



## Short Communication

# What the [beep]? Six-month-olds link novel communicative signals to meaning



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## ABSTRACT

Over the first year, infants tune into the signals of their native language and begin to link them to meaning. Here, we ask whether infants, like adults, can also infer the communicative function of otherwise arbitrary signals (here, tone sequences) and link these to meaning as well. We examined 6-month-olds' object categorization in the context of sine-wave tones, a signal that fails to support categorization at any point during their first year. However, before the categorization task, we exposed infants to tones in one of two vignettes. In one, the tones were produced by an actor in a rich communicative exchange; in the other, infants heard the very same tones, but these were uncoupled from the actors' activity. Infants exposed to the communicative vignette successfully formed object categories in the subsequent test; those exposed to the non-communicative vignette failed, performing identically to infants with no prior exposure to this novel signal. This reveals in 6-month-old infants a remarkable flexibility in identifying which signals in the ambient environment are communicative and in linking these signals to core cognitive capacities including categorization.

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## 1. Introduction

Over the first year of life, infants tune into the signals of their native language and begin to link them to meaning (Ferry, Hespos, & Waxman, 2010, 2013; Fulkerson & Waxman, 2007; Gervain & Mehler, 2010; Saffran, Werker, & Werner, 2007; Vouloumanos, Hauser, Werker, & Martin, 2010; Waxman & Lidz, 2006). During this same period, they also become increasingly attuned to the communicative functions of other signals, including eye-gaze and pointing (Krehm, Onishi, & Vouloumanos, 2012, 2014; Liszkowski, 2008; Senju & Csibra, 2008). This early-emerging communicative competence flourishes over development. Indeed, a hallmark of being human is the flexibility with which we infuse otherwise arbitrary signals – from billows of smoke to Morse code tones – with communicative status. Our goal in the current experiment was to ask whether this capacity to infer communicative function in arbitrary signals is available to infants, or whether this flexibility requires the scaffolding of more fully developed social or linguistic capacities.

We take as our starting point recent evidence that listening to human language engages infants' object categorization, a

fundamental conceptual capacity (Ferry et al., 2010, 2013). Ferry and colleagues documented that, for infants as young as three months of age, listening to the vocalizations of either human or non-human primates promoted the formation of categories in a way that listening to well-matched sine-wave tone sequences did not. By six months, this facilitative effect on object categorization becomes tuned specifically to human vocalizations. Thus, well before infants begin to speak, they have already begun to link language and cognition, a link that will serve them well as they acquire the meanings of their first words (Brown, 1958; Medin & Rips, 2005; Murphy, 2004).

But is this link to cognition, once tuned specifically to human language, then reserved exclusively to human language? Or might a novel signal also promote categorization if 6-month-old infants could be convinced that it served a communicative function? Two emerging themes in the developmental literature support the latter possibility. First, by 6 months, infants have begun to appreciate the communicative function of speech as well as non-speech signals (Imafuku, Hakuno, Uchida-Ota, Yamamoto, & Minagawa, 2014; Lloyd-Fox, Széplaki-Köllöd, Yin, & Csibra, 2015; Parise & Csibra, 2013). For example, they expect that speech will be directed to people and not artefacts (Augusti, Melinder, & Gredebäck, 2010; Legerstee, Barna, & DiAdamo, 2000) and that speech can transmit information that non-communicative vocal sounds (e.g., coughing) cannot (Vouloumanos, Martin, & Onishi, 2014).

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By at least 8–9 months, infants also appreciate the communicative functions of eye gaze and pointing (Krehm et al., 2012, 2014; Senju & Csibra, 2008; Senju, Csibra, & Johnson, 2008). Second, at least for these older infants, these non-linguistic signals (e.g., eye gaze, pointing) may, like language, support infants' learning about objects and object categories (Csibra & Gergely, 2009; Futó, Téglás, Csibra, & Gergely, 2010; Wu, Gopnik, Richardson, & Kirkham, 2011; Wu, Tummeltshammer, Gliga, & Kirkham, 2014; Yoon, Johnson, & Csibra, 2008).

But what remains unanswered is whether infants, like older children and adults, are flexible enough to identify a new communicative signal and relate it to meaning, as they do with language. To address this question, we examined 6-month-olds' ability to form object categories while listening to a novel sound (a sine-wave tone sequence). We selected tone sequences because previous work documents that, unlike language, this sound fails to promote object categorization at any point within the first year (Balaban & Waxman, 1997; Ferry et al., 2010; Fulkerson & Haaf, 2006; Fulkerson & Waxman, 2007). This provided us with an opportunity to discover whether there were conditions under which infants would infuse this otherwise inert non-linguistic sound with communicative status and relate it to categorization.

Our design is straightforward: We first exposed infants to sine-wave tone sequences within the context of a brief videotaped vignette. Each vignette featured two female actors, engaged happily with one another in a joint social activity. Importantly, we developed two vignettes that differed in the way in which the tones were embedded in the actors' interchange (see Fig. 1). In the *Communicative* condition, the tones were embedded within a rich social communicative exchange in which one actor spoke and the other "beeped." In the *Non-communicative* condition, infants heard the very same tone sequences, but these were uncoupled from the dialogue; they were no longer embedded in their communicative exchange. After this exposure period, all infants participated in

the same object categorization task (Ferry et al., 2010, 2013; Fulkerson & Waxman, 2007).

This design permitted us to explore infants' categorization in the context of a novel communicative signal in two ways. First, by varying the way in which tone sequences were embedded in the exposure vignette, we could identify whether communicative experience with the tones permitted infants to link them to object categories. Second, by exposing all infants to precisely the same set of sine-wave tone sequences, we could assess claims that signal familiarity alone can account for the influence of auditory stimuli on visual categorization (e.g., Robinson & Sloutsky, 2007a, 2007b; Sloutsky & Robinson, 2008).

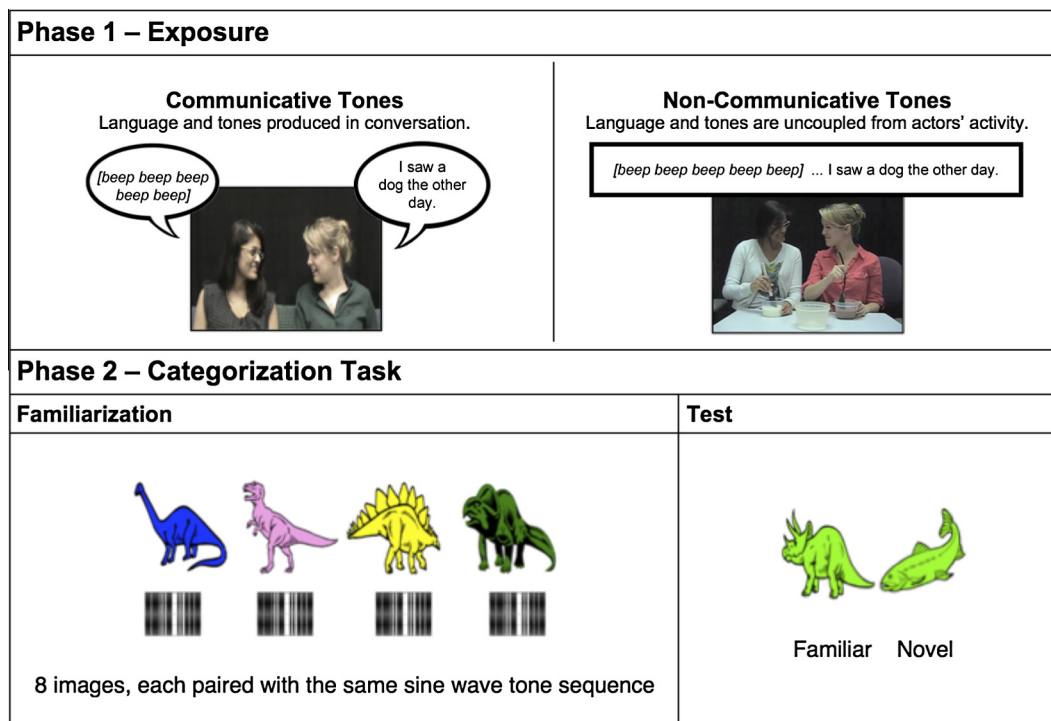
## 2. Methods

### 2.1. Participants

Twenty-four healthy, full-term 6-month-olds ( $M = 5.91$  months,  $range = 5.52$ – $6.44$ , 13 F) participated. An additional 7 infants were tested but replaced due to looking less than 25% of the time (i.e., accumulating, on average, less than 5 s of looking during either familiarization or test;  $N = 6$ ) or fussing out of the task before the test trials ( $N = 1$ ). One other infant, who was identified as an outlier ( $>2.5$  MADs and  $>2$  SDs from the condition mean), was replaced.

### 2.2. Apparatus

Infants sat on their caregivers' laps approximately 110 cm from the center of a white projector screen. The projected image was 125 cm (width) by 79 cm (height), although only the dialogue video used the full area of the projection. Auditory stimuli were played on two Audioengine A5 speakers placed beneath the screen 82 cm apart. The speakers and other equipment were concealed with black fabric. Sessions were recorded with a videocamera through a 3 cm hole in the fabric beneath the screen.



**Fig. 1.** A representation of the procedure. Infants were first exposed to the novel sound stimulus (sine-wave tones) in the context of either a Communicative or Non-communicative vignette. Next, they participated in an object categorization task while listening to tones.

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