

Two Minds Are Better Than One: Cooperative Communication as a New Framework for Understanding Infant Language Learning

Doireann T. Renzi, Alexa R. Romberg, Donald J. Bolger, and Rochelle S. Newman
University of Maryland, College Park

Infants and caregivers both actively shape and are shaped by their shared interactions. The construct *cooperative communication* captures the back and forth between parents' and infants' communicative behaviors during these interactions. Cooperative communication creates a dynamic feedback loop in which infant behavior shapes parent input and parent input shapes infant behavior, facilitating language learning. This review brings together findings from both social development and developmental psycholinguistics to illustrate the importance of cooperative communication as an interdisciplinary concept and as a driver of infant language learning. Shifting the focus from independent infant or parent behaviors to cooperative communication implies viewing infant language learning not as the sum of its dyadic parts, but as the interplay between parent and infant communicative behaviors in shared interactions. Measures of cooperative communication during the prelinguistic stage are of particular importance because early social interactions allow infants to develop their understanding of the reciprocal nature of communication and establish their role as communicators. Across development, infants learn to employ their continually expanding range of skills to elicit their parents' attention and engage in shared interactions. During these interactions, parent responses that are both developmentally appropriate and attuned to their infants' focus of attention push language development forward. Further study on the mechanisms supporting this dynamic reciprocity will advance our understanding of the role of early parent–infant interaction in the nascent stages of infant language learning. Implications and applications of research on cooperative communication to improve infant language learning are discussed.

What is the significance of this article for the general public?

This review proposes “cooperative communication” as a new framework for understanding the social mechanisms underpinning infant language learning. Understanding how infants learn language depends not just on understanding the input the parent provides, or the behaviors of the infant, but on the dynamic interplay between shared verbal and nonverbal communication in early parent–infant interactions. The review integrates prior work in the fields of social development and developmental psycholinguistics, and suggests directions for operationalizing cooperative communication and other future work.

Keywords: infancy, language development, dyadic interaction, parenting, social development

Doireann T. Renzi, Department of Human Development and Quantitative Methodology, University of Maryland, College Park; Alexa R. Romberg, Department of Human Development and Quantitative Methodology, Center for Advanced Study of Language, University of Maryland, College Park; Donald J. Bolger, Department of Human Development and Quantitative Methodology, University of Maryland, College Park; Rochelle S. Newman, Department of Hearing and Speech Sciences, MD Language Science Center, University of Maryland, College Park.

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Correspondence concerning this article should be addressed to Doireann T. Renzi, Department of Human Development and Quantitative Methodology, University of Maryland, College Park, College Park, MD 20742. E-mail: dhobbs@umd.edu

Effective interpersonal communication is vital to healthy development. Communication implies a back and forth, a mutual dependence between communicative acts wherein each person responds to and elaborates upon the other's contributions. The cooperative principle of Grice's (1975) maxims portrays communication as an active collaboration, with both contributors working together based on a shared understanding of a set of communicative norms. Although infants may not be initially aware of these norms, their early experiences pave the way for their understanding of how communication works and their own role as communicators. The interactive exchange of verbal and nonverbal communication with a social partner allows infants to hone and advance their communicative and subsequent language skills. The dynamic back and forth that occurs between infants and their parents can be thought of as *cooperative communication*. We use the term *cooperative communication* to bring together findings in diverse areas of language acquisition and social development that combine to make a strong case for the role of interdependent communication as a driver of language development.

Parents and their infants use their eyes, movements, affect, and vocalizations to share attention and communicate with one another (Lavelli & Fogel, 2005; Leclere et al., 2014; Vallotton & Ayoub, 2010). By accounting for both verbal and nonverbal individual behaviors while focusing on the dynamic shared communicative space created by the dyad, cooperative communication can provide a unified measure of early social interaction. Measures that operationalize this concept are necessary to determine how the richness of shared communication fosters infant language development. Among the range of behaviors both parents and infants use to communicate, the operationalization of cooperative communication can particularly benefit from insights on infant social cognition, parent responsiveness, and joint attention. Generally, parent responsiveness is defined as the range of behaviors parents use to acknowledge, enhance, or ignore an infant's social bid, thereby creating the opportunity for shared communication.

By combining a growing body of work on parent responding behaviors from a social development perspective with a robust literature of infants' social and communicative eliciting

behaviors from developmental psycholinguists, we aim to paint a rich picture of socially aware communicative behavior that develops with the infant. Measuring cooperative communication per se, as opposed to measuring only behaviors of individuals, is critical to understanding how interactions and the shared contributions of parents and infants facilitate infant language learning.

The goals of the following review are to (a) synthesize the research conducted to date on the behaviors of parents and infants that both contribute to language development and constitute cooperative communication and (b) highlight that, with appropriate operationalization and measurement, we can instantiate cooperative communication as a context in which infant language development occurs and investigate its impact on individual differences in acquisition early in development. We propose future steps for applying our understanding of cooperative communication with a specific eye toward intervention for early disparities in language acquisition that occur demographically, such as between high- and low-SES groups.

Infants as Drivers of Their Own Language Learning

Before ever uttering their first words, infants engage in a variety of communicative acts, such as smiles, vocalizations, and gestures. These behaviors allow infants to circumvent the limitations of their early lack of speech and vocabulary to engage and share attention with others. Critically, they use social interactions to advance their understanding of what communication is and how it works. In this review, we focus on how behaviors measured in newborns to 18-month-old infants are related to outcomes up to age 3. This age span covers prelinguistic communication and the early stages of speech development and incorporates nonverbal and verbal behaviors in both parents and infants. Research done on prelinguistic communicative behavior has shed light on how adept infants are at building social awareness through forming social expectations (McQuaid, Bibok, & Carpendale, 2009), making predictions based on observed patterns (Henrichs, Elsner, Elsner, Wilkinson, & Gredebäck, 2014; Romberg & Saffran, 2013), and initiating and guiding social interactions (Goldstein, Schwade, & Bornstein,

2009; Wu & Gros-Louis, 2014). Understanding early communicative behaviors in prelinguistic infants can therefore assist us in ascertaining their role as drivers of their own language learning.

Infants begin to use intentional communication by around 2–3 months of age with expressive vocalizations and smiles. As they develop, shared interactions improve and expand the infants' repertoire of communicative ability. The cooperative communication occurring during these interactions then sets a trajectory for expectations of responsiveness, familiar patterns of social interaction, and language input. With improved understanding of their social capacities as communicators, infants become more aware of their parent's behaviors and the impact they can have upon those behaviors. Based on interactions with their primary caregivers, infants create schemas surrounding cooperative communication in social interactions. The expectations supported by these schemas then dictate their own communicative behavior. For example, 4-month-old infants produce smiles and vocalizations preferentially to strangers who respond to their vocalizations with similar rates and timing as their mothers (Bigelow, 1998). Remarkably, these results were replicated in a study with 2-month-old infants (Bigelow & Rochat, 2006).

Infants not only exhibit preferences for familiar patterns of responsiveness during the early stages of infancy, but also use these patterns to guide their communicative behavior. McQuaid and colleagues (2009) discovered that 4- and 5-month-old infants create expectations of future responsiveness based on the contingent smiling behavior of their parent. This was measured using the "still face" paradigm, a common experimental manipulation used to study infants' early social behavior. The paradigm is named for the fact that in the middle of an otherwise normal interaction, the infants' social partner (e.g., their parent or an experimenter), stops responding to the infant for a period of time. The underlying assumption of this method is that infants create expectations based on the normal pattern of cooperative communication they are exposed to, and then attempt to elicit responsive behaviors when their partner no longer behaves as expected. Indeed, when parents provided more contingent smiles in the naturalistic observation, their infants produced more

vocalizations and social bids in an effort to get a response from the parents in the still face portion of the experiment (McQuaid et al., 2009). It is clear that infants want to partake in reciprocal communication and will use the skills they have to encourage reciprocity.

Infants understand the influence of their communicative skills and use them to elicit responses even when interacting with someone other than their primary caregiver (Vallotton, 2009). In another application of the still face paradigm in which infants interacted with an experimenter rather than their parent, Goldstein et al. (2009) found that 5-month-old infants expect social partners to respond to their intentional (noncry) vocalizations. Results from studies using the still-face paradigm highlight how infants utilize familiar patterns of social input to guide their own communicative behavior. Critically, infants' attempts to stimulate responses from their interactive partners demonstrate that infants initiate and shape communication rather than passively process input.

Using their rapidly expanding range of communicative abilities, infants begin to create their own opportunities for interaction. As their motor and vocal skills improve, infants use gesture and increasingly speechlike vocalizations to elicit and share attention with their parents (Carpenter, Nagell, Tomasello, Butterworth, & Moore, 1998; Gros-Louis & Wu, 2012; Vallotton, 2009). Gesture use, for instance, serves as an important indicator of later language attainment, particularly vocabulary and syntactic skill (Longobardi, Rossi-Arnaud, & Spataro, 2011). In fact, the number of items referred to with gesture by 18-month-old infants predicts their vocabulary attainment at 3.5 years old (Rowe & Goldin-Meadow, 2009a). Gesture use at 14 months also predicts vocabulary attainment, even when accounting for the overall amount of talk by the parent or infant (Rowe, Özçalışkan & Goldin-Meadow, 2008). Correspondingly, the combination of gesture and object-directed vocalizations predicts later syntactic complexity (Rowe & Goldin-Meadow, 2009a) and progress from one- to two-word utterances (Iverson & Goldin-Meadow, 2005). The use of object-directed vocalizations to share in a social interaction even predicts the types of words children learn. When 11.5-month-old infants receive a contingent response labeling an object, they re-

tain the label better if they not only looked at the object, but also produced an object directed vocalization (Goldstein, Schwade, Briesch, & Syal, 2010). The conclusion of the findings on gesture and early vocalizing behavior is that the schemas infants develop using social and linguistic input allow infants to enhance their communicative skills, such as speechlike vocalizations and gesture, and to foster new opportunities for shared interaction.

Broadly, individual infants' ability to attend to a situation and extract relevant information from both the linguistic and social context is a predictor of later language development. When parenting behaviors are considered in addition to infant language abilities both appear to play pivotal, and sometimes interdependent, roles in early language development. Both retrospective and prospective studies have found that individual differences in infants' skill in identifying individual words from fluent speech (or segmenting them) is correlated with vocabulary size at 2 years of age (Newman, Ratner, Jusczyk, Jusczyk, & Dow, 2006; Newman, Rowe, & Bernstein Ratner, 2016). However, the infant's cognitive skills are not the whole story: segmentation skill and the quality of parent input, each measured at 7 months of age, are independently predictive of vocabulary outcomes at age 2 (Newman et al., 2016). Similarly, prelinguistic infants who have better visual processing abilities and parents who participate in attentional guiding activities exhibit improved verbal development by age 2 (Bornstein, 1985). This suggests that both parent input and the child's developing awareness of language are shaping the infants' language learning trajectory.

Parents as Drivers of Infant Language Learning

Cooperative communication requires *both* participants to be engaged in the interaction. Parents create dyadic interactions with their children that foster and enhance language learning. High levels of parent language input predict larger vocabulary, better syntactic skill, and improved language processing (Cartmill et al., 2013; Hoff, 2006; Huttenlocher, Vasilyeva, Cymerman, & Levine, 2002; Weisleder & Fernald, 2013). In addition to sheer quantity, the quality and diversity of parent input is an important predictor of later language development

(e.g., Bornstein, Haynes, & Painter, 1998; Cartmill et al., 2013; Hirsh-Pasek et al., 2015; Rowe, 2012). However, speech is not the only critical input infants receive. Parents also respond to their infants' linguistic and social bids using a range of nonverbal behaviors. Shared attention, eye gaze, gesture, touch, and affect serve to inform the infant's understanding and negotiate further communicative exchanges (Bigelow & Power, 2016; Xu, Chen, & Smith, 2011; Yu & Smith, 2013, 2016). Therefore, it is important to understand dyadic cooperative communication in the context of the communicative back and forth including not only parents' input but also their responding behaviors, collectively captured as parent *responsiveness*.

The concept of responsiveness refers to the degree to which a parent provides a timely response with warmth and sensitivity to an infant's need, distress, or bid for attention. Measures of responsiveness most often involve coding observed parent-child interactions in terms of the amount and contingency of parent behaviors as well as the accompanying warmth and sensitivity (Funamoto & Rinaldi, 2015). Extensive research has established the positive implications of parent responsiveness for child development. Parent responsiveness in early development correlates with outcomes such as prosocial behavior (Davidov & Grusec, 2006), attachment security (Laranjo, Bernier, & Meins, 2008), and executive functioning skills (Lengua et al., 2014; Lucassen et al., 2015), all of which are components of positive child development.

Consistent with the idea that dyadic communication is a major driver of early language development, parent responsiveness is a strong predictor of infant language from birth up to age 3. Caregivers' responsiveness to their infants' communicative behavior and affect is correlated with the achievement and timing of early language milestones (Nicely, Tamis-LeMonda, & Bornstein, 1999; Tamis-LeMonda, Bornstein, & Baumwell, 2001), infant phonological and vocalization development (Goldstein & Schwade, 2008; Gros-Louis, West, & King, 2014), and later vocabulary size (Baydar et al., 2014; Tamis-LeMonda, Kuchirko, & Song, 2014). The converse is also true: the amount of prohibitive speech, such as "no, stop," which impedes reciprocity by terminating the opportunity for continued communication, is negatively correlated

with child language outcomes (Baumwell & Bornstein, 1997; Hoff-Ginsberg, 1991).

During prelinguistic development, parents' responses to their infant's communicative behaviors create a conversational dynamic with the infant. Familiarizing infants to the natural give and take implicit in conversational interactions enables them to learn how to both participate in and guide future interactions. As infants' communicative skills grow, parent responses evolve as well, illustrating the dynamic nature of cooperative communication. Findings on the progression of conversation and responsiveness over time support this hypothesis. Parents' conversations with their children actually undergo the most dramatic changes during the prelinguistic period of infant development as they attune their interactions and responses to their infants' growing skills (Snow, 1977). A longitudinal study investigating the differential nature of responsiveness between 10 and 21 months, found that parent responsiveness was broadly consistent over time: the proportion of responses to child vocalizations and attention eliciting behaviors were consistent at 10, 14, and 21 months (Bornstein, Tamis-LeMonda, Hahn, & Haynes, 2008). However, parents appeared to adjust aspects of their responsiveness to align with the ability level of their infant at that time. For example, question responses such as "What's that?" but not affirmation responses such as "that's right," increased between 14 and 21 months, demonstrating parent acknowledgment of their infant's enhanced expressive ability, and more frequent attempts to elongate conversations with their infant (Bornstein et al., 2008). Similarly, parents demonstrate stability in their use of sensitive responses over time but increase their use of *stimulating* responses significantly as infant communicative competence grows (Valloton, Mastergeorge, Foster, Decker, & Ayoub, 2016). More sensitive responses to 14-month-olds, and more stimulating responses to 18-month-olds, predict vocabulary development at 36 months, illustrating the interdependence of parent and infant communicative behaviors. Thus, it is not merely parent responsiveness, but how that responsiveness is tailored to the infant's developmental level, that leads to cooperative communication.

Parent responsiveness and speech input shape the acoustics of infants' early speechlike utter-

ances and facilitate more sophisticated linguistic skill, while different acoustic properties of infants' vocalizations elicit different caregiver responses. As infants transition from early vocalizations to more speechlike babbling, the give and take of cooperative communication clearly influences both infant and parent behavior. Parent contingent responsiveness is correlated with growth in infant vocal complexity and the infant's use of vocalizations to elicit parent attention (Gros-Louis et al., 2014). In fact, infants of responsive parents adjust their babbling to resemble their mothers' speech patterns and exhibit rapid phonological growth during the babbling period (Goldstein & Schwade, 2008). As infant communication becomes more sophisticated, parents are discerning in their use of contingent responsiveness, preferentially responding to more advanced speechlike vocalizations used by their 8-month-old infants (Gros-Louis, West, Goldstein, & King, 2006). Infants use such parent feedback to produce specifically those vocalizations that encourage responsive behavior, honing their communication to become more adultlike. Consequently, parents' preferential responsiveness encourages more sophisticated communication in the infant. This mutual dependence perfectly illustrates how cooperative communication facilitates infant language development.

Importantly, the developmental benefits of parent responsiveness can be seen in a range of diverse contexts. Responsiveness and cooperative communication are not restricted by parent gender (Malmberg et al., 2015), infant disability (Yoder, McCathren, Warren, & Watson, 2001), socioeconomic status (SES; Hirsh-Pasek et al., 2015), or culture (Bornstein et al., 1992). In children with developmental disabilities, maternal responsiveness during the prelinguistic period accounts for a statistically significant amount of the variance in their children's expressive and receptive language skills 6 months later (Yoder & Warren, 1999). Interestingly, this study also found that parental responsiveness was itself predicted by infants' intentional communication, which included early words and gestures (Yoder & Warren, 1999). This reciprocal relationship between infant communication and parent behavior illustrates the importance of the *cooperative* component of communication in parent-child interactions.

In couples, both fathers and mothers exhibit similar levels of overall responsiveness, and father responsiveness is associated with both positive language and cognitive outcomes in their children (Cabrerá, Shannon, & Tamis-LeMonda, 2007). Similarly, father and mother contingent responsiveness to their 10- to 12-month-old infants predicts later cognitive development at 18 months and language development at 3 years (Malmberg et al., 2015). Additionally, the positive outcomes of responsiveness are found to be consistent in the case of adopted children (Stams, Juffer, & van Ijzendoorn, 2002) discounting suggestions that the impact of responsiveness is based on a genetic relationship between parent and child.

Of particular interest when considering the applicability of cooperative communication and responsiveness as a potential point of intervention, is the fact that parent responsiveness is a cross-culturally valid concept. In a study of mothers in the United States, France, and Japan, patterns of responsiveness were shown to be consistent, particularly in terms of responses to vocalizations (Bornstein et al., 1992). Across cultures, infants also appeared to demonstrate similar patterns of eliciting behaviors contingent on parent responses (Bornstein et al., 1992). In a Finnish sample, infant language comprehension at 12 months related to both parent responsiveness and infant communication skills 2 months earlier (Paavola, Kunnari, & Moilanen, 2005). These studies illustrate that the influence of cooperative communication is consistent across cultures, at least for those studied to date. Exploring this issue in more disparate societies would be a worthwhile direction for future research.

As previously illustrated, communication in parent-child interactions must be cooperative to facilitate language learning. Parents with high rates of depression and toxic stress, which are often found in low-SES environments, generally provide less consistent shared interactions, and provide lower levels of input to their infants (Crosnoe, Leventhal, Wirth, Pierce, & Pianta, 2010; Goldsmith & Rogoff, 1997; Hart & Risley, 1992; Pan, Rowe, Singer, & Snow, 2005). Additionally, low-SES parents, particularly those suffering with depression and stress, are statistically more likely to exhibit lower levels of responsiveness due to additional pressures in their environment (Albright & Tamis-

LeMonda, 2002; Malin et al., 2012; Perkins, Finegood, & Swain, 2013). These suboptimal interactions have consequences: infants of mothers suffering from depression struggle to learn from shared interactions with their mother (Kaplan, Bachorowski, Smoski, & Hudenko, 2002; Kaplan, Dungan, & Zinser, 2004). The low rate of cooperative communication may then account for the later language and behavioral difficulties that infants in those environments experience (Henninger & Luze, 2013; Malin et al., 2012; Noel, Peterson, & Jesso, 2008). Notably however, infants of depressed mothers are still competent at learning from *other* dyadic interactions, suggesting that cooperative communication continues to facilitate infant language learning as long as the infant has a consistent source for those shared interactions (Kaplan et al., 2002, 2004). It is therefore likely that cooperative communication could have a mediating effect on the negative relation between SES and language learning.

Importantly, higher levels of parent responsiveness in early childhood mediate the relationship between school readiness and some of the social risks associated with living in a low-SES household (Mistry, Benner, Biesanz, Clark, & Howes, 2010). Similarly, responsive and supportive parenting also mediates the traditionally negative relationship between a child's performance on cognitive tasks and available family resources (Lugo-Gil & Tamis-LeMonda, 2008). These findings on the impact of SES on responsiveness and child language have been replicated in other cultures (Baydar et al., 2014). Across multiple contexts, the extant research indicates that responsive parent behaviors are instrumental to linguistic and social development.

Lower rates of cooperative communication are not restricted to low-SES parent-infant dyads. More generally, interactions in which infants and parents are "out of sync" produce fewer opportunities for optimal learning. In an experiment investigating the effects of noncooperative interactions, Miller and Gros-Louis (2013) specifically manipulated parents' behavior with their 13- to 16-month-old infants. The dyads took part in two conditions, after establishing a baseline for natural interactions: parents were instructed to either be vocally and behaviorally responsive to their infant's focus of attention, or to actively redirect their infant's

attention. At the end, they returned to natural interactions. During the conditional stage wherein parents redirected their infants' attention, infants exhibited shorter instances of held attention and produced significantly fewer vocalizations and communicative behaviors (Miller & Gros-Louis, 2013). This illustrates that when parents actively reject the focus of their infant's attention, infants react and reduce their communicative behavior. The decrease in communication closes off opportunities for learning. Thus, optimal learning occurs when parents use their infant's attentional focus to stimulate rich communicative interactions.

Is the Dyad More Than the Sum of Its parts?

Infant language outcomes arise from a combination of the input they receive and their own abilities. Given that we know that infants as young as 2 months old use social input to create expectations and guide their communicative behaviors, parent responses alone cannot account for the rapid language growth that occurs during early infancy. As illustrated above, our understanding of the influence of the parent and infant dimensions separately is quite robust, with numerous studies attesting to the infant and parent correlates of language learning. However, investigating infant or parent behaviors in isolation omits the reality that these behaviors each provide a dynamic context for the other. Infant language learning is not brought about by two individual contributors, but by the shared experience created by their interdependent communicative acts.

Reciprocal interactions require each participant to adjust to the other. These adjustments take place both within individual interactions and across development. As the infant develops, incremental changes in both parent and infant behavior feed one another to push language development forward. As Yoder and Warren (1999) found, parent responsiveness predicts infants' expressive skills, and infant intentional communication at the same timepoint was predictive of responsiveness. Therefore, parent and infant communicative behaviors are mutually dependent. Similarly, infant and parent affective synchrony as well as parent and infant coordinated behaviors are predictive of growth in infant symbolic play and verbal IQ (Feldman

& Greenbaum, 1997). Viewing infant language learning as embedded in acts of cooperative communication means viewing learning not as the sum of independent parts, but as a dynamic feedback loop in which parent input shapes infant behavior and infant behavior shapes parent input. This perspective is seen in paradigms that measure shared attention between infants and caregivers and that document or attempt to influence the real-time coordination of behaviors between infant-caregiver dyads. Such paradigms can be applied to ascertain how individual differences in social experience alter infant language trajectories. The framework of cooperative communication presents a unique opportunity to understand and influence the social drivers of infant language learning.

Cooperative Communication as a Driver of Infant Language Learning

A critical component of cooperative communication is the sharing of attention between social partners. Shared attention is investigated by some as dyadic mutuality or dyadic synchrony (for reviews see: Funamoto & Rinaldi, 2015; Harrist & Waugh, 2002) but is most commonly researched as joint attention. In the language learning literature, the term "joint attention" has been used primarily to describe situations in which the infant shares attention on an object or activity with another person (Fenson et al., 1994; Mundy & Newell, 2007). In other words, joint attention refers to times in which the infant and caregiver are both attending to the same object and, critically, *are aware* that they are sharing attention. As discussed above, infants gain awareness of their own role in interactions and understand that they are engaged in a mutually influential interaction extremely early in infancy. In turn, this impacts their communicative and attentional behaviors (Lavelli & Fogel, 2005). Episodes of joint attention provide an opportunity for parents to scaffold their infants' language learning. Infants successfully acquire new words when a label is provided for the object of their attention during a shared interaction (Goldstein et al., 2010). Moreover, more episodes of joint attention in parent-child interactions are associated with improved vocabulary and later language skills; specifically, object labels provided by the parent during episodes of joint attention are better retained by

children (Tomasello & Farrar, 1986). Parent sensitivity to their infants' attention is a predictor of language growth: At 12 months of age, both the amount of joint attention *and* parents' use of language pertaining to their infant's attention predict later language development (Carpenter et al., 1998). Therefore, it is not simply shared attention alone but also the parents' use of that attention to scaffold infant learning that drives later language development.

The opportunities for language learning during joint attentional states are not confined to responses to infant vocalizations. Gaze-following has been used as a measure of infants' ability to respond to adults' bids for joint attention (Frischen, Bayliss, & Tipper, 2007; Slaughter & McConnell, 2003). For example, the extent to which 6-month-old infants follow adults' gaze is predictive of their later vocabulary development (Morales, Mundy, & Rojas, 1998). Gesture is another tool infants use to initiate bids for joint attention. Providing a contingent labeling response to infants' gestures and vocalization facilitates both retention of the associated word and growth of receptive language skills (Iverson & Goldin-Meadow, 2005; Wu & Gros-Louis, 2014). Such nonverbal communicative behaviors present prime opportunities for cooperative communication and optimal infant learning. When social partners demonstrate interest in and visually attend to an object an infant is looking at, the infant's sustained attention increases during and after the joint attentional episode (Yu & Smith, 2016). In this way, joint attentional states are pathways for stimulating sustained attention, and provide a mechanism by which cooperative communication influences language learning.

Parental responses to nonverbal (or non-babble) infant cues are an important factor in cooperative communication. Parents of 12-month-olds provide more responses to their infants' gestures than to vocalizations alone, highlighting the ways in which parents scaffold infant learning by tailoring responses to their infants' developing communicative skills (Wu & Gros-Louis, 2015). Based on the study by Miller and Gros-Louis discussed above, the converse is also true: Parental redirection of infants' attention results in less infant communication, demonstrating that infants engage less when shared attention is not facilitated (Miller & Gros-Louis, 2013). Similarly, parents who do

not respond to their infants' attentional prompts or who redirect their infant's attention have infants with lower rates of language comprehension growth (Wu & Gros-Louis, 2014). In sum, these findings consistently point to the importance of the parent and child cooperating around a shared source of attention.

Research on the key drivers of infant language learning thus far has highlighted the role of the infant, the parent, and shared attention. Furthermore, these findings converge on the importance of cooperative interactions. Cooperative communication is at the nexus of how those shared interactions facilitate infant language learning. By targeting cooperative communication as a focus of study, the dyadic mechanisms underpinning infant language learning can be operationalized and a foundation for meaningful intervention created.

Applications and Next Steps

Cooperative communication captures the shared communicative moments in parent-infant interactions: not just what the infant is doing, not just what the parent is doing, but what they are doing *together*. Research operationalizing and measuring cooperative communication in the prelinguistic stages of development will deepen our understanding of the social mechanisms that facilitate infant language learning. The above studies on responsiveness and infant cognition during early development give us an insight into possible individual contributions to a shared communicative setting. Similarly, the varying paradigms used to model nonresponsiveness to attentional bids (e.g., still face task, attention redirection) illustrate the changes in infant behavior brought about by the absence of cooperative communication and suggest the importance of cooperation as a predictor of infant development. Work on shared attention, as both a facilitator of sustained attention and language learning, provides initial insights into the dyadic mechanisms driving cooperative communication and serves as a promising foundation for the creation of further measures.

Based on the synthesis of the research, the operationalization of cooperative communication in infancy involves a few crucial components. Both verbal and nonverbal communication such as affect and gesture must be included

in order to accurately depict infant communication and opportunities for parental responsiveness. Additionally, the dynamic give and take during real-time shared interactions must be analyzed in order to describe the mechanics of coordination (e.g., how joint attention is established) and make inferences about how coordination affects learning or other future behaviors (e.g., better word learning with more episodes of joint attention). Finally, measures involving holistic judgments about the cooperative quality of the interaction are needed to view the predictive validity of cooperative communication in terms of language learning. Such measures might involve coding schemes that capture verbal and nonverbal behaviors used to initiate, respond to, and expand upon communicative bids, as well as dyadic measures of affective synchrony, linguistic and behavioral turn taking, and the fluidity of shared communication.

Nonverbal measures used to model infant attention present promising methodological frameworks for measuring cooperative communication. For example, capturing the visual experience of an infant (e.g., using head mounted cameras) allows a real-time view of the dynamics of shared interactions. This method has been used to illustrate that infants and their parents use hand movements as guides for attention focusing, and use hand-eye coordination to facilitate switches in shared attention (Xu et al., 2011; Yu & Smith, 2013). Moreover, this method highlighted the mechanics of how joint attention leads to language learning within a dynamic interaction: object labels provided by the parent when the infant's visual focus was centered on the labeled object facilitated infants' learning of the label-object association (Pereira, Smith, & Yu, 2014). Increases in sustained attention and label learning during episodes of shared attention demonstrate two contexts in which language learning is advanced through dynamic communicative exchanges. The role cooperative communication plays in advancing language development can be determined using similar measures, without the emphasis on a third-party object.

Another operationalization of cooperative communication involves measuring parent-child interaction using both verbal and nonverbal measures. In 2-year-olds, nonverbal measures of interaction quality such as fluidity of the interaction and mutual attentional engage-

ment, as well as verbal measures of language input, accounted for over a quarter of the variance in children's expressive language skills a year later (Hirsh-Pasek et al., 2015). There are indications too that the dynamic nature of social interaction is influential extremely early in infant development. Parental responsiveness with their 1-month-old infants, measured verbally with vocalization, and nonverbally with smiles and affect, predicts infant social bidding behavior at 2 months. Additionally, verbal and nonverbal responsiveness is correlated with the duration of infant vocalizations at 3 months (Bigelow & Power, 2016). With the combination of nonverbal and verbal measures, investigations that capture the multidimensional nature of cooperative communication provide an insightful view into infant language learning. Such measures will elucidate the specific role of mutually reciprocal communication in infant development and shape the design of future interventions.

Beyond basic research investigating the origins of language development, the cooperative communication framework can be applied to inform intervention design. Although both infants and parents actively shape each other's behaviors, interventions targeting parent behavior are more tractable in early infancy. Also, interventions with parents of very young infants are advantageous due to the amount of time parents devote to their infants during this developmental stage. Focusing on the earliest stages of development, from birth to 18 months, provides parents with the greatest opportunity to impact their infant's development and provides infants with the strongest foundation for continued language learning and positive early development. "My Baby and Me," a longitudinal intervention from prebirth to 36 months, which targeted parenting skills such as engagement, early nonverbal responsiveness, and later verbal responsiveness showed promising results for enhancing cooperative communication through parent training. Parents involved in the most intensive iteration of the intervention used more contingent responses and verbal stimulation and had infants with higher expressive language skills and better social engagement at 30 months than the lower intensity group (Gutentag et al., 2014).

Crucially, parents' knowledge and beliefs about their influence on child development im-

pacts how they interact with their children (Hess, Teti, & Hussey-Gardner, 2004; Moorman & Pomerantz, 2010; Pomerantz & Dong, 2006; Rowe, 2008; Weigel, Martin, & Bennett, 2006; Sigel & McGillicuddy-DeLisi, 2002). Thus, a promising initial step may be helping parents understand the concept of cooperative communication and providing them with the necessary tools to initiate and sustain a shared communicative state with their infants. Although interventions targeting parental responsiveness may have the immediate goal of changing a single dimension of the dyadic interaction, steps can be taken to help the positive change propagate through the dynamic system. For example, interventions may highlight the nonverbal responses to which infants react, including gestures, eye gaze, and affect to amplify and complement increased verbal responsiveness. Interventions should focus on ensuring that parents understand how influential their verbal and nonverbal responses are in shaping their infants' attention and language learning. Moreover, interventions should emphasize that redirecting their infants' attention diminishes the opportunity for effective learning moments.

Results from prior interventions support the potential benefits of training parents to provide their children with richer interactive feedback. In an experimental study with 4- and 5-year-old children, parents trained to provide contingent responsive feedback had children with syntactically longer and richer verbal interactions (Brassart & Schelstraete, 2015). On a larger scale, interventions such as the Thirty Million Words Initiative are demonstrating gains in increasing parent input, knowledge, and conversational interaction in low-SES families (Leffel & Suskind, 2013). Increasing the number of words that infants hear is beneficial but does not facilitate optimal cooperative communication in and of itself as we've highlighted above. Nonetheless, the success to date of this intervention does provide a promising first step for targeting parent knowledge as a source of intervention. Heightening parent awareness of their own role as facilitators, as well as helping them understand how their infants learn from shared attention and their responses, is an applicable next step to increase cooperative communication in the home.

By learning to create communicative reciprocity in their interactions, parents and care-

givers from a variety of cultural backgrounds have the ability to enhance their infants' learning. Interventions aimed at increasing cooperative communication may be particularly beneficial for low-SES families, given that differences in parental responsiveness, input, and communicative consistency are a key predictor of the documented gaps in linguistic and academic attainment between high- and low-SES children (Fernald, Marchman, & Weisleder, 2013; Hart & Risley, 1992; Rowe & Goldin-Meadow, 2009b; Sohr-Preston et al., 2013). Additionally, high- and low-SES infants are equally likely to respond to joint attentional bids by their parents but high-SES infants are much more likely to initiate episodes of joint attention than their low-SES counterparts (Lavelli & Fogel, 2005). Interventions emphasizing the linguistic and developmental advancement associated with joint attention and linguistic scaffolding, and cooperative communication as a whole, will allow low-SES parents to empower their infants to become drivers of their own communication. By promoting cooperative communication in early infancy, these infants could be given an opportunity to enter school at a linguistic level equal to that of their high-SES peers and begin to close the early achievement gap.

Conclusion

Infants and caregivers both actively shape and are shaped by their daily social interactions. Successful intentional communication requires infants to effectively employ their cognitive, social, and linguistic skills. Analogously, parents must employ their knowledge of their infants' skills and the dynamics of their infants' attention to advance their infants' communicative learning. To fully understand how interdependent parent and infant behaviors interact, we must consider them not as two separate influences on infant development, but rather as *cooperative communication*, a harmonious interaction at the level of the dyad. By focusing on the transactional nature of dyadic interaction, cooperative communication generates a more complete picture of how interactions facilitate early language learning.

The instrumental role that early parent-child interactions play in infant language and social development is widely accepted. However, the

mechanisms underlying that relationship are less well-understood. Scientific paradigms that measure cooperative communication will allow us to explicate the influence early social interactions have on infant language learning. An advanced understanding of how cooperative communication varies across individuals and groups can then be applied to assist and empower caregivers in diverse contexts to enhance their interactions and create skilled young communicators and language learners. Parents and infants are cooperative partners who work together to shape development. Consequently, as the title of this article suggests, “two minds are better than one” when it comes to facilitating infant language learning.

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Correction to Im and Follette (2016)

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