential looking time.

We also tested whether infants' looking and handling of objects during the exploration phase accounted for differences in preferential looking. We correlated the amount of looking and handling of the HVOs and LVOs during the exploration period with the magnitude of their novelty preference for those objects in each test trial. Separate correlations were conducted for each behavior, vocalization condition, and test trial. None of the correlations between handling during exploration and strength of novelty preference during test or between looking during exploration and novelty preference during test were significant (all *p*s > .220). Thus, infants' discrimination between novel and familiar objects during the preferential looking task could not be explained by the amount of time infants spent looking at or handling those objects during the exploration period.

Discussion

Infants discriminated between familiarized and shape-distorted versions of an object that had elicited the most ODVs, as shown by their looking during the first trial. They did not show this discrimination for an object that had elicited the fewest or no ODVs. The results indicate that infants learned more about the features of objects that had elicited the most vocalizations. In the second trial, infants did not show significant differences in looking at the stimuli in either condition. It is likely that infants learned about the novel objects during the first looking trial; thus, they were no longer novel by the second trial and infants no longer showed a novelty preference. Such changes in looking time over trials are typical of looking time paradigms with children in this age range (e.g., Pruden et al., 2006).

Individual differences in the number of ODVs uttered during exploration had an effect on overall novelty preferences across trials. Infants who vocalized more during exploration maintained their attention to the target across test trials, perhaps demonstrating better control of attentional focus. By contrast, low vocalizers may not have maintained consistent attention to the target, perhaps because they were more distracted by the other object. However, differences in infant learning about object features were not explained by whether infants were high or low vocalizers relative to the rest of the sample. Instead, infants seemed to signal their attention to an object based on relative differences in babbling. Other forms of object-directed behavior, such as the amount of time spent looking at or handling the objects during exploration, did not predict learning. In addition, infant learning was not explained by inherent differences in object salience. All of the stimulus objects had features that were similarly salient or attractive to infants, as each one was chosen with roughly equal frequency as an HVO and LVO across infants.

The results support our hypothesis that ODVs signal a state of focused attention that facilitates learning. Previous research on perceptual learning and categorization has identified several behavioral correlates of focused attention that predict infant learning about objects' visual features (e.g., Oakes & Tellinghuisen, 1994; Ruff, 1986). For example, infants engaged in focused attention show an overall reduction in motor activity. Infants may also explore the object with their fingers or furrow their brow. In addition to these behavioral indices of focused attention, ODVs also signal a state of attention and arousal in which learning about object features is facilitated. Although infants' learning during object exploration was not reflected in changes in looking and handling, it was reflected in their vocalizations. Thus, prelinguistic ODVs may provide a more fine-grained and dynamic measure of infant attention and learning during object exploration when compared with total looking time at the object.

EXPERIMENT 2

Experiment 2 tested the role of infant babbling in learning associations between words and objects. Based on our findings from Experiment 1, we predicted that infants would be more likely to associate a label with an object after they babbled at it than when they had not vocalized. Thus, in a word learning task, we hypothesized that infants would show better learning of novel word–object associations when the object label was presented contingently on a look that was concurrent with an object-directed vocalization (ODV condition) versus a look alone (silent look [SL] condition). Experiment 2 thus tests whether the facilitative effect of ODVs on perceptual learning found in Experiment 1 extends to associative learning situated in a social context.

Methods

Participants

Forty infants (20 male, 20 female; *M* age = 11 months 63 days, range = 10 months 8 days to 12 months 4 days) participated. Families were recruited from the same population as Experiment 1 ($n = 36$ Caucasian, $n = 4$ Asian). No infants had previously participated in Experiment 1. An additional 16 infants were tested but excluded from analyses. Seven infants in the ODV condition failed to vocalize at least three times during each object presentation and thus could not receive nine object labels. Five infants (ODV $n = 2$, SL $n = 3$) were excluded for looking at the test pictures during less than 90% of the trial time after the novel label was presented (cf. Brandone, Pence, Golinkoff, & Hirsh-Pasek, 2007; Naigles, 1996). Four infants (ODV $n = 2$, SL $n = 2$) were excluded due to experimenter error. Infant gender was balanced in across conditions. Due to the yoked design, the first 20 infants were tested in the ODV condition. The remaining 20 infants were assigned to the SL condition and randomly paired with a previously tested ODV infant. Parents were given an infant t-shirt or bib for their participation.

Apparatus

The rooms and recording equipment used for the warm-up, training, and testing phases were the same as in Experiment 1. Infants' object exploration and vocalizations were recorded as in Experiment 1. The experimenter's speech to the infants was recorded by a wireless microphone attached to her collar with the transmitter carried in a small pouch attached to her waist by a belt. The experimenter also wore supra-aural wireless headphones (RadioShack model 33-1196; RadioShack Corporation, Fort Worth, TX) so that an observer in the control room could cue the timing of her labeling. During the test phase (a preferential looking task), novel object phrases were presented via a speaker (Bang & Olufson RL 35; Struer, Denmark) centered below the two images.

Stimuli

During the object training phase, infants were presented with two novel objects, one at a time, selected from the objects presented in Experiment 1 as shown in Figure 1. All infants saw the same two objects (the clear half-globe containing glitter balls and the green wooden sphere with five balls glued to it, both from Set 1). During the test phase (a preferential looking task), digital photographs of the two objects infants had seen in the object training phase were projected on the wall opposite the infant, in the same manner as Experiment 1. The photographs of these objects were the same as those used in the preferential looking task in Experiment 1.

At the beginning of each trial in the test phase, the photographs were presented silently for 2 sec before the onset of the labeling phrase. The object label was embedded in the labeling phrase, "Look at the ___! Can you find it?" Previous research on infant comprehension during preferential looking tasks has shown that infants' word recognition is facilitated when labels appear in sentences rather than in isolation (Fernald & Hurtado, 2006). There was a 1,000-msec pause between the labeling phrase and "Can you find it?" The phrases for the labels *riffy* and *koobie* were approximately the same duration (3,400 msec) and were recorded in the experimenter's voice, in infant-directed speech. The target label (*riffy* or *koobie*) began 533 msec after the speech onset, and "Can you find it?" began 2,200 msec after the speech onset.

Procedure

The session began with a 10-min warm-up period, during which the experimenter, the child, and the child's parent played together in a large playroom. The object training and test phases immediately followed. During these phases infants were seated on their parents' laps at an adult-sized table, as in Experiment 1. Parents listened to music over sound-attenuating headphones, as in Experiment 1, and received the same instructions not to touch or talk about the objects.

During the object training phase, the experimenter presented infants with two novel objects, one at a time in alternating trials, and allowed them to play with each object for three trials. One object was the target, the other was the distracter. Object assignment as the target and order of target–distracter presentation were counterbalanced across infants. The target object was labeled using infant-directed speech a total of nine times with a novel word, either *riffy* or *koobie*. The novel object label was presented in a labeling frame with three labels per trial (i.e., *Look at the riffy! See the riffy? That's a riffy.*). Novel object names were chosen to match phonological regularities of English nouns (Monaghan, Chater, & Christiansen, 2005). The distracter object was discussed with speech that was matched to the object label frames, but it was not given a novel label (i.e., *Oh, look at that! See that? Look at that.*) While labeling the object (or presenting matched speech for the distracter), the experimenter leaned in, touched the object, and maintained eye gaze with the infant.

Infants in the ODV condition received object labels or matched distracter speech immediately after they produced an ODV. The experimenter maintained a pause of at least 5 sec between each labeling frame. Thus, if an infant vocalized twice in quick succession, the experimenter would label the object once. Labeling in the SL condition was yoked to the ODV group. Each SL infant received object labels and distracter speech based on a schedule determined by a matched ODV infant. An observer in the control room cued the timing of the experimenter's labels via wireless headphones worn by the experimenter. In the SL condition, the timing of object labels thus matched the timing of labels for the matched ODV infant, but labels were presented when the infant was looking at the object without vocalizing. There were no chance contingencies between vocalizing and labeling. If an SL infant vocalized just as the observer was about to cue the experimenter to label the object, we planned to wait 5 sec, then cue the experimenter to label the object. However, this did not occur in the experiment. Trial length varied for infants within a condition but was matched across conditions with the yoking procedure. In both conditions, the experimenter responded to infants' exploration of the objects with spontaneous nonspecific verbal encouragement (e.g., *Yeah. What do you think? Are you having fun?*).

The test phase began immediately after the end of the object training phase. The test phase consisted of a preferential looking task. During test, parents wore a baseball cap with a short opaque veil attached to the brim, as in Experiment 1, and the sound-attenuating headphones. The experimenter left the room before the start of the preferential looking task. The task began with an animation in the center of the screen. When the infant looked at the screen, an observer in the control room started the test trials. In each of the two test trials, pictures of the target and distracter objects were projected side by side on the wall in front of the infant, with side counterbalanced across the two trials. One second after the pictures appeared on the screen, a speaker located between and below the pictures played the target label (e.g., *Look at the riffy! Can you find it?*). A camera located below the pictures recorded infants' eye gaze. Each of the two trials was 6 sec long, with an intertrial interval of 2 sec. During the intertrial interval, an animation was displayed in the center of the screen to bring the infants' gaze back to midline.

Data analysis

Coding

As in Experiment 1, infant behavior during object training was coded for number of vocalizations and proportion of the trial spent looking at and/or handling the objects. The duration of infant looking at the experimenter was also coded. Infant gaze during the preferential looking task was coded as in Experiment 1. Coders were blinded to the location of the target and distracter objects during the preferential looking task. Infant behavior was initially scored by one coder. Fifty percent of infants from each condition were randomly selected to be re-scored by a second coder to assess reliability. Reliability was $r = .98$ for looking during the object training phase, $r = .94$ for handling the objects, and $r = .93$ for looking during the preferential looking task.

As a validity check on the behavior of the experimenter in the two labeling conditions, a blinded coder assessed the level of engagement shown by the experimenter. Engagement was coded on a seven-point Likert scale for a single randomly selected target and distracter trial for each infant. Engagement levels were assessed by a two (condition: ODV, SL) $\times$ two (trial type: target, distracter) ANOVA. No significant main effects or interactions were found.

Looking at target

Our comparisons of infant learning across conditions were based on the "looking while listening" procedure (e.g., Fernald, Perfors, & Marchman, 2006). These studies assessed infants' online comprehension of familiar words (e.g., *dog* and *ball*) embedded in sentence frames (e.g., *Look at the doggie! Can you find it?*). To obtain a baseline measure of infants' attention to the two objects during the preferential looking task, the duration of each infant's looking at the target before the onset of the speech stream (the first 2,000 msec of the trial) was divided by the sum of their looking at the target and distracter (cf. Ballem & Plunkett, 2005; Swingley & Aslin, 2007). To measure word comprehension, we calculated infants' attention to the two objects after the labeling frame, beginning immediately after the offset of the phrase *Can you find it* (2,833 msec after the onset of the target word), and continuing for 1,430 msec (until 4,263 msec after the onset of the target word). Comprehension was thus calculated for the same duration as in previous studies.

Previous studies (e.g., Fernald & Hurtado, 2006; Swingley & Aslin, 2000) calculated the proportion of looking at the target by examining infants' attention to the target relative to the distracter, beginning 367 msec after the onset of the target word until the end of the trial (1,800 msec after the onset of the target word). The 367-msec interval allows enough time for the infant to initiate an eye movement after the onset of the target word. In comparison with previous work in online word comprehension (all with older infants or adults), the time window in the present study began later due to: (1) our use of novel objects and novel words as stimuli; and (2) younger infants' slower reaction time. Previous studies using online measures of comprehension have established developmental changes in the speed with which infants orient to the correct target (i.e., reaction time). Infants aged 12–14 months have a mean reaction time of about 1,200 msec for trials in which two *known* objects are shown and one is labeled (Zangl, Klarman, Thal, Fernald, & Bates, 2005). During the second year of life, infants show dramatic increases in the speed of their recognition of familiar words (Fernald, Pinto, Swingley, Weinberg, & McRoberts, 1998). For example, from 15 to 18 months of age, infants' reaction time for familiar words decreases by 17% (Fernald et al., 1998). However, word recognition is significantly slower when one of the targets is novel. Children as old as 34 months were significantly slower (approximately 35% slower, on average) to orient to a target when it was unfamiliar than when it was familiar (Zangl & Fernald, 2007).

As the reaction time for infants as young as 11.5 months has not been established for novel words, we examined the proportion of infants looking at the target in each video frame throughout Trial 1. We found the frame in which more than half of the infants reliably shifted their gaze in either direction and began the 1,430-msec comprehension window (to match that of Fernald & Hurtado, 2006) at that point. Thus, we could be sure that infants had enough time to orient in response to the novel object label. Within the comprehension period, we calculated mean proportion of target looking (PTL) scores separately for each condition (cf. Fernald et al., 2006; Mani & Plunkett, 2008). PTL was calculated as the amount of looking at target divided by the amount of looking at target plus distracter within the 1,430-msec window. Looks away from the two pictures were excluded. For each trial, looking during the comprehension period was compared with baseline looking and with chance levels (50%).

Relations between behavior during training and testing

In the yoked control design, trial length for both conditions was controlled by the time it took for infants in the ODV group to produce a vocalization. Thus, the amount of time spent with the objects was the same across both conditions. However, infants' interactions with the objects during training could differ and may have influenced infants' looks to the target during the test trials. The exploration behaviors were the proportion of time spent looking at the target object, proportion of time spent looking at the experimenter, and proportion of time spent in contact with the target object. We assessed the effects of object exploration on comprehension in two ways. First, we used *t*-tests to compare exploration between the ODV and SL conditions. We performed Bonferroni corrections for multiple comparisons (corrected $\alpha = .017$). Second, to assess individual differences, we correlated infants' PTL at test with their behavior during the training trials. We also correlated PTL with the duration of exposure to the target object (i.e., the total length of the three training trials).

Results

Looking at target

To compare looking at the target object from the baseline to the comprehension periods, we analyzed PTL in a two (condition: ODV, SL) × two (period: baseline, comprehension) × two (trial) ANOVA with repeated measures on period and trial. Data were analyzed for infants who looked at the stimuli during the comprehension periods of both trials. Four ODV and seven SL infants did not look during Trial 1; two ODV and seven SL infants did not look during Trial 2. Two infants in each condition did not look during the comprehension period of either trial. All infants looked during baseline. Thus, the ODV $n = 16$ and SL $n = 8$. The analysis revealed a

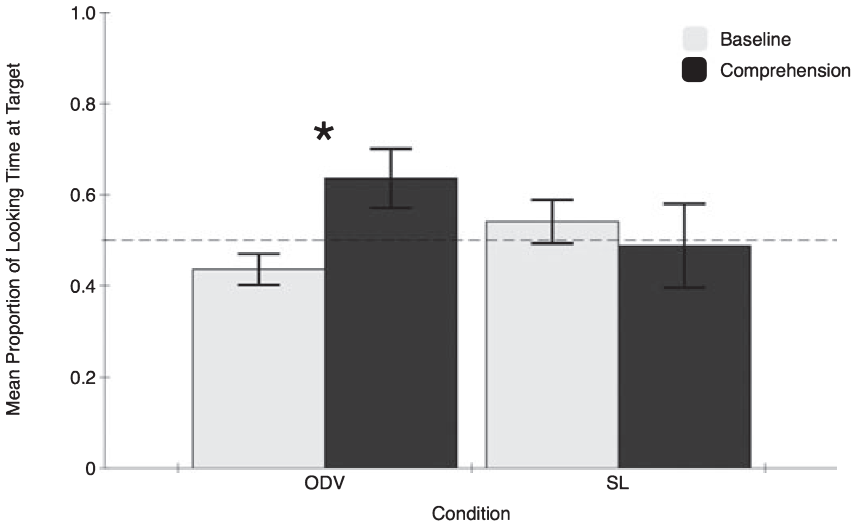

Figure 3 Mean proportion of target looking (amount of time spent looking at the target picture divided by the amount of time spent looking at either picture) during baseline and the comprehension period in Experiment 2. Data are averaged over the two test trials. Error bars represent $\pm$ 1 *SE*. The dotted line indicates chance looking (50% of the period spent looking at the target). $*p < .05$.

significant main effect of trial, $F(1, 22) = 6.62$, $p = .02$, $\eta_p^2 = .23$. Overall, infants looked longer at the target in Trial 1 ($M = .63$, $SD = .21$) than in Trial 2 ($M = .43$, $SD = .23$). Importantly, the ANOVA also found a significant interaction of Condition × Period, $F(1, 22) = 4.62$, $p = .04$, $\eta_p^2 = .17$, and a significant interaction of Trial × Period, $F(1, 22) = 5.63$, $p = .03$, $\eta_p^2 = .20$. No other main effects or interactions were significant, Fs < 1.55, ps $> .23$.

Each significant interaction was decomposed with tests of simple main effects. We followed up the significant Condition × Period interaction with tests of simple main effects on condition. For the ODV infants, there was a main effect of period, $F(1, 15) = 8.23$, $p = .01$, $\eta_p^2 = .35$ as shown in Figure 3. ODV infants looked longer at the target during the comprehension period than during baseline. By contrast, the SL infants showed no significant effect of period, $F(1, 7) = .34$, $p = .58$. We followed up the significant Trial × Period interaction with tests of simple main effects on period. During the comprehension period, there was a significant main effect of trial, $F(1, 23) = 9.22$, $p = .006$, $\eta_p^2 = .29$. Infants looked longer at the target during Trial 1 ($M = .75$, $SD = .33$) than during Trial 2 ($M = .43$, $SD = .40$). By contrast, there was no significant effect of trial during baseline, $F(1, 23) = 1.30$, $p = .27$.

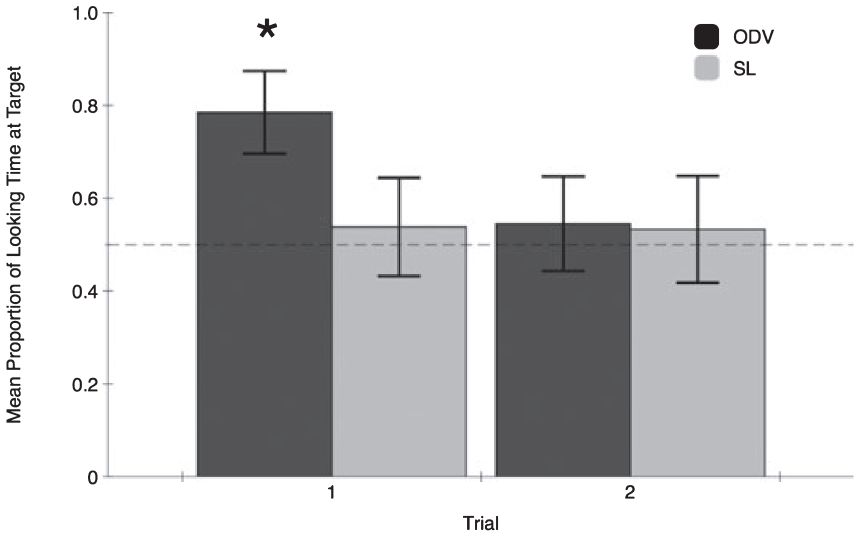

Figure 4 Comparison of mean proportion of target looking during the comprehension period to chance, by trial and condition, in Experiment 2. Error bars represent $\pm$ 1 *SE*. The dotted line indicates chance looking (50% of the period spent looking at the target). $^*p < .05$ (Bonferroni-corrected).

To obtain an absolute measure of learning, we compared infant PTL after naming to chance looking, defined as 50% attention to the target. With both trials averaged together, infants in the ODV condition looked at the target significantly more than chance (50% looking at target), $t(15) = 2.14$, Bonferroni-corrected $p < .05$, $d = .52$. By contrast, infants in the SL condition did not look at the target significantly more than chance, $t(7) = -.12$, $p = .91$. Following Ballem and Plunkett (2005), we also analyzed the first and second trials separately. These analyses included the infants who looked during a single trial and were excluded from the analyses above. Infants in the ODV condition looked at the target after naming significantly more than chance in Trial 1, $t(15) = 3.19$, Bonferroni-corrected $p < .02$, $d = .80$, but not during Trial 2, $p = .66$, as seen in Figure 4. Infants in the SL condition did not look at the target after naming significantly more than chance in either trial, ps $> .73$.

To test whether a significant number of infants showed a preference for the target object, separate Wilcoxon signed rank tests were conducted for each condition and trial. A significant number of infants ($n = 13$ of 20) in the ODV condition looked longer after naming at the target than the distracter in Trial 1, $T(-) = 125.00$, $p = .003$, two-tailed. By contrast, infants in the SL condition did not show a reliable preference for the target

($n = 8$ of 20), $T(-) = 56.00$, $p = .46$. In Trial 2, neither group of infants showed a reliable preference for the target, ODV ($n = 10$ of 20), $T(-) = 100.50$, $p = .51$; SL ($n = 6$ of 20), $T(-) = 37.5$, $p = .58$.

Relations between behavior during training and PTL

During the training phase, infants spent a mean of 2.12 min with the target object (range = 1.00–6.08 min; $SD = 1.32$) and 2.28 min with the distracter object (range = .67–7.32 min; $SD = 1.93$). There was no significant difference in duration of exposure to the target and to the distracter, $t(39) = -.41$, $p = .69$. In addition, there were no significant differences between conditions in any of the object exploration behaviors (Bonferroni-corrected ps > .15, Table 2). No significant correlations between behavior during training and PTL at test during the comprehension period were found for ODV or for SL infants. When infants from both conditions were combined, the proportion of time that the infants spent in contact with the objects positively correlated with mean PTL across both comprehension trials, $r(36) = .34$, $p = .04$. No other correlations between infant behavior during training and PTL during test were statistically significant.

Discussion

Infants showed stronger associations between novel objects and their labels when they had been presented contingently on an ODV, compared with being presented on a look alone. ODV infants showed a significant increase in looking at the target object from the baseline to comprehension periods. In addition, infants in the ODV condition looked at the target object significantly more than by chance during the comprehension period. PTL decreased over trials. By contrast, SL infants did not change their amount of looking at the target object over the test trial; their looking time remained at

TABLE 2
Infant Behavior During Training Trials With the Target Object in Experiment 2, by Condition

	Condition		
Behavior	*ODV* *Mean (SD)*	*SL* *Mean (SD)*	*Significance*[a]
Proportion of time spent looking at the target object	.70 (.13)	.60 (.18)	$p = .16$
Proportion of time spent looking at the experimenter	.15 (.10)	.25 (.21)	$p = .19$
Proportion of time spent in contact with the target object	.71 (.22)	.57 (.28)	$p = .29$

Note: [a] p-values include Bonferroni corrections for multiple comparisons.

chance levels. Presenting the object label contingently on an ODV thus facilitated learning word–object associations. The SL infants did not learn, despite receiving the same number of labels with equal density and equal duration of object exposure as the ODV infants.

There were no group differences in time spent handling the target or distracter objects or in exploratory behavior during training. In both groups, no infant behaviors during training specifically predicted looking at the target. However, when the groups were combined to examine individual differences, handling behavior during training showed some predictive power for infant looking at the target. Infants who spent more time handling the target object were more accurate during the preferential looking test. Recent studies of word learning have found that toddlers are more likely to learn a name for an object when they are holding it than when they are not (Smith, Yu, & Pereira, 2009).

GENERAL DISCUSSION

The present experiments provide evidence that ODVs signal a state of readiness to learn. In Experiment 1, infants were given opportunities to explore novel objects. Infants learned the visual properties of objects at which they vocalized the most. By contrast, infants did not learn the properties of objects that elicited the fewest or no vocalizations. The amount of vocalizing that mattered for learning was relative for individual infants; there did not seem to be an absolute threshold for the amount of vocalizing that would facilitate learning. Experiment 2 showed that labeling an object contingently on an ODV facilitated learning associations between words and objects. Yoked control infants, who received labels after an equivalent amount of exposure to the objects but not contingently on an ODV, did not learn word–object associations. Taken together, these experiments provide support to our hypothesis that ODVs signal a state of focused attention. Object-directed babbling may signal a general readiness to learn.

Our findings indicate a new function of babbling in the development of cognition and language. In the past, babbling was thought to be completely separate from later advances in speech and language (Jakobson, 1941/1968; Lenneberg, Rebelsky, & Nichols, 1965). The disconnect between babbling and speech was due to attempts to categorize sounds based on the International Phonetic Alphabet, which is designed for categories of well-formed adult speech (see review in Oller, 2000). As babbling was studied with better acoustic tools that revealed the details of acoustic change over the first year, continuities between babbling and later language became apparent. For example, there is a great deal of acoustic overlap between preferred babbling sounds and early words (Stoel-Gammon, 1992). In addition, the number of syllable types in the prelinguistic repertoire predicts the onset of words (Stoel-Gammon, 1992). However, most of the work on continuity between babbling and speech has been at the acoustic level. The present experiments show functional links between early vocalizing and learning words.

ODVs, and social responses to them, create opportunities for socially guided learning to facilitate early language development. The important role of contingent social feedback to babbling has been shown in vocal development, such as learning mature syllable forms (Bloom, Russell, & Wassenberg, 1987; Goldstein et al., 2003) and phonological patterns (Goldstein & Schwade, 2008). The present experiments suggest that responses to ODVs have similar significance for learning. ODVs have signal value as an indicator of focused attention. Caregiver responses that label the object at which the infant is vocalizing should facilitate word learning. Indeed, reactions to the ODVs of 9-month-olds predict later language growth at 15 months (Goldstein & Schwade, 2010). The relation between ODVs and later vocabulary was positive when caregivers accurately labeled the object and negative when caregivers uttered a word that, although contingent on babbling, did not match the object. Thus, ODVs, when uttered in social contexts, play an important role in the development of communication and language.

Before words can be learned, infants must first realize that sounds are linked to objects and events. Young infants (aged 7–8 months) can learn to associate sounds with objects when they are synchronized, such that infants dishabituate when word–object pairings are switched during a habituation task (Gogate & Bahrick, 2001). Later in development, infants learn that words can stand for objects. Children form generalizations about a word and a category of referents after more prolonged exposure to word–object pairings (e.g., Hollich et al., 2000; Smith, 2000). Over time, patterns of caregiver responsiveness make the connections between words and objects more salient by providing reliable patterns of co-occurrences of words and objects. These co-occurrences afford word learning from mechanisms that pick up on cross-situational statistics (e.g., Smith & Yu, 2008; Yu & Smith, 2007). However, outside of the laboratory, statistical learning of word–object associations could be facilitated by naturally occurring social cues that direct attention (Wu & Kirkham, 2009). Presenting object labels in response to ODVs, when infants are particularly attuned to learning, would serve to make some word–object correspondences more salient than others and influence patterns of learning. Interactions organized by ODVs are thus a likely source of early word learning.

Infant vocalizations and social responses to them might also facilitate the learning of words that refer to people and social events. Many of infants' first words are not names for objects, but are instead names for people (e.g., *daddy*), requests (e.g., *more*), or social words (e.g., *hi*; Bloom, Tinker, & Margulis, 1993; Nelson, 1973). As infants are engaged in social interactions, their vocalizations might also help them to learn the names for common events and routines. Just as caregivers respond to ODVs by labeling the object to which the infant is attending, they may respond to infant vocalizations with an appropriate social phrase. For example, a caregiver may say "Hi, daddy!" when the child vocalizes at a returning parent or "more" when the infant vocalizes at an empty bowl. Some early words could arise specifically out of prelinguistic turn-taking interactions, such as when an infant points at an object and vocalizes, then the parent names it (Bates, Camaioni, & Volterra, 1975). A common early word is "that!" (Bloom et al., 1993; Nelson, 1973), which could arise from these social interactions.

Our findings on infant learning while vocalizing pertain to noncry vocalizations produced in social interactions. Infants produce different kinds of vocalizations when they are in social interactions compared with when they are alone. When engaged in social interactions, infants tend to make shorter, more punctate sounds than the longer vocalizations produced in isolation (D'Odorico & Franco, 1991). We do not predict that all prelinguistic vocalizations are indicative of focused attention. Different types of vocalizations may serve different functions and may elicit different responses from caregivers. The present study did not investigate relations between vocal complexity and infant learning. An infant who produces a more recently acquired or more developmentally advanced sound as an ODV might elicit a different reaction from a caregiver than if they had produced a less developmentally advanced sound. Previous studies of spontaneous maternal reactions to infant vocalizations indicate that babbles containing speechlike acoustic structure, such as fully resonant vowel nuclei and consonant–vowel combinations, may change the form of mothers' responses, although reactions to ODVs and nondirected vocalizations were not compared (Goldstein & West, 1999; Gros-Louis, West, Goldstein, & King, 2006). Vocal complexity also might interact with infants' own arousal and attention. Future studies will investigate the role of vocalization complexity in predicting infant arousal and attention.

A remaining question concerns the direction of causality between vocalizing and focused attention. Our initial claim is that ODVs uttered in social context are a consequence of focused attention, but it could be the case that vocalizing serves a self-stimulation function, increasing arousal and attention. Prelinguistic grunts are also thought to serve as a source of vocal self-stimulation (McCune, 2008). In several species, the act of vocalizing has been found to alter endocrine activity and arousal level (Cheng, 1992, 2003). Thus, vocalizations may have functions for the sender as well as the receiver. Such activity-dependent developmental processes are evident when infants' own actions serve as an important catalyst for future development, as has been found in the ontogeny of cognitive and motor function (e.g., Piaget, 1954; Thelen & Smith, 1994). For example, infants' self-produced movement through space is crucial for the development of visual depth perception (Campos et al., 2000). Infants' vocalizations may have a similarly important role in moderating their own attention as well as in eliciting object labels from adults. Current studies in our laboratory are addressing the role of babbling as a mechanism for the self-regulation of attention and arousal.

While ODVs signal an attentional state that facilitates learning associations between objects and labels, they are not required for such learning to occur. Even 12-month-old infants can learn word–object associations given sufficient statistical (Smith & Yu, 2008) and perceptual (Pruden et al., 2006) support. Additional support for word learning may come from infants' interactions with objects, as suggested by Smith et al. (2009) and by the relation between handling objects and learning their labels in Experiment 2. Later in development, when infants have acquired a number of words, they are in a better position to use contextual information to learn object names, without vocalizing. However, to get language learning started, caregivers' verbal responses to prelinguistic infant vocalizations may be crucial.

The present studies represent a first step in establishing links between prelinguistic vocal development and early word learning. When uttered in social interactions, infants' vocalizations elicit maternal responses and provide opportunities for learning about sounds and objects. These social interactions with caregivers are structured in a way that can facilitate learning associations between objects and words, as ODVs bring together infant attention and caregiver labeling in a coherent, time-locked fashion. By producing ODVs, infants organize social interactions around nearby objects and, with their caregivers, facilitate learning more about their environment.

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