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## How do infants and adults process communicative events in real time?



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### ABSTRACT

Speech allows humans to communicate and to navigate the social world. By 12 months, infants recognize that speech elicits appropriate responses from others. However, it is unclear how infants process dynamic communicative scenes and how their processing abilities compare with those of adults. Do infants, like adults, process communicative events while the event is occurring or only after being presented with the outcome? We examined 12-month-olds' and adults' eye movements as they watched a Communicator grasp one (target) of two objects. During the test event, the Communicator could no longer reach the objects, so she spoke or coughed to a Listener, who selected either object. Infants' and adults' patterns of looking to the actors and objects revealed that both groups immediately evaluated the Communicator's speech, but not her cough, as communicative and recognized that the Listener should select the target object only when the Communicator spoke. Furthermore, infants and adults shifted their attention between the actors and the objects in very similar ways. This suggests that 12-month-olds can quickly process communicative events as they occur with adult-like accuracy. However, differences in looking reveal that 12-month-olds process slower than adults. This early developing processing ability may allow infants to learn language and acquire knowledge from communicative interactions.

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## Introduction

Speech allows people to quickly and efficiently transfer information to others. Early in development, understanding this communicative function of speech helps infants to navigate the social world and acquire knowledge in social interactions (reviewed in [Vouloumanos & Waxman, 2014](#)). What we know about infants' understanding of communication is largely based on violation-of-expectation (VOE) methods (e.g., [Cheung, Xiao, & Lai, 2012](#); [Krehm, Onishi, & Vouloumanos, 2014](#); [Martin, Onishi, & Vouloumanos, 2012](#); [Song, Onishi, Baillargeon, & Fisher, 2008](#); [Vouloumanos, Martin, & Onishi, 2014](#); [Vouloumanos, Onishi, & Pogue, 2012](#)) or play-based methods (e.g., [Akhtar, Jipson, & Callanan, 2001](#); [Grosse, Behne, Carpenter, & Tomasello, 2010](#); [Liszkowski, Carpenter, & Tomasello, 2008](#); [Schulze & Tomasello, 2015](#)) that only provide evidence for how infants evaluate communicative events and do not assess how infants process the dynamics of communication as it unfolds in real time. Recent eye tracking studies have shown that infants recognize that speech is directed at others ([Thorgrimsson, Fawcett, & Liszkowski, 2015](#)). But no study of real-time processing has examined whether infants understand that speech (but not non-speech) may transfer information to a listener, eliciting an appropriate response. In this study, we asked whether infants and adults process communicative events involving speech or non-speech in real time while the event is occurring or retrospectively only after seeing the outcome and, moreover, whether infants and adults anticipate the outcome of a communicative event by making predictions about how others will respond.

Within their first year of life, infants use speech to learn about the world and the people around them. Infants treat others' speech and non-speech as functionally distinct when categorizing objects ([Balaban & Waxman, 1997](#); [Ferry, Hespos, & Waxman, 2010](#); [Fulkerson & Waxman, 2007](#)), labeling objects ([Mackenzie, Graham, & Curtin, 2011](#)), and individuating objects ([Xu, 2002](#); [Xu, Cote, & Baker, 2005](#)). Infants also use speech to identify potential communicative partners and learn from communicative interactions. By 5 months, infants match human speech, but not other human vocalizations such as laughter, to human faces rather than monkey faces ([Vouloumanos, Druhen, Hauser, & Huizink, 2009](#)). By 6 months, infants use cues such as speech and eye gaze as signals of communication and an opportunity for learning ([Csibra & Gergely, 2009, 2011](#)). Before their first birthday, infants use others' speech to learn who to communicate with and how to interact with others.

Infants' looking time to the outcome of an event in VOE procedures (reviewed in [Baillargeon, Scott, & He, 2010](#); see also [Krehm et al., 2014](#); [Lieberman, Kinzler, & Woodward, 2014](#); [Martin et al., 2012](#); [Song et al., 2008](#); [Vouloumanos et al., 2012, 2014](#)) or their behavioral responses in play-based procedures (e.g., [Akhtar et al., 2001](#); [Grosse et al., 2010](#); [Liszkowski et al., 2008](#); [Schulze & Tomasello, 2015](#)) suggest that infants understand how speech and gestures communicate information to others. VOE and play-based studies have shown that infants as young as 6 months, who have a limited receptive vocabulary ([Bergelson & Swingley, 2012](#); [Tincoff & Jusczyk, 1999, 2012](#)), recognize that speech, but not a non-speech cough, is communicative, allowing the speaker to provide information to a listener ([Martin et al., 2012](#); [Vouloumanos et al., 2014](#)). By 12 months, infants also recognize that speech and social actions such as clapping can inform others about observable and unobservable intentions ([Cheung et al., 2012](#); [Vouloumanos et al., 2012](#)). At 12 months, infants will also tailor their gestures to the knowledge state of their communicative partner; infants gesture more often to an object's location when interacting with an ignorant partner compared with a knowledgeable partner ([Liszkowski et al., 2008](#)). VOE and play-based studies suggest that by 12 months infants have some understanding of how speech and gestures communicate in social interactions and use this knowledge when interacting with others.

How long infants look at the outcome of a scene or how infants respond to an experimenter in a play-based scenario allows for broad inferences about how infants evaluate communication in social interactions. However, communication and social interactions are dynamic processes, with actions and vocalizations shifting in time and space. Within this dynamic environment, adults can quickly identify, predict, and evaluate others' behaviors in real time as the actions are unfolding (e.g., [Daum & Gredebäck, 2011](#); [Flanagan & Johansson, 2003](#); [Langdon & Smith, 2005](#)). However, little is known about how infants process dynamic communicative scenes and whether they perceive and interpret

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