An Exploration of Caregiver Object Labels to Children at High vs. Low Risk for Autism Spectrum Disorder: The Role of Child Factors and Joint Engagement Context

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The current study presents a characterization of parent object labels to children at high risk (HR) for Autism Spectrum Disorder (ASD). Parent object labeling has been well-studied in typical development and has begun to be characterized among children with ASD, however, no studies have examined how parents use object labels in interaction with HR children (i.e. children with an older sibling with ASD). Children with ASD show deficits in social communication and interaction, therefore, the social aspects of interactions are thought to be at the root of differences in language and communicative development among these children. Despite evidence that these deficits are present among HR children, few studies have examined how object labels and others aspects of input may vary within different joint engagement (JE) contexts. The present study aimed to fill these gaps by observing and recording naturalistic parent-child interaction at 18-months in the home. Parent speech was transcribed and coded, dividing the interaction into mutually exclusive engagement states and coding utterances containing object labels. Features of object labels including diversity of labels, length, sentence position, function, parent prompts for child speech, and contingency of labels on children's focus were coded. At 36-months all HR children were classified into one of three outcome groups: high risk children who received no diagnosis (HR-ND), high risk children who had a language delay but not ASD (HR-LD), and HR children who went on to receive a diagnosis of ASD (HR-ASD). Parent use of object labels in interaction

were compared across these outcome groups, additionally, use of labels within different engagement states was compared across outcome groups. Differences in parents' use of object labels were only present when examined within individual joint engagement states. Within included joint engagement contexts, parents of HR children prompted children to produce fewer labels, used shorter and simpler utterances with labels, and used fewer diverse label types and tokens. Additionally, only the position of labels within sentences were significantly related to toddler language, however, higher rates of simpler sentences predicted poorer toddler language outcomes. Findings and implications are discussed.

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Preface

I would like to thank my advisor, Dr. Jana Iverson and graduate mentor Emily Roemer for their guidance and support through the completion of this project. I would also like to thank Christina Miceli for her help in completing coding and transcription and the infant communication lab at the University of Pittsburgh! Lastly, I would like to thank the participating infants and families without whom this research would not be possible.

1.0 INTRODUCTION

Development is a complex process affected by many factors acting together. Caregiver input, environment, and children's abilities all interact to shape the development of each child. When considering the development of language and communication, it is important to examine how these factors affect the way infants interact with the world around them and how differences in any of these factors can impact opportunities for learning and development. Interactions between caregivers and children make up the communicative environment in which each child lives, and from the day they are born, children play an influential role in the shaping of these environments.

Autism Spectrum Disorder (ASD) is a neurodevelopmental disorder characterized by deficits in social communication and restricted and repetitive behaviors (American Psychiatric Association, 2013). While language impairment is not a core deficit of ASD, and language outcomes are quite diverse, most children with ASD lag behind their typically developing (TD) peers in numerous domains such as word comprehension, production, and gesturing (Charman, Drew, Baird, & Baird, 2003; Anderson et al., 2007). It is thought, however, that these language impairments in ASD may stem from social communicative deficits at the core of ASD (see Arunachalam & Luyster, 2018 for a review). The development of language is inextricably linked to social communication and engagement early in life, and it is well established that children with ASD perform worse on measures of joint engagement (JE) – the shared attention between a child and social partner on an object - than TD children (Dawson et al., 2004; Wetherby, Watt, Morgan, & Shumway, 2007). Additionally, measures of naturally occurring JE and JE-based interventions

are consistently linked to positive language outcomes for children with ASD (Anderson et al., 2007; Kasari, Paparella, Freeman, & Jahromi, 2008).

In seeking to understand the impact social attention and caregiver input can have on development, the study of children at risk for developmental disabilities may be especially revealing. The younger siblings of children with ASD are at heightened biological risk for developing ASD themselves (Ozonoff et al., 2011). In recent years, researchers have attempted to characterize this group of children (referred to as high risk siblings; HR) to learn about the early signs and development of ASD (Ozonoff et al., 2011, Messinger et al., 2013). Studies have compared the development of HR infant siblings with that of infants with a neurotypically developing older sibling (low risk; LR).

Comparisons of HR and LR groups have provided insight about atypical developmental trajectories. HR children have diverse outcomes that range from neurotypical development to language delays to ASD (Ozonoff et al., 2011; Messinger et al. 2013, Charman et al., 2017). This HR group also gives us a unique opportunity to study the communicative environments of children with diverse developmental outcomes. Recent literature indicates that when children are delayed in achieving communicative milestones (e.g., talking, gesturing, engaging in episodes of joint attention), caregivers may have fewer natural opportunities to provide enriching input for their children (Iverson & Wozniak, 2016). These early differences can provide important insights into the ways differing trajectories in language and social attention impact how caregivers may be speaking to their children and how infants learn from this early input (Fusaroli, Weed, Fein, & Naigles, 2019).

A recent study conducted by Roemer (2018) illustrates the complex interactions between child factors (e.g., developmental level), caregiver input, and social context. It's aim was to

characterize HR infants' social communicative environments at 12 and 18 months of age by exploring how aspects of caregiver input within the context of JE were related to later language outcomes for infants with different developmental outcomes in toddlerhood. Using a coding scheme developed by Adamson et al. (2004), this investigation distinguished between input provided during Coordinated JE vs. Supported JE. Both states require that caregivers and children are engaged in the same activity. In Coordinated JE, however, infants must be engaged with a partner demonstrated by eye contact, whereas eye contact acknowledging caregivers is not required in Supported JE. Roemer (2018) found that caregivers of HR children who were eventually classified as having ASD or non-ASD language delays increased the rate of object labels they produced in Coordinated JE from 12 to 18 months. Caregivers of LR and HR-ND children did not increase in their rate of object labels between these observation time points. Surprisingly, object labels in Coordinated JE at 18 months negatively predicted later language for these children.

This unexpected result raises questions about how and when caregivers provide labels in input directed to their children and why this might vary for children with differing developmental outcomes. The current study was designed to shed light on this finding by providing a detailed characterization of the content and structure of caregiver utterances containing object labels directed to their 18-month-old children who varied in developmental outcomes determined at age 3 years: low risk infants (LR), high risk infants with no diagnosis (HR-ND), high risk infants with a language delay but not ASD (HR-LD) and high risk infants who received a diagnosis of ASD (HR-ASD).

1.1 LITERATURE REVIEW

1.1.1 Object Labels and Language Development

Labeling objects is crucial for children's early language development. For example, when a caregiver says, "there's the teddy bear", this allows the child to link the name of the object and its referent. Object labels such as these are extremely effective for word learning. Labels increase infants' attention to objects during interaction and even after the interaction has ended (Baldwin & Markman, 1989). However, this process is not as simple as it may seem. Interaction is complex and subtle variations in how labels are delivered can impact how children learn from them.

In neurotypical development, studies have shown that both quantity and quality of labels impact children's language development. Studies have often examined word types and tokens in the study of caregiver and child speech to demonstrate lexical diversity (Watkins, Kelly, Harbers, & Hollis, 1995). The quantity of input (word tokens) caregivers provide is related to children's language development, but the diversity of that input (different word types) explains language development above and beyond the sheer quantity of input (Rowe, 2012; Jones & Rowland, 2017). Research has shown that caregivers' mean noun phrases per utterance in speech to children positively predicts noun phrases per utterance in child speech (Hoff-Ginsberg, 1986; Huttenlocher, Vasilyeva, Cymerman, & Levine, 2002). Additionally, object labels may play a unique role in other aspects of language development. Different parent noun phrase types positively predicted sentence diversity growth in children between 21 and 30 months (Hadley et al., 2017). In addition to exposure to nouns, slight variations in the delivery of an object label can significantly impact how children learn from these utterances. For example, Fernald and Mazzie (1991) demonstrated that using a label in the final position of an utterance (sentence-final position; e.g. "is that your

ball?", "there is your doll!") increases its salience, and that doing so may help facilitate word learning in children. Repetition of a label in successive sentences also assists in word learning for young children (Schwab & Lew-Williams, 2016).

The interactive context in which labels are delivered and the functional purpose of an utterance significantly influences how children learn from caregiver speech. Distinctions are often made between labels that refer to an object a child is already focused on (follow-in) and objects to which a child is not attending (lead-in). Follow-in labels are associated with positive language development and lead-in labels tend to be negatively associated with language development, as they require children to shift their attention in order to connect the label with its meaning (Sigman & Siller, 2002; Smith, Adamson, & Bakeman, 1988; Tomasello & Todd, 1983). Lead-in labels may be even more difficult for children with ASD to learn from due to increased impairment in attention shifting compared to TD children (Siller & Sigman, 2002; Sacrey, Bryson, & Zwaigenbaum, 2013).

In addition to exploring differences in how children with ASD learn from follow-in and lead-in labels, Siller and Sigman (2002) examined whether the functional purpose of a follow-in label impacts child learning. There was a significant relationship between utterances that described or commented on the child's focus of attention (follow-in commenting; i.e. if a child was focused on a ball and a caregiver says, "there is your red ball") and later language, but none between follow-in utterances that suggested change in some aspect of the child's behavior (follow-in directives; i.e. if a child was holding a ball and a caregiver says, "throw your ball up in the air!"). Subsequent research has found that follow-in directives are predictive of later language for children with ASD after controlling for child engagement, indicating the important role of child attention in language learning, especially in this population (Shimpi & Huttenlocher, 2007; McDuffie & Yoder, 2010).

Aspects of responsiveness to children's focus of attention (i.e. follow-in, lead-in) and the functional purpose (i.e. directives, comments) of object labels in caregiver speech have been well characterized among children with ASD (McDuffie & Yoder, 2010; Haebig, McDuffie, Weismer, 2013), but much less is known about the structural aspects of labels. There is a large body of literature characterizing how caregivers label objects in typical development, including contingency of labels on child focus, structural and grammatical features, diversity, and complexity (Hadley et al., 2017; Hoff-Ginsberg, 1986; Goldfield, 1993). Little is known about these aspects of input to children with ASD. Even less is known about these features of input to HR children, as caregiver object labels have not been studied in this population. HR children, especially those who go on to develop ASD, demonstrate delayed language and differences in early social attention that likely impact how caregivers and infants interact with one another and with objects (Iverson et al., 2018; Messinger et al., 2013; Luyster, Lopez, & Lord, 2007). In light of these differences in early social communication and engagement with objects and evidence from Roemer (2018), it is possible that caregivers of HR and LR children use object labels differently. There is a lack of a clear characterization of object labeling among caregivers of HR children.

1.1.2 Language Development and Joint Engagement

The variation and generally below average language outcomes in children with ASD are thought to be rooted in challenges in social communication, joint attention, and joint engagement (Sigman et al., 1999; Murray et al., 2008). Joint engagement (JE) refers to the shared attention between two social partners and an object or another referent. In a classic study, Tomasello & Farrar (1986) demonstrated the link between JE and language by showing that object labels referring to a child's focus of attention during JE were related to later language outcomes, but

labels outside of a JE context were unrelated to later language. This study also reported generally richer maternal input during JE, including more utterances, comments, and back-and-forth conversation. Studies of neurotypically developing populations have replicated findings of links between richer input within JE contexts and later language (Carpenter, Nagell, Tomasello, Butterworth, & Moore, 1998; Tomasello & Todd, 1983).

Children with ASD demonstrate differences in JE compared to TD peers, including less time spent in JE, reduced rates of initiation and responses to JE bids from caregivers, as well as fewer advanced JE behaviors (Adamson, Bakeman, Deckner, & Romski, 2009; Adamson, McArthur, Markov, Dunbar, & Bakeman, 2001; Shumway & Wetherby, 2009; Heymann et al., 2018). It is important to note that JE is related to language outcomes for children with ASD, with time spent in JE predicting positive language outcomes as it does in TD (Murray et al., 2008; Charman et al., 2003). Deficits in JE among children with ASD may disrupt the social aspects of interaction that are central to language learning. Fewer episodes of JE give caregivers fewer opportunities to provide the same enriching input that TD children receive when they are jointly engaged with the same object or within the same activity. These lost opportunities can cascade and lead to significantly fewer subsequent opportunities for learning and development (Iverson & Wozniak, 2016).

The traditional conceptualization of JE is often referred to as Coordinated joint engagement (CJE), where children are actively engaged with both an object and their social partner during interaction, most commonly indexed by eye contact with the social partner (Bakeman & Adamson, 1984). Most of the existing literature on JE refers to CJE. As researchers have begun to broaden the definition of JE, results suggest that some JE contexts may be more helpful for language learning for children with ASD than others.

In Supported joint engagement (SJE), children and a social partner are engaged with the same object, but children are not making eye contact or acknowledging the caregiver in the same way as in CJE (Bakeman & Adamson, 1984; Adamson, Bakeman, & Deckner, 2004). SJE may provide a context where children and caregivers can engage together while reducing some of the social and cognitive demands required in CJE (Dawson et al., 2004). At 30 months, children with ASD did not show differences compared to 18-month old TD children in time spent in SJE, and instances of SJE where the child was responding to caregiver input predicted expressive and receptive language (Adamson et al., 2009).

Despite the significant role that JE plays in language development and the vast body of literature describing this relationship, relatively few studies have characterized the input provided to toddlers within SJE vs. CJE contexts. Few characterizations of input to children with ASD during JE exist and no such characterization exists in the study of HR infants with varying developmental outcomes. Increased characterization of caregiver speech within these different engagement contexts is needed if we are to better understand how these contexts relate to development.

1.2 THE PRESENT STUDY

Caregivers' use of object labels during interaction with HR children remains largely uncharacterized, despite developmental variations present in this population that could impact caregiver input. Results from Roemer (2018) suggest differences in the production of object labels within CJE in caregivers of HR children. We do not know what is driving these differences. Are they limited to the quantity of object labels? Do other aspects of input, such as

diversity of labels, length and complexity of utterances containing labels, or the social context in which labels are delivered vary as well? The present study aims to answer these questions by characterizing multiple aspects of caregiver-produced object labels during naturalistic interactions with their 18-month-old LR and HR children. Further, we aim to explore how production and characteristics of caregiver object labels may vary within Supported and Coordinated JE.

To characterize caregiver object labeling, we transcribed caregiver speech and selected measures designed to capture multiple features of object labels: quantity and diversity (types and tokens); utterance length (mean length of utterance; MLU in words (Blake, Quartaro, & Onorati, 1993); repetitions; sentence position; and presence of multiple labels. Additionally, parent prompts, or utterances that ask a child to produce a label themselves (e.g. “what is that?”, “what is that toy called?”), are examined, along with use of labels in follow-in comments and directives, as well as lead-in labels. As noted above, these variables have not been used previously to characterize parent speech to HR infants.

The overarching goal of this research was to identify similarities and differences in parents’ object labels provided to LR vs. HR children with varying developmental outcomes. The study has three aims.

Aim 1. We aim to provide a rich description of parent object labels to HR and LR children during naturalistic interaction. First, we will examine the entire observation to determine whether there are differences in parent object labels across outcome groups. As discussed above, characteristics of object labels (e.g. types, tokens, sentence position) to HR children have not yet been characterized, therefore, this aim is descriptive in nature. This study will be an important

first step in understanding how parents of children with differing developmental outcomes use object labels.

Aim 2. We will compare parent object labeling to HR and LR children within distinct JE contexts (SJE vs. CJE) to describe parents' use of object labels within each engagement state. Roemer (2018) demonstrated that compared to LR/HR-ND children, HR-ASD/HR-LD children spend less time in CJE and parents of these children increase in their use of object labeling within CJE from 12 to 18 months. Based on these findings we expect that characteristics of parent object labels will differ across outcome groups and that this may vary by JE context.

Aim 3. Finally, we aim to characterize the relationship between aspects of parent labeling within SJE and CJE and language abilities in toddlerhood. We expect differences in the relationship between object labels in different engagement states and toddler language development, as demonstrated in Roemer (2018), and we hope to clarify these findings by exploring relationships between specific features of object labels and language in toddlerhood.

2.0 METHODS

The present study is an extension of a previous investigation of parent speech across JE states. The methods described below are adapted from the larger study as data collection and elements of coding schemes are shared between the two studies. For additional details on the methods employed in the original study, see Roemer (2018).

2.1 PARTICIPANTS

The present sample included 57 total parent-child dyads, including 43 children (26 male) with an older sibling with ASD (HR), and 14 children (10 male) with typically developing older siblings, referred to as low risk (LR). At 18-months, 51 mothers and 6 fathers participated. All children in the HR group had an older sibling with a confirmed diagnosis of ASD from a trained clinician using the Autism Diagnostic Observation Schedule (ADOS-G; Lorde., 2000). HR infants were recruited from the Autism Research Program at the University of Pittsburgh, as well as other organizations in the Pittsburgh area serving children with ASD. All children included in the HR group were assessed and classified into one of three outcome groups (described below) at 36 months of age. LR infants were recruited as a part of a separate investigation of motor development. Infants were eligible for participation if they had at least one older sibling, came from monolingual English speaking homes and full-term pregnancies without complications. Table 1 displays demographic information for parents. Maternal and paternal ages were both

significantly higher in the HR group than their counterparts in the LR group, and there was no significant difference in parental education across groups.

Table 1 Demographic Information for High Risk (HR) and Low Risk (LR) groups

	LR (n = 14)		HR-ND (n = 14)		HR-LD (n = 17)		HR-ASD (n = 12)	
Racial or Ethnic Minority (%)	1	(7%)	0	0%	4	(24%)	3	(25%)
Mean age for Mothers*	31.07	(4.50)	33.93	(3.25)	35.35	(3.69)	32.58	(4.50)
Mean age for Fathers *	32.36	4.52	37.43	(6.10)	38.41	(4.30)	34.92	(4.66)
Mean Parent Education[a]	1.43	(0.43)	1.15	(0.61)	1.30	(0.58)	1.13	(0.80)

* HR and LR groups significantly differ ($p < 0.05$)
[a] Parent education based on averaging education scores for mothers and fathers.
0 = High school, 1 = Some college or college degree, 2 = Graduate or professional school.

2.2 PROCEDURE

As a part of the larger study, infants were observed in their homes at multiple time points between the ages of 5 months and 3 years. For a complete description of the procedures in this larger longitudinal study see Roemer (2018). For both HR and LR groups, video data was collected in participants' homes at a time of day when caregivers felt infants would be most alert and likely to participate.

The present study focused on the naturalistic toy play segment of the 18-month home visit. In this segment, research staff instructed parents to play with their children as they normally would in the home, using an age appropriate set of toys provided by the research team. Naturalistic play segments lasted three minutes with additional time to take out toys and clean-up, for a total interaction time ranging from 3 to 6 minutes. The toy set was the same for all home visits and

included a stuffed bear, cup, bowl, spoon, washcloth, and brush. All interactions were recorded by an assistant trained to keep the infant and parent in view during interaction. Infants wore cloth vests with microphones attached to ensure quality audio recording of parent and infant speech.

2.3 MEASURES

2.3.1 MacArthur-Bates Communicative Development Inventory (CDI)

The CDI is a parent report measure of communicative ability in young children, commonly used for research and clinical purposes in typically and atypically developing populations (Fenson et al., 1993, 1994). The CDI consistently demonstrates strong test-retest reliability, validity, and internal consistency in typically developing children and in children with a range of early language differences (Fenson et al., 1994; Heilmann et al., 2005; Luyster, Lopez, & Lord, 2007). During the 18-month and 24-month visits, parents completed the CDI-II which is normed for children aged 18-30 months. The CDI-II consists of a 680-word checklist on which parents indicate which of the listed words their child can say. At 36-months parents completed the CDI-III, a 100-item vocabulary checklist, which reflects language expectations appropriate for children between 30-37 months. The present study includes age and gender-normed CDI percentile scores from the 24- and 36-month visits as a part of a composite measure of language ability in toddlerhood.

2.3.2 Mullen Scales of Early Learning

The Mullen Scales of Early Learning (MSEL; Mullen, 1995) is a measure of cognitive functioning in infants and children. The scale shows strong convergent validity with measures of cognitive ability and has been validated within typically and atypically developing populations (Bishop et al., 2011). The measure includes sections reflecting fine and gross motor skills, visual reception, and receptive and expressive language abilities. The MSEL was administered by a trained experimenter at all visits as a part of the larger study. In the current study, T-scores from the Expressive Language section were used as a measure of concurrent language ability, and T-scores from the Expressive and Receptive Language sections at 24 and 36 months were used to create a composite toddler language score.

2.3.3 Outcome Classification

At 36 months of age, all HR infants were evaluated and classified into one of three outcome groups: Autism Spectrum Disorder (ASD), Language Delay (LD), and No Diagnosis (ND). LR infants were not formally evaluated, however, parents completed the M-CHAT (Modified Checklist for Autism in Toddlers; Fein, Barton, & Green, 2001) at 18 and 24 months, with all children scoring negative for ASD.[1] One infant did not have M-CHAT data at either age. The three HR outcome groups are as follows:

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[1] [1] Two children from the LR group met criteria for a language delay, as defined below. Analyses were run with these two children included and excluded. The pattern of results was the same, so results are reported with these two children included in the LR group

HR-ASD. All HR infants were evaluated for ASD at 36 months, except for one infant who received a diagnosis of ASD at 24 months before withdrawing from the study. Infants were evaluated using the ADOS-G, a widely-used evaluation designed to assess the symptoms of ASD in a structured play context (Lord, 2000). HR infants received a diagnosis of ASD if they met or exceeded ADOS-G algorithm cutoffs and had this confirmed by a trained clinician using the DSM-IV-TR criteria. Using these criteria, 12 infants (9 male) were diagnosed with ASD.

HR-LD. HR Infants were classified as language delayed (HR-LD) if they did not meet the criteria for ASD and fit one of the following descriptions: 1) Received standardized CDI score at or below the 10th percentile during more than one visit between 18 and 36 months (Heilmann, Weismer, Evans, & Hollar, 2005); and/or (2) had standardized scores on the CDI at or below the 10th percentile *and* standardized MSEL receptive and/or expressive scores at or greater than 1.5 standard deviations below the mean at the 36-month assessment. Based on these criteria, 22 infants (13 male) were classified as language delayed (LD); 17 (10 male) of these infants had usable video data available at the appropriate ages for the present study and were included in the present study.

HR-ND. All 39 HR infants (20 male) infants that did not meet the above criteria at 36 months were classified as having no diagnosis (ND). Within this group, 34 infants had usable video data and 14 infants (7 male) were chosen at random to be included in the sample.

2.4 PARENT SPEECH TRANSCRIPTION AND CODING PROCEDURES

2.4.1 Transcription Procedures

All parent speech within video recordings of parent-child interactions were transcribed using ELAN software (ELAN; Brugman & Russel, 2004). The first author and a second transcriber, who were both blind to risk status and outcome classification, completed all transcriptions. Only infant-directed parent speech was included in transcription; any utterances from the infant and all parent utterances not directed at the infant were not transcribed. Transcriptions included contractions (i.e. “can’t”) but did not include interjection, which are any utterances or noises that do not add meaning to a sentence (i.e. “ah”, “huh”, “um”). A detailed description of transcription procedures can be found in Appendix A.

The transcriptions of each interaction were used to complete coding procedures detailed below and to obtain several variables indicating lexical diversity and sentence complexity. Transcriptions were used to obtain label types and tokens from each dyad, which are common measures of vocabulary diversity. For the purposes of the present study, types refer to the number of unique labels that are used throughout the interaction, and tokens refer to the total number of labels used. Sentence complexity was measured using the mean length of utterances (MLU), MLU was calculated using the word count of an utterance and averaging across all utterances containing a label.

2.4.2 Coding Engagement States

The initial study segmented all videos into six mutually exclusive engagement state categories. The coding scheme used in the original study was developed based on a scheme used by Adamson and colleagues in multiple investigations of the relationship between joint engagement and language development in children with ASD (Bakeman & Adamson, 1984; Adamson et al., 1984; 2004; 2009). This coding scheme differentiates between six mutually exclusive engagement states. The present study focused on Coordinated and Supported JE which are described below, additional engagement states (i.e. object engagement, unengaged) were coded (see Roemer 2018 for details) but were not included in the present study.

Supported Joint Engagement (SJE). Both JE states require that infant and caregiver are actively engaged with the same object. In SJE, the infant does not visually acknowledge the caregiver, however, the caregiver's actions must influence the child's interaction with the object. For example, if a child and mother are engaged in a puzzle together, and the child waits for the mother to take a turn putting down a puzzle piece, but remains looking at the puzzle the entire time, this is considered SJE.

Coordinated Joint Engagement (CJE). In CJE, an infant and caregiver are engaged with the same object, and the infant is coordinating their attention between the object and caregiver during play. The infant must make eye contact with the caregiver for the episode to be considered CJE. The infant glancing back and forth between caregiver and object is the most common form of CJE, for example, an infant and caregiver rolling a ball back and forth and an infant glancing between the ball and caregiver.

To avoid micro-coding brief shifts in attention, a 3-second rule was applied when coding engagement states. If the infant looks away from an interaction to attend to an accidental noise,

another person or object or any other brief distraction, this was not coded as a change in engagement state if the change in attention was under 3 seconds. However, if there is a clear shift in attention or a behavior (i.e. the infant is in CJE and then walks away for 5 seconds before returning to CJE), that shift would be coded as unengaged between the two SJE episodes.

2.4.3 Coding Parent Speech

Roemer (2018) focused mainly on parent-child interaction and involved coding aspects of parent speech, including labeling and child attention, that are relevant to the present study. The initial coding schemes distinguished between parent utterances that were related to the child's current focus of attention, whether the utterance was contingent (i.e., the child was focused on this object during the two seconds before the utterance), and finally whether the utterance contained an object label (i.e., a noun naming the object).

An additional coding scheme was created for the purposes of the present study to further characterize the features of parent speech and labeling in this sample. All utterances with labels had already been identified from the original coding; all but one code (Parent Prompts) focused exclusively on the utterances that included a label.

Code	Definition	Example
Lead-in Label (LD)	The label referred to an object the child was not attending to in the two seconds prior to the utterance.	If a child is focused on a teddy bear and a parent brings out the cup, saying, "Look, I found a cup!" this would be coded a lead-in label, regardless of whether the child shifts their focus to the cup after the utterance.
Follow-in Directive (FW-D)	If the child was attending to the referent of the label within the two seconds prior to the	If a child is focused on the teddy bear and a parent

	utterance, it was coded as a follow-in label. Utterances were coded as follow-in directives if the content requested or implied that the child change some aspect of his/her behavior.	says, "Give teddy bear some food!", only if the child was not already pretending to feed the bear.
Follow-in Comment (FW-C)	If the content of an utterance described what the child was already doing or did not direct the child's attention or behavior, this was coded as a follow-in comment.	If a child is playing with the cup, and a parent comments, "Are you drinking from your cup?"
Multiple Labels	The number of distinct labels within an utterance. An utterance containing a single label would be marked as a 1, an utterance would be marked as a 2 if it contained two different labels within the utterance, and so on.	"Bring me the cup and the bowl", would be coded as a 2 for the two distinct labels cup and ball.
Repetition	Codes reflect the number of times a single label was repeated within an utterance, if a label was used only once it received a 1, if it was repeated twice it received a 2, and so on.	"The ball, do you see the ball?", would be coded as a 2.
Sentence-Final Position	Utterances were coded to reflect where in the sentence a label occurred. This code was adapted from Goldfield (1993), and indicated both the length of the sentence and the position of the label. All utterances were classified into one of the following categories: (1) A one word sentence (2) a two-word sentence (3) a two-word sentence with a label as the final word (4) a three word or longer sentence with a label as the final word.	"Should we feed the bear?" would be coded as a 4, or "Get cup?" would be coded as a 3.
Parent Prompts (PP)	Parent utterances that prompted the child to produce the name of an object themselves in conversation. These utterances did not necessarily contain a label themselves, but were clear requests for the child to produce a specific object name.	"What is that?", "What toy are you playing with?"

2.4.4 Reliability

Inter-rater reliability was assessed for both transcription and coding schemes. First, percent agreement was calculated for identification of utterances; mean percent agreement was 93% (range: 80-97%). Reliability for joint engagement state coding was assessed by creating one-second bins for each video and calculating a Cohen's kappa statistic based on matching bins between two coders. Mean Cohen's kappa statistic for engagement state (7 possible codes) was 0.75 (range 0.63 to 0.92).

Using the object labels coding scheme, the first author and a second coder, both blind to risk-status, each independently transcribed and coded approximately 23% of the recordings (n=13), with each outcome group equally represented. Transcriptions were considered reliable if 85% or more of utterances matched across coders. The average reliability between transcribers was 91% and coding reliability averaged 92% for these videos. All transcription and coding discrepancies were discussed by the coding team and consensus agreements were reached and coded accordingly. Identification of parent prompts had a mean 90% agreement between coders. Utterances across all reliability videos were combined, and Cohen's kappa statistic was calculated for identification of labels (label/no label), contingency of labels (lead-in/follow-in), functional purpose of labels (follow-in comment/follow-in directive), multiple labels within an utterance (1-3), repetitions of labels within utterances (1-5), and sentence position (final position/not final position). Cohen's Kappa was 0.87 for the identification of labels, 0.81 for contingency and functional purpose, 0.87 for multiple labels, 0.80 for repetition, and 0.88 for sentence-final position. Due to the low prevalence of non-contingent (lead-in) labels an intraclass correlation coefficient (two-way random effects, average-measures) was calculated; this was .80 (95% CI: .77 to .83).

3.0 RESULTS

The current study was designed to examine characteristics of parents' object labeling during interaction with their 18-month-old children with diverse developmental outcomes at age 3 years (high risk children that went on to receive an ASD diagnosis (HR-ASD), high risk children with language delays but no ASD (HR-LD), high risk children that received no diagnosis (HR-ND), and low risk children with a typically developing older sibling (LR)). It had three main goals. The first was to determine whether parents' production of object labels and the characteristics of these labels differed across outcome groups across the full observation. Second, parent object labels within SJE and CJE were compared across outcome groups. We hypothesized that parents of children with different developmental outcomes would differ in their use of object labels across these engagement states. Finally, we sought to determine if features of parent object labeling within different engagement states predict toddler language outcomes.

3.1 PRELIMINARY ANALYSES: CHILD LANGUAGE AND JOINT ENGAGEMENT

Before presenting the main results, we present descriptive statistics related to child language and joint engagement that are relevant for the primary analyses. These results are described in further detail in Roemer (2018). First, Table 2 displays descriptive statistics characterizing child Receptive and Expressive language and Visual Reception, which is considered a measure of nonverbal cognitive ability (Bishop, Guthrie, Coffing, & Lord, 2011), at 18, 24, and 36 months. There were significant differences in expressive language scores at the 18-month time

point across outcome groups (F (3, 53) = 9.92, p = 0.00). Gabriel's post-hoc tests revealed that there were significant differences between the LR/HR-ND groups and the HR-LD/HR-ASD groups (LR > HR-LD, p = 0.00; LR > HR-ASD, p = 0.00; HR-ND > HR-LD, p = 0.04; HR-ND > HR-ASD, p = 0.00).

Table 2 Descriptive Statistics Characterizing Outcome Groups at 18, 24, & 36 Months

		Low Risk			HR – No Diagnosis			HR – Language Delay			HR – ASD		
Measure	Month	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD
CDI: Words	18	13	26.5	23.5	14	31.4	19.9	17	7.60	12.3	12	6.67	9.37
Produced	24	11	42.7	25.1	12	46.7	22.2	17	16.2	17.5	11	2.73	4.67
	36	13	21.5	19.1	13	27.3	29.6	17	4.12	4.41	11	0.00	0.00
MSEL:													
Receptive	18	14	40.4	12.4	14	42.6	16.9	17	34.5	12.0	12	28.4	14.6
Language	24	10	53.2	10.7	13	56.3	5.12	17	41.2	14.3	9	25.6	8.23
	36	13	53.8	6.47	14	55.1	8.87	17	45.0	7.60	9	29.6	10.3
MSEL:													
Expressive	18	14	50.9	8.64	14	47.7	7.46	17	38.7	6.72	12	34.3	13.0
Language	24	19	52.7	10.2	13	55.1	5.33	17	43.9	8.65	9	28.8	10.7
	36	13	56.6	11.2	14	59.7	8.45	17	50.2	7.47	9	31.1	11.3
MSEL:													
Visual	18	14	48.9	8.60	14	47.6	6.93	17	40.9	8.76	12	36.3	12.7
Reception	24	11	52.4	11.0	13	50.5	9.41	17	45.6	7.93	10	38.7	8.42
	36	13	68.5	7.31	14	60.4	9.37	17	53.1	13.2	9	31.6	13.3

Note: CDI = MacArthur-Bates Communicative Development Inventory, CDI percentile scores are reported; MSEL = Mullen Scales of Early Learning, MSEL standardized T-scores are reported.

Second, there were differences in the amount of time spent in CJE across groups. Table 3 reports the means and standard deviations for proportion of observation time spent in each engagement state for all groups. Planned contrasts using the Mann-Whitney U test were completed to determine whether there were differences in time spent in SJE and CJE. Roemer (2018) demonstrated that only LR and HR-ND children increased in their time spent in CJE from 12 to 18 months. At 18 months, after collapsing between HR-ASD/HR-LD and HR-ND/LR groups,

results showed a trend for non-typically developing infants (HR-LD/HR-ASD) to spend less time in CJE than typically developing infants ($U = 293.5$, $p = 0.07$).

Table 3 Mean Proportions and Standard Deviations of Time Spent in Engagement States for Each Outcome Group at 18 months

	Low risk (n = 14)		HR-ND (n = 14)		HR-LD (n = 17)		HR-ASD (n = 12)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
SJE	0.30	0.19	0.37	0.19	0.43	0.15	0.34	0.21
CJE	0.27	0.23	0.25	0.23	0.15	0.17	0.16	0.13

Before analyses were completed, distributions for object labeling variables were examined, revealing significant skew and unequal variance within several variables. Data transformations were performed where necessary to ensure the assumptions for analysis of variance (ANOVA) were met. Additionally, examination of the distribution for sentence position and length codes revealed low frequencies for several classifications. Therefore, codes were collapsed to reflect labels in sentence-final position (including one word utterances with labels and two-or-more word utterances with the label in the final position) or not sentence-final position (e.g., the teddy bear is eating). This variable is referred to as sentence-final position throughout.

3.2 OVERALL CHARACTERIZATION OF PARENT LABELING ACROSS GROUPS

The first set of analyses focused on characterizing parent labeling input during the overall observation period to determine whether differences existed between outcome groups. MLU,

types, and tokens are reported as averaged totals across each group. All other results are reported as rates per minute across the full session. Given small variations in durations across infants, rates allow for the most appropriate comparison across infants.

Notably, all variables characterized only utterances with labels, with one exception – prompts, which encouraged labels (e.g., "What is that?", "What do we call that?"). Therefore, all parents who provided prompts were included in analyses of parent prompts, and parent-child dyads that produced no labels were list-wise deleted from analyses of all other variables. Three infants (1 HR-ASD, 2 HR-LD) had 0 labels provided to them and were subsequently not included in analyses of labeling variables. Table 4 presents the means and standard deviations for each variable across each of the four outcome groups as well as the results of one-way ANOVAs comparing these groups on each variable.

Table 4 Descriptive Statistics for Parent Labeling Variables During Overall Observation at 18 Months

	LR (n = 14)	HR-ND (n = 14)	HR-LD (n = 17)	HR-ASD (n = 12)			
	Mean(SD)	Mean(SD)	Mean(SD)	Mean(SD)	F	p-value	eta-sq
MLU	5.56(1.27)	5.04(1.05)	5.04(0.89)	4.52(1.21)	1.84	0.15	0.09
Types	10.14(4.17)	10(3.4)	8.33(2.69)	7.36(3.12)	1.99	0.13	0.11
Tokens	28.86(13.41)	27.64(12.79)	25.8(8.34)	25.82(13.85)	0.21	0.89	0.01
Rate of Lead-in Labels	1.75(1.51)	1.56(1.15)	1..57(0.97)	1.51(1.17)	0.12	0.95	0.01
Rate of Follow-in Directives	1.36(0.65)	2.08(1.5)	1.56(0.97)	1.41(0.96)	0.99	0.41	0.05
Rate of Follow-in Comments	2.26(1.15)	2.42(1.46)	2.19(.96)	2.14(1.17)	0.14	0.94	0.01
Rate of Multiple Labels	0.93(0.79)	0.8(.91)	0.7(0.58)	0.5(0.39)	0.53	0.67	0.03
Rate of Repetition	0.16(0.21)	0.06(.13)	0.1(0.23)	0.05(0.1)	0.46	0.72	0.11

Rate of Sentence-Final Position	4.19(1.9)	4.52(2.35)	3.75(1.98)	3.79(2.25)	0.72	0.55	0.04
Rate of Prompts	1.05(0.69)	0.74(0.87)	0.63(0.57)	0.37(0.29)	2.43	0.08	0.16

To compare parent use of labels across groups, one-way ANOVAs were used to detect possible differences in the rates or totals in each labeling variable across the four outcome groups. While none of the above analyses reached statistical significance, these results suggest some trends in parent speech patterns, the strongest of which were evident in the average MLU of utterances containing labels, number of different labels used (types), and rate of parent prompts. As the table shows, these variables display a descending pattern in means across groups, with the parents of the HR-ASD group providing the shortest labeling utterances, the fewest label types, and the lowest rate of prompts. However, none of these differences reached statistical significance.

3.3 CHARACTERIZATION OF PARENT LABELING WITHIN ENGAGEMENT STATES ACROSS OUTCOME GROUPS

We next focused on characterizing parent object labels to toddlers in the four outcome groups during SJE and CJE. We aimed to describe parent use of object labels to HR and LR children within SJE and CJE, and expected that parents across outcome groups would differ in their use of object labels within distinct JE contexts. Specifically, parents of HR-LD and HR-ASD children may be capitalizing on limited time spent in CJE.

All variables are presented as rates and were computed by dividing the total occurrence of a variable by the total time spent in that engagement state (SJE or CJE). Rates are expressed per minute for ease of comparison. Each labeling variable was calculated as a rate in this manner for SJE and CJE. All variables with skewed distributions and/or unequal variances were transformed to meet the assumptions of ANOVA. Due to low frequencies within each engagement state, rate of repetition was not included in the following analyses. Additionally, it is important to note that only dyads that spent some time in each engagement state could be included in these analyses. Thus, sample sizes for each outcome group reflect the numbers of dyads that spent time in that JE state. We expected that there would be differences in parent labeling input across outcome groups when it was examined in relation to individual engagement states, due to findings from Roemer (2018). To test this hypothesis and provide rich descriptions of parent object labels, we performed one-way ANOVAs to compare rates of each variable within each engagement state across outcome groups. The means and standard deviations for each variable within SJE are presented below in Tables 5 along with the results of the one-way ANOVAs.

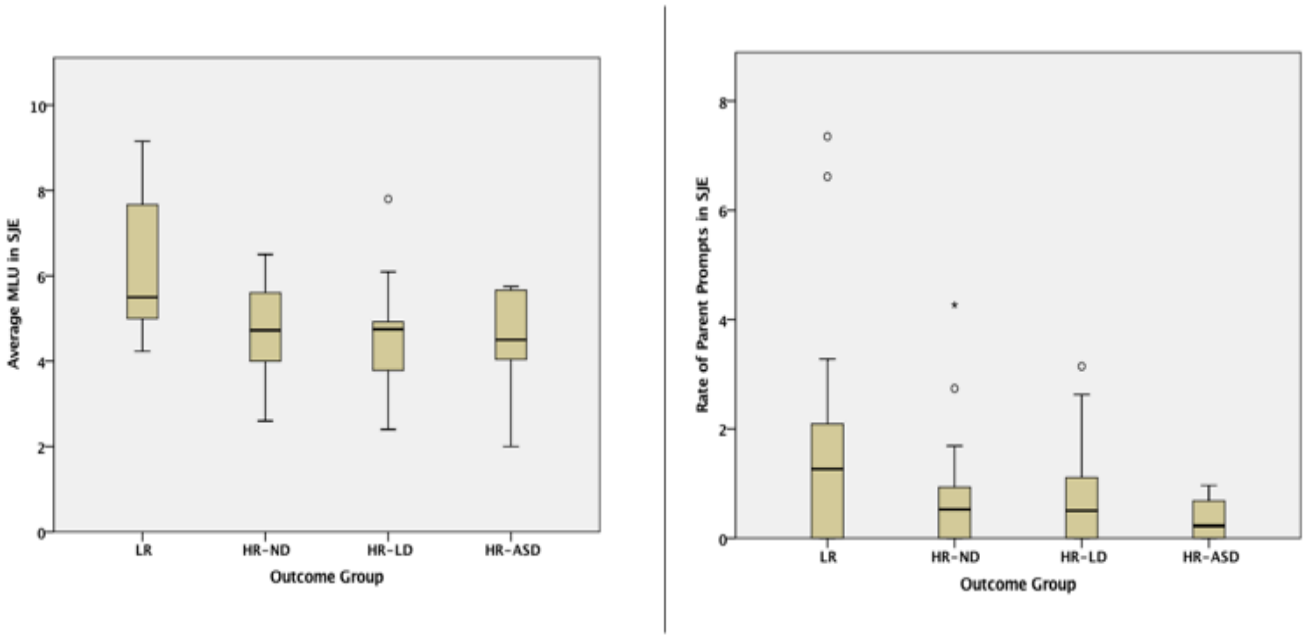
Table 5 Descriptive Statistics for Rates of Parent Labeling Variables During Supported Joint Engagement at 18 Months

Variable	F statistic	P-value	Effect size	LR (n = 14) Mean rate (SD)	HR-ND (n = 14) Mean rate (SD)	HR-LD (n = 17) Mean rate (SD)	HR-ASD (n = 12) Mean rate (SD)
Supported JE							
MLU	4.35	**0.01****	0.21	6.15(1.67)	4.72(1.13)	4.59(1.3)	4.49(1.22)
Types	0.67	0.56	0.04	6.25(6.86)	4.25(4.11)	3.98(3.76)	3.93(4.42)
Tokens	0.32	0.81	0.02	15.77(17.05)	13.28(12.63)	11.39(11)	15.44(25.28)
Lead-in Labels	0.77	0.52	0.05	1.93(1.78)	2.47(1.93)	1.27(0.92)	1.55(1.32)

Follow-in Directives	0.18	0.91	0.01	2.26(1.14)	2.6(2.3)	1.79(1.28)	1.96(1.78)
Follow-in Comments	0.91	0.45	0.06	2.75(2.32)	2.4(2.53)	2.51(1.03)	2.47(2.12)
Multiple Labels (within utterances)	0.87	0.47	0.1	1.28(2.42)	0.94(0.84)	0.41(0.61)	0.39(0.69)
Sentence-Final Position	1.28	0.29	0.07	5.96(2.7)	5.78(2.56)	4.3(1.83)	4.65(3.66)
Parent Prompts	5.03	**0.01****	0.34	1.57(1.47)	0.87(1.26)	0.74(0.96)	0.35(0.38)

*p < 0.05, **p < 0.01

Figure 1 Average MLU and Rate of Parent Prompts during Supported Joint Engagement by Outcome Group



As shown in Figure 1, in SJE, parents of HR-ASD children are using the shortest MLU, an indicator of complexity, for labeling utterances and the lowest rate of prompts for children to produce labels. Parents of LR children are using the longest MLUs and highest rates of prompts. As seen in Table 5, there were significant differences in the rates at which parents were prompting their children to produce labels in SJE, F (3, 29) = 5.03, p = .01. Results of the Gabriel's test show

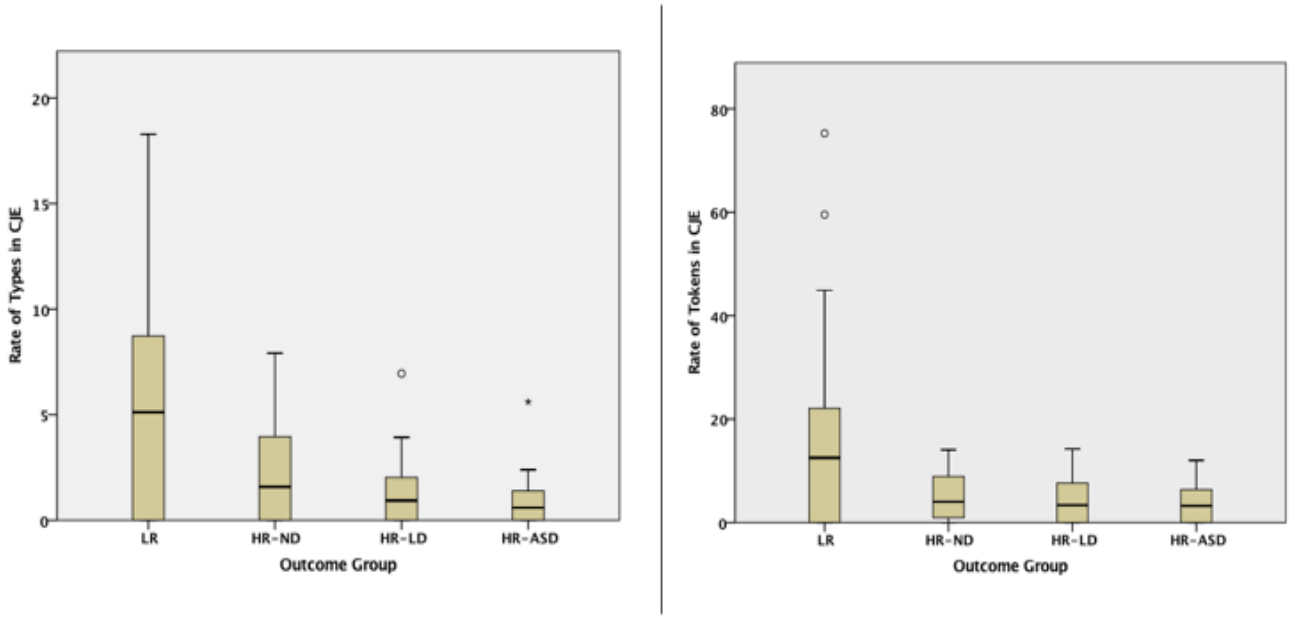
that this was mainly due to differences between the LR and HR-ASD groups (p = 0.00). In Figure 1, the same descending pattern can be seen in the average MLUs for labeling utterances for each outcome group, and the Gabriel's test for MLU in SJE revealed significant differences between the LR group and the HR-ND (p = 0.05), HR-LD (p = 0.02), and HR-ASD (p = 0.02) groups.

Table 6 Descriptive Statistics for Rates of Parent Labeling Variables During Coordinated Joint Engagement at 18 Months

Variable	F statistic	P-value	Effect size	LR (n = 12) Mean rate (SD)	HR-ND (n = 11) Mean rate (SD)	HR-LD (n = 9) Mean rate (SD)	HR-ASD (n = 9) Mean rate (SD)
Coordinated JE							
MLU	0.45	0.72	0.04	4.97(1.31)	4.71(1.72)	5.48(1.34)	5.04(1.38)
Types	8.78	**0.00****	0.47	5.15(4.79)	2.38(2.62)	1.31(1.85)	1.06(1.61)
Tokens	3.69	**0.02***	0.25	15.9(17.48)	5.22(4.96)	4.34(5.06)	4.26(4.36)
Lead-in labels	0.86	0.48	0.12	2.11(2.79)	0.89(1.06)	0.75(0.93)	1.78(2.11)
Follow-in Directives	0.06	0.98	0.01	1.93(1.77)	2.33(2.34)	1.82(1.73)	2.48(2.49)
Follow-in Comments	2.7	0.06	0.19	3.52(2.13)	1.87(1.46)	3.19(1.53)	4.13(3.15)
Multiple labels (within utterances)	1.63	0.22	0.22	1.27(1.37)	0.3(0.51)	0.55(0.86)	1.07(1.07)
Sentence-Final Position	3.56	**0.02***	0.24	6.27(3.29)	3.91(1.87)	4.68(1.77)	7.45(3.02)
Parent prompts	0.12	0.95	0.03	1.05(1.41)	0.45(0.68)	0.87(1.31)	0.45(0.74)

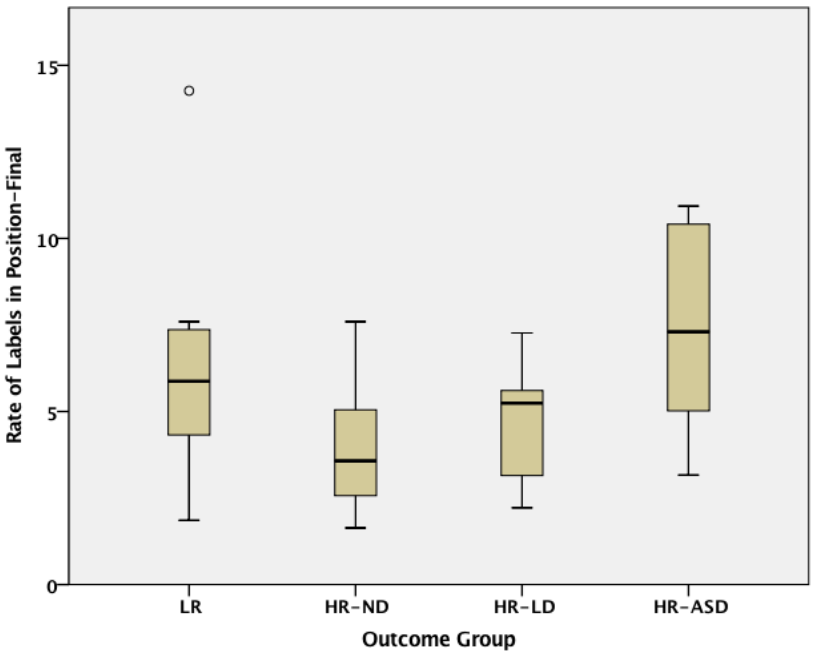
*p < 0.05, **p < 0.01

Figure 2 Rates of Caregiver Produced Types and Tokens during Coordinated Joint Engagement Across Outcome Groups



As Table 6 shows, the rate of different labels (types), the rate of total labels (tokens), and the rate of labels in sentence-final position (the most salient sentence position) within CJE varied significantly across groups. Figures 1-3 display these variables as boxplots. Inspection of the boxplots and data displayed in Table 6 reveals two distinct patterns. For rates of label types and label tokens, the LR group had the highest mean rates, and all 3 HR groups had significantly lower means, with the lowest in the HR-ASD group. Parents of LR children produced significantly higher rates of label types (F (3, 30) = 8.78, p = 0.00) and label tokens (F (3, 34) = 3.94, p = 0.02) than all HR groups. Post-hoc analyses confirmed that rate of types in CJE was significantly different between LR groups and HR-ND, HR-LD, and HR-ASD (p = 0.04; p = 0.00; p = 0.00 respectively) and group differences in rate of tokens in CJE were driven by a significant difference between the LR and HR-ND groups (p = 0.02) and a marginal difference between the LR and HR-ASD groups (p = .10).

Figure 3 Rate of Caregiver Labels in Sentence-Final Position during Coordinated Joint Engagement Across Outcome Groups



As seen in Figure 3, parents of HR-ASD children used the highest rates of labels in sentence-final position, increasing the salience of labels, but an unexpected pattern was observed concerning speech of the LR compared to HR-ND groups. There were significant differences across groups in the rate parents used labels in sentence-final position F (3, 34) = 3.59, p = 0.02. However, post-hoc analysis using Gabriel's test revealed that these group differences were driven by the difference between the HR-ND and HR-ASD groups (p = 0.03) while the means of the LR and HR-ASD groups were quite similar.

The same pattern is observed for follow-in commenting, another variable that increases label salience by mapping a label directly onto the child's focus of attention. As can be seen in the table, the ANOVA for follow-in commenting was nearly significant (F (3, 34) = 2.7, p = 0.06) and follows the same pattern as sentence-final position, with the largest difference existing between the HR-ND and HR-ASD groups (p = 0.10). Although not statistically significant at conventional

levels, it is notable that this pattern is consistent for the two behaviors that most directly increase the salience of labels in CJE.

A potential explanation for these group differences is that caregivers are adapting their speech to their children's language level. A series of bivariate correlations were performed to examine the relationship between child language at 18 months and variables for which significant group differences were identified. Concurrent language data comes from scores on the expressive language section of the MSEL administered at 18 months (see Table 2). As shown in Table 7, rate of different labels (types) in CJE and parent prompts in SJE were positively and significantly correlated with concurrent expressive language ability.

Table 7 Correlations Between Significant Parent Labeling Variables and Concurrent Language Ability at 18 Months

Labeling Variable	*r*
Supported JE	
Prompts	0.53*
MLU	0.14
Coordinated JE	
Types	0.45**
Tokens	0.13
Follow-in Comments	-0.27
Sentence-Final Position	-0.26

*p < 0.05, **p < 0.01

3.4 RELATIONS BETWEEN PARENT LABELING VARIABLES AT 18 MONTHS AND LATER CHILD LANGUAGE

The final aim of this study was to examine potential relationships between parent labeling variables and children's later language abilities. To follow up on group differences reported above,

we examined rate of prompts and MLU during SJE, and rates of types, tokens, labels in sentence-final position, and follow-in comments during CJE in relation to language in toddlerhood.

For the regression analyses described below, we used a measure of toddler language that combined standardized scores from the CDI and MSEL administered when children were 24 and 36 months old. The toddler language score was created by standardizing into z-scores and averaging together the CDI words produced percentile scores and MSEL receptive and expressive language T-scores. One LR infant did not have language data at either age due to withdrawal from the study. This composite measure of language ability showed high internal consistency in prior studies (Northrup & Iverson, 2015) and within this sample (Cronbach's alpha = 0.86)

Results of the regression analyses indicated that the rate of different labels (types), follow-in comments, and labels in sentence-final position in CJE and rate of parent prompts in SJE significantly predicted toddler language. In SJE, parent prompts positively predicted toddler language (B = 1.34, p = 0.01) and in CJE rate of label types also predicted better language abilities in toddlerhood (B = 1.12, p = 0.00). Rate of follow-in comments and label in sentence-final position in CJE were also significantly related to toddler language, but higher rates of these variables predicted poorer toddler language outcomes (B = -0.54, p = 0.02; B = -0.15, p = 0.01). Neither tokens in CJE nor MLU in SJE were significant predictors of toddler language.

To determine whether these relationships held after controlling for concurrent child language, we reran the analyses and included expressive language at 18-months in step-wise regressions. The results are displayed in Table 8. As can be seen in the table, only labels in sentence-final position predicted toddler language outcomes after including child expressive language at 18-months in Step 2, but this relationship was negative in direction. Parent prompts in

SJE, types, and follow-in comments in CJE did not significantly predict later language above and beyond child language at 18-months.

Table 8 Step-Wise Regression for Parent Labeling Variables Predicting Toddler Language Outcomes Controlling for Expressive Language at 18-Months

Variable	Step 1	Step 2
Expressive Language (18-months) (B)	0.77**	0.76**
Prompts in SJE (B)		0.04
R2	0.58	0.59
F	43.23**	0.23
Expressive Language (18-months) (B)	0.73**	0.64**
Types in CJE (B)		0.21
R2	0.54	0.57
F	36.0**	2.43
Expressive Language (18-months) B	0.77**	0.72**
Follow-in Comments in CJE (B)		-0.18
R2	0.59	0.62
F	50.52**	2.62
Expressive Language (18-months) (B)	0.77**	0.70**
Sentence-Final Position in CJE (B)		-0.26*
R2	0.59	0.66
F	50.52**	6.27*

*p < 0.05, **p < 0.01

Table 9 Summary of Results

Engagement State	Variable	Finding	Group Differences	Relation to Language
Overall Observation	All	There were no significant differences across groups when analyzed within the full observation	None	N/A
Supported JE	Parent Prompts (ex: what is that? What do we call this?)	Parents of LR children used higher rates of parent prompting than all HR groups within SJE and a significantly higher rate than parents of HR-ASD children	LR > HR-ASD	Parent prompts significantly and positively predicted toddler language, but was no longer significant after including expressive language at 18-months
Supported JE	MLU (mean length of utterance - word count)	Parents of LR children used significantly longer average MLUs in SJE than all HR groups	LR > HR-ND, HR-LD, HR-ASD	MLU did not significantly predict toddler language
Coordinated JE	Types (different labels used)	Parents of LR children used a significantly higher rate of different label types than all HR groups	LR > HR-ND, HR-LD, HR-ASD	Types significantly and positively predicted toddler language, but was no longer significant after including expressive language at 18-months
Coordinated JE	Tokens (total labels used)	Parents of LR children used higher rates of tokens than all HR groups, but only the LR group and HR-ND were significantly different from one another	LR > HR-ND	Tokens did not significantly predict toddler language
Coordinated JE	Follow-in Comments	Parents of HR-ASD children used the highest rates of follow-in commenting and a significantly higher rate than the HR-ND group and parents of LR children had rates more similar to HR-LD and HR-ASD groups than HR-ND	HR-ASD > HR-ND	Follow-in commenting significantly negatively predicted toddler language, but was no longer significant after including expressive language at 18-months

Coordinated JE	Sentence-Final Position (labels in the final position; “there is your ball” “do you see your teddy bear?”)	Parents of HR-ASD children used the highest rates of labels in the sentence-final position and a significantly higher rate than the HR-ND group, here, parents of LR children had rates more similar to HR-LD and HR-ASD groups than HR-ND	HR-ASD > HR-ND	Sentence-final position was the only variable that significantly predicted toddler language above and beyond child expressive language at 18-months; higher rates of sentence-final position predict poorer child language

4.0 DISCUSSION

This research aimed to characterize how parents of HR and LR children use object labels when interacting with their children. Additionally, we sought to determine whether parents of children with different developmental outcomes (HR children with no diagnoses (HR-ND), HR children with language delays and no ASD (HR-LD), HR children who received ASD diagnoses (HR-ASD), and LR children) used labels differently, and whether use of object labels differed within different JE contexts. We predicted that parents of children across outcome groups would be using object labels differently, specifically within Supported and Coordinated JE contexts (SJE and CJE). Findings suggest that parents of HR and LR children differ in their production of object labels and in the characteristics of these labels. Importantly, these differences were only detectable when input was examined within SJE and CJE.

4.1 HOW DO OBJECT LABELS VARY ACROSS SUPPORTED AND COORDINATED JE?

4.1.1 Supported JE

In SJE, there were significant differences between parents of LR and HR-ASD children in their rate of prompting. There were also significant differences between parents of LR and all HR groups in average MLU, with parents of HR-ASD children producing the shortest utterances with labels. SJE is a less demanding JE state, as this context does not require that children coordinate

attention between an object and a social partner as CJE does (Bakeman & Adamson, 1984). By 30-months of age children with ASD match 18-month old TD infants in time spent in SJE (Adamson et al., 2009). Although there were no significant differences across groups in time spent in SJE in the present study, HR-LD and HR-ASD children did display significantly different expressive language abilities at 18-months. While child speech was not examined within JE in the present study, these expressive language differences are likely present across multiple JE contexts, including SJE.

One possible explanation for these differences in SJE is that parents of LR children are scaffolding more challenging language (MLU and prompts) into SJE as children become more skilled in this context. Adamson & Bakeman (2004) discuss this process in TD within the context of the social constructivist theoretical framework. They suggest that parents slowly push children beyond their capabilities as they move from relying on SJE to increasing time spent in CJE, and they infuse more complex input and behaviors into their interactions to scaffold child learning (Vygotsky, 1978; Bruner, 1983). In interactions between parents and children with ASD, this process can break down as children engage atypically, and parents' ability to scaffold interactions decreases (Adamson, Bakeman, Suma, & Robins, 2017). Results of the present study are consistent with this theory; relative to parents of LR children, parents of HR children provided labels in shorter utterances during SJE. This may be because HR parents are aware of their children are not ready for more complex input based on language abilities.

Interestingly, only rate of prompts in SJE were significantly correlated with concurrent expressive language ability. MLU in SJE was not, although these variables followed a similar pattern. It is possible that use of parent prompts was reflective of children's language; parents may be aware of the extent to which their children can produce labels and match this ability with their

use of prompting. Therefore, parents' use of prompts may be a potential index of parent sensitivity to the language abilities of their children. It may be that parent MLU is more closely related to child engagement or aspects of social attention that are more characteristic of the entire HR group, rather than child language. However, we cannot draw conclusions about this relationship as no measures of children's social attention or social abilities were included in the present study.

4.1.2 Coordinated JE

In CJE, the rates of different object labels (types) and total object labels (tokens) were significantly higher for the LR groups compared to all HR groups, and these rates were similar across all three HR outcome groups. These differences may reflect parents adapting their speech to their child's language level as discussed above. However, because differences in rates of types and tokens existed between the LR and all HR groups (in which language abilities varied widely), other factors may be at play here.

Differences between HR and LR infants in object exploration can be detected as early as 6 and 9 months, even among a group of HR children who did not receive a diagnosis of ASD (Koterba, Leezenbaum, & Iverson, 2014; Kaur, Srinivasan, & Bhat, 2015). Additionally, early atypical object play, tendencies to explore fewer objects, deficits in shifting attention, and delays in functional object use have been reported for children with ASD (Ozonoff et al., 2008; Pierce & Courchesne, 2001; Landry & Bryson, 2004; Luyster, Lopez, & Lord, 2006). Differences in object exploration and related attention provide parents of HR children fewer natural opportunities to provide diverse object label types and tokens during play interactions with their children. It is also possible that the lower rate of object label types stems from less imaginative play among children with ASD (Jarrold, 2003). Little is known about pretend play in HR children, though one study

indicated that HR children engage in pretend play at similar rates to LR children (Campbell, Leezenbaum, Mahoney, Moore, & Brownell, 2016). During the observations, parents often involved objects in imaginative play, for example, pretending that a cup was full of juice. If, after talking about the cup, a parent then says, "should the teddy bear have some juice?", the input heard by the child now contains two distinct object labels (the juice is referring to the cup). Parents in dyads that engage in less imaginative play may use fewer label types, as they may only have opportunities to refer to objects by their canonical names.

A different pattern was observed for parents' rate of labels in sentence-final position within CJE. Parents of LR and HR-ASD children produced labels in sentence-final position at similar rates, while significant differences were only evident between the HR-ND and HR-ASD groups. The finding that parents of HR-ASD children would place labels at the end of utterance more frequently supports the interpretation that parents are adapting their speech to their children's language levels, as labels in sentence-final position increases the salience of a label. However, results for the other groups are more difficult to explain. It is important to note that this measure has not been used before in research on HR children or children with ASD. It is striking that although LR and HR-ND children had apparently similar language abilities (as assessed on the MSEL), their parents differed quite a bit on this variable. This raises the possibility that although HR-ND children appeared to be typically developing, some aspects of their input differ, possibly due to their risk status. A similar pattern was observed for follow-in commenting within CJE, another variable that increases the salience of labels by mapping an object name onto a child's current focus.

Differences in rates of label types, label tokens, labels in sentence-final position, and follow-in commenting were all only observed within CJE. This raises the following question: what about

this context influences parent object labeling in these specific ways? Prior studies of children with ASD have revealed persistent deficits in CJE, and while few studies of CJE in HR children exist, there is evidence for delays in social communication and attention among HR children (Adamson et al., 2009; Adamson et al., 2012; Leezenbaum et al., 2014; Winder et al., 2014; Parlade & Iverson, 2015; Yirmiya et al., 2006). In this study, HR-LD/HR-ASD also spent less time in CJE than HR-ND/LR children. Since time spent in CJE is reduced for HR-ASD and HR-LD children, parents may be capitalizing on these infrequent moments of engagement and attempting to provide the most targeted and salient input to their children. Additioanlly, CJE may provide a context in which differences in children with ASD are most pronounced, and this may extend to HR infants as well, though to a lesser degree. Parents may be especially sensitive to differences in language, social, and cognitive ability within this interactive context and subsequently adapt their language to match the needs of their child.

4.2 WHY DOES PARENT SPEECH VARY ACROSS OUTCOME GROUP?

The results of the present study provide evidence that parents of children across a range of developmental outcomes may be adapting their input to match their children's language ability. Our results focus on parent object labels, but these results fit into a larger body of literature that has begun examining the role children play in the creation of their own communicative environments. Interactions between parents and children are shaped by child factors such as language, cognitive ability, and even interest in objects and persons (Sameroff, 2010). A recent investigation shows that infants' initial expressive language and nonverbal cognition predicted subsequent parent input and later language for both TD and ASD groups. Additionally, parents

and infants across both groups matched one another on syntactic and lexical production at all time points within the study (Fusaroli, Weed, Fein, & Naigles, 2019).

This focus on child factors provides an interesting lens with which to view the present study. It appears that parents of HR children are using fewer labels, simplifying utterances containing labels, and increasing the salience of labels within speech and interaction. Our results suggest that parents of HR-ASD children (and in some cases, all HR groups) are using the simplest speech and parents of LR the most complex. It is possible that parents are adapting their use of object labels to their child's linguistic and cognitive ability. We extend previous research by including not only children with ASD outcomes, but also HR children with diverse developmental outcomes by analyzing parent speech within the context of different JE states. Findings suggest that the inclusion of JE context is an important one when considering how child factors may impact parent speech, especially in the study of children with ASD and HR children. Differences in joint attention and social communication among this population make the context of interaction pivotal in understanding how and why parents may speak differently to children with different developmental outcomes.

Our findings also provide some clues as to how differences in parent speech may relate to children's later language. The only variable that related to toddler language above and beyond language at 18-months were labels in sentence-final position in CJE, and higher rates of label in sentence-final position predicted negative toddler language. Previous studies of parent language suggest that children with ASD and TD benefit from similar features of parent input, but that the social nature of interaction may disrupt the language learning process in children with ASD (Bang & Nadig, 2015; Arunachalam & Luyster, 2018). Multiple studies have shown that providing children with ASD with more complex speech, including longer utterances with more

morphological structures is beneficial for later language development, as it is in TD (Fusaroli et al., 2019; Venker et al., 2015). Labels in sentence-final position enhance the salience of labels and may also reflect simpler utterances, as one and two word utterances (e.g. “ball!”, “your ball”) were included in this code. Additionally, higher rates of labels in sentence-final position may reflect less varied sentence structure. For example, utterances with labels in sentence-final position, such as “go get your ball” or “you’re washing the dish” have similar structures. Therefore, labels in sentence-final position may not be as beneficial for language development as more varied and complex sentences (Hoff-Ginsberg, 1982). This finding suggests a potential mismatch between some aspects of how parents adapt speech to HR children and the type of input that may be most beneficial for language learning.

4.3 WHAT DO THESE RESULTS TELL US ABOUT HR CHILDREN?

This study is the first exploration of how parents of HR children label objects during every day play interactions. Our results suggest that differences in how parents use object labels are not limited to children who go on to develop ASD. Parent MLU in SJE and rates of label types and tokens in CJE differed between the LR group and all HR groups. In all cases, parents of HR-ASD children displayed the lowest MLU and lowest type and token rates. These results may reflect delays in social communication that are shared among HR groups (Yirmiya et al., 2006) that may in turn shape the level of complexity of input directed to HR children. Variability in children’s language skill may also be implicated in these differences, as rate of label types produced by parents was significantly correlated with children’s language at 18 months. Further studies that take a more explicit look at children’s behaviors during parent-child interaction and include

measures of child social communication may be needed to fully capture the influence of these behaviors in this bidirectional process.

Notably, there are few examinations of SJE and CJE in samples of HR infants, and this study begins to fill in some of the gaps in this literature. It appears that input in SJE is not quite the same for HR and LR children. Prior research has suggested that SJE is an engagement context in which fewer differences exist for children with ASD, ranging from parent behaviors in SJE to its effectiveness as a language learning context (Adamson et al., 2017). While there were fewer differences in parent speech in this context compared to CJE, the present study does suggest that there are some aspects of parent object labeling in SJE that differ between LR and HR parents. Additionally, as previously discussed, prior work suggests that parents of LR children use SJE as an important context to scaffold more challenging input (Adamson et al., 2017), and in the case of object labeling, parents of HR children may not be altering their input in the same ways.

4.4 LIMITATIONS

When considering these results, it is important to note several limitations of the study. First, the sample of the study was predominantly White and the majority of parents were highly educated, thus these findings may be limited in their external validity. Additionally, the observation period for parent-child interaction was relatively brief (3 to 6 minutes). A longer observation period would allow us to capture increased parent input and perhaps additional time spent in each engagement state. Finally, sample sizes for each outcome group were relatively small, especially once data was split into time spent in SJE or CJE. There were dyads in each outcome group that spent no time in

CJE, and therefore parent input within these dyads could not be examined in analyses focused on CJE.

4.5 FUTURE DIRECTIONS AND CONCLUSIONS

The present study adds to a growing body of literature characterizing the early communicative environments of HR children. However, gaps remain in our characterization of these environments. Additional characterization of early social and language differences among HR children would add to our understanding of how child factors may impact parent speech. Our results revealed differences in parent object labeling that held across LR and all HR groups, suggesting that there may be some shared differences among HR children despite heterogeneous outcomes within this group. Additional studies are needed to further characterize the extent to which variation in social attention and factors related to the environments of HR children may impact parent input.

Future work is also needed to further explore parent and child behaviors within different JE states in populations with diverse developmental outcomes. Our results suggest that JE context impacts different aspects of parent object labeling across outcome groups. However, our study was focused on object labels, therefore, other studies might determine whether our findings extend to other aspects of parent speech and parent behavior.

It is important to note that the definitions of JE used in this study, with CJE relying heavily on eye contact to indicate engagement, is one of many ways to define JE. Some researchers challenge the assumption that eye contact is necessary for establishing social connections and indicating attention and interest among children with ASD (Jaswal & Akhtar, 2018). Yu & Smith

(2013) suggest that hand-eye coordination (e.g. children's focus on parent's hands) may provide a better understanding of the coordination of attention between children and parents during interaction. Future explorations may consider replicating findings from the current study using measures of JE that capture more fine-grained details of the interaction.

Characterizing the communicative environments of HR children helps us better understand the complex interplay of social interactions, child factors, and parent speech. Providing a characterization of how parents of children with diverse developmental outcomes label objects during parent-child interaction provides information that can help us understand the role children play in shaping their own language learning environments. Individual child-based differences influence aspects of parent speech, and differences in child language and social attention provide parents different opportunities to respond and engage their children. These interactions are the basis of early learning and while this study adds to the literature of how these differences impact child learning, additional work is needed to clarify this process for children with developmental differences.

Appendix A Caregiver Labeling Input Transcription and Coding Manual

Step 1: Transcription

- Transcribe all caregiver speech directed to the child exactly as spoken. Only transcribe speech directed to the child. Do not transcribe any communication between the mother and the Team Leader or any other adult, as they will often chat throughout the clip.
- Communication will already be separated into utterances, an utterance is any sequence of words and/or gestures that is preceded and followed by a *silence,* a *change of conversational turns,* or a *change in intonational patterns*. An utterance may or may not be grammatically structured. All speech will already have been separated into utterances, so these are the only spots you will need to transcribe and code.
- Each line in the coding file represents a different utterance, with its related codes next to it and the time stamp at which the utterance occurred.
- Utterances or portions of utterances that cannot be distinctly understood should be represented by XXX. (e.g., "Where is the XXX?"; "Come on XXX"). If the entire utterance cannot be heard, enter XXX
- Transcribe all meaningful speech sounds, including "uh oh," "yeah," "yay," "ok," "oops,"
  - **Do not** transcribe sounds like "pouring" (e.g., mother pretends to pour something into a cup), eating/drinking noises; "gasping"/ "surprise" noises, or anything that does not convey speech.
  - **Do not** transcribe any non-meaningful words should be transcribed as [play noise] if they are the sole speech in an utterance. Any non-meaningful speech sounds in another utterance should be left out
- **DO NOT** transcribe any parent utterances directed at the research team or other children/family members, make a note that the utterance was not directed at the infant
- Oftentimes in parent speech there will be phrases that are unclear or are slightly slurred or muffled, **only** transcribe words you are certain you hear.
- When a parent uses a child's name, the name should be coded as [name]. Do not include children's names in transcription
- **Do not** transcribe interjections (i.e. part of speech that shows the emotion or feeling of the speaker) there utterances are not needed to convey meaning of the sentence and should be excluded
  - Examples: aha, boo, aw, ha, oh, oops, oh no, uh oh, ugh, yikes, yuck, aw, ahh, huh, um, hmm, mhm, oop
  - **Do** transcribe: boo, oops, oh no, uh oh, yuck, boo
  - **Don't** transcribe: aha, ew, ha, oh, ugh, aw, ahh, huh, um, hmm, mhm, oop, uh

Step 2: Parent Prompts

First, create a tier for "Parent Prompts"

These utterances explicitly prompt or ask the child to produce a label themselves

- EX: “Say X”, “Can you say X”, “What/who is this?”, “What do we call this?”, “What else is in here?”
- Prompts will often come in these forms but are not necessarily limited to these questions alone, think about whether the utterance is asking the child to produce a label

- These utterances may or may not contain labels themselves so the entire video should be checked for these utterances, not just utterances marked with Labels already
- If prompts

  If a prompt exists, code: PP
- Note that you do not need to code any further information regarding parent prompts

Step 3: Syntactic Features of Parent Labels:

All of the following steps only apply to utterances that have already been marked as Labels “L”, only code these utterances for the following:

Each of the following variables will require a new tier in each new video, these are the names of the tiers you should create in the following order:

a.) Multiple Labels
b.) Repetition
c.) Postition_Length_Score

1) Multiple Labels

Multiple labels refer to an utterance that contain two ***different*** labels within a single utterance

In this tier you will enter a number for how many distinct labels there are in the single utterance:

- Ex: if a parent says “Your spoon is in the bowl”
  - You would enter a “2” in the tier because you have two distinct (spoon and bowl) labels
- Ex: if a parent says “Look at the cup”
  - You would enter a 1 because there is only one label
- Ex: if a parent says “look at the cup, what do we do with the cup?”
  - You would still enter 1, even though the label is repeated there is only one label type in the utterance
- Ex: if a parent says “look it’s a blanky, he has a blanket”
  - You would enter **2** even though these labels are referring to the same object, they are two different labels

One and two will be the most common but be on the lookout for as many labels as exist!!

Note

There is currently no indication of multiple labels already coded in the videos, no matter how many labels are in an utterance the utterance will only be marked with “L”

- Therefore coders must discern whether two labels are present and code accordingly
  Use these tips to determine what is and what is not counted as a label

- To determine whether an utterance contains a label, it must clearly be a noun naming the object. “Are you drinking”, “brushing” used as a verb, etc. do not count as labels.
    - To determine if the label is naming an object, listen for articles and possessive pronouns (*the* bear, *a* cup, *a* drink, *his* brush, *my* hair, etc.).
    - However, labels will not always be preceded by these. You may code label if there is another clear indicator that the caregiver is *naming* the object (for example, mom picks up the cup and shows it to the child, or points to the cup, with a single word utterance, “cup!”). If the utterance is being used as a verb (i.e. “brush, brush, brush” as mom is brushing child’s hair), do not count it as a label.
    - Other objects and even body parts can count as the object of focus and as a label (i.e., “those are my *glasses*”; “let’s brush his *hair*”). We want our coding to be representative of typical interactions, so we do not want to treat objects outside our teddy bear set differently.
- Unusual labels may be counted *if* they are clearly the referent. A few examples:
    - The mother points to the bear’s nose and says “look at his nose”, or to the pictures on the cup and says “there’s a mouse”. These would count as a label.
    - The caregiver consistently uses “tub” to refer to the bowl, or “blanket” to refer to the washcloth, as they are using it as this object in pretend play. In this case, “tub” or “blanket” would count as a label.
        - Additionally, if the caregiver consistently names some food (i.e., “some cereal”) in pretend play with the bowl/spoon, this would count as a label.
        - If the caregiver lists off many types of food, count these as a label but make a note in the comments and tracking spreadsheet about the unusual number of labeling instances.

    The caregiver uses a different label to name the object, such as “baba” for bottle

2) Repetition

In the repetition tier, you will code for how many times a label is repeated inside that utterance

- Ex: if a parent says “I see the cup; do you see the cup?”
    - You would enter a 2, because the **same** label is repeated twice
- Ex: if a parent says “Will you hand me the cup?”
    - Enter a 1

The repetition label refers only to the repetition of *exact* same label, if there is more than one label in an utterance and they are not exactly the same this should be reflected in the “Multiple Labels” tier and not the repetition tier

3) Sentence Position and Length

All labels will be coded into one of the following 5 groups regarding sentence length and the position of the label within the sentence:

- 1) one word sentences 2) two word sentences 3) final position in two word sentences 4) final position in sentences with three or more words 0) none of the above
    a. Only code each label as one of the above, if it is a two-word sentence with a label in the final position only code as “3”, do not code as 2 and 3

Some utterances might contain more than one label, in cases of repetition and multiple labels

- These sentences will likely either fall under none of these categories (0) or 4 (final position in a long sentence) – this is what is most important
    - If a sentence has multiple labels but none are in the final position then code this as 0

Note: If there are two different sentences in an utterance, code the final position of the whole utterance

- If a sentence has multiple labels and one is in the final position of the sentence code as a 4
-

Step 4: Social Context of Labels

Every utterance containing a label will receive one of the following

- Do not code for context for any other utterances besides those with already marked labels
- You are coding for the purpose of the entire utterance, not just that of the labeling word

First look at the existing "Verbal input CODE" tier (these will already be present within all videos)

If an utterance is marked as OF in this tier, follow these steps:

- Check the "Verbal input CC-NC" tier
    - If the tier is marked as NC, don't code
- If the tier is marked CC
    - Determine the function of the utterance
        - If it is 1) suggesting that the child change some aspect of their behavior with the object (ex: "can you give the teddy bear a drink of water?") then mark the utterance as a "FW-D" for follow-in directive
            - Should be thought of as changing the direction of a child's behavior – this can take more forms than a question such as the above example
        - If it is 2) commenting on or describing what the child is already doing with the object (ex: are you brushing the bear's hair?") then mark the utterance as **"FW-C"** for follow-in comment

Notes:

When coding, especially in uncertain instances, check the video a few seconds before the utterance to determine what the child was or was not already playing with or focusing on. This will help coders determine if parents are truly commenting on behavior or if they're somehow introducing a new object or action

- Note: directives may not always be in the form of "Can you give me the cup?" or in question form they may be more suggestions.

In instances of imaginative play, the parent might make a comment about what the child is or could be pretending to do – even if the coder cannot tell that this is what the child is already doing, these should be coded as comments UNLESS the parent is introducing a new object or action into the play

If a parent tells a child not to do something or "we don't use spoons for brushing" – consider this a directive, because they are asking for a behavior change

If a child is playing with an object and a parent asks the child to give them the object or makes a request that would alter the child's play with the object even if it's not expressly about the child's behavior – code as directive

- In these instances think about what the child is already doing and think about if this request would alter their current play in some way

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