ABSTRACT

Title of Dissertation: INFANT LANGUAGE LEARNING & COOPERATIVE COMMUNICATION: THE INFLUENCE OF CONTINGENT RESPONSIVENESS AND SES

Doireann Renzi, Doctor of Philosophy, 2018

Dissertation directed by: Donald J. Bolger, Associate Professor Department of Human Development and Quantitative Methodology

Early language development relates to a child's later language ability, cognitive development, and academic achievement. Parent input has long been studied as a predictor of infant language acquisition, and consequently, as a predictor of the differences in early language attainment associated with the documented 'word gap' between children from high and low Socio-Economic Status (SES) backgrounds. This dissertation sought to investigate the specific mechanisms of early parent-infant interactions that facilitate infant language learning, and whether SES differences are evident in those mechanisms at 10 months. Specifically, cooperative communication: the conversation-like back and forth between parents and infants, and parents' contextualized responsiveness: use of responses that contingently elaborate on the infant's attentional focus, were examined. These relationships were also examined in terms of infant language outcomes at 18 months.

Controlling for infant communication and parent input, SES was significantly correlated with parents' responses to infant vocalizations, in particular when they were paired with a gesture or other behavior, and to parents' use of object labels in their interactions with their infants. These noted differences suggest that input differences associated with the 'word gap' are evident in development as early as 10 months old.

Children who were exposed to more contextualized responses overall and in particular those that contained a question, a label, or that responded to infant behavioral communication had better language performance at 18 months, even controlling for child communication and total parent input. Importantly, these components of contextualized responsiveness had a larger effect than SES on language outcomes, such as child word types and scores on the standardized Mullen Scales of Early Learning. This suggests that while SES is related to some positive components of responsiveness (labels and responses to vocalizations), the relationship between SES and language outcomes is often mediated, in full or in part, by parents' use of specific contextualized responses.

Together, the findings present contextualized responsiveness as a promising foundation for interventions aimed at diminishing and preventing the word gap and that, for parents from all SES backgrounds, their use of specific contextualized responses elaborating on their infant's attentional focus facilitates optimal infant language learning.

Infant Language Learning & Cooperative Communication: The Influence of Contingent Responsiveness and SES

By

Doireann T. Renzi

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Advisory Committee:
Professor Donald J. Bolger, Chair
Professor Natasha Cabrera
Professor Brenda Jones-Harden
Professor Rochelle Newman
Professor Meredith Rowe

Dedication

To my Father, Tony Hobbs.

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CHAPTER 1 - INTRODUCTION

Introduction

Language underlies how we form relationships, convey ideas, and process the events in our lives. Infants begin to learn the contexts, sounds, and pragmatics of communication long before they utter their first word. For infants, taking part in the back and forth of communication is a foundational step in the important process of being able to understand and produce language (Brooks & Meltzoff, 2008). While they cannot yet use words, prelinguistic infants are, in fact, more capable 'conversational' partners than they seem - they initiate and participate in social interactions using gestures, affect, and vocalizations (Bigelow & Rochat, 2006; McQuaid, Bibok, & Carpendale, 2009; Vallotton, 2009; Wu & Gros-Louis, 2016). How parents choose to respond to those early communicative bids, as well as their own communication style, is crucial to development as it not only facilitates infant language learning, but also the development of social understanding. The conversation-like back and forth between infants' social and communicative bids, and parents' responses to those bids can be thought of as cooperative communication. Responses that take place during these cooperative episodes that relate to an infant's attentional focus can be considered contextualized responses. However, early dyadic interactions are influenced not just by shared interactions and parent responsiveness, but additionally, by external cultural and societal factors such as Socio-Economic Status (SES).

SES is a measure of social and economic wellbeing, and is generally quantified as household education, income, occupational status, or some combination of the three. Advances in the theoretical investigation of how SES influences development, has also led to the emergence of the use of income-to-needs ratio, which takes into account

household size, and risk composites accounting for depressive factors, household instability, etc. (Dearing, McCartney, & Taylor, 2015; Henninger & Luze, 2013; Lengua et al., 2014; Mistry, Benner, Biesanz, Clark, & Howes, 2010). For the purposes of this study income and education were considered. SES is associated with many life-success factors such as access to resources, physical and emotional wellbeing, as well as educational attainment. Families living in low SES environments are at risk for health-related issues due to chronic stress, different neurocognitive growth patterns, and differing access to healthcare and education (Bradley & Corwyn, 2002; Duncan, Ziol-Guest, & Kalil, 2010; Harden, Whittaker, Hancock, & Wang, 2010; Sheridan, Sarsour, Jutte, D'Esposito, & Boyce, 2012). Additionally, low SES communities are more likely to experience social issues such as criminality and racism, which have severely detrimental effects to mental health and development (Burdick-Will, 2013; Margolin, 2005; Westbrook & Harden, 2010). Efforts to improve the adverse effects of SES on wellbeing and development are, as yet, unclear as to whether income, education, or poverty-related risk factors, is the best modality to target for intervention.

The risks associated with low SES environments can be particularly adverse if experienced in the early stages of development (Duncan et al., 2007, 2010) and are considered to be a major causal factor in the documented language gap, now referred to as the 'word gap', between high and low SES children at school-age. Research on the word gap has shown that children living in low SES environments often hear fewer words (Hart & Risley, 1992), less diverse language (Cartmill et al., 2013), and have less responsive parents (Evans, Boxhill, & Pinkava, 2008). Given that quality and quantity of input, as well as responsiveness, are known to facilitate language learning, these

suboptimal early language experiences may be at the source of the word gap (Hoff, 2006; Rowe, Suskind, & Hoff, 2013). Early language skill not only predicts later language, but also school readiness, improved executive functioning, and a range of other cognitive and academic milestones (Forget-Dubois et al., 2009; Newman, Ratner, Jusczyk, Jusczyk, & Dow, 2006). Thus, discovering the earliest origins of the language gap, and at a young enough age to propose intervention is crucial to solving this problem. The following study aims to investigate the role of cooperative communication, and parents' use of contextualized responses within interactions, as a predictor of language development in infancy, and specifically investigate how that relationship differs as a function of SES.

Conceptual Framework

Social constructivist frameworks, such as Vygotsky's Social Interactionist Theory (Vygotsky, 1978), have long posited that the development of cognition is driven largely by the social interactions between children and their caregivers. From these models, language is both the primary means for the transmission of knowledge, but it is also a skill that is dependent on the nature of social interactions (Snow, 1977; Tomasello, 1995). However, the nature of the interactions between children and their caregivers are often susceptible to larger economic, cultural, and societal forces that influence the family context. The Family Stress Model (Conger, Conger, & Martin, 2010) provides a framework to understand how larger societal factors, and in particular the stress and hardship associated with low SES environments, impact the quantity and quality of the social interactions we have. Considering the higher-order influence of SES, as well as the more direct influence of early social interactions, this study aimed to provide a socially grounded view of early infant language learning.

Significance

Understanding of the early predictors of language development, specifically those arising from social interactions, is vital in determining novel, developmentally appropriate approaches to early parenting interventions on infant communication, particularly in populations that are known to be at risk for disparities in language acquisition. As discussed, children from low SES families generally have fewer language-rich interactions in early life and therefore often enter school with lower levels of expressive and receptive language than their higher SES peers, on average. This may be due to reduced levels of language input compared to children from higher-SES families (e.g. Crosnoe, Leventhal, Wirth, Pierce, & Pianta, 2010; Hart & Risley, 1992; Pan, Rowe, Singer, & Snow, 2005), as well as lower levels of responsiveness to infant communicative bids (e.g. Albright & Tamis-LeMonda, 2002; Perkins, Finegood, & Swain, 2013). Measuring parent responsiveness, as well as the types of responses, to infant *prelinguisti*c behaviors (e.g. gestures, vocalizations, sustained attention) in dyadic interactions can potentially determine what particular parent actions are facilitative of language development and attainment, as well as detect if those behaviors differ demographically.

This dissertation makes a unique contribution to the existing research on infant language development with its simultaneous focus on prelinguistic interactions between parents and their infants, and on the importance of specific contextualized input during shared attentional episodes. By providing an in-depth look at the importance of early social interaction for infants, and how it guides language development, this work suggests avenues of intervention for parents, pediatricians, and others who work with infants.

Understanding the social mechanisms behind language learning this early in life also could also prove instructive to parents in guiding language development in infancy rather than later in life when language disparities are normally detected.

Moreover, this research has the potential to point to a mechanism implicated in the "word gap" between children in high and low SES beyond the quantity of input and the diversity of input on a linguistic level, but rather stemming from dynamics in the social interactions. Generally, it could create awareness surrounding the importance of early parent-infant communication. Specifically, by identifying the global factors (e.g. cooperative communication) and specific factors (e.g. types of contextualized responses), that relate to growth in infant communicative ability, this research can provide a basis for a mechanistic understanding of how parents can scaffold optimal language learning. If SES differences are found, the knowledge from this study may be particularly helpful for low SES parents to optimize their children's language foundation prior to school, and may provide a first step in creating early intervention for preventing the language gap.

Study Overview

In order to address gaps in the literature relating to the influence of SES on prelinguistic dyadic communication and to begin to investigate the mechanism of cooperative communication in early parent-infant interactions, this dissertation has two phases. Phase 1 involved creating a global measure of cooperative communication (PIICS)*, appendix B*, and was followed by the creation of the subsequent transcript-based measure of the concept (CLAN – PIICS, *appendix C*). This research was conducted with data from 121 mid to high SES parents interacting with their 7-month-old children as part of the speech and non-speech predictors of language development project (Newman,

Rowe, & Bernstein Ratner, 2015). The details of that measurement and study are explained in Chapter 3. Phase 2 of the study seeks to investigate the specific mechanisms of cooperative communication as they relate to SES and later language outcomes by particularly focusing on the quantifiable component of cooperative communication: contextualized responses to infant vocal and behavioral communication. Contextualized responses are responses that occur after an infant action (e.g. vocalization, gesture, etc.) that indicates their attentional focus, and that acknowledge or elaborate on their infant's attention. The second phase of the study uses data from 47 parent-child dyads participating in a 15-minute semi-structured play task when children are 10 months old in an economically diverse sample from the 'Pointing to Success' intervention project (Rowe, NICHD R21HD078771). This sample was coded for contextualized responses – using the modified CLAN PIICS measurement tool (explained in *chapter 4).* All codes were validated for contingency (a response that occurs within a 4 - 10 second window) based on reviewing the video-recorded observations. Data based on these two measurements is used to address the following research aims:

Research Aims and Questions

Phase 1 – Research Aim 1. The aim for phase 1 of the dissertation was to develop a measurement tool to operationalize the concept of cooperative communication. I created a global measure of early dyadic interaction called the Parent-Infant Interaction Coding Scheme (PIICS) (Renzi, 2017) in order to investigate key mechanistic contributors to early dyadic interaction. My subsequent aim was to discover whether a more quantified operationalization of cooperative communication could be created in order to test the

influence of particular types of contextualized responses in dyadic interactions. The research questions addressed in study 1 were:

A1.1. Is the Parent-Infant Interaction Coding System (PIICS) a reliable global measure of infant-parent cooperative communication?

A1.2. How can the key mechanisms behind cooperative communication be quantified for further study?

Phase 2 - Research Aim 1. The first aim for phase 2 of the dissertation expands on study one to examine whether cooperative communication, captured using the global PIICS measurement relates to SES and to examine the following questions:

- *Research question 1.1.* Does quantity of cooperative communication in early parent-infant interactions relate to SES?
- *Research question 1.2.* Do specific indicators of cooperative communication in early parent-infant interactions relate to infant language outcomes?

Research Aim 2. The second research aim for this study is to take a quantitative look the relationship between SES and cooperative communication by establishing how SES relates to contextualized responsiveness to infant communication (e.g. behavioral and vocal). Additionally, specific features of those responses (e.g. questions, elaborations, etc.) were examined to determine if they are related to family SES. The following questions are addressed:

- *Research question 2.1.* Does overall quantity of contextualized responses to infant communication in early parent-infant interactions relate to SES?
- *Research question 2.2.* How does SES relate to parent responsiveness to infant vocal communication?

- *Research question 2.3.* How does SES relate to parent responsiveness to infant behavioral communication?
- *Research question 2.4.* Do specific features of contextualized responses to infant communication in early parent-infant interactions relate to SES?

Research Aim 3. The final research aim for this study is to examine whether cooperative communication at 10 months relates to child language outcomes at 18 months. Importantly, due to the nature of the original data, all analyses to address these questions include group membership as a covariate. Additionally, the features of cooperative communication that appear to be most useful for language development were investigated. In order to address this aim, the following questions are examined:

- *Research question 3.1.* Does quantity of contextualized responsiveness to infant communication in early parent-infant interactions relate to infants' communicative development?
- *Research question 3.2.* Do specific features of contextualized responsiveness to infant communication in early parent-infant interactions relate to infants' communicative development?

Chapter 2 – LITERATURE REVIEW

The following literature review is an expansion of the literature review produced for the partial completion of requirements for the dissertation portfolio. It was subsequently published under the title of '*Two Minds Are Better Than One: Cooperative Communication as a New Framework for Understanding Infant Language Learning* ' (Renzi, Romberg, Bolger, & Newman, 2017). None of the pre-published content will be reproduced in the final dissertation publications.

Abstract

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.

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 Grices's maxims portrays communication as an active collaboration, with both contributors working together based on a shared understanding of a set of communicative norms (Grice, 1975). While 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 in order 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 infants' social bids, thereby creating the opportunity for shared communication.

By combining a growing body of work on parental 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 which 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 in order 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 three. 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 parents' 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 and colleagues found that 5-month-old infants expect social partners to respond to their intentional (non-cry) vocalizations (Goldstein, Schwade, & Bornstein, 2009). 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 speech-like 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, 2009b). Gesture use at 14 months also predicts vocabulary attainment, even when accounting for the overall amount of talk by the parent or infant (Rowe, Ozcaliskan, Goldin-Meadow, Özçalışkan, & Goldin-Meadow, 2008). Correspondingly, the combination of gesture and object-directed vocalizations predicts later syntactic complexity (Rowe & Goldin-Meadow, 2009) and progress from one- to two-word utterances (Iverson & Goldin-Meadow, 2005). The use of object-directed vocalizations in order 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 retain 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 speech-like 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 et al.,

2006, 2015). 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, Rowe, & Bernstein Ratner, 2015). 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 pro-social 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; Catherine S. 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 with 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 acknowledgement 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 (Vallotton, 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 speech-like utterances 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 speech-like 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 speech-like 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 adult-like. 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). Yoder and Warren (1999) found that in children with developmental disabilities, maternal responsiveness during the pre-linguistic period accounts for a statistically significant amount of the variance in their children's expressive and receptive language skills 6 months later. 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 (Cabrera, Shannon, & Tamis-LeMonda, 2007). Similarly, father and mother contingent responsiveness to their 10 – 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 in order 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 et al., 2010; Goldsmith & Rogoff, 1997; Hart & Risley, 1992; Pan et al., 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 et al., 2013). These suboptimal interactions have consequences: infants of mothers experiencing depression have difficulty learning from shared interactions with their mothers (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 et al., 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 non-cooperative 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 or that 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.

SES, Language, and Early Social Interaction

In the above sections, the contributions of the parent, dyad, and infant to early social interactions have been discussed. However, when considering cooperative communication as a potential early predictor of language development, it is important to include the environmental contexts that are known to relate to differences in early social interaction and later language. Socio-economic status (SES) has a documented impact on language learning, as well as on parenting in early life. Children who are being raised in low SES environments have different language trajectories than children from middle or higher SES homes, and often have lower language skills when they reach school (Brooks-Gunn, J., Rouse, C., & McLanahan, 2007; Hernandez, Denton, & Macartney, 2007; Hoff, 2013). Children from lower SES backgrounds have been shown to have lower overall levels of language comprehension, to have significantly lower expressive vocabularies, and to speak with less complexity than their middle and high SES counterparts from infancy through the early childhood period (Arriaga, Fenson, Cronan, & Pethick, 1998; Fernald, Marchman, & Weisleder, 2013; Hoff, 2006; Huttenlocher, Waterfall, Vasilyeva, Vevea, & Hedges, 2010).

SES disparities in language at school entry put low SES children at risk for language delays that may persist over time and cause significant academic achievement gaps (Bradley & Corwyn, 2002; Duncan et al., 2007; Morrison, Bachman, & Connor, 2005; Nelson, Welsh, Trup, & Greenberg, 2011). Additionally, these early differences in language use and expressive ability are associated with school readiness, which is predictive not only of success at school entry but also academic and professional success in adulthood (Duncan et al., 2007, 2010). As of 2012, an estimated 48% of children living

in low SES environments do not meet school readiness criteria in terms of language or numerical skills and are consistently outperformed by their middle SES peers (Calvo & Bialystok, 2014; Isaacs, 2012). In fact, lower SES children have been shown to be half a standard deviation behind their middle SES counterparts in linguistic ability even before school entry (Lee & Burkham, 2002). Notably, these differences were significantly related to differences in SES only and not race or ethnicity.

Prior to even 24 months old, differences manifest between high and low SES children's linguistic and prelinguistic ability. At 24 months old, low SES infants are approximately 6 months behind their high SES counterparts in terms of language processing speed, which relates to the ability to acquire new vocabulary and later literacy skills (Fernald et al., 2013). SES differences have even been found in prelinguistic indicators of language in female infants (Betancourt, Brodsky, & Hurt, 2015).

SES based differences in language trajectories for low SES children are often attributed to differences in the amount and diversity of linguistic input they receive from their parents. Low SES Parents use fewer total words when speaking to their infants than their high SES counterparts (Hart & Risley, 1992; Huttenlocher, Haight, Bryk, Seltzer, & et al, 1991; Huttenlocher et al., 2010; Rowe et al., 2013). In their famous study, Hart and Risley (1992) reported that low SES infants heard approximately 62,000 words a week, as compared to the 215,000 words heard by high SES infants (Hart & Risley, 1992). Additionally, this reduced input and lack of diversity in input associated with low-SES parents is related to their children's rate of vocabulary acquisition (Huttenlocher, Haight, Bryk, Seltzer, et al., 1991) as well as overall vocabulary at school-entry (Cartmill et al., 2013).

Fewer words and shorter sentences lead to a reduction in the number of opportunities for parents to create episodes of cooperative communication. Moreover, low SES parents use speech less frequently than their high SES counterparts to generate episodes of shared attention (Hoff, Laursen, Tardif, & Bornstein, 2002), which are crucial for language acquisition and early social understanding. Additionally, low SES parents use a smaller range of behaviors to engage their infants compared to their higher SES counterparts (Hirsh-Pasek et al., 2015). However, in a study conducted solely on low income mothers, mothers who engaged in and initiated more episodes of shared attention with their infants had infants who produced more social bids (Raver, 1996) suggesting that the reciprocal nature of cooperative communication dynamics are present in low SES families. Also, while income is most commonly used for measurements of the influence of SES, studies suggest that it may be in fact the parents' reduced experience with academic institutions that lead to their decreased use of language to engage with, and respond to, their children (Hoff-Ginsberg, 1991; Richman, Miller, & LeVine, 1992). Similar findings point to parent knowledge of child development as, in fact, a potential mediator for the impact of SES on language development (Rowe, Denmark, Harden, & Stapleton, 2016)

In infancy, the use of child-directed speech differs by SES, with parents in high SES families using language more frequently to engage the infant and low SES parents using language more often to manage behavior (Rowe, 2008). Similarly, parents from low SES families use more prohibitive language (often because it is environmentally necessary) (Hart & Risley, 1992). Prohibitive language reduces the opportunity for elaborated discourse and consequently, the opportunity for cooperative communication.

SES differences also apply to gesture, which is a vital part of cooperative communication, as it is an active component of infant prelinguistic communication and also predictive of later language acquisition (Kuhn, Willoughby, Wilbourn, Vernon-Feagans, & Blair, 2014; Rowe & Goldin-Meadow, 2009b; Vallotton & Ayoub, 2010). Rowe & Goldin-Meadow (2009) found that high SES parents gestured more with their children, which in turn predicted their children more frequently using gesture to communicate at 14 months and having larger vocabularies at 54 months (Rowe & Goldin-Meadow, 2009a).

An additional issue present in low SES homes is the increased likelihood of experiencing high levels of stress and depression. Depressed and stressed parents generally display fewer conversational interactions with their children (Albright & Tamis-LeMonda, 2002; Newland, Crnic, Cox, & Mills-Koonce, 2013). Similarly, marital instability and household inconsistency, which are more prevalent in low SES environments, have a negative effect on children's expressiveness and later literacy skill (Foster, Froyen, Skibbe, Bowles, & Decker, 2016; Konishi, Froyen, Skibbe, & Bowles, 2018). The combination of risk factors that can influence the early social interactions experienced by low SES infants makes it important to examine poverty in future studies of cooperative communication.

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 insight into possible individual contributions to a shared communicative setting. Similarly, the varying paradigms used to model non-responsiveness 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 in order 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 in order 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 non-verbal measures. In 2-year-olds, nonverbal measures of interaction quality such as fluidity of the interaction and mutual attentional engagement, 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 one-month-old infants, measured verbally with vocalization, and non-verbally with smiles and affect, predicts infant social bidding behavior at two months. Additionally, verbal and nonverbal responsiveness is correlated with the duration of infant vocalizations at three 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. While 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 pre-birth 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 (Guttentag et al., 2014).

Crucially, parents' knowledge and beliefs about their influence on child development impacts 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-De Lisi, 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. While 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 in order 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. Many interventions suggest that it is possible to increase different aspects of parents' input (e.g., Matthews et al., 2012; Suskind et al., 2013). 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 caregivers 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, as discussed above, differences in parental responsiveness, input, and communicative consistency are key predictors of the documented gaps in linguistic and academic attainment between high- and low-SES children (Fernald et al., 2013; Hart & Risley, 1992; Rowe & Goldin-Meadow, 2009a; Sohr-Preston et al., 2013). Further, given that knowledge about development is a factor in positive parenting and input, and SES measurement often captures differences in educational attainment, knowledge provided from research on cooperative communication can act as an easy point of intervention for parents. 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. In order 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 paper suggests, ‘two minds are better than one’ when it comes to facilitating infant language learning.

CHAPTER 3: STUDY 1 - METHODS & MEASURES

A publishable version of this measurement analysis is currently in preparation.

Background

Investigating cooperative communication can help identify the optimal dyadic interaction patterns that facilitate language learning. Given that, as previously mentioned, prelinguistic infants have a range of communicative abilities that exhibit social intentionality and can facilitate episodes of shared attention (Rowe & Goldin-Meadow, 2009b; Slaughter & McConnell, 2003; Vallotton, 2009), a coding scheme was developed to capture cooperative communication between parents and their prelinguistic infants. Many measurements of parent-child interaction quality focus on older children, thus missing the important impact of prelinguistic exchanges between parents and infants. The Parent-Infant Interaction Coding System (PIICS) (Renzi, 2017) was created to accurately reflect the mutual influence of parent and infant behaviors during dyadic interactions in the prelinguistic stage of life. By focusing on both linguistic and non-linguistic behaviors, cooperative communication aims to capture a full range of early social communication. Measured behaviors include joint attention, responsiveness, affect, positive and negative talk, and elaboration on infant focus.

Participants

Initial analyses were conducted on a longitudinal sample collected as part of a study on the speech and non-speech predictors of later language development conducted by Dr. Rochelle Newman and Dr. Nan Bernstein Ratner at the University of Maryland, College Park.

The sample consisted of 121 mother-child dyads (63 girls, 58 boys). Data were collected at 7, 10, 11, 18, and 24 months. For the purposes of the following coding validation study, only videos at the 7-month time-point were coded. The sample consisted of all mid to high SES mothers with an average of 17.1 years of education. Despite the lack of variability in education, the quantity and quality of observational data in the sample provided a useful basis for developing a coding scheme based on typical parent-child dyadic behaviors during infancy.

Table 1: Demographic Description of Study 1 Sample

Demographic variable	[*n* (%)]
Child gender (*n=125*)	
Male	58 (46.4%)
Parent race/ethnicity (*n=125*)	
White, European-American	97 (77.6%)
African-American	9 (7.2%)
Hispanic	6 (4.8%)
Other	13 (10.4%)
Household (*n=125*)	
1 Caregiver	5 (4.1%)
2 Caregivers	113 (91.9%)
>2 Caregivers	5 (4.1%)
Maternal education (*n=125*)	
High school	4 (3.2%)
Professional School	6 (4.8%)
College	49 (39.5%)
Masters	48 (38.7%)
Doctoral degree	17 (13.7%)

Procedure

For the original study, mothers engaged in 20-minute one-on-one play sessions with their 7-month-old infants involving free play with toys. Mothers were instructed to play with their infants as they do at home. All observations were reliably transcribed and coded using CLAN analysis tools based on CHILDES (MacWhinney, 2000) transcription manuals. A manual was created for the PIICS coding system and coders were trained and coded a sample of 25 videos (approximately 20%) to achieve reliability of above 90%. These videos were not used in the final analysis as they were chosen based on later attrition from the study. Coders watched each video twice and assigned a score on 13 global indicators of cooperative communication. Coders took regular breaks and videos were randomly selected for verification by other coders. The full coding manual appears in *Appendix B.*

Parent-Infant Interaction Coding System (PIICS)

The PIICS draws on previous work done on coding parent-child interactions such as the Parent-Child Interaction System (PARCHISY) (Deater-Deckard, Pyland, & Petrill, 1997) and joint engagement codes (Adamson, Bakeman, Deckner, & Nelson, 2014). Adapting joint interaction coding schemes for infancy involved omitting language-heavy metrics and including behavioral and other dyadic measurements. The PIICS is a global code measuring behaviors associated with rich early parent-infant interactions and is comprised of 13 codes including shared attention, gesture, and affect with 6 parenting indicators, 4 infant indicators, and 3 dyadic indicators (see *table 2* below for full list). Possible scores range from 0 to 5; 0 indicates no opportunity; 1 indicates that the behavior was observed at most once (or generally negative in the case of affect); and 5

indicates it was substantial/constant (or generally positive in the case of affect). These scores are coded proportionally based on the duration of the interaction e.g. if something happens 'often' within the 20-minute interaction as opposed to 'often' from the coder's perspective. Upon review of the descriptive statistics for the codes, however, infant affect (IC3) had to be removed from further analysis due to excessive instances of the code '0'. Coders indicated that due to camera placement in many of the videos, infant affect was difficult to see and, thus, was difficult to assess with integrity.

Table 2: Definitions of PIICS Indicators

PC1	Parent responsiveness to vocal communication
PC2	Parent responsiveness to behavioral communication
PC3	Parent affect
PC4	Parent initiates shared attention
PC5	Parent talk
PC6	Parent elaborates on infant attentional focus
DYC1	Infant and parent share attention
DYC2	The dyad exhibits turn-taking (behavioral and/or vocal)
DYC3	Fluency of dyadic interaction
IC1	Infant vocal communication
IC2	Infant behavioral communication
IC3	Infant affect
IC4	Infant initiates shared attention

Reliability

The reliability analysis was conducted on a subset of 25 videos used for the coding. Training was provided on videos for participants that had been dropped from the study. Overall inter-rater reliability for the measure is 91.4% (Cronbach's Alpha =

0.914), suggesting that cooperative communication can be consistently captured using the PIICS.

Principal Components Analysis

A principal components analysis was conducted to determine if the PIICS was truly capturing one larger concept, known as cooperative communication. Preliminary tests indicated that the data were very well suited to factor analysis. The Kaiser-Meyer-Olkin (measure of sampling adequacy) value was .866 signifying that 87% is the proportion of variance that may be attributable to underlying components, which meet the recommended threshold of .6 (Kaiser, 1974) . Similarly, Bartlett's test of sphericity was statistically significant ($p < .001$) indicating that the correlation matrix of the variable was suited for factoring (Bartlett, 1954).

The initial principal components analysis presented 3 components with an eigenvalue above 1, exceeding the Kaiser criterion (Kaiser, 1974). Three combined components accounted for 70% of the variance. However, the scree plot display of the components revealed a large drop after 1 and clear cutoff with 2 and 3 in close proximity. Thus, based on the scree test (Cattell, 1966), components 2 and 3 were further reviewed. Finally, the decision was made to retain 3 components due to the proportion of variance explained being just above 70. Components 1 and 2 explained 49% and 12% respectively for a combined explained variance of 61%, however component 3 contributed an additional 9% of explained variance and was also retained. The final three retained components explained an approximate 70% of the total variance in the codes.

The principal components analysis was then conducted on the 3 retained components and with an oblimin rotation in order to interpret the components. The

pattern matrix and the rotated solution of the components represented three distinct behavioral contributions to dyadic interaction. The loading table of the pattern matrix is included in *table 3* below. Based on the loadings, component one seemed to represent parent behaviors and shared attentional behaviors, which suggest that shared attentional episodes may be largely parent driven at 7 months. The loadings of component 2 specifically related to infant vocalizations and parent responsiveness to those vocalizations as well as some turn-taking behavior. Finally, component 3 appeared to represent that infant behavioral communication and other social bidding made an independent contribution to these early interactions.

Table 3: PCA Component Loadings for PIICS Indicators

Variable	**Component**		
	1	2	3
PC6. Parent elaborates on infant attention	0.944		
PC4. Parent initiates shared attention	0.922		
PC3. Parent affect	0.831		
PC5. Parent talk	0.801		
PC2. Parent responsiveness to beh. comm.	0.766		
DYC1. Infant and parent share attention	0.753		
DYC3. Fluency of dyadic interaction	0.678		
DYC2. The dyad exhibits turn-taking	0.606	0.383	
IC1. Infant vocal communication		0.845	
PC1. Parent responsiveness to vocal comm.		0.772	
IC4. Infant initiates shared attention			0.88
IC2. Infant behavioral communication			0.812

Extraction Method: Principal Component Analysis
Rotation Method: Oblimin with Kaiser Normalization

Conclusions and Next Steps

The PIICS data suggested that parent infant interactions can be reliably coded, which is promising for future research on the pertinent topic of cooperative communication as it relates to infant language development, especially in the prelinguistic stages. However, the principal component analysis of the coding scheme also detected that certain patterns of behavior drive early social interaction in distinct ways.

Interestingly, infant behavioral communication was the only component that predicted growth in scores from 7 to 10 months ($r=.21$, $p<.05$) on the Macarthur Child Development Inventory (MCDI), a parent report measure of infant communicative skills, highlighting the importance of measuring gesture and behavioral communication in early interactions. Additionally, infant vocal communication and parent talk both were significantly positively correlated with their corresponding measures from the transcripts using CLAN analysis. Upon reviewing the distinct components, the coding scheme was adapted for study 2 (see *chapter 3*) to facilitate its use on transcripts and to quantifiably capture these distinct contributions to early parent-infant social interactions. Based on the principal component analysis and findings relating to infant behavioral communication, a more quantifiable measure was required to operationalize the mechanisms involved in early social interaction. To generate variables with more specificity of influence, and variation, the PIICS was adapted for use with CLAN transcripts. Using transcript data the PIICS –CLAN measures parent use of contextualized responses to infant vocal and behavioral communication as well as the types and features of those responses *within* cooperative communication episodes, such as a 'conversational' turn or shared attentional episode. Additionally, this measure allows us to investigate which types of parent

responsiveness (questions, elaborations, labels, etc.) are most predictive of language development. By quantifiably operationalizing cooperative communication and using this adapted coding scheme for study 2, the hope is to capture the patterns involved in early dyadic interaction, as well as identify which features of cooperative communication are most useful in facilitating language development. Notably, using this quantitative measure does not account for more abstract components of dyadic interaction (e.g. dyadic fluency) and therefor the use of both measures together is particularly useful for a holistic view of early parent-infant interactions. Additionally, relationships between the global codes and the corresponding relevant variables they are detecting (e.g. infant behavioral communication, parent talk, etc.) can be investigated to test the validity of this coding scheme. Importantly, validity of the measure can be investigated with a more heterogeneous sample such as that used in study 2.

CHAPTER 4: STUDY 2 - METHODS & MEASURES

Participants

The sample was recruited from the Boston greater metropolitan area. The data were originally collected as part of an intervention study, which aimed at increasing parents' use of pointing. The study protocol was approved by Harvard University's Institutional Review Board (IRB) including informed consent for all waves of data collection. Inclusion criteria for the first wave of collection were as follows: the target child must be between 10 and 12 months of age at the time of the first observation; the target child must be exposed to English at least 75% of the time at home; and the target child must not have a known hearing loss or other condition that might affect language and overall development. Participation was open to all primary caregivers and the final sample (n=47) was made up of 46 mothers and 1 grandmother. At the onset of the study, children (girls=23, boys =22) were an average of 10 months and 7 days old (Range = 9;7 -11;6).

Table 4: Demographic Description of Study 2 Sample

Demographic variable	[*n* (%)]
Child age in months [Mean (SD)]	10.7 (.49)
Child gender (*n=47*)	
Male	22 (48.9%)
Parent race/ethnicity (*n=47*)	
White, European-American	34 (72.3%)
African-American	4 (8.5%)
Mixed-Race/Other	9 (19.1%)
Family income (*n=47*) [*n* (%)]	
< $15,000	5 (10.4%)

$15,000 to $30,000	7 (14.6%)
$30,000 to $45,000	3 (6.3%)
$45,000 to $60,000	0 (0%)
$60,000 to $75,000	2 (4.2%)
$75,000 to $90,000	5 (10.9%)
> $90,000	24 (52.2%)
Maternal education *(n=47)*	
Some high school	1 (2.2%)
High school graduate (or GED)	3 (6.5%)
Some college (or two-year degree)	17 (37%)
Four-year college degree	9 (19.6%)
Advanced degree	16 (34.8%)

Data

This research was conducted on previously collected data. The design for this study involved applying the PIICS and the CLAN PIICS to the observational data, and transcripts of parent-child interaction at child age 10-months. Reliability of 90% or more was established across coders for both coding schemes. Data on coded variables at 10 months was then related to family SES indicators and language outcomes at 18 months. Analyses were consequently conducted using *SPSS* in order to answer the aforementioned research questions.

Forty-seven caregiver-infant dyads participated in approximately 15-minute observations of a semi-structured play task in their homes when the infants were 10 months old. The play activity consisted of the 'three-bag task' – the bags contained one book, one barnyard set, and a shape-sorting toy in the shape of an elephant. Parents were instructed to explore the bags, with their infants, in consecutive order (first the book, then the shape sorter, and a farmyard set) but to otherwise play with their infants as they

normally would. The data were transcribed for speech and gesture by reliable coders using the CHAT conventions of the CHILDES program (MacWhinney, 2000). All videos, transcripts, and data points were assigned an ID code to protect any identifying information, and all coders had completed CITI trainings and had been reviewed by the principal investigator. De-identified data was used for all of the analyses.

Measures

A summary of the measures included in this study is included in *appendix A*.

MCDI

The Macarthur Bates Child Development Inventory (hereafter referred to as MCDI) was used as a measure of infant behavioral and linguistic communication growth. The MCDI is a standardized parent report measure of infant emergent language ability. For this study the short-form of the *'CDI: Words and Gestures'* was used, which is normed for children between 8 and 18 months. This report provides a checklist of 89 words for parents to indicate whether their child understands, or understands and uses each word. It also collects information on a series of questions relating to specific language milestones (e.g. *'does your child do respond when his/her name is called?'*), and gesture milestones (e.g. *'does your child nod his/her head yes?'*). MCDI data were collected at 10 and 18 months. The standardized scores were used as a measure of communicative ability.

Mullen Scales of Early Learning

Infant's expressive language ability was measured at 18 months using the Mullen Scales of Early Learning (MSEL) (Mullen, 1995). The MSEL is a standardized, measure, and is reported to be high in validity and internal reliability (.83–

.95). Expressive language is measured using a 28-item scale designed to test infants' productive vocabularies by eliciting the correct labels for objects and pictures. The Mullen scales produce standardized t-scores and percentile rankings that were used in the analyses for this study.

Parent and Infant 'Talk'

CLAN analyses were performed on the transcripts in order to generate measurements of language for the parent, including *tokens* (the number of words used), *types* (the variety of words used), *type/token ratio* (a measure of input throughout an interaction), and *mean length of utterance (MLU),* which is used as measurement of grammatical complexity. All language produced, including infant vocalizations, were transcribed. Infant vocalizations were standardized in the transcripts to ensure accurate analyses and were coded as xxx (=vocalizes). The CLAN manual standards (MacWhinney, 2000) were followed when coding infant babble, which are normally categorized as vocalizations including a phonemic sound (e.g. 'b' while looking at a ball). All vegetative sounds such as coughs and sneezes were omitted. Parent tokens were used as a control for overall talkativeness to ensure that results were driven by responsiveness rather than total input. Child types (language variability) at 18 months were used as a key language outcome, as types are indicative of range of infant vocabulary ability. Tokens are a less useful indictor of language development at 18 months due to natural patterns of repetition in infant speech at that age and were omitted.

Gesture

Gesture was also coded in the transcripts, which was defined as a non-verbal communicative act. *Deictic gestures* are used to indicate reference and include pointing,

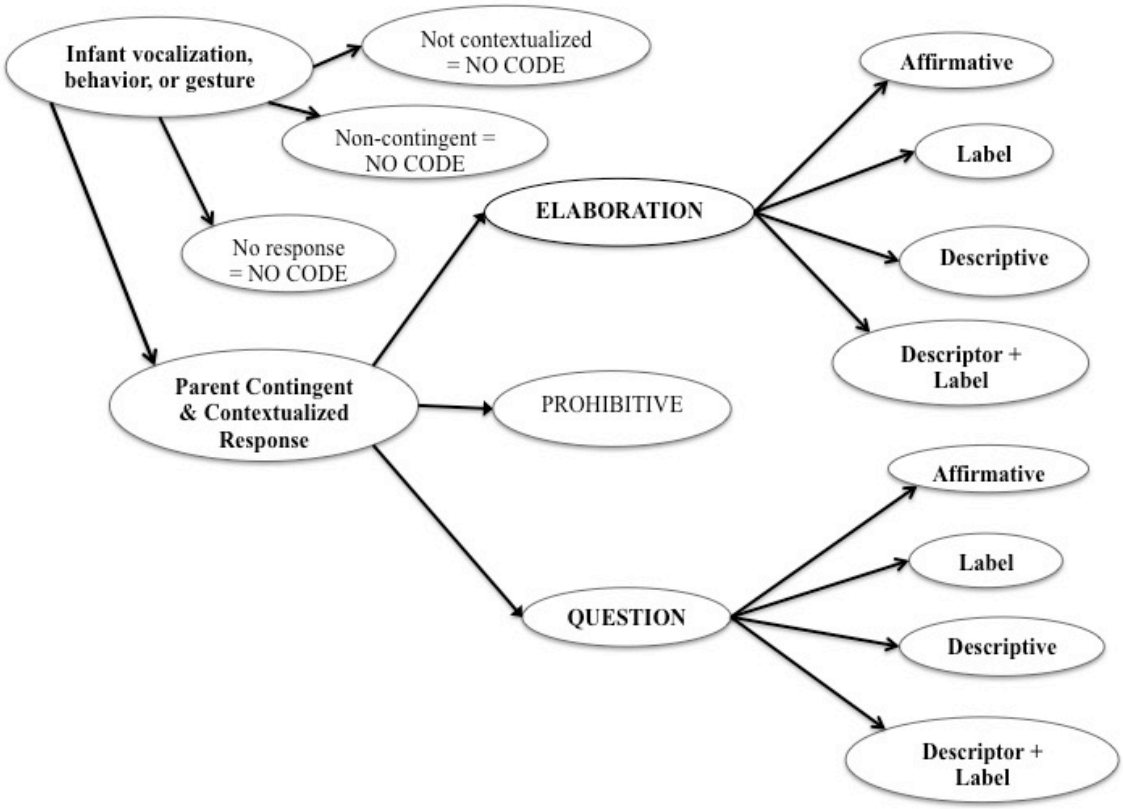
showing, and holding out a hand to be given an object. *Conventional gestures* are culturally determined behaviors that are assigned a communicative meaning (e.g. nodding the head to mean 'yes', or waving a hand to indicate 'goodbye'). *Representational gestures* are less common in children and are used to metaphorically represent an action or object (e.g. moving your arms rhythmically in front of you to mimic the action of swimming). These were added to the transcripts on a separate tier labeled '%gpx', for analysis. Actions such as reaching or manipulating the toys were also coded but labeled as actions rather than gestures.

Coding and Measures of Cooperative Communication

Cooperative Communication codes were added to the transcripts. The Parent Infant Interaction Coding Scheme (PIICS) was used to provide a measurement of global indicators of parent infant interactions. The full description can be found in *chapter 3*.

Coding and Measures of Contextualized Responsiveness

Figure 1: Contextualized Responsiveness Coding Tree



Each infant vocalization, gesture, and action was transcribed using CLAN transcription tools as stated above. A responsiveness coding-scheme based on the PIICS (Renzi, 2017) has been adapted for CLAN (see *appendix C*) to code each response that occurs doing shared attentional episodes to one of these infant actions. These 'conversation-like' reciprocal interactions were coded and added into the transcripts under a new tier (%res) created for this coding scheme. Transcripts were verified by a trained research assistant, reliable on the coding scheme, against the videos to ensure all labeled responses are contingent within the predefined window of 10 seconds between behavior and response (Suanda, Smith, & Yu, 2012).

All parent responses that are contextualized (referring to or elaborating on the infant's immediate attentional focus or activity), and that are contingent (occurring within a 4 – 10-second window) were coded. The first level of coding categorized the response based on whether the parent responded to their infant' behavior, gesture (labeled as contextualized responses to infant actions), or vocalization, or some combination of these.

Contextualized responses were further broken down into categories as to whether the response was *elaborative*, a *question*, or a *prohibitive*. Elaborative responses will necessarily provide some acknowledgement or expansion on the infant's activity or attentional focus, a question is an elaborative response with the cadence and denotation of a question, and a prohibitive response is a response that provides no contextual information about the infant's activity or attention but ends that episode of attention (e.g. stop!).

Further, those contextualized responses are then subcategorized as to whether they contained an affirmative confirmation, an object label, a descriptor, or both a label and a descriptor. For example, an elaborative response that is coded as *affirmative* is a response that simply acknowledges or praises the infant's attention without providing any contextual information (e.g. 'that's right.', 'nice work!'). A response that is *descriptive* provides the infant with a verb describing the action he/she is doing, or a description, most likely an adjective, of the object on which their attention is focused (e.g. 'You're having fun chewing it.', 'it's yellow'). A response that is a *label* captures instances where the parent provides the correct object label for the item the infant is attending to (e.g. 'it's an elephant', 'He's Mr. cow'). A response that includes both a label and a descriptor (e.g.

'That's the brown cow!', 'you really love the red barn') are coded as providing a descriptor and label (desclabel).

Parent responses that are questions receive the higher-order code of *question,* and then the same criterion detailed above is applied to the parent's vocal response. *Table 5* below shows examples of each type of code. Responses that are coded as *prohibitive* refer to responses where the parent only uses a prohibitive word or phrase when interacting with the infant (e.g. 'no', 'don't', 'stop that'). Responses that contain a prohibitive word or phrase but also expand on the context of the infant's attention were labeled as elaborative (e.g. 'stop playing with the gray wire').

Table 5: Examples of Contextualized Responsiveness Coding

Question/ Elaboration	Parent contingent response with a word/phrase/sentence that provides:	Example:
Affirmative	Acknowledgment of infant's attention without referring to the object or activity	*"Yeah?"* *"Good job!"*
Descriptive	Adjective or other descriptor of the object or activity to which the infant is attending	*"Is that red?"* *"They do look tasty."*
Label	Label for the object or activity to which the infant is attending	*"How about the square?"* *"It's an elephant!"*
Desclabel	Label and a descriptor for the object or activity to which the infant is attending	*"Are you eating a star?"* *"That is not a free-range chicken."*
Prohibitive	Parent contingent response that uses a prohibitive phrase	*"Stop that."*

Additionally, behavioral responses, that are contingent, were included in the transcripts on the same tier (e.g. if a parent responds to a gesture with a gesture). Once coding was completed, CLAN analyses were used to quantify the number of instances of each type of response and the variety of those responses, similar to how types and tokens

are calculated. Further, analyses were conducted to determine if certain types of responses are more differentially predictive of later language outcomes than others.

Family Socioeconomic Status (SES)

Socioeconomic Status (SES) was measured using parent-report surveys of demographic data originally collected for the larger intervention study from which this data is drawn. Participants categorically indicated their level of education in years and household income in US dollars. Income was allocated into six categories from below 15,000 a year, to above 90,000 a year. Education was allocated into 5 categories from 'some high school' to an 'advanced degree'. It is important to note that for the purposes of the original intervention study, participants were selected in order to facilitate an approximately equal amount of caregivers with and education level of 2 years of college or fewer (47% of the final sample), and caregivers with a 4-year college degree or more (52% of the final sample). Education and income were highly correlated ($r=.70$, $p <.001$) in the sample and a composite of these variables was used as the measure of SES. The inter-relatedness of the variables, as well as research indicating that both income (Hanson et al., 2013; Yeung, Linver, & Brooks-Gunn, 2002) and education (Harding, 2015; Hoff, 2006; Sayer, Gauthier, & Furstenberg, 2004) are uniquely important for development justified the creation of a composite. However, once the composite was created, the SES variable was heavily weighted toward income (as seen in table 6 below), therefore, throughout the analyses reported in the results section below (*chapter 5*), where there were specific relationships related to education as distinct from SES, those findings are additionally examined. SES was related to child types as a language outcome, and

education was related to scores on the MSEL, thus predictor models for those outcomes include only the relevant indicator.

Table 6: Bivariate Correlations between SES Indicators

	SES	Income	Education
SES	1	.999**	.730**
Income	.999**	1	.702**
Education	.730**	.702**	1
**p<.01			

CHAPTER 5: RESULTS

Research Aim 1

To address research aim 1 - to examine the relationship between cooperative communication (as measured using the PIICS), SES, and language development the following analyses were conducted examining the influence of SES, testing the relationship between the codes and language development, and finally examining significant pathways between all three measures. Importantly, due to the nature of the original data coming from an intervention study, all analyses related to language outcomes at later times include group membership as a covariate.

COOPERATIVE COMMUNICATION

Description of Cooperative Communication Measurement

The PIICS global coding scheme was applied to the sample. The aim of the PIICS (Renzi, 2017) is to capture global components of dyadic interaction (e.g. fluency, shared attention, etc.) that cannot be detected using only quantitative coding of responses that occur during shared attentional episodes. The measurement was on a scale from 0 to 5 and the full details of each component can be found in *table 5*.

Cooperative Communication Descriptive Statistics

Table 7: Descriptive Statistics – Cooperative Communication PIICS Indicators

Variable	*N*	*Mean*	*SD*	*Min*	*Max.*
PC1. Parent responsiveness to infant vocal bid	46	3.00	1.96	0	5
PC2. Parent responsiveness to infant behavioral bid	46	4.04	0.56	3	5
PC3. Parent affect	46	4.61	0.49	4	5

PC4. Parent initiates shared attention	46	3.93	0.53	3	5
PC5. Parent Talk	46	4.24	0.57	3	5
PC6. Parent Elaboration	46	4.20	0.54	3	5
DYC1. Infant and parent share attention	46	4.33	0.70	2	5
DYC2. Instances of turn-taking	46	3.61	0.68	2	5
DYC3. Fluency parent-infant interaction	46	3.96	0.60	2	5
IC1. Infant vocal communication	46	2.57	1.19	1	5
IC2. Infant behavioral communication	46	3.89	0.64	2	5
IC3. Infant affect	46	4.22	0.76	2	5
IC4. Infant initiates shared attention	46	2.70	0.66	2	4
PCALL	46	24.02	2.57	19	28
DYCALL	46	11.89	1.54	8	15
ICALL	46	13.37	1.98	8	17
PIICSALL	46	49.28	4.15	41	60

There was relatively low variability in cooperative communication across the sample with the overall scores ranging from 41 to 60 with a mean of 49 (SD=4.15). There were not high levels of variance in the sample with regard to the parent indicators with most of the codes ranging from 3 – 5 with most of the means above 4, suggesting that parents in our sample were generally engaging in scaffolding behaviors very often, or almost throughout the interaction. Parent affect ranged from only 4-5 with a mean of 4.6 (SD=.49) suggesting that almost all parents were exhibiting clear positive affect while engaging with their children. Parent total behaviors ranged from 19 – 28 with a mean of 24 (SD=2.57). Dyadic indicators all ranged from 2 to 5, with a total range of 8 - 15 and the mean of 11.9 (SD=1.54). Infant indicators had more variability with the total infant scores ranging from 8 to 17 with a mean of 13.4 (SD=1.98). The trend toward positive affect was also found in infants with the mean affect score being 4.2 (SD =.76) suggesting that infants were exhibiting largely positive affect throughout the interaction.

Overall, it appears that most dyads were engaging in the behaviors associated with cooperative communication very often in our sample.

Cooperative Communication and contextualized responsiveness

Contextualized responsiveness (measured using the coding scheme in *Appendix B* using Clan analysis tools) was used to capture quantitative aspects of the conversation-like back and forth between parents and their infants known as cooperative communication, while PIICS measures cooperative communication in a global sense by capturing the overall fluidity of the interaction and key indicators of interaction quality (e.g. turn taking, parent input, etc.) In order to test the validity of the PIICS coding scheme and further investigate the relationship between cooperative communication and contextualized responsiveness, analyses were run investigating the relationship between the PIICS indicators (see *table 2*) and both the specific variables that the indicators are designed to detect (e.g. parent talk, infant behavioral communication, etc.), and also the various features of contextualized responsiveness that were related (see *table 5* for examples).

Parent Codes. Parent responsiveness to an infant's communicative bid (PC1) was not correlated with the measure of contextualized responses to vocalizations alone but was correlated to the measure of responsiveness to vocalizations coupled with a simultaneous behavior ($r=.39$, $p<.01$). Parent responsiveness to an infant's behavioral bid (PC2) was directly correlated to the measure of parent responsiveness to behaviors only ($r=.30$, $p<.05$). Parent affect (PC3) was, as expected, unrelated to any of our contextualized responsiveness measures. PC4. Parent initiates shared attention/communication was inversely related to almost all of our measures of

contextualized responses because our coding was contingent on the infant having initiated or provided the opportunity for cooperative communication and a contextualized response. Parent talk (PC5) as measured using the global code was positively significantly related to parent tokens – amount of words the parent said – ($r=.43$, $p<.01$), and parent types – the variety of words the parent used – ($r=.35$, $p=<.05$). Parent Elaboration (PC6) was related to both overall contextualized responsiveness ($r=.31$, $p<.05$) and elaborative responses in particular ($r=.33$, $p<.05$).

Dyadic Codes. Infant and parent shared attention (DYC1) was related to parents responding to infant behaviors ($r=.54$, $p<.01$) and gestures ($r=.39$, $p<.01$) when not coupled with a vocalization. DYC1 was also related to all measures of contextualized response types; overall responsiveness ($r=.49$, $p<.01$); elaborations (.39, $p<.01$); and questions ($r=.47$, $p<.01$). Instances of turn-taking during the parent-infant interaction (DYC2) were unrelated to any measure of contextualized responsiveness, which may be due in part to our having to the 10-second contingency window and viewing each turn as a separate responsiveness episode. The fluency of the parent-infant interaction (DYC3) also related to parents responding to infant behaviors ($r=.46$, $p<.01$) and gestures ($r=.42$, $p<.01$) with no accompanying vocalization. DYC3 was also related to all measures of contextualized response types; overall responsiveness ($r=.37$, $p<.01$); elaborations (.31, $p<.01$); and questions ($r=.34$, $p<.01$).

Infant Codes. IC1. Infant vocal communication (IC1) was related to responsiveness to vocalizations coupled with a behavior ($r=.49$, $p<.01$), but not to responsiveness to vocalizations alone. Infant behavioral communication (IC2) was related to infant gesture tokens - the total amount of gestures infants produced in the interaction -

(r=.32, p<.05), parents responding to infant behaviors without a simultaneous vocalization (r=.55, p<.001), and contextualized responses to gestures without an accompanying vocalization (r=.41, p<.01), overall responsiveness (r=.52, p<.001), elaborations (.35, p<.05), and questions (r=.61, p<.001). Infant affect (IC3) was also related to parents responding to infant behaviors without a vocalization (r=.51, p<.001), overall responsiveness (r=.39, p<.01), elaborations (.32, p<.05), and questions (r=.37, p<.05). Finally, infant initiates shared attention (IC4) was not significantly related to any of the measures of contextualized responsiveness. These findings suggest that the PIICS may be a useful tool for quickly measuring the qualities of parent-infant interaction and detecting the variables underlying those concepts with validity. A more quantitative approach may be more useful in detecting group differences and the specific components of parent-infant interaction that facilitate optimal language development.

Cooperative Communication – A note on gender

Table 8: Relationships between Gender and Cooperative Communication

PIICS Variable	Gender
PC1. Parent responsiveness to infant vocal bid	-.44**
PC2. Parent responsiveness to infant behavioral bid	-.04
PC3. Parent affect	-.12
PC4. Parent initiates shared attention	-.12
PC5. Parent Talk	.03
PC6. Parent Elaboration	.03
DYC1. Infant and parent share attention	.34*
DYC2. Instances of turn-taking	.28
DYC3. Fluency parent-infant interaction	.38*
IC1. Infant vocal communication	-.39**
IC2. Infant behavioral communication	.32*
IC3. Infant affect	.35*

IC4. Infant initiates shared attention	.08

Many of the PIICS outcomes were strongly related to gender in our sample. Notably, gender was negatively related to parent responsiveness to infant's vocally communicative bids ($r = -.44$, $p<.01$). Additionally, gender was negatively correlated to infant vocal communication overall ($r = -.39$, $p<.01$) suggesting that parents may respond less to their daughter's vocal bids as compared to their sons and that, in our sample, female infants produced fewer vocally communicative bids overall. An additional important consideration is that gender also related to behavioral communication ($r=.32$, $p<.05$) suggesting that female infants were more likely to produce behaviorally communicative bids, which may account for them using fewer vocalizations as infants commonly transition from more gestures and fewer vocalizations to the inverse as they begin to acquire vocabulary (Rowe & Goldin-Meadow, 2009b). Gender was additionally positively correlated with infant affect ($r=.35$, $p<.05$) suggesting that female infants may have demonstrated more positive affect than male infants. Specific differences were found in measures of dyadic measures of cooperative communication. Female gender was related higher instances of infant and parent sharing attention ($r=.34$, $p<.05$) and more fluency in the interaction ($r=.38$, $p<.05$) suggesting that parents may engage in more dyadic 'back and forth' with their daughters compared to their sons. There is evidence in the existing literature that female infants experience more variability in growth from behavioral to vocal communication, which may account for these findings (Johnson, Caskey, Rand, Tucker, & Vohr, 2014). Additionally, the literature supports the finding that mothers produce more responses to their female infants, which is perhaps the trend we're seeing replicated here (Clearfield & Nelson, 2006). Given that our sample consists

of female caretakers only, it would be an interesting next direction for research to investigate whether these gender findings are replicated with father-daughter and father-son relationships.

SES and Cooperative Communication

SES was unrelated to all measures of cooperative communication at 10 months suggesting that the quality of synchronous dyadic interaction between parents and their infants does not differ significantly in this sample as a function of family socio-economic status. However, our sample, compared to national averages, have high levels of education and income and so these effects may be partially attributed to the homogeneity of the sample. This finding also suggests that the 'word gap', and the SES differences found in child language development (Hoff, 2013; Perkins et al., 2013) may not be related to overall interaction quality but to specific mechanisms of parent-infant interactions. This lays the foundation for our subsequent research aims using contextualized responsiveness, as a quantified measure of cooperative communication, to detect the specific mechanisms of parent-infant interactions that facilitate language learning, and whether those mechanism are related to SES.

Cooperative Communication and Language outcomes at 18 months

Group membership was controlled for in all analyses concerning language outcomes at 18 months due to the dataset being drawn from an original study that was intervention-based. As stated above, gender was also controlled for given its significant relations with many PIICS variables.

Parent talk (PC5) was related to children's receptive vocabulary scores at 18 months as measured on the CDI ($r=.37$, $p<.05$) replicating previous findings on parent input and language comprehension (e.g. (Huttenlocher, Haight, Bryk, & Seltzer, 1991; Huttenlocher et al., 2010). Overall parent-driven components of cooperative communication were also significantly related to higher scores on the productive vocabulary measure of the CDI at 18 months ($r=.36$, $p<.05$). This distinction suggests that other parent activities, beyond just input, such as parent initiation of shared attention and elaboration on shared attention may be more useful in predicting expressive, rather than receptive, language skills at this age.

Interestingly, the only infant variable related to a language outcome was infant behavioral communication, which was positively related to child word types at 18 months ($r=.35$, $p<.05$). This finding indicated that infants' use of behavioral communication, or perhaps their behavioral and gestural communication coupled with contextualized responses to those behaviors, is driving part of their language development trajectory. These findings replicate our original results of Study 1, and are also replicated in our analyses of contextualized responsiveness under research aim 2 below.

Research Aims 2 and 3

To address research aim 2 - establish whether parents' use of contextualized responses to infant communication is related to SES, and research aim 3 - to examine whether contextualized responsiveness at 10 months relates to child language outcomes at 18 months, responsiveness was analyzed according to the cascading categories highlighted in the coding tree (*figure 1*). Contextualized responses to infant actions were analyzed first, followed by types of contextualized responses, and finally features of contextualized responses. A definition of each level of responsiveness coding is provided in *table 9* below.

Table 9: Definitions of Contextualized Responsiveness Categories

Variable	Definition
Contextualized response to infant action	Infant indicates attentional focus via vocalization, gesture, or behavior and parent responds
Type of contextualized response	Parent produces a question, a prohibitive, or an elaborative response
Features of contextualized response	Parent response contains a label, affirmation, descriptor, or descriptor and label combined.

CONTEXTUALIZED RESPONSES TO INFANT ACTIONS

Description – Responses to Infant Actions

Using the CLAN coding scheme created to examine the benefits of specific responses (Renzi, 2018), all responses were first labeled based on whether they were responding to an infant attentional bid that was vocal, behavioral, or a gesture. Vocalizations were coded as all non-vegetative vocalizations including babble and early words (e.g. mama). Behaviors were all coded actions or act related to the infant's attentional focus (e.g. turning a page in a book, holding a toy, etc.), and gestures were coded as infant behaviors with implicit communicative intent (e.g. showing a parent a toy, pointing to an object, etc.).

Descriptive Statistics – Responses to Infant Actions

Table 10: Descriptive Statistics – Contextualized Responses to Infant Actions

Variables	N	Min.	Max.	Mean	SD
All Responses to Vocalizations	46	0	47	13.30	12.39
Responses to Vocalizations Only	46	0	20	6.33	6.71
Responses to Behavior Only	46	21	94	49.59	19.10
Responses Vocal & Behavior	46	0	28	5.93	7.34
Responses to Gesture Only	46	0	10	2.15	2.98
Responses Vocal & Gesture	46	0	22	1.04	3.83
All Responses to Behavior and Gesture	46	21	104	51.74	20.42

The most common responses were parents responding to infant behavior (M=50, SD=19.1), which is developmentally appropriate for 10 months, and is to be expected as the number of behaviors that infants are producing at 10 months far exceeds the number of gestures and vocalizations that would be produced at that age. Responsiveness to vocalizations of any kind (including those coupled with a gesture or behavior) proved to

be the next most likely infant action to be responded to (M=13, SD=12.4) and varied widely across the sample with some parents not producing any responses to vocalizations and one parent with as many as 47. Responses to vocalizations alone occurred less than half as many times with a mean of 6 (SD=3.7) and responses to a vocalization paired with a behavior occurring a similar number of times (M=6, SD=7.3). Overall, responsiveness to gestures were the least common, whether without (M=2.2, SD=3), or with, a simultaneous vocalization (M=1, SD=3.8).

Responses to specific infant actions were highly correlated with one another with the notable exception of responses to infant vocalizations produced with no accompanying behavior or gesture, which were not significantly related to any other type of responses. This reflects the findings from phase 1 of the study (see *chapter 3*) indicating that infant vocal communication is responded to and reacted to distinctly by parents. Existing research suggests that vocalizations may be favored by parents as opportunities to respond due to their 'speech-like' nature as compared to behavioral communication because they associate vocalizations with improvements in word learning (Gros-Louis et al., 2006). Additionally, responsiveness to gesture alone was unrelated to vocal responsiveness and to overall responsiveness to vocalizations (including those paired with a behavior or gesture). Reflecting the PIICS findings, infant gender was associated with behavioral communication ($r=.35$, $p<.05$), female infants producing more behaviors than male infants, and so was included as a control for the following analyses.

SES and parent responses to infant actions

SES related to parent responsiveness to vocalizations (including those that were paired with a behavior or gesture) ($r = .41$, $p < .05$). In particular, SES was related to

parents' responsiveness to infant vocalizing and when they produced a behavior at the same time ($r = .36$, $p < .05$). These positive associations suggested that higher levels of income and education (presented here as an SES composite) relate to higher rates of parent responsiveness to infant vocalizations (with and without accompanying behaviors).

Importantly, the relationship between SES and responsiveness to vocalizations remained statistically significant after controlling for parent input, infant gesture, as well as number of infant vocalizations and behaviors. With those controls in place, SES was significantly positively associated with responsiveness to overall vocalizations ($r=.33$, $p<.05$) suggesting that parents from higher SES families are more likely to produce a contextualized response once their infant indicates attention using a vocalization. Additionally, with controls in place, higher levels of education were related to higher levels of responses to behaviors when coupled with a vocalization ($r=.34$, $p<.05$) Neither SES nor either indicator was a significant predictor of parents responding to infant gestures, with or without a simultaneous vocalization.

Table 11: Partial Correlations between SES Indicators and Contextualized Responsiveness to Infant Actions

Variable	SES	Education	Income
All Responses to Vocalizations	.326*	.279	.324*
Responses to Vocalizations Only	.202	.082	.206
Responses to Behavior Only	.129	.259	.118
Responses Vocal & Behavior	.269	.339*	.260
Responses to Gesture Only	-.047	.175	-.060
Responses Vocal & Gesture	.286	.285	.281
All Responses to Behavior and Gesture	.123	.283	.111

*p < 0.05

Controls: Infant action, gesture, vocalizations, gender, and parent input

When parent types are additionally controlled for, higher levels of education

continue to be positively related to responses to vocalizations coupled with a simultaneous behavior or gesture ($r=.34$, $p<.05$).

Contextualized Responsiveness to Infant Actions and Language Outcomes at 18 months

In order to further examine the effect of parent responses to specific actions at 10 months on language outcomes at 18 months, each category of actions infants produced to demonstrate their interest or attention: vocalizations; behaviors; and gestures, was investigated independently.

Responses to Vocalizations. Responses to infant vocalizations alone at 10 months were unrelated to infant language outcomes at 18 months. Responses to infant vocalizations coupled with a behavior were related to child word types ($r=.36$, $p<.05$) at 18 months.

Responses to Behaviors. Responses to infant behaviors were related to raw scores ($r=.36$, $p<.05$), t scores ($r=.37$, $p<.05$), and percentile ranking on the MSEL ($r=.32$, $p<.05$), as well as child word types ($r=.39$, $p<.05$) at 18 months. Responses to behaviors and gestures (as a composite) were related MSEL scores: raw ($r=.38$, $p<.05$); t-scores ($r=.39$, $p<.05$), and percentile ranking ($r=.34$, $p<.05$), as well as child word types ($r=.40$, $p<.05$) at 18 months.

Responses to Gestures. More responses to infant gestures alone at 10 months were related to higher raw scores on the MSEL ($r=.34$, $p<.05$), and higher children's productive vocabulary at 18 months as measured by the CDI ($r=.34$, $p<.05$). Responses to infant vocalizations coupled with a gesture were not significantly related to any language outcomes at 18 months.

After controlling group membership, mother input, and productive and receptive vocabulary at 10 months, responsiveness to behaviors were positively related to child types at 18 months (r=.44, p<.05), as well as t-scores on the MSEL(r=.37, p<.05). Additionally, responses to both gestures and behaviors as an overall composite were also related to t-scores on the MSEL (r=.39, p<.05), and child word types (r=.45, p<.05) at 18 months, suggesting that responses to behavioral communication may be optimal for facilitating word learning.

Table 12: Partial Correlations between Contextualized Responsiveness to Infant Actions and Language Outcomes

Variable	MSEL t	MSEL %	Child Types	Rec. vocab	Exp. vocab
All Responses to Vocalizations	.118	.077	.212	.244	.068
Responses to Vocalizations Only	-.015	-.027	-.038	.016	-.088
Responses to Behavior Only	.370*	.314	.444**	.129	.207
Responses Vocal & Behavior	.174	.118	.306	.335	.141
Responses to Gesture Only	.257	.208	.211	.234	.334
Responses Vocal & Gesture	.102	.092	.204	.158	.116
All Responses to Behavior and Gesture	.387*	.326	.451**	.160	.249

*p < .05
**p<.01
Controls: Group, 10 months receptive and productive CDI, gender, and parent input

When group membership, mother input, and productive and receptive vocabulary at 10 months, as well as child gesture, behaviors and vocalizations, are all added as controls all findings become non-significant. Overall, these findings suggest that infant behavioral communication is a strong predictor of infant language outcomes, and that the contextualized responses that infants receive in response to behavioral bids, with and without vocalizations, are also consequential for language development**.** The dynamic view of cooperative communication presented at the beginning of this study is also

supported by these findings. In fact, when infant behaviors are combined with responses to behaviors, they account for a statistically significant 21% of the variance in child types in particular. This may be in part due to infant behaviors and the contextualized responses they elicit create a dynamic back-and-forth whereby infants that produce more behavioral indications of attention receive more contextualized responses to that behavior, thus receiving more input to scaffold their understanding of their attentional focus, subsequently facilitating language learning.

The relationship between SES, responses to infant actions, and language outcomes

Given that behaviors and gestures were the strongest predictor of language outcomes at 18 months, stepwise regression was conducted in order to test the impact of SES, overall infant behaviors, and responsiveness to behaviors and gestures at 10 months as predictors of child types at 18 months. The stepwise multiple regression including SES as a predictor was statistically significant $F(1, 39) = 4.89$, $p < .05$, and explained 11% of the variance in child word types. The addition of responsiveness to behaviors and gestures as a predictor also revealed a statistically significant regression model (model 2) $F(2, 38) = 5.59$, $p < .01$, and accounted for an additional 12% of the variance in child types – a statistically significant change in R squared, F change $(1, 38) = 5.71$, $p < .05$) and the SES effect became non-significant. Together, both variables accounted for a cumulative 23% of the variance in child word types at 18 months. The inclusion of responsiveness to behaviors and gestures leads SES to become non-significant, thus responsiveness to behaviors is a useful predictor of child use of word types at 18 months. Due to the lack of a relationship between the predictors, mediation analyses were not conducted. Additionally, including child behaviors during the interaction as a control

produces a non-significant effect for all variables in the model. See *Appendix E* (page 112) for the full model.

TYPES OF CONTEXTUALIZED RESPONSES

Description – Types of Contextualized Responses

Parent contextualized responses were categorized as a prohibitive, a question, or an elaboration (see *table 5* for examples). In order for a response to qualify as contextualized the parent had to be referring to be object or activity that the infant was attending to and occur within the contingent window of 4 seconds. In order for a response to be coded as elaborative parents had to acknowledge, label, or describe the object or activity the infant was focusing on. In order for a response to qualify as a question, naturally, the parent had to be asking a question about the object or activity in the infant's attentional focus. Finally, prohibitives were coded as contingent responses where parent and infant attention was still shared but the parent provide no contextual information but rather produced a prohibitive utterance (e.g. stop that, no).

Descriptive Statistics – Types of Contextualized Responses

Table 13: Descriptive Statistics – Types of Contextualized Responses

Variable	N	Min.	Max.	Mean	SD
All Elaborations	47	13	98	41.06	19.65
All Questions	46	7	54	22.59	11.75
All Prohibitives	46	0	20	1.54	3.52
Contextualized Responsiveness	46	26	141	63.44	26.96

Elaborative responses were by far the most common type of parent response with a mean of 41 (SD=19.7), although there was wide variability across the sample with a minimum of 13 elaborative responses and a maximum of 98. Elaborative responses

occurred almost twice as much as the next category, which were questions. Questions in parent responses (M=23, SD=11.8) also varied widely across the sample with a range from 7 to 54 contingent responses containing a question. Prohibitives occurred much less frequently in the sample (M=1.5, SD=3.5) ranging from no prohibitives at all to a maximum of 20.

All aspects of responsiveness were highly correlated with one another, with the significant exception of the use of prohibitive language e.g. 'don't; stop'. Prohibitives were only statistically significantly negatively correlated with parent tokens, suggesting that parents using more words overall produced fewer prohibitive responses ($r = -.30$, $p < .05$). The use of elaborations and questions were statistically significantly related ($r=42$, $p <.01$). A composite of contextualized responses was made to account for both questions and affirmative responses that elaborate upon and scaffold the infant's attentional focus.

SES and types of contextualized responsiveness

SES was not significantly related to any particular type of parent responsiveness. However, after controlling for parent input as measured in tokens, infant gesture at 10 months, and number of infant actions and vocalizations produced during the interaction, education alone (and not part of the income and education composite) was significantly related to the use of elaborative responses ($r=.34$, $p<.05$) and overall use of contextualized responses ($r=.38$, $p<.05$). The relationship between education and elaborative responses also remained significant when controlling for parent types ($r=.33$, $p<.05$). These findings indicate that parents with higher levels of education may be more likely to produce a contextualized and contingent elaborative response when interacting with their infants. Given that elaborative responses were more likely to contain

contextual information about the infant's attentional focus this may be a mechanism through which education impacts infant language outcomes through responsiveness, rather than input alone.

Table 14: Partial Correlations between SES Indicators and Types of Responses

Variable	SES	Income	Education
All Elaborations	.148	.134	.339*
All Questions	.140	.135	.179
All Prohibitives	-.243	-.242	-.189
Contextualized Responses	.197	.183	.375*

*p < .05

Controls: Infant action, vocalizations, gesture, and parent input

Types of Contextualized Responses and Language Outcomes at 18 months

Initial correlations between types of contextualized responsiveness at 10 months and language outcomes at 18 months indicated quite a few significant relationships. Overall contextualized responsiveness at 10 months was related to t-scores on the MSEL ($r=.35$, $p<.05$), as well as child types ($r=.51$, $p<.01$). There is a significant negative relationship between parents' use of prohibitive response and child word types at 18 months ($r= -.31$, $p<.05$) suggesting that the use of prohibitives in response to infant attention does not appear to scaffold language acquisition. The use of questions in responses to their infants was significantly related to 18-month scores on the MSEL; t scores ($r=.53$, $p<.01$), and percentile ranking ($r=.51$, $p<.01$). Questions were also predictive of child word types ($r=.57$, $p <.01$) and productive vocabulary scores as measured using the CDI ($r=.32$, $p<.05$). Elaborations related to child word types also ($r=.34$, $p<.05$).

When group membership, parent input, and infant scores on the CDI at 10 months are controlled for overall contextualized responsiveness remains statistically significantly predictive of child word types (r=.46, p<.01). Questions in contextualized responses remain the strongest predictors of language outcomes. Questions are significantly related to t-scores (r=.54, p<.01), and percentile ranking (r=.52, p<.01) on the Mullen Scales of Early Learning and the positive correlation between questions and expressive vocabulary as measured on the CDI trended toward significance. Questions in contextualized responses also strongly positively related to child word types (r=.60, p <.01). The use of elaborations and prohibitives are no longer significant predictors of any language outcomes once these controls are in place. This indicates that questions as a form of responsiveness may be key to facilitating language learning, also questions inherently afford the opportunity for a back-and-forth between parents and their infants, thus supporting the original hypothesis for optimal language learning being facilitated by dyadic cooperative communication.

Table 15: Partial Correlations between Language Outcomes and Types of Contextualized Responsiveness

	MSEL t-score	MSEL %	Child Types	Rec. vocab	Exp. vocab
All Elaborations	0.072	0.012	0.248	0.204	0.161
All Questions	.539**	.516**	.602**	0.171	0.334
All Prohibitives	-0.143	-0.146	-0.26	-0.18	-0.178
Contextualized Responses	0.299	0.245	.455**	0.227	0.273

*p<.05
**p<.01
Controls: Group, 10 months receptive and productive CDI, and parent input

When infant actions, gestures, and vocalizations are added to the controls, questions continue to significantly predict t-scores (r=.49, p<.01), and percentile ranking

(r=.48, p<.01) on the MSEL, as well as child word types (r=.50, p <.01). These findings indicate that the reciprocal dynamic this study hypothesized to be at the core of infant language learning, cooperative communication, may be best facilitated by the use of question responses to infants' indications of attention. Consequently, these questions facilitate heightened language learning perhaps because questions were related to the use of more scaffolding language such as labels and descriptions (rather than just affirmative responses), thereby providing the infant with more contextualized input to label and describe the object of their attention.

The relationship between SES, contextualized responsiveness types, and later language

Given that both SES and overall responsiveness were significant predictors of child word types, a hierarchical regression was run to detect the cumulative and individual impact of these variables as predictors of child word types.

Overall Contextualized Responsiveness. In order to test the impact of SES and overall contextualized responsiveness at 10 months on child types at 18 months a hierarchical regression was conducted. The hierarchical multiple regression including SES as a predictor was statistically significant $F(1, 39) = 4.89$, $p < .05$, and explained 11% of the variance in child word types. The addition of contextualized responses as a predictor also revealed a statistically significant regression model (model 2) $F(2, 38) = 8.62$, $p < .001$ and accounted for an additional 18% of the variance in child types – a statistically significant R squared change = .18, F change $(2, 38) = 9.89$, $p < .01$). Together, both variables accounted for a cumulative 30% of the variance in child word types at 18 months. Once SES and overall contextualized responsiveness are combined in the model however, SES is no longer a significant predictor. Therefore, contextualized

responsiveness appears to have a larger independent effect on child word types than SES and is potentially a useful area for future intervention research to target.

Questions. Given the role of question-based contingent responses in predicting child language outcomes, stepwise regression analyses were conducted in order to determine which variables were significant predictors, or combinations of predictors, of child language outcomes. The hierarchical multiple regression including SES as a predictor was statistically significant $F(1, 39) = 4.89$, $p < .05$, and explained 11% of the variance in child word types. The addition of contextualized responses with questions as a predictor also revealed a statistically significant regression model (model 2) $F(2,38) = 11.13$, $p < .001$ and accounted for an additional 26% of the variance in child types, more than double the effect size of SES as a predictor – a statistically significant change in R squared, F change $(2,38) = 15.53$, $p < .01$. Together, both variables accounted for a cumulative 37% of the variance in child word types at 18 months. However, when both variables are included in the model, SES becomes non-significant as a predictor thus parents' use of contextualized responses containing a question relating to their infant's attentional focus strongly reduces the effect of SES on child language outcomes.

Table 16: Regression Models of Responsiveness Types Predicting Child Types

	Model 1	Model 2	Model 3	Model 4	Model 5
SES	.33*		.23		.21
Question Responses		.57**	.52**		
Overall Responses				.51**	.45**
F	4.89*	18.24**	11.13**	13.34**	7.96**
R Squared (%)	11%	32%	37%	26%	30%

*p<.05
**p<.01

The effect of parent responsiveness using a question also results in parent education becoming a non-significant predictor of child t-scores and percentile ranking on the MSEL. Question responses accounted for almost twice as much variance (21%) in child types as education, indicating that contextualized responses containing a question make a key contribution to infant language learning and is a potential area for future intervention for parents of all education levels.

Table 17: Regression Models of Education and Question-Responses predicting MSEL %

	Model 1	Model 2	Model 3
Education	.33*		.26
Question Responses		.51**	.47**
F	4.78*	13.50**	8.99**
R Squared (%)	11%	26%	32%

*p<.05
**p<.01

FEATURES OF CONTEXTUALIZED RESPONSES

Description – Features of Contextualized Responsiveness

Parent contextualized responses, once coded as a prohibitive, a question, or an elaboration, were further subcategorized as either an affirmative confirmatory responses, a label, a descriptor, or a label and a descriptor combined. In order for a response to qualify as affirmative it had to simply acknowledge the child's gesture, vocalization, or action pertaining to his/her attentional focus. In order for a response to be coded as containing a label, naturally, the parent must have provided a noun labeling the item to which the child was attending. Similarly, a descriptive code indicates that the parent responded contingently with an adjective describing the object on which the child is attending, or explicitly describes the action he child is doing e.g. 'you're reading!' while holding a book. The finally category of a descriptor and label combination related mostly to parents label an object and adding a descriptive adjective e.g. 'that's a yellow star'. (See *table 5* for examples).

Variable Descriptive Statistics

Table 18: Descriptive Statistics - Features of Contextualized Responsiveness

Response	N	Min.	Max.	Mean	SD
All Affirmative	47	6	57	24.91	12.60
All Label	47	2	36	11.45	7.40
All Descriptive	47	4	38	18.38	8.74
All Desclabel	47	0	23	8.85	5.35
Total Labels	47	6	59	20.30	11.51
Total Descriptors	47	6	55	27.23	12.49

The most commonly used features of contextualized responses were descriptions (when taken cumulatively as descriptors and responses that contained descriptors and

labels) (M=27, SD=12.5), affirmative responses (M=25, SD=12.6), and labels (when taken cumulatively as labels and responses that contained labels and descriptors) (M=20, SD=11.5), respectively. This implies that parents, across the sample, were more often providing useful contextual information for their infants than simply acknowledging or praising them without any contextual information about their attentional focus. There was however a wide range with parents producing a minimum of 6 of each response and a maximum of 59 labels, 57 affirmatives, and 55 descriptions throughout the interaction. Responses containing both a descriptor and a label (e.g. 'you love that brown horsey') were the least common occurrence (M=9, SD=5.3) with some parents producing no such responses and a smaller range across the sample with a maximum of 23, almost 3 times fewer than labels, descriptions, or affirmations. All of the features of contextualized responsiveness were highly correlated.

Relationships between types, and features of contextualized responses

All types and features of contextualized responses were strongly inter-correlated with the exception of prohibitives, which were non-significantly negatively related to almost all response types and features. A full correlation table is available in *Appendix E*.

SES and Features of Contextualized Responsiveness

Higher SES parents were significantly more likely to produce a contextualized label (e.g. saying 'oh the horse!' while the child was holding or playing with a horse toy) in their responses with or without a descriptor ($r=.34$, $p<.05$), or simply individually ($r=.34$, $p<.05$). Once parent input, child actions, gestures, and vocalizations were controlled for, SES was still related to the use of labels overall ($r=.38$, $p<.01$), individually ($r=.36$, $p<.05$), indicating that parents from higher SES families produced

more responses containing a contextualized label and are providing more labeling references for their infant's attentional focus. Bids provided by infants indicating object-directed attention prime them for learning object labels (Goldstein et al., 2010), thus receiving a contingent and contextualized label response capitalizes on the infant's attentional focus as a prime moment for learning, and parents appear to engage in this type of responsiveness distinctly by SES.

Table 19: Partial Correlations between SES Indicators and Features of Responsiveness

Variable	SES	Education	Income
All Affirmatives	.049	.189	.039
All Label	.359*	.386*	.351*
All Descriptive	-.047	.232	-.063
All Desclabel	.282	.204	.281
Total Labels	.380*	.360*	.375*
Total Descriptors	.091	.255	.079

*p < 0.05

Controls: Infant action, vocalizations, gesture, and parent input

Features of Contextualized Responsiveness and Language Outcomes at 18 months

Initial correlations show affirmative responses as unrelated to all language outcomes at 18 months. This is to be expected given that affirmative responses are the least linguistically-rich response type relating to infant's attentional focus because they provides no contextual markers in order for the infant to formulate a schema around that object or activity. In our sample affirmative responses were also commonly shorter than elaborative responses and generally consisted of praise such as 'Well done!' or confirmatory responses such as 'yeah!'.

Responses containing labels (with or without descriptors) were related to higher scores on the MSEL: t score ($r=.42$, $p<.05$); and percentile ($r=.37$, $p<.05$). They were also

related to child types (r=.54, p<.01) and productive vocabulary as measure on the CDI (r=.32, p<.05). Labels with a descriptor were related to t scores and percentile on the MSEL and child types. Labels used individually were also related to the same outcomes with the exception of the MSEL percentile score.

Responses containing descriptors were similarly predictive of child language outcomes 8 months later. Overall use of descriptors was related to higher scores on the MSEL; t score (r=.38, p<.05); and percentile (r=.37, p<.05). They were also related to child types (r=.53, p<.01) and productive vocabulary as measure on the CDI (r=.40, p<.05). Higher use of descriptors without labels was also related to child types (r=.44, p<.01) and productive vocabulary scores on the CDI (r=.40, p<.05). These correlations indicate that descriptors provide linguistically rich responses that have a positive relationship to child language outcomes.

Table 20: Partial Correlations between Language Outcomes and Features of Contextualized Responsiveness

	All Affirmatives	All Labels	All Descriptors	All Desclabel	Total Labels	Total Descriptors
MSEL t-score	.145	.367*	.207	.343*	.389*	.288
MSEL percentile	.079	.302	.206	.319	.338*	.277
Child Types	.262	.460**	.354*	.467**	.509**	.447**
Receptive vocab	.019	.297	.349*	.159	.261	.310
Productive vocab	.074	.360*	.313	.224	.332	.314

*p<.05
**p<.01
Controls: Group, 10 months receptive and productive CDI, and parent input

With group membership, parent input, and infant scores on the CDI at 10 months controlled for, affirmatives remained non-significant as a predictor of language outcomes. Responses containing labels (with and without descriptors) were still statistically

significantly predictive of higher scores on the MSEL; t score ($r=.39$, $p<.05$); and percentile ($r=.34$, $p<.05$). Total number of labeling responses were also still predictive of child types ($r=.51$, $p<.01$). Labels used individually were also related to the MSEL t-score ($r=.37$, $p<.05$), child productive vocabulary as measured using the CDI ($r=.36$, $p<.05$) and child types ($r=.46$, $p<.01$). Labels with a descriptor were related to child types at 18 months ($r=.47$, $p<.01$), and MSEL t-scores ($r=.34$, $p<.05$).

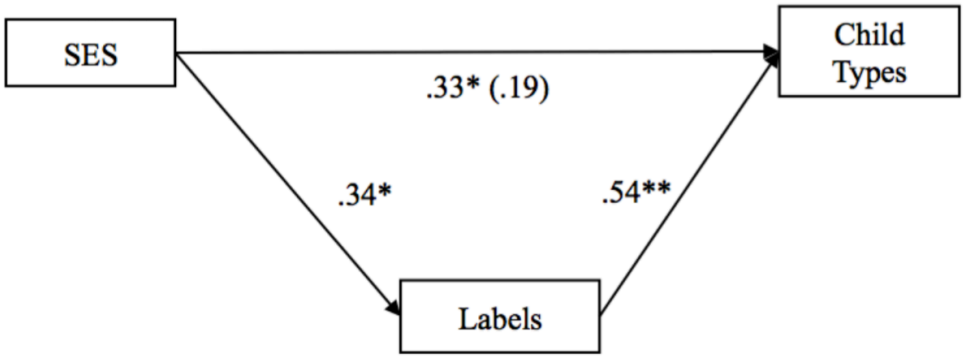
Use of responses containing descriptors (with and without a label) 10 months were related to child types at 18 months ($r=.45$, $p<.05$). Interestingly, higher use of descriptors without labels was related to child types ($r=.35$, $p<.05$), as well as receptive vocabulary scores on the CDI ($r=.35$, $p<.05$). This finding appears to support existing research on the importance of input 'quality' for language development (Rowe, 2012). The more diverse and varied input the infant receives the wider the breadth of their possible vocabulary understanding, which is indicated in receptive vocabulary measures.

When infant gesture, vocalizations, and actions are added to the controls, child types continue to be predicted by labels without a descriptor ($r=.37$, $p<.05$), with a descriptor ($r=.36$, $p<.05$), and overall use of labels ($r=.42$, $p<.05$) suggesting that the contribution of label-based responses is positive for language outcomes, regardless of specific infant actions. Taken together, these findings suggest that it is not overall talk, but the specific use of referential labels and descriptors surrounding infants' attentional focus that facilitate improved language growth.

The relationship between SES, features of contextualized responsiveness, and later language

SES, labels, and child word types. In order to test the impact of SES and the use of labels as contextual responses (with our without descriptors) at 10 months on child types at 18 months a stepwise regression was conducted. The initial model including SES as a predictor was statistically significant $F(1, 39) = 4.89$, $p < .05$, and explained 11% of the variance in child word types. The addition of labeling responses as a predictor also produced a statistically significant regression model (model 2) $F(2, 38) = 8.77$, $p < .01$ and accounted for an additional 20% of the variance in child types – a statistically significant change in R squared, F change $(1, 38) = 15.99$, $p < .01$). Together, both variables accounted for a cumulative 32% of the variance in child word types at 18 months. Once SES and labels are combined in the model however, SES is no longer a significant predictor. In order to investigate the mediation effect (Hayes, 2013; Hayes & Preacher, 2010), and determine the significance of the mediation, the Sobel test (Preacher & Hayes, 2004; Sobel, 1982) was applied to the mediation. The Sobel test statistic was significant ($p<.05$) indicating that the use of labels as a form of contingent responsiveness mediates the effect of SES on child word types. The full model is in *figure 2* below.

Figure 2: Mediation Model of SES, Label Responses, and Child Word Types



SES, descriptors, and child word types. In order to test the impact of SES and the use of descriptors as contextual responses (with our without labels) at 10 months on child types at 18 months a hierarchical regression was conducted. The hierarchical multiple regression including SES as a predictor was statistically significant $F(1, 39) = 4.89$, $p < .05$, and explained 11% of the variance in child word types. The addition of labeling responses as a predictor also produced a statistically significant regression model (model 2) $F(2, 38) = 9.41$, $p < .01$ and accounted for an additional 22% of the variance in child types – a statistically significant change in R squared, F change $(1, 38) = 12.48$, $p < .01$). Together, both variables accounted for a cumulative 33% of the variance in child word types at 18 months. Once SES and descriptors are combined in the model however, SES is no longer a significant predictor. A full mediation is not present as SES is not a predictor of descriptors. However, the findings confirm that responses containing descriptors of the child's activity or attentional focus predict twice as much variance in child types at 18 months than SES.

Table 21: Regression Models of Features of Responsiveness Predicting Child Types

	Model 1	Model 2	Model 3	Model 4	Model 5
SES	.33*		.17		.23
Total Labels		.54**	.48**		
Total Descriptors				.53**	.48**
F	4.89*	15.99**	8.77**	15.14**	9.41**
R Squared (%)	11%	29%	32%	28%	33%
*p<.05					
**p<.01					

Education, labels, and MSEL scores. Both education and labeling responses were found to relate to t-scores and percentile scores on the Mullen Scales of Early Learning. In order to test the independent and cumulative predictive effect of education and

responses containing labels on MSEL scores, stepwise regression analyses were conducted. The regression including education as a predictor was statistically significant $F(1, 39) = 4.54$, $p < .05$, and explained 10% of the variance in child word types. The addition of labeling responses as a predictor also produced a statistically significant regression model (model 2) $F(2, 38) = 5.76$, $p < .01$ and accounted for an additional 13% of the variance in child types – a statistically significant change in R squared, F change $(1, 38) = 6.35$, $p < .05$). Together, both variables accounted for a cumulative 23% of the variance in child word types at 18 months. The inclusion of label responses into the model resulted in education no longer being a significant predictor. These model effects were retained with the MSEL percentile scores but with smaller effect sizes. The findings suggest that responses containing descriptors of the child's activity or attentional focus are more useful in predicting infant language development than education, and thus a helpful addition to interventions for parents hoping to optimize language learning in their infants, regardless of their education level.

Education, responses with both a descriptor & label, and MSEL scores. Both education and labeling responses that contain a descriptor were found to relate to t-scores and percentile scores on the Mullen Scales of Early Learning. In order to test the independent and cumulative predictive effect of education and descriptive labeling responses on MSEL scores, stepwise regression analyses were conducted. The regression including education as a predictor was statistically significant $F(1, 39) = 4.54$, $p < .05$, and explained 10% of the variance in child word types. The addition of descriptive labeling responses as a predictor also produced a statistically significant regression model (model 2) $F(2, 38) = 6.1$, $p < .01$ and accounted for an additional 14% of the variance in

child types – a statistically significant change in R squared, F change (1, 38) = 6.97, $p < .05$). Together, both variables accounted for a cumulative 24% of the variance in child word types at 18 months. The inclusion of descriptive label responses into the model resulted in education no longer being a significant predictor. These findings add to our previous findings suggesting that labels, and in particular labels with other contextual informational such as an adjective may be the optimal contextualized input for infant language learning, and is particularly useful for parents with lower levels of education whose infants may be at risk for differing language outcomes related to the word gap. This is further discussed in Chapter 6.

Table 22: Regression Models of Features of Responsiveness Predicting MSEL T-Scores

Variable	Model 1	Model 2	Model 3	Model 4	Model 5
Education	.32*		.25		.28
Total Labels		.42**	.37*		
[a]Desclabel				.41**	.38*
F	4.54*	8.21**	5.76**	7.76**	6.1**
R Squared (%)	10%	17%	23%	17%	24%

*p<.05
**p<.01
[a]Contextualized responses that contain a descriptor and a label e.g. 'the yellow star'

CHAPTER 6: DISCUSSION

Research aim 1

The original research aim for the study was to investigate the relationships between SES and global measures of cooperative communication, and how those relationships were related to language outcomes. SES was unrelated to the indicators of cooperative communication measured on the PIICS (Renzi, 2017). This finding indicates that these global components of early interactions do not appear to differ by SES in our sample, thus a more quantitative approach may be necessary to understand and detect group differences. However, it is important to highlight that our sample is slightly more homogenous in terms of race and education than national averages for low SES communities so this effect may only be true for our sample. Additionally, it suggests that the origin of the word gap, how parents from different SES use differing amounts of parent input, may be less related to overall cooperative communication, but more to fine-grained elements of parent-infant interactions.

Nonetheless, overall parent-driven components of cooperative communication were also significantly positively related to scores on the productive vocabulary measure of the CDI at 18 months ($r=.36$, $p<.05$). This lends to the theoretical argument that dynamic and dyadic components of early infant interactions, and not just input relate to later language learning (Head Zauche et al., 2017). This findings from this particular coding scheme suggest that other parent activities, beyond just input, such as parent initiation of shared attention and elaboration on shared attention may be more useful in predicting expressive language skills at this age (Carpenter et al., 1998; Yu & Smith, 2012).

Cooperative communication can be measured with validity using the PIICS. The coding scheme successfully detected major aspects of the parent-infant interaction (e.g. parent talk, infant communication, overall responsiveness etc.) thus it may be a useful tool for quickly measuring the qualities of parent-infant interaction and detecting the variables underlying those concepts with validity. Due to the lack of variability its predictive validity appears to be limited. Thus, a more quantitative approach, such as that applied to address research aims 2 and 3, may be more useful in detecting specific mechanisms of parent-infant interaction that facilitate language development.

Additionally, gender differences were detected using the PIICS, particularly relating to indicators of dyadic fluency, where female caregivers and daughters appeared to have more numerous positive dyadic exchanges than female caregiver-son dyads. Similarly, female infants were producing more behavioral bids, and fewer vocal bids in this sample. This appears to contradict research indicating the female infants generally outperform their male counterparts on communicative measures (Olafsen et al., 2006). However, some research has shown that female infants experience fluctuations in vocalization growth, where male infants are more static so perhaps these differences may be due in part to the transition from behavioral to vocal communication (Sung, Fausto-Sterling, Garcia Coll, & Seifer, 2013). These findings do extend on existing research indicating that mothers are more responsive to infant girls than infant boys in the first year of life (Clearfield & Nelson, 2006; Johnson et al., 2014). An interesting avenue for further study using this coding scheme would be to examine if similar trends would be found with male caregiver pairings.

Applying the PIICS to the more diverse sample in Study 2 did lead to confirmation of the importance of infant behavioral communication as a driver for language development (Iverson & Goldin-Meadow, 2005; Rowe & Goldin-Meadow, 2009b) and a replication of the findings from study 1 of this dissertation, whereby infant behavioral communication at 10-months predicted child word types at 18 months. Quantitative measures of responses also detected this trend that infant actions, as well as responses to those actions related to language outcomes. This suggests that the combination of the attentional bid and the contextualized response it receives creates a dynamic learning environment that appears to facilitate later language ability. The results of this first investigation support the work indicating that infants, and in particular the behavioral bids they use, have the ability to guide their own language learning, in part by facilitating responses from their caregivers (Vallotton, 2009). It also extends perspectives put forth on 'intersubjectivity' wherein parents assign meaning to infant's behavioral communication and respond accordingly, and the infants assign meaning to the parent's response and subsequently increase those behaviors, facilitating a cyclical interaction pattern that facilitates language learning (Legerstee, 2009).

Research Aims 2 and 3

Contextualized responses to infant actions. SES was related to responsiveness to overall vocalizations and education was related to heightened responsiveness to infant behavior and gestures that were coupled with a vocalization, even controlling for total number of infant vocalizations and actions. The most common responses were parents responding to infant behavior (M=50, SD=19.1), which is developmentally appropriate for 10 months, and is to be expected as the number of behaviors that infants are

producing at 10 months far exceeds the number of gestures and vocalizations that would be produced at that age. However SES differences related only to responses to vocal bids, suggesting that parents with higher levels of education may be more sensitive to behaviors and gestures as opportunities to respond when they are paired with traditional early language markers, such as babble and other vocalizations. The relationship found in this study between SES and responsiveness to vocalizations, and between education and vocalizations that are coupled with actions and gestures, may elucidate the relationship that has been well-documented between SES and the word gap (Hirsh-Pasek et al., 2015). These findings suggest that it may be related to specific patterns of responsiveness, above and beyond the contribution of parent input or demographic indicators alone (Fernald & Weisleder, 2015; Romeo et al., 2018). These findings lend support for the hypothesized dyad-driven theory of change: cooperative communication, quantified here as contextualized responsiveness. The bidirectional view of infant language learning being contributed to by both infant behaviors and the scaffolding responses they receive (Vallotton et al., 2016). If an infant produces more vocalizations, they generate more opportunities to receive input and improve their language understanding. However, given that SES is unrelated to the amount of infant vocalizations, but does influence the number of responses infants receive to those vocalizations, it implies that receiving fewer contingent responses may potentially delay the cyclical learning pattern, manifesting in the different outcomes in expressiveness and vocabulary that we associate with the achievement gap (Duncan et al., 2007; Lee & Burkham, 2002; Noble, Farah, & McCandliss, 2006).

While parents in lower SES households appear to talk less, on average, than parents in higher SES households (Bradley & Corwyn, 2002; Fernald et al., 2013; Hart & Risley, 1992; Hoff, 2013; Vernon-Feagans, Garrett-Peters, Willoughby, Mills-Koonce, et al., 2012), perhaps the nature of the issue has less to do with parent input, and more to do with parents not taking advantage of as many opportunities to elaborate and expand on their infant's attentional focus. This lays the foundation for the potential importance of recommending parents from lower SES families not just to talk to their infants more often but also to provide targeted responses to infant behaviors that indicate they are already engaged (Landry, Smith, Swank, & Guttentag, 2008; Miller & Gros-Louis, 2013; Miller & Lossia, 2013). Further, those same responses to vocalizations coupled with a behavior at 10 months predicted infant language outcomes such as word types and standardized scores on the Mullen Scales of Early Learning at 18 months. Additional analyses indicated that responsiveness to behavioral communication, which did not differ by SES, had an even greater effect on language outcomes than vocalizations alone. This replicates findings on the importance of infant behavioral communication as a driver of infant language learning (Congdon et al., 2017; Goldin-Meadow, 2017), and emphasizes the importance of highlighting to parents, of all backgrounds, that responses to early infant behaviors and gestures may be particularly beneficial for language development. Given that responses to specific infant actions were highly correlated with one another with the notable exception of responses to infant vocalizations produced with no accompanying behavior or gesture, which were not significantly related to any other type of responses. This reflects the findings from phase 1 of the study and indicates that infant vocal communication is responded to and reacted to distinctly by parents. Existing research

suggests that parents view vocalizations as more sophisticated bids by their infants and are more likely to respond to speech-like bids in order to encourage word learning (Gros-Louis et al., 2006). However, this study supports other current research, which finds that behavioral communication is key driving factor in word learning and thus may be an important point to highlight in future interventions on parent knowledge and parent input. Increased responsiveness to vocalizations will likely encourage more vocalizations, but findings from this study suggest that capitalizing on behavioral bids that indicate the infants attentional focus may be more crucial for word learning.

Types of Contextualized responses. Controlling for infant actions, gestures, and vocalizations as well as parent input, education was significantly related to overall responsiveness, and to elaborative responses. Additionally, contextualized responsiveness, but particularly questions, were related to many language outcomes including all measures on the MSEL and child word types. This adds to the literature on the important influence of responsiveness for language learning overall, and in particular when infant attentional focus is in place (Gros-Louis et al., 2014; Miller & Lossia, 2013; C S Tamis-LeMonda, Bornstein, & Baumwell, 2015). This association was significant, even with parent input and child gesture, actions, and vocalizations controlled for. The effect for the influence of questions was also larger than other responsiveness findings ($r=.56$, $p<.01$) in predicting child types. This supports previous findings on the importance of questions as facilitators of language growth (Leech, Salo, Rowe, & Cabrera, 2013; Valian & Casey, 2003) and provides an important additional note that contextualized responses with questions pertaining to the infant's attentional focus may be even more instructive as a tool for parents who want to improve their children's early

language acquisition. It is important to note that the use of questions in this study were driven by prosody, such that parents using a question indicated by their intonation were included, as well as standard wh-questions. A distinct investigation of just wh-questions may be a useful next step in supporting the existing literature on question-use, while also advancing our understanding of questions in the specific context of parent responses.

Features of Contextualized responses. Overall, parents in this sample produced a wide variety of contextual input to their infants including descriptors and labels based on the infant's activity or the object of the infant's attentional focus. SES was related to responses containing a label (with our without a descriptor). Labeling responses also proved to be a significant predictor of many language outcomes including t-scores on the MSEL and child word types, echoing previous findings on the importance of object labeling for vocabulary acquisition (Goldstein et al., 2010; Longobardi et al., 2011). When SES and responses containing a label were included in a model predicting child word types at 18 months, labeling responses actually mediated the effect of SES on word types. Parent responsiveness differences, detected here in the form of providing labels for objects within the infant's attentional focus out-predicted SES by almost a factor of 2 as a predictor of child word types. This provides strong support for the argument that the origin of the word gap may not be driven by education or income alone but by differences in specific components of interactions occurring between parents and their infants. This finding adds contextualized responsiveness to the list of important factors relating to language outcomes that make a significant contribution beyond parent input, such as the variety of verbal input, parent overall responsiveness, and parent-infant conversational interactions(Bigelow & Power, 2016; Cartmill et al., 2013; Gros-Louis et al., 2014;

Romeo et al., 2018). These findings support a new view of infant language learning as a process facilitated by dyadic interaction and specific diversity of responses within early interactions. These findings support arguments for adjusting the perspective of input, as a predictor of the word gap and more generally, toward a discussion of diversity and context of linguistic interactions (Montag, Jones, & Smith, 2018; Renzi et al., 2017) as areas for intervention. By considering language 'nutrition' and the bi-directionality of early interactions we can heighten our understanding of language development and also empower parents to view themselves as key influencers of their infant's communicative development and reframe the importance of infant's own communicative behavior as a driver of language learning.

Limitations on Findings

This study has some limitations to be considered. While the sample varies in SES, participants represent lower socio-economic status families living near a large metropolitan city, thus, findings cannot be broadly generalized to the experiences of all parents. Similarly, while the sample is somewhat demographically diverse, it is a sample of geographical convenience (i.e. living near a campus in a large northeastern city), and is comprised of parents who signed up to participate in the study and thus applies only to parents with this commonality. It is important to note that this sample was selected for an approximate even split of primary caregivers with 2 years of college or fewer (47.5% of the final sample), and caregivers with 4 years of college or more (52.5% of the final sample), thus, moving forward education may be a more indicative variable to include in analyses of this type. Further, the literature supports education as a more valuable predictor of language outcomes (Roberts, Bornstein, Slater, & Barrett, 1999). However,

the research findings here elaborate on existing work on the impact of education by focusing on 10 months and highlighting differences occurring even that early in development, such as labels and responses to vocalizations.

Language input differs according to parent gender (Feldman, 2003; Malmberg et al., 2015; Pancsofar & Vernon-Feagans, 2006) and so the absence of fathers from this sample means that this project does not address parents in general, but female caregiver interactions and input in particular. This is a key factor for consideration for future research given that parent gender is not only associated with responsiveness and input but also related to question-use which was found to be a key indicator of later language in our sample (Leech et al., 2013; Schwab, Rowe, Cabrera, & Lew-Williams, 2018). An additional important limitation is that this study is being conducted on previously collected data therefore some project-level issues cannot be addressed, however, all analyses did control for any expected confounding variables.

The issue of variability in the PIICS code is an important consideration before using that coding scheme going forward, also its limited predictive ability for language outcomes is consequently related to this variability issue. The coding scheme appears to not have a wide enough range to account for variability in parent behaviors. Infant behaviors had significantly more variability and infant behavioral was found to predictive of child language growth in study 1 – predicting growth in MCDI scores, and in study 2 – predicting child word types.

While the contextualized responsiveness-coding scheme had a much wider range and appeared to capture important trends in parent and infant contributions to language learning, it only captures confirmed contingent responses. It may be a useful next step to

measure incidences where no response was given to an infant behavior, gesture, or vocalization. By including a measure of 'misses' in responsiveness, we may get a view of patterns of responsiveness in parents and how those differ by SES, or differentially predict language outcomes.

Conclusion

Taken together, the findings from this research provide an excellent lens into the key social-interaction factors influencing early language learning. By conducting this research on interactions occurring at 10 months, the original hypothesis is supported that the influence of the word gap and its origins can be measured earlier in development than previously thought and, therefore, potentially intervened upon earlier.

Higher levels of SES, and education in particular, appear to be associated with an increase in certain beneficial qualities of parent responsiveness to their infants – namely, responses to infant vocalizations (alone and those coupled with a behavior or gesture) and parents' use of labeling responses when engaged in joint attention with their infants. This provides a lens for understanding how perceived differences in language input, associated with the word gap, may have been detecting, not the difference in input itself but, differences in responsiveness that are facilitative of language learning, in particular the provision of object labels, with and without descriptors, to the infants attentional focus.

Importantly, the influence of responses to behavior on early language development suggests that programs aimed at helping parents facilitate more behavioral communication, such as gesture-use, as in the intervention developed by Rowe and colleagues (Rowe & Leech, Under review), may be particularly useful for language learning. Additionally, by focusing on providing responses to early gestures and other

behaviors infant language outcomes could be improved, regardless of demographic influences. This effect was similarly detected for the use of questions and labels in contextualized responses.

Furthermore, the mediating effects of responsiveness are particularly compelling as a foundation for future interventions. Particular aspects of responsiveness (e.g. questions, labels, descriptors), as well as overall responsiveness reduced (or fully mediated in the case of labels) the effect of SES on many language outcomes at 18 months. This supports previous findings in the literature on the potentially mediating effects of parenting on the development risks associated with SES (Matthews, Gallo, & Taylor, 2010; Taylor & Seeman, 1999; Vernon-Feagans, Garrett-Peters, Willoughby, & Mills-Koonce, 2012). Given the difficulty of education and income as variables to strategically change in order for parents to flourish in their interactions, a targeted focus on contextualized responsiveness paints a more optimistic view of what may be accomplishable through working with parents early on in their infant's development. Increasing parents' use of contextualized responses that contain questions, labels, descriptors, and that are addressed toward infant behaviors and gestures may set the foundation for optimal language development. In fact, research focusing on both conversational exposure and contextual responsiveness indicates that it is not only beneficial for language development but for neurocognitive development also (Head Zauche et al., 2017; Romeo et al., 2018; Roseberry, Hirsh-Pasek, & Golinkoff, 2014).

Taken together, these findings add to the literature on the importance of parent responsiveness as a powerful mechanism in the development of infant's early language learning, and a potential answer to the question of the origin of the word gap. Further,

given the predictive nature of both infant early language indicators, and also the responses that they receive the hypothesis for the change mechanism this study proposed was supported. The dyadic back and forth between and infant indication of attention and the scaffolding response occurring within the window of infant's sustained attention appears to prime infants for language learning, and lead to improved language outcomes later in development. Additionally, given that contextualized responsiveness has a larger independent effect on language outcomes at 18 months than SES, this provides a positive and hopeful outlook for the future of parent interventions as a mechanism to close the word gap in infancy. By targeting parents' awareness and use of contextualized responses, particularly to early behavioral cues, and containing questions, labels, and descriptors parents, of all demographic backgrounds, can be empowered as facilitators of their infant's optimal language, and overall, development.

APPENDICES

A: Summary of Measurements Table

Variable	Name of Instrument	Dependent Variable(s)
DEMOGRAPHIC MEASURES		
SES	Demographic Survey	• Years of education and annual household income
DYADIC INTERACTION MEASURES		
Cooperative Communication	Parent Infant Interaction Coding Scheme	• Total number of instances of cooperative communication • Total number of instances of cooperative communication broken down by parent, dyad, and infant indicator
Contextualized Responsiveness	Parent Infant Interaction Coding Scheme for CLAN	• Total number of contextualized responses to specific infant actions (behavior, gesture, or vocalization) • Total number of different types of contextualized responses (elaborations, questions, or prohibitives) • Total number of different features of contextualized responses (affirmatives, descriptors, labels, descriptor-label pairs)
CHILD LANGUAGE MEASURES		
Child Language and Gesture Development	Macarthur Bates Child Development Inventory –MCDI	• Standardized score based on age (in months) (M = 100; SD = 15)
Child Productive Language Use	CLAN - Word Types as measured using CLAN	• Total variety of words used by the child during an interaction at 18 months
Child Language Development	Mullen Scales of Early Learning - MSEL	• Percentile and t-scores on the MSEL designed to measure children's age-appropriate linguistic ability
PARENT INPUT MEASURES		
Parent Speech and Gesture	CLAN - Word and Gesture types and token using CLAN	• Overall quantity (tokens) and diversity (types) of behavioral and vocal input

B: PIICS - Parent Infant Interaction Coding Scheme

PARENT CODES

PC1. Parent responsiveness to infant *communicative* bid – purposeful vocalization (non-vegetative i.e. not coughs or sneezes), words, questions, or other vocalizations **used to get the parent's attention**

0. No opportunity for parent to respond to infant vocalization
1. None or only one instance of parent responding to infant vocalization
2. A few instances of parent responding to infant vocalization
3. Several instances of parent responding to infant vocalization, parent responds to about half of the infant's vocalizations
4. Frequent instances of parent responding to infant vocalization
5. Substantial (only one non-response)/constant parent responding to infant vocalization

PC2. Parent responsiveness to infant *behavioral* bid – gestures (e.g. pointing), reaching, other physically communicative actions **used to get the parent's attention (can include eye gaze)**

0. No opportunity for parent to respond to infant behavior
1. None or only one instance of parent responding to infant behavior
2. A few instances of parent responding to infant behavior
3. Several instances of parent responding to infant behavior, parent responds to about half of the infant's behaviors
4. Frequent instances of parent responding to infant behavior
5. Substantial (only one non-response)/constant parent responding to infant behavior

PC3. Parent affect – facial expression and behavioral demeanor

0. No opportunity to view parent affect
1. Affect is either disruptive, inappropriate, or very flat and constricted
2. Affect is inappropriate, generally negative, and impedes cooperative communication
3. Affect appears mellow or content; affect neither impedes nor enhances cooperative communication
4. Affect is mostly appropriate and provides some opportunity for cooperative communication
5. Affect is appropriate, generally positive, and enhances or fosters cooperative communication

PC4. Parent initiates shared attention/communication

1. No instances of shared attention initiation
2. One or two instances of shared attention initiation
3. Several instances of shared attention initiation, initiating shared attention for about half of the interaction
4. Frequent instances of shared attention initiation
5. Substantial/constant shared attention initiation, initiating shared attention throughout task

PC5. Parent talk or verbalizations (excluding when child is speaking) – overall talkativeness

1. No instances of parent talking
2. Infrequent instances of parent talking
3. Moderate amounts of talking; talking for about half of the interaction
4. Frequent instances of parent talking
5. Substantial/constant parent talk throughout the interaction

PC6. Parent elaborates on infant attentional focus – if infant is focused on one item (or gestures or vocalizes toward an item) parent fosters communication (e.g. talks about or explains item) or play (e.g. parent interacts with item, plays with item) surrounding the infant's attentional focus

1. None or only one instance of parent acknowledging/elaborating on infant attentional focus
2. Infrequent instances of parent acknowledging/elaborating on infant attentional focus
3. Moderate amounts of parent acknowledging/elaborating on infant attentional focus; parent elaborates on infant attention about half of the time
4. Frequent instances of parent acknowledging/elaborating on infant attentional focus
5. Substantial/ constant parent acknowledgement/elaboration on infant attentional focus

DYADIC CODES

DYC1. Infant and parent share attention, either with one another or surrounding an object, throughout the interaction

1. None or only one instance of shared attention
2. Infrequent instances of shared attention
3. Moderate amounts of shared attention
4. Frequent instances of shared attention
5. Substantial/constant shared attention between infant and parent

DYC2. Instances of turn-taking – conversational or behavioral turn taking involving at least one back and forth e.g. infant points, and parent names, a full turn taking episode where, for example, parent offers, infant takes, and parent responds

1. None or only one instance of cooperative communication
2. Infrequent instances of cooperative communication
3. Moderate amounts of cooperative communication; cooperative communication in about half of parent-infant exchanges
4. Frequent instances of cooperative communication; at least one full turn-taking episode
5. Substantial/constant cooperative communication between infant and parent

DYC3. Fluency parent-infant interaction – shared behaviors and conversation-like interactions appear natural and balanced

1. No shared balanced parent-infant interaction or conversation is established
2. Infrequent instances of fluid, balanced parent-infant interaction or conversation
3. Conversation or shared behavior occur but lack smoothness and synchrony
4. Frequent instances of fluid, balanced conversation or shared behavior
5. Fluid and balanced conversation and interaction is continually maintained throughout most of the interaction

INFANT CODES

IC1. Infant vocal communication – vocalizations, talk, verbalizations – overall talkativeness

1. None or just one instance of infant talking or vocalizing
2. Infrequent instances of infant talking or vocalizing
3. Moderate amounts of communication; infant talking or vocalizing for about half of the interaction
4. Frequent instances of infant talking or vocalizing
5. Substantial/constant infant talking or vocalizing

IC2. Infant behavioral communication – gesture and other communicative behavior use

1. None or just one instance of infant communicative behavior
2. Infrequent instances of infant communicative behavior
3. Moderate amounts of communication; infant gesturing e.g. for about half of the interaction
4. Frequent instances of infant communicative behavior
5. Substantial/constant infant communicative behavior

IC3. Infant affect – facial expression and behavioral demeanor

0. No opportunity to view infant affect
1. Affect is either disruptive, inappropriate, or very flat and constricted
2. Affect is inappropriate, generally negative, and impedes cooperative communication
3. Affect appears mellow or content; affect neither impedes nor enhances cooperative communication
4. Affect is mostly appropriate and provides some opportunity for cooperative communication
5. Affect is appropriate, generally positive, and enhances or fosters cooperative communication

IC4. Infant initiates shared attention/communication

1. None or just one instance of shared attention initiation
2. Infrequent instances of shared attention initiation
3. Several instances of shared attention initiation, initiating shared attention for about half of interaction
4. Frequent instances of shared attention initiation
5. Substantial/constant shared attention initiation, initiating shared attention throughout task

C: CLAN Edition - Parent Infant Interaction Coding Scheme

INFANT PRODUCTION

$CRV – Contingent Response - Vocal

- Based on parents' contingent responses to infants' **vocal** communicative bid
- The infant produced a non-vegetative vocalization (not coughing or sneezing or crying).

$CRB - Contingent Response – Behavioural

- Based on parents' contingent responses to infants' **behavioural** communicative bid/action
- The infant produced an action using an object or activity on which their attention is sustained.

$CRG - Contingent Response – Gestural

- Based on parents' contingent responses to infants' **gestural** communicative bid
- The infant used a gesture to direct their parent's attention or demonstrate their own attention on an object.

NOTE: If a vocalization is coupled with a gesture or behavior, both code letterings are used e.g. $CRBG, $CRGV

PARENT PRODUCTION

:VOC – The parent responded vocally to the infant

:BEH – The parent responded with an action to the infant.

:GES – The parent responded with a gesture to the infant.

NOTE: If a vocalization is coupled with a gesture or behavior, both code letterings are used e.g. :VOCBEH, :VOCGES

PARENT VOCAL PRODUCTION

#question – the parent asks a question…

|**affirmative** – which was affirmative, in that it acknowledged what the infant was doing or praised the infant without using any words referring to the object or activity the infant is engaging with. e.g. :You love this game!

|**descriptive** – which was descriptive, in that it provided an adjective or other description of the object to which the infant is paying attention or what the infant is doing. E.g. you like it because it's yellow? Are you playing?

|**label –** which provided a label for the object the infant is attending to or engaging with. E.g Is it a ball? Are you eating the blocks?

|**desclabel** – which provided a label AND a descriptor for the object the infant is attending to or engaging with. E.g The yellow star is your favourite, huh? That red ball is great fun right?

#elaborative – the parent elaborates on what the infant is playing with or doing…

|**affirmative** – which was affirmative, in that it acknowledged what the infant was doing or praised the infant without using any words referring to the object or activity the infant is engaging with. e.g. Good Job!

|**descriptive** – which was descriptive, in that it provided an adjective or other description of the object to which the infant is paying attention or what the infant is doing. E.g. yeah it's a yellow one., You're throwing them.

|**label –** which provided a label for the object the infant is attending to or engaging with. E.g You like the farmer. This one's the star

|**desclabel** – which provided a label AND a descriptor for the object the infant is attending to or engaging with. E.g The yellow star is great! Your favorite is the little barn

#prohibitive – the parent uses a prohibitive phrase. E.g 'no, stop, don't'

CHAT CODING SCHEME

%res: Tier for contingent responsiveness

$CRV - Contingent response by the parent to infant vocalization

$CRB - Contingent response by the parent to infant behavior

$CRG - Contingent response by the parent to infant gesture

:GES

#question

|affirmative

|descriptive

|label

|desclabel

#elaboration

|affirmative

|descriptive

|label

|desclabel

#prohibitive

|descriptive

|label

|desclabel

#prohibitive

:VOC

#question

|affirmative

|descriptive

|label

|desclabel

#elaboration

|affirmative

:BEH

#question

|affirmative

|prohibitive

|descriptive

|label

|desclabel

#elaboration

|affirmative

|descriptive

|label

|desclabel

#prohibitive

EXAMPLES

Example:

Parent responded to an infant vocalization with a contingent vocalization that was a question and an affirmative response.

*CHI: xxx

*MOT: you like that?

%res $CRV:VOC#question|affirmative

Example:

Parent responded to an infant action with a contingent vocalization that provides a label and a descriptor

*CHI: 0

%act: Infant plays with yellow star

*MOT: That’s a yellow star !

%res: $CRB:VOC#elaborative|desclabel

FREQ ANALYSES

> freq +t%res +s"$*" @- to extract all types of codes

>freq +t%res +s"$CRV*" @ - to extract all of CRV ONLY

> freq +t%res +s"$CRG*" @ - to extract all of CRG ONLY

> freq +t%res +s"$CRV:GES*" @ - to extract a specific response only

> freq +t%res +s"$CRV:GES#*" @- To extract the subtype of a category.

D: PARENT AND CHILD DEMOGRAPHIC FORM

Study_____ ID#_____

CHILD Info:

1. **I would identify my child's sex as:**

   _____/_____/_____

   _____ Male

   _____ Female

2. **My child's date of birth is**

3. **I would identify my child's ethnicity as:**

   _____ Hispanic or Latino

   _____ Non-Hispanic or Latino

4. **I would identify my child's race as:**

   _____ American Indian/Alaska Native

   _____ Asian

   _____ Native Hawaiian or Other Pacific Islander

   _____ Black or African American

   _____ White

   _____ More than One Race

   _____

   _____ Other: _____

PARENT 1 Info:

5. **I would identify my sex as:**

   _____ Male

   _____ Female

6. **My date of birth is** _____/_____/_____

7. **My relationship to my child is (Parent 1):** (circle one)

   Biological Mother

   _____

   Biological Father

   Other _____

   If other, are you the child's legal guardian? (Circle One) Yes No

8. **A. Occupation:** _____

   B. Hours per week

9. **I (Parent 1) would identify my ethnicity as:**

   _____ Hispanic or Latino

10. **I (Parent 1) would identify my race as:**

    _____ American Indian/Alaska Native

_____ Non-Hispanic or Latino

_____ Asian
_____ Native Hawaiian or Other Pacific Islander
_____ Black or African American
_____ White
_____ More than One Race

_____

_____ Other: _____

11. My (Parent 1) highest educational level is:

_____ 8th grade or less
_____ Some high school
_____ GED
_____ High school diploma
_____ Some college
_____ 2 year or professional degree
_____ 4-year college degree
_____ Advanced degree

PARENT 2 Info:

12. I (Parent 2) would identify my sex as:

_____/_____/_____

_____ Male
_____ Female

13. My date of birth is

14. My relationship to my child is:

(circle one)

Biological Mother

_____

Biological Father

Other _____

If other, are you the child's legal guardian? (Circle One) Yes No

15. A. Occupation: _____

B. Hours per week

16. I (Parent 2) would identify my ethnicity as:

_____ Hispanic or Latino
_____ Non-Hispanic or Latino

17. I (Parent 2) would identify my race as:

_____ American Indian/Alaska Native
_____ Asian
_____ Native Hawaiian or Other Pacific Islander
_____ Black or African American

_____ White

_____ More than One Race

_____

_____ Other: _____

18. My (Parent 2) highest educational level is:

_____ 8th grade or less

_____ Some high school

_____ GED

_____ High school diploma

_____ Some college

_____ 2 year or professional degree

_____ 4-year college degree

_____ Advanced degree

19. Our average annual household income is:

_____ < $15,000

_____ $15,000-$30,000

_____ $30,000-$45,000

_____ $45,000-$60,000

_____ $60,000-$75,000

_____ $75,000-$90,000

_____ > $90,000

CHILD HOME AND CARE Info:

20. Who lives in the child's household? Please include yourself and the child.

First Name	Relationship to Child	Age	Sex

21a. Do you use any type of childcare for your child?

_____ Yes

_____ No

b. If yes, which of the following best describes your current childcare arrangement?

_____ Relative (other than parent) cares for child

_____ Child care provider in child's own home

_____ Child care provider out of child's home (unlicensed)

_____ Licensed family day care

_____ Day care center

_____ Other (please describe): _____

c. If yes, about how many hours per week does your child spend in childcare?

_____ (number of hours per week)

Child Information

Child's birth weight _____

How old was your child when he/she began obtaining toys on his/her own? e.g., grasping objects and picking them up? (in months and weeks, if possible)

Is your child sitting up on his/her own? (Circle one) Yes No

If yes, at what age did this begin?

Has your child begun crawling effectively? (Circle one) Yes No

If yes, at what age did this begin? (in months and weeks, if possible)

Does (or did) your child ever cruise? (Circle one) Yes No

Cruising is standing with the support of furniture and shuffling legs side to side.

If yes, at what age did this begin? (in months and weeks, if possible)

Has your child begun walking on his/her own? (Circle one) Yes No

If yes, at what age did this begin?

E: ADDITIONAL ANALYSES TABLES

Bivariate Correlations for Key Variables

	1	2	3	4	5	6	7	8	9	10	12	11	13	14	15	16	17	18	19	20	21	22	23
1. SES	1																						
2. Income	.99**	1																					
3. Education	.73**	.70**	1																				
4. Child Actions	.17	.18	.06	1																			
5. Child Vocs.	.23	.23	.17	.50**	1																		
6. Child Gesture	.08	.09	-.11	.49**	.27	1																	
7. All Responses to Vocalizations	.41**	.41**	.31*	.49**	.60**	.37*	1																
8. Responses to Voc. Only	.26	.26	.17	.05	.08	-.09	.68**	1															
9. Responses to Beh. Only	.19	.18	.16	.63**	.01	.34*	.38**	.17	1														
10. Responses Vocal & Behavior	.36*	.35*	.35*	.57**	.74**	.25	.79**	.19	.33*	1													
11. Responses to Ges. Only	.17	.17	.04	.38**	.369*	.87**	.53**	.07	.29*	.32*	1												
12. Responses Vocal & Gesture	.09	.09	.02	.54**	.26	.83**	.26	-.18	.38**	.30*	.58**	1											
13. All Responses to Behavior & Gesture	.19	.19	.16	.66**	.04	.44**	.39**	.13	.99**	.36*	.36*	.50**	1										
14. All Elaborations	.26	.26	.28	.67**	.48**	.52**	.73**	.25	.69**	.72**	.54**	.49**	.72**	1									
15. All Questions	.20	.20	.16	.57**	.10	.35*	.30*	.05	.79**	.30*	.31*	.43**	.80**	.42**	1								
16. All Prohibitives	-.28	-.28	-.22	-.05	-.02	-.08	-.19	-.23	-.04	-.08	-.07	.02	-.03	-.14	-.19	1							
17. Contextualized Responsiveness	.28	.28	.27	.74**	.40**	.54**	.67**	.21	.85**	.66**	.53**	.55**	.88**	.92**	.75**	-.18	1						
18. All Affirmatives	.18	.18	.21	.67**	.36*	.35*	.59**	.29	.69**	.58**	.30*	.39**	.70**	.75**	.61**	-.21	.81**	1					
19. All Label	.34*	.34*	.24	.56**	.38**	.60**	.49**	-.08	.66**	.56**	.63**	.58**	.70**	.71**	.56**	.04	.77**	.43**	1				
20. All Descriptors	.14	.13	.28	.55**	.32*	.29	.53**	.25	.66**	.49**	.34*	.34*	.67**	.73**	.58**	-.11	.79**	.45**	.51**	1			
21. All Desclabel	.28	.28	.12	.49**	.09	.57**	.41**	.07	.68**	.37*	.52**	.49**	.70**	.64**	.60**	-.29	.75**	.39**	.62**	.55**	1		
22. Total Labels	.34*	.35*	.21	.59**	.29	.65**	.50**	-.02	.74**	.53**	.65**	.60**	.78**	.76**	.64**	-.11	.85**	.45**	.93**	.58**	.86**	1	
23. Total	.21	.21	.24	.58**	.26	.44*	.54	.20	.74**	.49*	.46	.43	.76*	.79**	.66	-.20	.86*	.48*	.62*	.93*	.81**	.78*	1

Descriptions						*	**			*	**	**	*		**		*	*	*	*		*	
24. Child Gender	.09	.09	-.04	-.01	-.38	-.04	-.20	.02	.35*	-.22	-.25	.14	.35*	-.06	.22	-.03	.06	-.02	.08	.04	.16	.12	.09

Extended Regression Models

Table: Regression models for SES, infant behaviors, and responses to behavior on C types

	Model 1	Model 2	Model 3	Model 4	Model 5	M
SES	.33*			.27	.26	
Infant Behaviors		.42**		.38*	.27	
Responses to Behavior & Gesture			.40**		.17	
F	4.89*	8.56**	7.29*	6.34**	4.49**	5
R Squared (%)	11%	18%	16%	25%	27%	

*p<.05
**p<.01

Table: Regression models for SES, infant behaviors, and questions on Child types

	Model 1	Model 2	Model 3	Model 4	Model 5
SES	.33*			.27	.22
Infant Behaviors		.42**		.38*	.13
Question Responses			.57**		.44**
F	4.89*	8.56**	18.24**	6.34**	7.61**
R Squared (%)	11%	18%	32%	25%	38%

*p<.05
**p<.01

Table: Regression models for SES, infant behaviors, and Labels on Child types

	Model 1	Model 2	Model 3	Model 4	Model 5
SES	.33*			.27	.17
Infant Behaviors		.42**		.38*	.17
Total Labels			.54**		.38*
F	4.89*	8.56**	15.99**	6.34**	6.21**
R Squared (%)	11%	18%	29%	25%	34%

*p<.05
**p<.01

Figure: Histogram of SES distribution

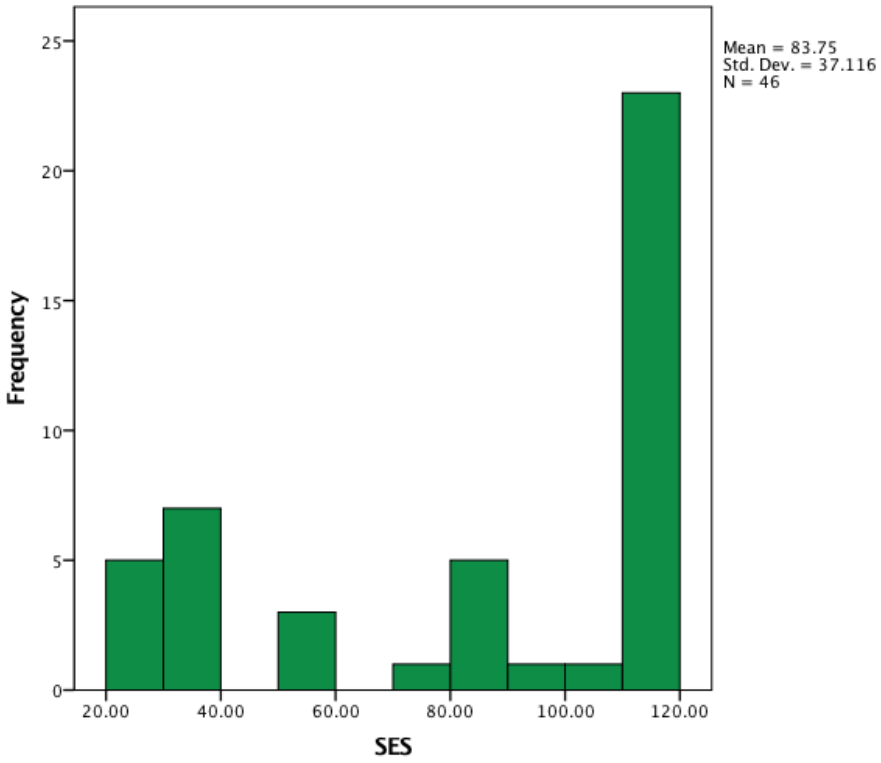


Figure: Relationship between SES and Child Types

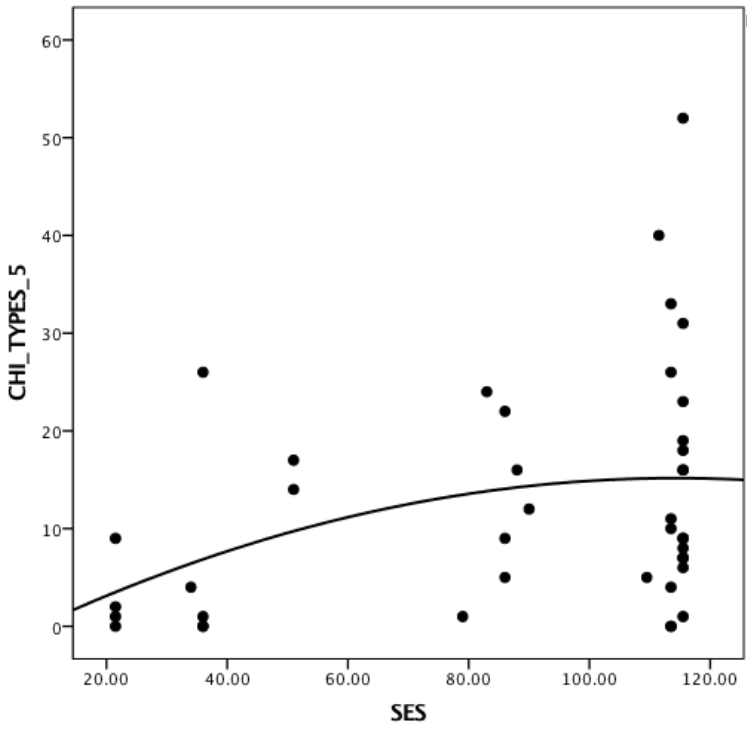


Figure: Histogram of Distribution of Education

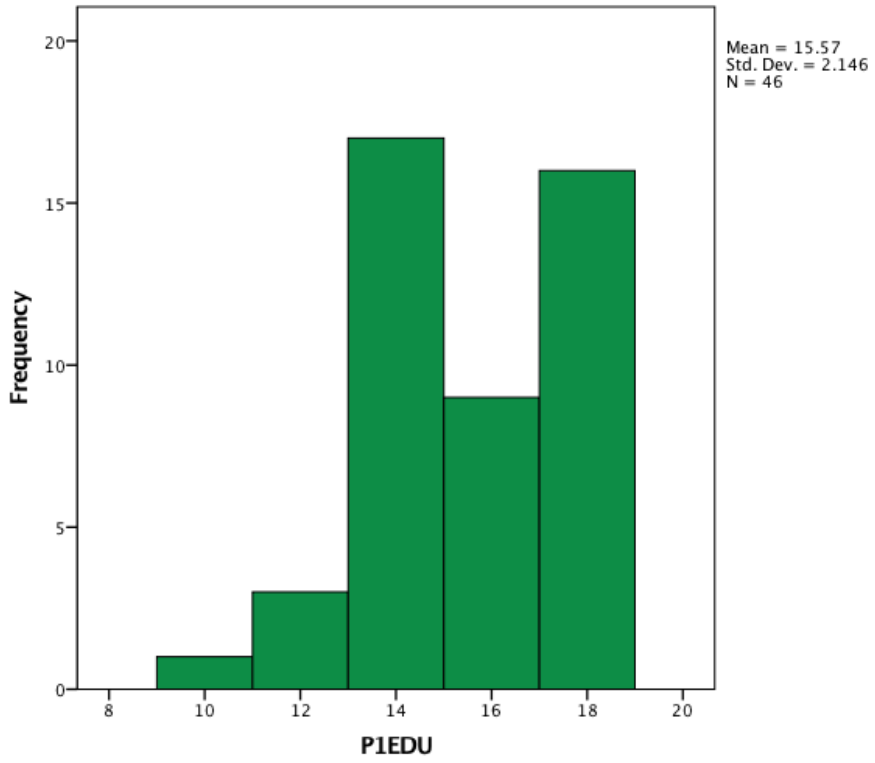
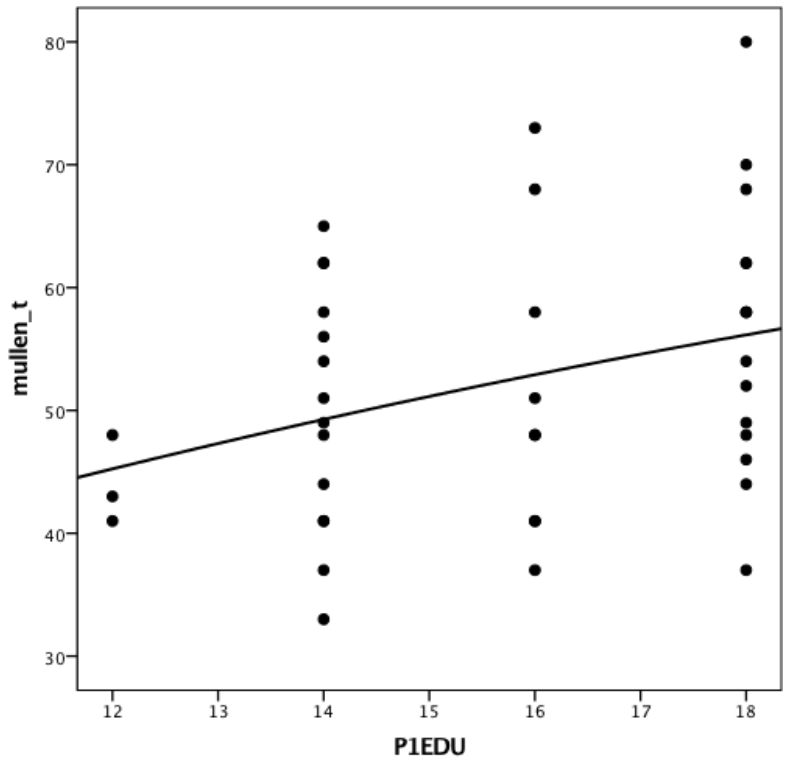


Figure: Relationship between Education and MSEL t-scores



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