



SHORT REPORT

Do 6-month-olds understand that speech can communicate?

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Abstract

Adults and 12-month-old infants recognize that even unfamiliar speech can communicate information between third parties, suggesting that they can separate the communicative function of speech from its lexical content. But do infants recognize that speech can communicate due to their experience understanding and producing language, or do they appreciate that speech is communicative earlier, with little such experience? We examined whether 6-month-olds recognize that speech can communicate information about an object. Infants watched a Communicator selectively grasp one of two objects (target). During test, the Communicator could no longer reach the objects; she turned to a Recipient and produced speech (a nonsense word) or non-speech (coughing). Infants looked longer when the Recipient selected the non-target than the target object when the Communicator spoke but not when she coughed – unless the Recipient had previously witnessed the Communicator's selective grasping of the target object. Our results suggest that at 6 months, with a receptive vocabulary of no more than a handful of commonly used words, infants possess some abstract understanding of the communicative function of speech. This understanding may provide an early mechanism for language and knowledge acquisition.

Introduction

The communicative function of speech is separable from its lexical content. Utterances that have the form of speech can be interpreted as communicative even when the content cannot be comprehended. For instance, an adult hearing a conversation in a foreign language may infer that the speaker is providing information to the listener. Even 12-month-old infants show understanding of the communicative function of speech (Martin, Onishi & Vouloumanos, 2012; Vouloumanos, Onishi & Pogue, 2012); they understand that speech can transfer information even when the speech is novel to the infants themselves.

Infants understand that speech is communicative before they acquire a large vocabulary and begin to speak. Infants' understanding of the communicative function of speech may thus precede, and provide a mechanism for, early language acquisition; infants may start with an early recognition that the form of speech (but not non-speech sounds) can transfer information, and use this abstract understanding to learn individual word meanings (e.g.

Waxman & Leddon, 2002). However, by 12 months infants already have productive vocabularies of about 3 words and receptive vocabularies of about 50 words (Fenson, Dale, Reznick, Bates, Thal, Pethick, Tomasello, Mervis & Stiles, 1994; Fenson, Pethick, Renda, Cox, Dale & Reznick, 2000; Hamilton, Plunkett & Schafer, 2000). Thus it is also possible that 12-month-olds' experience with language may have allowed them to grasp the communicative function of speech. On this view, abstract principles of how language is used in the service of communication would have emerged from item-specific lexical knowledge (e.g. Nazzi & Bertoncini, 2003; Smith, 2000).

If an abstract understanding of the communicative function of speech provides a mechanism to guide language acquisition, it must be present early, perhaps before infants are skilled word learners. At 6 months, infants prefer speech over other sounds (Vouloumanos & Werker, 2004) and show some understanding of how speech functions; they use speech, but not non-speech, to detect similarities between instances and generalize to

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novel instances (Balaban & Waxman, 1997; Ferry, Hespos & Waxman, 2010; Fulkerson & Waxman, 2007). They also show some signs of understanding the contexts in which speech is typically used. They associate speech with its usual source, humans (and not other animals; Vouloumanos, Druhen, Hauser & Huizink, 2009), and expect speech to be addressed toward other humans (rather than objects; Legerstee, Barna & DiAdamo, 2000). At the same time, 6-month-olds do not yet show evidence of preferentially using speech over non-speech to individuate objects or make sound-object mappings (MacKenzie, Graham & Curtin, 2011; Xu, 2002; Xu, Cote & Baker, 2005). And despite findings that 6-month-olds understand a handful of commonly used nouns (Bergelson & Swingle, 2012; Tincoff & Jusczyk, 1999, 2012), there is little evidence of word form-object learning in laboratory settings (but see Shukla, White & Aslin, 2011). In the current study we examined whether 6-month-old infants, who are in the earliest documented stages of word learning, already understand the communicative function of speech.

To investigate this question we used a third-party scenario (e.g. Akhtar, Jipson & Callanan, 2001; Cheung, Xiao & Lai, 2012; Martin *et al.*, 2012; Song, Onishi, Baillargeon & Fisher, 2008; Vouloumanos *et al.*, 2012) in which a Communicator directed a novel word to a Recipient with the infant observing the communicative exchange. Under these circumstances, for the infant to make sense of the Recipient's response to the speech, the infant must infer that the speech can convey information to the Recipient, even though the novel word has no established meaning for the infant (Martin *et al.*, 2012). This third-party scenario, in which infants observed an interaction and evaluated the potential for transfer of information between two people, allowed us to examine whether infants understand that the form of speech is communicative.

Specifically, we asked whether 6-month-old infants recognize that a Communicator can inform a Recipient about a target object by using speech (a novel speech token, 'koba') but not non-speech (a coughing sound, 'xhm-xhm-xhm'). Infants saw an actor (the Communicator), alone, repeatedly and selectively grasping one object (the target object) over another object. Next, infants saw a second actor (the Recipient), alone, who briefly interacted with both objects. Finally, in the test event, both actors were present; however, due to a change in the scene, the Communicator could no longer reach the objects whereas the Recipient could (see Figure 1). From an adult perspective, the Recipient could subsequently select the target object if the Communicator produced an informative vocalization such as speech (Speech condition), but not if the Communicator pro-

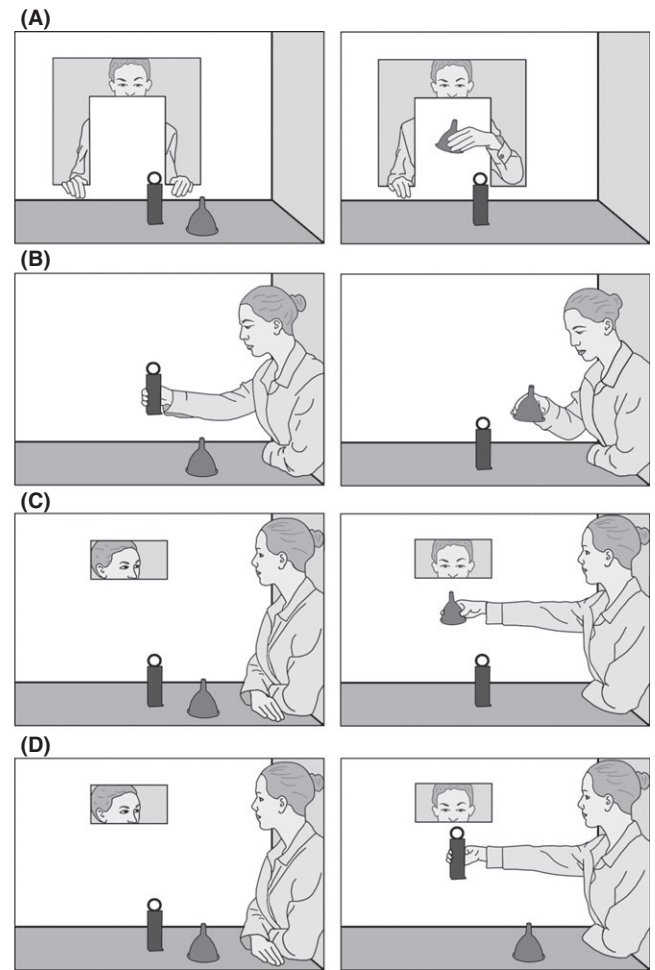


Figure 1 Procedure. (A) Familiarization: The Communicator looked at two novel objects, and then grasped the target object (in the Speech and Cough conditions, the Communicator was alone in the scene; in the Cough-Visual Access condition, the Recipient was also present). Here, the target object was the red funnel, placed on the right side (target object and object location were counterbalanced across participants). (B) Pretest: The Recipient interacted with both objects. (C and D) Test: The Communicator could no longer reach the objects because the opening she had reached through was covered by a panel. The Communicator turned toward the Recipient and produced a vocalization. The Recipient then selected the target object (C), or the non-target object (D). Reprinted from *Cognition*, Vol 123 (1), Martin, A., Onishi, K.H., & Vouloumanos, A., Understanding the abstract role of speech in communication at 12months, pp. 50-60, 2012, with permission from Elsevier.

duced a non-informative vocalization such as coughing (Cough condition), unless the Recipient had additional information such as having previously observed the Communicator's selective grasping of the target (Cough-Visual Access condition).

If infants in the Speech condition evaluated the Communicator's speech vocalization as conveying information to the Recipient about the target object, then they would look longer when the Recipient selected the non-target object (Non-target outcome) than the target object (Target outcome; Baillargeon, Spelke & Wasserman, 1985; Wang, Baillargeon & Brueckner, 2004). In the current scenario, a coughing vocalization should not indicate which object was the target (Martin *et al.*, 2012). If infants in the Cough condition did not evaluate the Communicator's vocalization as conveying information to the Recipient about the target (making the Recipient equally likely to select either object), then infants would look equally to Non-target and Target outcomes. In the Cough-Visual Access condition we examined whether infants consider the Recipient's current information state when evaluating the Recipient's ability to identify the target in the absence of an informative vocalization from the Communicator. If infants recognized that prior visual access to the Communicator's selective grasping of the target object should provide the Recipient with information about the target (Song *et al.*, 2008), regardless of the Communicator's uninformative vocalization, then they would look longer to the Non-target outcome than the Target outcome.

Prior to the test event, infants had information about which object was the Communicator's target (through their prior observation of the Communicator's selective grasping), but the Recipient only received information about which object was the target if the Communicator produced an informative vocalization or if the Recipient had witnessed the Communicator's selective grasping. If infants made inferences about the Recipient's ability to select the target object from their *own* perspective, then infants' evaluation of the Recipient's ability to select the target object would sometimes be incorrect (i.e. they should always look longer when the Recipient selects the non-target than the target). If, however, infants understood that some vocalizations (speech) but not others (coughing) lead to successful communication, they would expect the Recipient to select the target object only when the Communicator vocalized informatively or when there was evidence that the Recipient had prior information about the target.

Method

Participants

Forty-eight healthy, full-term infants (mean age = 6 months, 6 days; range = 5,20 to 6,20) participated, 16 in

the Speech condition (8 female), 16 in the Cough condition (8 female) and 16 in the Cough-Visual Access condition (8 female). Data from 7 additional infants were excluded from analysis due to fussiness or crying (1), inattentiveness (1), parental interference (1) or experimenter or computer error (4).

Apparatus

Infants sat on a parent's lap facing a display resembling a puppet stage. From the infant's point of view, the back wall contained a window permitting the Communicator to be visible, or not. The right wall had a large opening covered by a yellow curtain, permitting the Recipient to be visible, or not. On either side of the display were two panels which isolated the parent and infant, and allowed an online coder to see the infant while preventing the coder from seeing the events in the display. The coder recorded when the infant was looking at the display by pressing a button on a game pad attached to a computer running the Windows-based program Baby (Baillargeon & Barrett, 2005). Both the infant and the events in the display were recorded on video.

Stimuli

Two novel objects were used: a red funnel, and a rectangular blue plank with a looped pipe cleaner attached to its top. The placement of the objects ensured that the Communicator and Recipient could reach both objects.

The target object's identity (funnel or plank) and location (left or right) were fully crossed across participants such that for half the infants within each condition the target was the funnel (and for the others, the plank) and within each target-object subgroup, for half the infants the target was on the left from the infant's perspective (and for the others, the right).

Procedure

This experiment was conducted as a between-subjects design with three conditions. Each infant saw five trials: three familiarization trials, one pretest trial, and one test trial (see Figure 1). A curtain covered the scene between trials. Each trial contained initial and main sections: During the *initial section*, the actors performed the informative actions (e.g. in the Familiarization trials, the Communicator reached for the target object). During the *main section*, the actors remained still, or performed a non-informative action to maintain the infant's interest (e.g. in the Familiarization trials, the Communicator tilted the object back and forth).

The looking times that are reported were measured during the main section of the trials after all informative actions had ceased. Trials ended when the coder signaled that the infant had looked away from the scene for 2 consecutive seconds after having looked for at least 2 s in the main section of the trial, or when the infant looked for the maximum duration for the main trial. Trial-specific actions were performed in time to a metronome clicking once per second. In the test trials, in each condition, half the infants saw the Recipient offer the target object, and the other half saw the Recipient offer the non-target object.

Familiarization

The curtain rose to reveal the Communicator in the back opening with the top of her face and her arms visible. During the initial section, the Communicator looked neutrally toward the center (2 s), then looked at one object (2 s), then the other object (2 s), looked at and reached for the target object (2 s), lifting it (1 s) and bringing it closer just below her face (1 s). She then tilted the object back and forth (2 s). During the main section, the Communicator looked at the target object while tilting it back and forth until the trial was ended after 18 s or when the infant looked away thus ending the trial (see trial-end criteria below). The familiarization trial was presented three times. In the Speech and Cough conditions, only the Communicator was present during Familiarization. In the Cough-Visual Access condition, the Recipient was also present during Familiarization trials and thus could see the Communicator grasping the target. In this condition, the Recipient was visible through the side opening of the display, with her eyes following the actions performed on the target object by the Communicator.

Pretest

The curtain rose to reveal the Recipient in the side opening. The Communicator was no longer present. During the initial section, the Recipient looked neutrally toward the center (2 s), at one object (2 s), then at the other object (2 s). Next, she looked at the first object (1 s), grasped and lifted it (2 s), tilted it towards and away from herself once (2 s), put it down and withdrew her hand (2 s). This 7-s look-lift-tilt sequence was then performed with the second object, ending the trial's initial section. During the main section, the Recipient performed the 7-s sequence once on each object again, stopping when the trial was ended after 15 s or when the infant had looked away (see trial-end criteria below). The pretest trial was presented once and was identical across all conditions.

Test

The curtain rose to reveal both actors in their respective locations; however, the Communicator was unable to reach the objects as the opening was now smaller, again revealing the top of her face, but now obscuring her arms because the panels were closed. After the infant looked at the display for 2 s, the initial section began. During the initial section, the Communicator looked at each object (4 s), then turned to make eye contact with the Recipient (who turned to look at the Communicator) and produced a vocalization which differed by condition twice (4 s). In the Speech condition, the vocalization was the novel speech token 'koba', and in the Cough and Cough-Visual Access conditions the vocalization was a coughing sound 'xhm-xhm-xhm'. Across the three conditions, except for the vocalization itself, all actions (including eye contact between Communicator and Recipient) were identical. The Recipient looked at then grasped one of the two objects (2 s), and raised it just below the Communicator's face (2 s), and held it there (2 s), ending the initial section. During this sequence of actions, the Communicator looked at the Recipient until the moment the Recipient grasped the object, at which point the Communicator followed the motions of the object with her eyes. During the main section, both actors looked at the object until the trial was ended after 40 s or when the infant looked away (see trial-end criteria below). Each infant saw a single test trial in which either the target or the non-target object was selected.

Coding

Looking times during the main sections were determined by the online coder who was blind to target object identity, target object location, and test outcome (Target or Non-target). A second coder, also blind to target object identity, location, and test outcome verified that the test trial ended correctly from the video of the infant's face. The two coders were in agreement on 96% of test trials, and disagreements were resolved by a third blind coder.

Results

Infants evaluated the Communicator's speech and the Recipient's prior visual access, but not the Communicator's coughing, as informing the Recipient about the target object (see Figure 2). A 3 (condition: Speech, Cough, Cough-Visual Access) by 2 (outcome: Target, Non-target) between-subjects Analysis of Variance (ANOVA) showed a main effect of condition [$F(2, 42)$

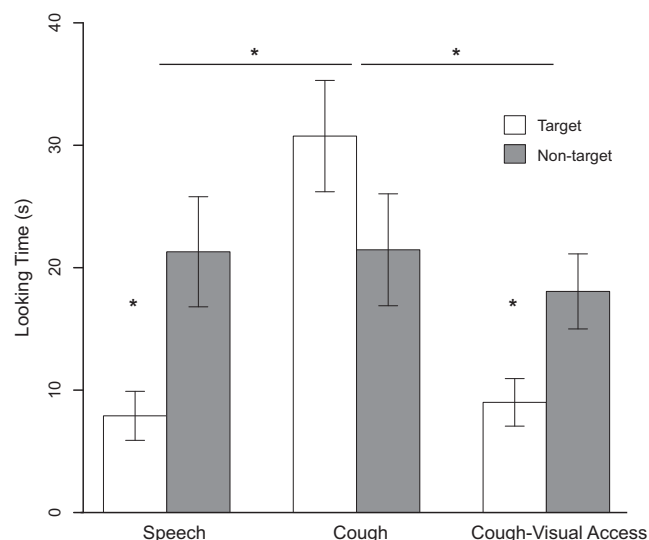


Figure 2 Results. Mean looking time (in s) \pm SEM across infants for each test outcome (Target, Non-target) for each condition. * over bars indicates a significant difference in test outcomes and over lines indicates a significant interaction between condition and test outcome at $p < .05$.

$= 7.39$, $p = .002$, $\eta^2 = .26$] and a reliable interaction between condition and outcome [$F(2, 42) = 5.51$, $p = .007$, $\eta^2 = .21$]. When the Communicator produced speech (Speech condition), infants looked significantly longer when the Recipient selected the non-target object ($M_{\text{non-target}} = 21.3$ s) than the target object ($M_{\text{target}} = 7.9$ s) [$t(14) = 2.72$, $p = .017$, $\eta^2 = .35$]. When the Communicator coughed (Cough condition), infants looked equally to Non-target and Target outcomes ($M_{\text{non-target}} = 21.5$ s, $M_{\text{target}} = 30.8$ s) [$t(14) = 1.44$, $p = .172$, $\eta^2 = .13$]. When the Communicator coughed, but the Recipient had previously seen the Communicator selectively grasp the target object during the familiarization trials (Cough-Visual Access condition), infants looked significantly longer when the Recipient selected the non-target ($M_{\text{non-target}} = 18.1$ s) than the target object ($M_{\text{target}} = 9.0$ s) [$t(14) = 2.50$, $p = .026$, $\eta^2 = .31$]. Infants looked longer in the test trial overall in the Cough condition than in the Speech condition or the Cough-Visual Access condition (both $ps < .01$).

Test outcome interacted reliably between the Speech and Cough conditions [$F(1, 28) = 7.82$, $p = .009$, $\eta^2 = .22$], as well as between the Cough and Cough-Visual Access conditions [$F(1, 28) = 6.15$, $p = .019$, $\eta^2 = .18$]. Outcome did not interact between the Speech and Cough-Visual Access conditions [$F(1, 28) = .50$, $p = .484$, $\eta^2 = .02$].

We ran the original 3×2 ANOVA on the sum of looking time to the main sections of the familiarization

and pretest trials, and found no significant main effects or interactions (all $ps > .08$).

Discussion

By 6 months, infants recognize the communicative function of speech. Infants recognized that the Communicator's novel speech sound, which had never been explicitly associated with or spoken while she manipulated the target object, could communicate information about the target to the Recipient. Infants did not evaluate the Communicator's coughing as conveying the same information, but recognized that the Recipient could select the target even when the Communicator produced this uninformative vocalization if the Recipient had prior visual access to information about which object was the target.

Six-month-old infants inferred that speech should communicate successfully in at least one situation in which a coughing vocalization should not. This is consistent with 12-month-olds' understanding that speech is often a more efficient means of communication than other vocalizations, allowing identification of particular objects in a wider range of contexts (Martin *et al.*, 2012). Thus, by 6 months, infants not only privilege speech in their listening preferences (Vouloumanos & Werker, 2004), learning (Reeb-Sutherland, Fifer, Byrd, Hammock, Levitt & Fox, 2011), and generalization about the physical world (Ferry *et al.*, 2010; Fulkerson & Waxman, 2007), but they also have some understanding that speech plays a privileged role in transferring information between people.

Infants appear to be sensitive to the communicative function of speech without necessarily evaluating its lexical content. The 12-month-old infants who succeeded in this task in previous studies were more experienced word learners, and may have evaluated the communicative exchange by inferring the meaning of the word 'koba' rather than using an abstract understanding that the *form* of speech is communicative. For instance, 12-month-olds may have first inferred the content of the Communicator's speech by connecting it to her prior grasping of the target object, and then evaluated the outcome of the communicative interaction by assuming that the Recipient would select the object picked out by the word 'koba'. Six-month-olds on the other hand, have small receptive vocabularies and likely know the labels for only a few commonly labeled objects in their environment (Bergelson & Swingle, 2012; Tincoff & Jusczyk, 2012). The only study showing learning of word-object associations in 6-month-olds used multiple trials, with concurrent presentation of a highlighted

object and word form that infants could extract using multiple cues (aligned statistical and prosodic cues; Shukla *et al.*, 2011). Furthermore, infants have difficulty with learning new word–object pairings when single words are presented in isolation until 14 months (Werker, Cohen, Lloyd, Casasola & Stager, 1998). Thus it is unlikely that the 6-month-old infants in our experiments evaluated the communicative exchange in our study by inferring the meaning of ‘koba’ based on the Communicator’s prior selective grasping of the target. Indeed, there is no empirical evidence that even 12-month-olds can learn word–object mappings from such limited and non-concurrent exposure. Our results suggest that by 6 months infants understand that the form of speech, independent of any specific lexical content, can communicate information about an object. This is the strongest evidence to date that an understanding of the communicative function of speech precedes, and may help to guide, early word learning.

Infants in the current study must have inferred that the Communicator’s word ‘koba’ was able to pick out the target object for another person, the Recipient. This assumption is consistent with data from 24-, 19- and 12-month-olds who infer that language use is conventional among speakers (Graham, Stock & Henderson, 2006; Henderson & Graham, 2005; Martin *et al.*, 2012). That 6-month-olds who have very limited vocabularies (Bergelson & Swingley, 2012) expect the *form* of speech (a novel speech token not yet associated with any established meaning) to allow a Communicator to transfer information to a Recipient suggests that an abstract understanding that language can be generalized across speakers does not rely on an extensive vocabulary (Moore, 2013; unlike in e.g. Nazzi & Bertoncini, 2003; Smith, 2000). This understanding may provide a foundation on which a more sophisticated understanding of the conventionality of language is built.

A critical question for future research is to establish why speech holds such communicative potential, while coughing does not. One possibility is that speech elicits referential expectations. Consistent with this possibility, infants as young as 3 months expect words (but not most other non-speech sounds) to refer to categories of objects (Ferry *et al.*, 2010; but see Ferry, Hespos & Waxman, 2013), and even for adults, certain words may hold special referential status (Lupyan & Thompson-Schill, 2012). For infants speech and coughing did not have the same communicative power, but infants recognized that with prior visual access to the Communicator’s selective grasping the Recipient could select the target even if the Communicator coughed. One possible interpretation of these results might be that infants generally expect different actors to select the same object, but that

hearing a cough somehow disrupted this expectation. This interpretation seems unlikely because in a non-communicative scenario infants fail to extend expectations about one actor’s object preference (indicated by selective grasping) to a second actor (Buresh & Woodward, 2007; Henderson & Woodward, 2012), and because in scenarios identical to those in the current experiment, coughing shows the same pattern of results as no vocalization at all for infants of 12 months (Martin *et al.*, 2012). How infants evaluate the potential communicative affordances of non-speech is an open question for future research.

In addition to showing early understanding of speech in communication, our results show that 6-month-olds already track different information states in order to interpret communicative attempts. By 6 months, infants understand that a person will grasp an object to which she has visual access rather than one to which she does not (Luo & Johnson, 2009), and thus that individuals’ visual perceptions affect their actions. Moreover, slightly older infants (the youngest at 7 months) recognize that others’ information states can differ from the infants’ own (e.g. Kovács, Téglás & Endress, 2010; Luo, 2011; Onishi & Baillargeon, 2005; Surian, Caldi & Sperber, 2007). In our study, despite the fact that infants always knew which object the Communicator had selectively grasped, they did not assume that the Recipient would also have this information. Instead, infants inferred that hearing speech or witnessing previous relevant actions provided the Recipient with the necessary information to select the target. Hearing an underspecified vocalization, like coughing, did not. To predict the Recipient’s response infants thus had to reason about how speech or coughing would influence the *Recipient’s* knowledge and not their own. Our results show that 6-month-olds already have some understanding that an agent’s behavior is guided by its knowledge state (Buttelmann, Carpenter & Tomasello, 2009; Onishi & Baillargeon, 2005; Scott & Baillargeon, 2009; Southgate, Chevallier & Csibra, 2010; Surian *et al.*, 2007), not only by its current perceptual access (Luo & Johnson, 2009), and that knowledge states can be updated by relevant information from an interlocutor (Song *et al.*, 2008) even when the infants themselves are merely observers and they have access to different information. By 6 months, infants may have some inkling of the importance of common ground in communication (Clark, 1996); tracking different information states and the conditions under which they can be updated may allow infants to understand that even ambiguous communication can be informative if interlocutors share some relevant background.

Understanding that speech is a tool for transferring information is a likely precursor to early knowledge

acquisition. Infants' assumption that speech communicates before they know the meanings of many words might drive language acquisition, for example allowing them to more easily detect the referents of novel labels (Bergelson & Swingle, 2012; Parise & Csibra, 2012). Moreover, speech could index opportunities for learning (Gelman, 2009), providing infants with an important mechanism for learning beyond acquiring item-specific mappings, and perhaps bolstering their ability to acquire knowledge from third-party interactions (e.g. Akhtar, 2005).

Conclusion

Six-month olds infer that a vocalization that takes the form of speech, even without any previously established meaning, can communicate information about an object. Infants of this age can assess a person's information states and behaviors based on the utterances directed towards her and her visual access to information. Even before knowing many words, infants can already use their understanding of the abstract role of speech in communication to evaluate the outcome of communicative interactions. Like other early-emerging biases which guide and constrain language learning (e.g. Vouloumanos & Werker, 2007), an abstract understanding of the communicative function of speech may provide an early vehicle for infants' own language and knowledge acquisition.

Acknowledgements

This research was supported by NYU research funds. We'd like to thank the members of the NYU Infant Cognition and Communication Lab and especially the parents and infants who participated.

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Received: 5 June 2013

Accepted: 25 November 2013