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Joint engagement, parent labels, and language development: Examining everyday interactions in infant siblings of children with autism

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Abstract

This study examined joint engagement, parent labels, and language development in infants with an elevated (EL) and typical likelihood (TL) for ASD. Parent-child interactions were coded for joint engagement and parent labels at 12 and 18 months, and language skills were assessed later in toddlerhood for 12 EL infants diagnosed with ASD (EL-ASD), 17 EL infants with language delay (EL-LD), 14 EL infants with no diagnosis (EL-ND), and 12 TL infants. Infants spent substantial time in supported joint engagement and received similar rates of input from parents across outcome groups. However, parents of EL-ASD infants increased the rate of labels provided in coordinated joint engagement. While labels positively predicted language for TL infants, the opposite pattern emerged for EL-ASD infants.

Keywords

autism spectrum disorder; infants; joint engagement; parent input; language

Infants develop in a complex social environment full of opportunities to learn from parental input. As infants share attention and engage together with people and objects, parents provide a scaffold for infants' learning about social and cultural communicative norms (Vygotsky, 1978). Dyadic toy play interactions are filled with labels from parents, helping infants map words onto objects and supporting language development (e.g., Bruner, 1983;

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Declarations

Conflict of interest. The authors declare that they have no conflict of interest.

Ethics Approval. All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional research committee and with the 1964 Helsinki declaration and its later amendments.

Informed Consent. Informed consent was obtained for all individual participants in the study.

Tomasello, 1988). Further, infants shape their own opportunities for learning as new communicative skills emerge, forming a collaborative, dynamic landscape for language learning (e.g., Adamson, Kaiser, Tamis-LeMonda, Owen, & Dimitrova, 2020; Sameroff, 2009).

Challenges with social communication are a core feature of Autism Spectrum Disorder (ASD), a neurodevelopmental condition with a substantial genetic contribution (American Psychiatric Association, 2013; Iakoucheva, Muotri, & Sebat, 2019). While nonverbal (e.g., eye contact, gesture, joint attention) and verbal skills develop rapidly in the first and second years of life in infants with neurotypical development, this developmental landscape differs for children with ASD. Language delays are common for children on the autism spectrum (see Tager-Flusberg, 2016 for a review), and infants with ASD experience substantial challenges with nonverbal communication (e.g., Manwaring, Stevens, Mowdood, & Lackey, 2018). These challenges with early communicative skills may limit opportunities for parents to provide responses to communication (e.g., Leezenbaum, Campbell, Butler, & Iverson, 2014). However, parent speech targeted to the child's interests and communicative skill has been shown to support language development for both children with neurotypical development and children with ASD (see Swanson, 2020; Bottema-Beutel & Kim, 2021, for review). Additionally, recent work suggests that parent speech during joint engagement (i.e., actively playing together with the same object) is particularly important for language learning in children with ASD (Bottema-Beutel, Yoder, Hochman, & Watson, 2014).

While joint engagement in young children with ASD has been well described (e.g., Adamson, Bakeman, Deckner, & Romski, 2009; Adamson, Bakeman, Suma, & Robins, 2019; Bottema-Beutel et al. 2014), no work to date has examined its development in infants with ASD prior to two years of age. One challenge in doing so is that the average age of ASD diagnosis is not until around 4 years (Baio et al., 2018). However, many studies have leveraged prospective designs to follow infants with an older sibling with autism, who have an elevated likelihood (EL)[1] of an ASD diagnosis themselves. Approximately one in five EL infants are diagnosed with ASD (Ozonoff et al., 2011) in comparison to recent estimates of 1 in 54 in the general population (Maenner, Shaw, & Baio, 2020). There is also substantial variability in the developmental outcomes of EL infants who are not on the autism spectrum (e.g. Charman et al., 2017). EL infants without ASD are more likely to have language delays compared to their peers with no family history of ASD (Drumm & Brian, 2013; Marrus et al., 2018). Thus, a nuanced picture of the developmental landscape of language learning for EL infants with a range of outcomes is crucial for informing targets for early intervention. In this research, we examine the dynamic interplay between joint engagement, parent labels, and language development for EL infants followed prospectively in the first three years of life in comparison to infants with no family history of ASD (typical likelihood; TL infants).

[1]While the field has traditionally referred to EL infants as "high risk" (HR), this terminology conveys a view that having an autism spectrum diagnosis is inherently negative. While many individuals with autism need substantial support, many also view their autism as a positive aspect of their identity (e.g., Kenny et al., 2016; Robison, 2019). We use the terms "elevated likelihood" (EL) and "typical likelihood" (TL) here in place of the stigmatizing language predominant in the medical model of autism.

Joint Attention and Joint Engagement in ASD

Joint attention is often defined by measures that assess discrete skills using structured tasks (i.e., whether an infant can use pointing and eye gaze to share attention to an object). Infants and children with ASD clearly experience challenges with these skills; they are among the earliest signs of diagnosis (e.g., Rozga et al., 2011). However, in real world interactions neurotypical infants rarely look at the parent's face prior to attending to the same object (Yu & Smith, 2013, 2016; Suarez-Rivera, Smith, & Yu, 2019), and individuals with ASD may engage with others in ways that are not captured in standard measures of joint attention (Akhtar & Gernsbacher, 2008; Jaswal & Akhtar, 2019).

Rather than assessing discrete skills, joint engagement (JE) reflects a dyadic process in which a child and social partner sustain active involvement with the same object during an interaction (Bakeman & Adamson, 1984; Adamson, Bakeman, & Deckner, 2004; Adamson et al., 2019). Adamson and colleagues distinguish two types of JE, which may shed light on how infants with ASD engage with social partners during play. One of these, *coordinated JE*, requires the infant to visually acknowledge (i.e., make eye contact with) the social partner. The other, *supported JE*, is a state in which the infant is actively involved with the same object as the social partner *without* making eye contact. Supported JE does not simply reflect the parent looking on and talking while the child plays alone with a toy – both must be actively engaged with and sustain a shared focus on an object, and the parent's involvement must influence the child's experience with the object (Adamson et al., 2004, 2009). However, in supported JE, the child does not look at the parent's face and make eye contact.

For infants with neurotypical development, supported JE accounts for a substantial portion of time in toy-play interactions throughout the first two years of life, while coordinated JE emerges by around 12 months of age and increases in frequency through the second year of life (Bakeman & Adamson, 1984). Two- to three-year-old children with ASD spend less time in coordinated JE compared to chronological age- and language-matched neurotypical peers, and they spend more time in object engagement (i.e., exclusively engaged with objects and not with the social partner; Adamson et al., 2009; 2019). Yet children with ASD spend a substantial proportion of parent-child toy play interactions in supported JE, in some cases on par with their neurotypical peers (Adamson et al., 2009; Bottema-Beutel et al., 2014). One study to date has examined JE in EL infants, reporting on measurement stability of a coding scheme for two subtypes of supported JE in 10 EL infants aged 7 to 17 months (Bottema-Beutel et al., 2019). However, to our knowledge, no prior work has examined the development of supported and coordinated JE in children with ASD prior to two years of age. To address this gap in the literature, the first aim of this study is to examine the distribution of time spent in engagement states (i.e., supported JE, coordinated JE, object engagement) during toy play with parents at 12 and 18 months of age in EL infants and their TL peers. We expected that neurotypically developing infants would increase time spent in coordinated JE, and that EL infants later diagnosed with ASD would spend less time in coordinated JE, more time in object engagement, and similar proportions of time in supported JE compared to their TL peers.

Parent Labels and Language Development

For neurotypical infants, it is well established that hearing more speech is associated with better language skills (e.g., Hart & Risley, 1995; Huttenlocher, Waterfall, Vasilyeva, Vevea, & Hedges, 2010; Rowe, 2008). Although multiple aspects of parent speech are related to children's linguistic development (e.g., Hirsh-Pasek et al., 2015; Rowe et al., 2012; 2017), many studies of neurotypical development have characterized how parents label objects. For example, a higher rate of parent labels regarding the child's focus of attention is associated with larger vocabularies (e.g., Baldwin, 1995; Tomasello & Farrar, 1986), and recent work suggests that parent labels in the context of neurotypical infants' sustained attention to an object (i.e., looks to an object for more than three seconds) are particularly beneficial for language learning (Yu, Suanda, & Smith, 2019). For young children with ASD, parents provide similarly rich input as parents of neurotypical children, and positive relations have been found between parent speech and later language skills (Haebig, McDuffie, & Weismer, 2013; Siller & Sigman, 2002; 2008). Labels from parents have also been shown to facilitate attention to novel objects for young children with ASD (McDuffie, Yoder, & Stone, 2006).

A growing body of research has examined various aspects of parent speech to EL infants (e.g., Choi, Nelson, Rowe, & Tager-Flusberg, 2020; Jakubowski & Iverson, 2019; Leezenbaum et al. 2014; Northrup & Iverson, 2015; Swanson et al., 2019; Talbott, Nelson, & Tager-Flusberg, 2016; Wan et al., 2012, 2013). Overall, these studies show that parents of EL infants provide similar rates of language input as parents of TL infants, and that parent input is positively related to language skills (see Swanson, 2020; Bottema-Beutel & Kim, 2021, for review). However, a few aspects of parent input differ in subtle ways. For instance, parents of EL infants are rated as more directive in their input than parents of TL infants, which may reflect adaptations in play style due to limited skills in their older children with ASD (Wan et al., 2012; 2013). Recent work also highlights the bi-directional nature of parent-child interactions (Choi et al., 2020; Swanson et al., 2019). For example, Choi et al. (2020) found that better language skills at 18 months predicted subsequent longer utterances from parents for EL infants, but not TL infants. Thus, while parent input is generally similar across groups, infants shape their communicative environments, and these early differences may have cascading effects on language learning (e.g., Adamson et al., 2020).

While parent labeling is well explored among parents of infants with neurotypical development, only a few studies have described parent labels to EL infants. For example, Talbott et al. (2016) show a trend for parents of infants later diagnosed with ASD to respond to a higher proportion of infant vocalizations with labels, and Leezenbaum et al. (2014) show parents of EL infants respond to a higher proportion of gives and requests with labels than parents of TL infants. Another study found a lower rate of parent labels to a small sample of EL infants without an ASD diagnosis compared to their TL peers (Jakubowski & Iverson, 2019). Prior work has shown that infants with ASD progressively diverge from their TL peers in receptive and expressive language in the second year of life (Franchini et al., 2018; Iverson et al., 2018; Longard et al. 2017), and these early differences may impact how parents label objects. However, to our knowledge, no studies to date have examined parent labels as a predictor of language skills for EL infants.

Joint Engagement, Parent Labels, and Language

Given that infants' abilities shape the communicative input they receive (Choi et al., 2020; Leezenbaum et al., 2014; Swanson et al., 2019), and that supported JE is a relative strength for young children with ASD (Adamson et al., 2009), investigating parent labels in the context of joint engagement may be particularly informative for interventions. We know from studies of neurotypical development that parent labels in the context of an infant's sustained attention to an object predict language (Yu et al., 2019). Further, parent speech appears to promote longer episodes of engagement for neurotypical infants (Suarez-Rivera et al., 2019). For children with ASD, parents are also more likely to provide input targeted to the child's focus of attention during periods of supported JE (Bottema-Beutel, Lloyd, Watson, & Yoder, 2018). However, parent labels and joint engagement have not been examined together in EL infants. Thus, a second aim of the present study was to characterize parent labels to EL infants and to explore relations between parent labeling and the proportions of time dyads spend in different engagement states, including supported and coordinated JE. Based on prior literature showing a tight coupling between supported JE and parent input for young children with ASD (Bottema-Beutel et al., 2018), we expected that parent labels about the child's focus would be positively associated with time spent in supported JE.

We also know that parent speech *within* supported JE predicts language skills the following year for neurotypically developing toddlers (Adamson et al., 2004; Trautman & Rollins, 2006) and for 2- to 4-year-olds with ASD (Adamson et al., 2009; 2019; Bottema-Beutel et al., 2014; Crandall et al., 2019). Additionally, children with ASD spend substantial proportions of interactions in object engagement rather than jointly engaging with parents (Adamson et al., 2009; Patterson, Elder, Gulsrud, & Kasari, 2014), yet we know little about parent speech in the context of object engagement. Parent training interventions with toddlers and preschoolers with ASD that specifically target JE have shown promising results; these studies show that following intervention, children increase time spent in JE and decrease time in object engagement (Gulsrud, Hellemann, Shire, & Kasari, 2016; Kasari, Gulsrud, Wong, Kwon, & Locke, 2010).

Thus, we have a growing understanding that parent speech during JE is supportive of language development for young children with ASD. However, parent-child interactions are a dynamic process that change throughout development (Adamson et al., 2020), and the interplay between joint engagement, parent labels, and language development has yet to be examined in the first two years of life for infants later diagnosed with ASD. Further, EL infants without ASD are also at increased risk of language delays (Marrus et al., 2018), but no studies to date have examined joint engagement and parent input to EL infants with non-ASD language delays. To address these gaps in the literature, the final two goals of the present study are to characterize parent labels in the context of JE, and to examine whether parent labels within engagement states predict language skills for EL infants with diverse outcomes and their TL peers. Based on prior work with young children with ASD, we expected that parent labels about the child's focus of attention would predict language skills, and that labels during supported JE would be particularly beneficial for language development across outcome groups (Adamson et al., 2009; Bottoma-Beutel et al., 2014).

The present study

In sum, the present study aimed to examine the interplay between joint engagement, parent labeling, and later language abilities in the first three years of life by addressing four questions: (1) How does joint engagement (JE) develop in infants with varied developmental outcomes? (2) How does parent labeling behavior relate to the proportions of time dyads spend in different engagement states, including supported and coordinated JE? (3) Does parent input *within* engagement states differ by age and developmental outcome? (4) How do parent labels overall and within object engagement, supported JE, and coordinated JE relate to language abilities in toddlerhood? To address these questions, we examined parent-infant interactions in the home at 12 and 18 months of age in four groups of infants: EL infants diagnosed with ASD (EL-ASD), EL infants who exhibited language delays but no ASD (EL-LD), EL infants who appeared to be developing typically (EL-ND), and infants with no family history of ASD (TL).

Methods

Participants

The present study included 43 EL infants (26 male) and 12 TL infants (8 male) from two larger longitudinal studies investigating communication and motor development. EL infants were recruited through a university autism research program, parent support organizations, local agencies and schools serving children with ASD. Prior to enrollment, the older sibling's ASD diagnosis was confirmed by a trained clinician using the Autism Diagnostic Observation Schedule (ADOS-G; Lord et al., 2000). TL infants were followed as part of a separate longitudinal study investigating motor development and were recruited through a university research registry and word of mouth. Infants from both groups had at least one older sibling, were from full-term, uncomplicated pregnancies, and came from English-speaking homes. Most infants were White (11 TL, 36 EL), the remaining were Hispanic (4 EL), Asian (1 EL), African American (1 EL), or multiracial (1 TL, 1 EL). Consistent with prior research (e.g., Croen, Najjar, Fireman, & Grether, 2007), mothers and fathers of EL infants were significantly older than mothers and fathers of TL infants (ps < 0.05). There were no likelihood status or outcome group differences in infant sex or parent education (ps $> .35$), with most parents having completed some college or greater (see Table 1 for demographics by outcome group, described below).

Procedure

Infants in the EL group were observed during monthly home visits from 5–14 months of age, with follow-up visits at 18, 24 and 36 months. Infants in the TL group were observed every other week from 2.5 months until one month after onset of independent sitting, with follow-up visits at 12, 18, 24, and 36 months. At each visit for both groups, the infant was videotaped in the home completing several procedures as part of the larger study, including a brief toy play with a primary caregiver that is the focus of the present study.

The present study uses data collected at the 12- and 18-month visits, as these ages span the period when coordinated JE begins to emerge in neurotypical development (Bakeman

& Adamson, 1984). At each of these visits, a 3- to 6-minute segment was video-recorded, during which the parent and infant were given a standard set of age-appropriate toys (teddy bear, brush, washcloth, cup, spoon, bowl) and asked to play on the floor together as they normally would. The infant wore a cloth vest holding a microphone to enhance audio recordings. The parent participating in the toy play observation was consistent across visits for 52 infants (48 mothers, 4 fathers); for three infants, mother participated at one visit and father at the other due to visit scheduling constraints.

Inclusion criteria for the present study required that TL and EL infants had a complete parent-child toy play observation at both the 12- and 18-month visits, and that EL infants had a complete outcome evaluation (described below). This excluded 7 additional EL infants from the larger longitudinal studies who withdrew or were lost to follow-up prior to outcome evaluation. An additional 15 infants (5 TL, 10 EL) were excluded because they did not have a complete toy play observation at both visits due to a missed visit, no parent-child toy play was collected at one of the visits, or there were problems with the recording (e.g., audio quality insufficient to hear parent speech).

Language Measures

The MacArthur-Bates Communicative Development Inventory (CDI) is a parent-report measure of communication widely used with both typically and atypically developing populations (e.g., Fenson et al., 1993; Mitchell et al., 2006). The CDI has high levels of internal consistency, test-retest reliability, and validity with experimenter-administered measures (Fenson et al., 1994). Parents completed the CDI-I at 12 months, the CDI-II at 18 and 24 months, and the CDI-III at 36 months. The CDI-I includes a vocabulary checklist in which parents are asked to indicate words their child understands and says, while the CDI-II and CDI-III include checklists for words the child says. Age and sex-normed CDI percentile scores for Words Produced from the 24- and 36-month visits contributed to a composite measure of language ability in toddlerhood.

Participants also completed the Mullen Scales of Early Learning (MSEL; Mullen, 1995) at 12, 18, 24, and 36 months. The MSEL is a standardized experimenter-administered assessment of cognitive functioning designed for infants and young children. It is widely used in EL sibling studies (e.g., Jones et al., 2014) and has good convergent validity with other measures (Bishop, Guthrie, Coffing, & Lord, 2011). The MSEL Receptive Language and Expressive Language T-scores from the 24-, and 36-month visits contributed to a composite measure of language in toddlerhood.

To create a composite measure of language ability in toddlerhood (denoted as “Toddler Language” in the results), we standardized into z-scores and averaged together the CDI Words Produced percentile scores, the MSEL Receptive Language T-scores, and the MSEL Expressive Language T-scores from the 24- and 36-month visits. One TL infant was not included in the composite measure due to withdrawal from the study prior to 24 months. A high level of internal consistency for this composite measure was found in prior studies (Northrup & Iverson, 2015), and in the present sample (Cronbach’s alpha = .866).

Outcome classification

While TL infants did not receive a formal diagnostic evaluation, a primary caregiver completed the M-CHAT-R/F (Modified Checklist for Autism in Toddlers; Robins, Fein, & Barton, 2009) at 18 and 24 months. One infant did not have M-CHAT data at either age; the remainder scored negative for ASD. Two of 14 TL infants with complete 12- and 18-month toy play observations met criteria for language delay (defined below) and were excluded from the present study, leaving a sample of 12 TL infants.

EL infants completed the ADOS-G (Lord et al., 2000) and were classified into one of three mutually exclusive outcome categories: Autism Spectrum Disorder (ASD), Language Delay without ASD (LD), and No Diagnosis (ND), defined as follows:

EL infants received an ASD diagnosis (EL-ASD) if they met or exceeded ADOS-G algorithm cutoffs for ASD[2] and had this confirmed using DSM-IV-TR criteria (data were collected prior to the release of DSM-5) by a trained clinician naive to previous study data. Using these criteria, 12 EL infants (9 male) were diagnosed with ASD. All EL-ASD infants had complete toy play observations at 12 and 18 months and were included in the present study. The recurrence rate for ASD in the larger study was 16.44% (12 of 73 infants with outcome evaluations).

Infants were classified with Language Delay (LD) if they *were not* diagnosed with ASD and either (1) had standardized CDI scores at or below the 10th percentile at more than one administration between 18 and 36 months (Heilmann, Weismer, Evans, & Hollar, 2005); and/or (2) had standardized CDI scores at or below the 10th percentile *and* standardized MSEL receptive and/or expressive language scores greater or equal to 1.5 standard deviations below the mean at 36 months (e.g., Ozonoff et al., 2010). Using these criteria, 22 EL infants (13 male) were classified as LD; 17 of these infants (10 male) had complete toy play observations at both 12 and 18 months and were included in the present study.

The remaining 39 EL infants (20 male) who completed the study were classified as having No Diagnosis (EL-ND). Thirty-four EL-ND infants had complete toy play observations at 12 and 18 months. As is common in studies of EL infants, power is limited by the small sample of EL-ASD infants (n=12). To reduce coder burden while retaining maximal power of an approximately equal sample per group, 14 (7 male) of these 34 EL-ND infants were randomly selected for inclusion by an individual not otherwise involved in the study.

To characterize each outcome group, descriptive statistics and group comparisons at 12, 18, 24, and 36 months are reported in Table 2, including Receptive and Expressive Language from the CDI and MSEL, and Visual Reception from the MSEL, which is considered a measure of non-verbal cognitive ability (e.g., Bishop et al., 2011). Consistent with prior work, the second year of life marks a period in which EL-LD and EL-ASD infants

[2]EL infants were evaluated at 36 months with the exception of one EL infant who was evaluated at 24 months of age and received an ASD diagnosis prior to withdrawing from the study. This participant is included in analyses.

progressively diverge in their receptive and expressive language abilities compared to their TL and EL-ND peers (Franchini et al., 2018; Iverson et al., 2018; Longard et al., 2017).

Coding of parent-child interaction

Video recordings of the parent-child toy play interactions at 12 and 18 months were coded using a time-linked multimedia annotation program (ELAN; Brugman & Russel, 2004). Coding was completed by the first author, who was naive to outcome classification, and four additional coders (two trained to reliability criteria on each coding scheme, described below) who were naive to familial likelihood status, outcome, and study hypotheses.

The entire toy-play observation was coded into mutually exclusive engagement states, such that the end of one code signified the beginning of another code, using a coding scheme developed by Adamson and colleagues (Bakeman & Adamson, 1984; Adamson et al., 1998; 2004; 2009). Engagement states included *unengaged, object engagement, supported JE*, *coordinated JE,* and *other;* these are described in Table 3. To avoid micro-coding very brief fluctuations in attention, a 3-second rule was applied. Thus, if the child briefly looked away from the interaction for less than three seconds towards another object, towards an accidental noise from the recording assistant, or another brief fluctuation, this was not coded as changing engagement state. However, if there was a clear switch from one behavioral state to another for more than 3 seconds, that fluctuation was coded (i.e. if the child is in supported JE, wanders away for 5 seconds, then enters supported JE again, that was coded as unengaged between two episodes of supported JE; Adamson et al., 2004).

An additional coding scheme was used to classify parent verbal input. All *parent utterances* across the toy-play observation were coded, with the boundary between utterances defined by a change in intonation, a pause or a breath in speech, and/or a change in subject. Utterances were coded as *object of focus* if they clearly referred to and/or described a distinct object or event in the immediate environment that the child attends to within a period extending two seconds before and/or after the utterance. Utterances were further classified as *parent labels* regarding the child's object of focus if they included a noun that clearly named that object or a part of that object (e.g., "Aww you found the *teddy bear";* "brush his *hair").* Utterances were considered *uncodable* if the coder was unable to classify the utterance due to poor sound quality or if the camera angle did not provide an adequate view of the child's focus.

To assess inter-coder reliability, 22% of the observations (n=24) were independently coded by the first author and a secondary coder. Reliability sessions were chosen at random with the constraint that each outcome group and age was equally represented. For engagement states, reliability was assessed by creating one-second bins for each video and calculating Cohen's kappa on the number of matching bins between two coders, with a one-second tolerance window. Using this procedure, coders were trained to a criterion of a Cohen's kappa of at least 0.70 (considered good to excellent agreement; Fleiss et al., 1981) for three consecutive videos prior to independent coding. Mean Cohen's kappa for engagement state (7 possible codes; all categories including two in "other" were retained for reliability calculations) was 0.75 (range 0.63 to 0.92 for the 24 reliability sessions). Disagreements were resolved through discussion, and three videos with low reliability (Cohen's kappa

< 0.70) were coded by consensus. For parent verbal input coding, coders were trained to a criterion of at least 85% agreement on identification of utterances and at least a 0.70 Cohen's kappa for categorical variables on three consecutive videos. Mean percent agreement for identification of utterances was 92.5% (range: 80–97.1%). Mean Cohen's kappa was 0.87 (range 0.63 to 1.0) for determining whether or not the utterance included a label.

Data Reduction and Preliminary Analyses

Due to the nature of the larger study protocol, observations lasted at least 3 minutes but varied somewhat in duration, (12 months: $M = 4.40$, $SD = 0.96$; 18 months: $M = 4.17$, $SD = 0.62$), and TL infants had significantly longer observations than EL-ND and EL-ASD infants at 12 months (ps < 0.05). The proportions of each observation considered uncodable were examined in a repeated measures mixed ANOVA; there was no significant effect of age (12 and 18 months) or outcome (TL, EL-ND, EL-LD, and EL-ASD). Thus, uncodable segments were excluded from analyses, such that engagement variables were calculated as proportions of the total observation duration minus the duration of uncodable segments. Parent input variables were calculated as rates per minute; rates of input within engagement states were calculated by dividing the numbers of utterances or labels delivered within each engagement state by the total time (in minutes) spent in that engagement state.

Due to group differences in parent age, all parent input analyses were conducted with and without mean parent age included as a covariate (i.e., ANCOVAs and regressions). The pattern of results was the same, so analyses are reported without co-varying parent age for ease of interpretation of coefficients. As noted above, a mother participated at one visit and father at the other for three infants (1 EL-ND, 1 EL-LD, 1 EL-ASD); these three infants were excluded from analyses examining change in parent input from 12 to 18 months.

Analytic Plan

The first goal of this study was to examine the development of engagement states across outcome groups. Data were examined for violations of assumptions of normality and homoscedasticity; visual inspection of the engagement state data using Q-Q plots revealed significant positive skew and kurtosis. Therefore, non-parametric statistics (i.e., Kruskal-Wallis tests) were used to examine group differences of the proportions of time spent in each engagement state at 12 and 18 months, with Bonferroni corrections applied for multiple comparisons.

Our second and third goals were to explore how parent labels relate to time in engagement states and to characterize parent input across age and outcome group. Positive skew was revealed in 12-month parent labels in coordinated JE and 12- and 18-month parent labels in object engagement. Relevant analyses were performed with data square root transformed and the pattern of results was identical; results from untransformed data are reported for ease of interpretation. Pearson's correlations were used to examine associations between parent input variables and time in engagement states. A series of 2 (age) x 4 (outcome) repeated measures mixed ANOVAs was conducted to examine the rates of parent utterances and parent labels in the overall observation and within engagement states. Bonferroni corrections were applied to correct for multiple comparisons.

Finally, a series of multiple linear regressions was conducted to examine the relation between parent input variables as predictors of Toddler Language (a composite measure of language ability at 24- and 36- months of age), with concurrent Expressive Language (MSEL T-scores) included as a covariate and outcome classification as a moderator, and with TL infants as a reference group. Where significant interactions emerged between a group of EL infants and the reference group of TL infants, post-hoc analyses were conducted to examine the relation between parent labels and Toddler Language for that group by rotating the reference group.

Results

The present study examined joint engagement, parent labeling, and later language ability in infants later diagnosed with ASD (EL-ASD), infants with non-ASD language delays (EL-LD), EL infants who appear typically developing at 36 months (EL-ND), and infants with no family history of ASD (TL). The goals were to: (1) examine the development of supported and coordinated JE, as well as time spent engaged with objects and unengaged, in infants with varied developmental outcomes; (2) explore how parent labeling behavior relates to the distribution of time dyads spend in different engagement states; (3) characterize parent labels during engagement states across age and developmental outcome; and (4) determine whether parent labeling overall and within engagement states predicts language abilities in toddlerhood. Results for each of these study goals will be presented in turn.

How does joint engagement develop in infants with varied developmental outcomes?

Means and standard errors for the proportions of time spent in each engagement state (unengaged, object engagement, supported JE, and coordinated JE) by age and outcome group are displayed in Figure 1. Based on prior work with young children with ASD (Adamson et al., 2009), we expected that EL infants later diagnosed with ASD would spend more time in object engagement, similar proportions of time in supported JE, and less time in coordinated JE compared to their TL peers.

As shown in Figure 1a, EL infants spent less time unengaged than their TL peers at 12 months of age ($H(3) = 20.5$, $p < 0.001$). Pairwise comparisons with a Bonferroni correction applied for multiple comparisons revealed significant differences between TL infants and their EL-ND and EL-ASD peers (*p*s < 0.01). By 18 months (Figure 1b), only EL-ND infants spent significantly less time unengaged than TL infants ($p = 0.028$).

With regard to object engagement, all EL groups spent nearly a third of the interaction in this engagement state at 12 months of age (Figure 1c). Differences between groups were revealed at 12 ($H(3) = 9.25$, $p = 0.026$) but not 18 months (Figure 1d; $H(3) = 3.37$, $p = 0.338$), with Bonferroni-corrected pairwise comparisons demonstrating that EL-ND infants spent significantly more time in object engagement than their TL peers at 12 months ($p = 0.03$). There was also a trend for EL-ASD infants to spend more time in object engagement than TL infants at 12 months, though this difference was not significant ($p = 0.078$).

Based on prior work with young children and toddlers with ASD (e.g., Adamson et al., 2009), we expected EL and TL infants, regardless of 36-month outcome, to spend substantial proportions of toy play interactions in *supported* JE, a state in which the parent and infant are actively involved with the same object *without* eye contact. This prediction was supported by the data; although there was a high degree of variability, infants spent on average 26–43% of the observation in supported JE (Figure 1e and 1f), with slight increases from 12 to 18 months apparent in the TL, EL-ND, and EL-LD groups. Consistent with hypotheses, the proportions of time spent in supported JE did not differ across groups at either 12 (H(3) = 3.03, $p = 0.388$) or 18 months (H(3) = 4.77, $p = 0.190$).

Based on a large body of work examining joint attention and coordinated JE in toddlers with and without ASD and in EL infants (e.g., Adamson et al., 2009; Rozga et al., 2011; Sullivan et al., 2007), we expected EL-ASD infants to spend less time in coordinated JE (a state in which infants and parents are actively involved with the same object *and* make eye contact) compared to their neurotypically developing peers. It is important to note that there was substantial variability in time spent in coordinated JE, with 24 infants spending *no* time in this engagement state at one or both time points, including infants in each outcome group.[3] As can be seen in Figure 1g, across outcome groups, infants spent similar proportions of time on average (approximately 14–18%) in coordinated JE at 12 months. By 18 months (Figure 1h), TL and EL-ND infants spent approximately 25% of the observation in coordinated JE, while both the EL-LD and EL-ASD groups remained low and stable across time. However, differences across outcome groups were not significant at either 12 (H(3) = 1.11, $p = 0.776$) or 18 months (H(3) = 2.91, $p = 0.405$).

How does parent labeling relate to time spent in object engagement and joint engagement?

The second goal of this study was to characterize overall parent verbal input in relation to time spent in object engagement, supported JE, and coordinated JE. Descriptive statistics for rates of parent input (i.e., total and labeling utterances per minute) are reported in Table 4. Based on prior literature (e.g., Choi et al., 2020; Leezenbaum et al., 2014; Swanson et al., 2019), we expected that overall parent input would be similar across outcome groups. While there was substantial individual variability in the rates of parent input, ranging from 0 utterances across the observation to 27 utterances per minute, repeated measures mixed ANOVAs revealed no significant effects of age or outcome and no significant interactions for parent utterances and parent labels in the overall observation.

As shown in Figures 2a and 2b, infants who spent more time in object engagement (i.e., focused solely on objects and not jointly engaged with the parent) received lower rates of labels throughout the observation at 12 months (Pearson's $r = -0.374, p < .01$), but not 18 months ($r = -0.003$, $p = .981$). Based on prior literature showing that parent utterances regarding the child's focus elicit supported JE (Bottema-Beutel et al. 2018), we expected that the rate of parent labels across the overall observation would be positively associated

[3]Four infants (one in each outcome group) spent 0% of the observation at *both* 12 and 18 months in coordinated JE. An additional 8 infants (2 TL, 2 EL-ND, 0 EL-LD, 4 EL-ASD) at 12 months and 12 infants (1 TL, 2 EL-ND, 7 EL-LD, 2 EL-ASD) at 18 months spent 0% of the observation in coordinated JE.

with time spent in supported JE. Consistent with this hypothesis, infants who spent more time in supported JE received higher rates of labels throughout the observation at both 12 and 18 months (see Figures 2c and 2d; *r*s = 0.569, 0.288, *p*s < 0.05). While time in supported JE was positively related to parent labeling, time in coordinated JE was not. As shown in Figures 2e and 2f, parents provided a similar rate of labels throughout the observation regardless of time spent in coordinated JE (*r*s = −.083 and −.053 for 12 and 18 months respectively, *p*s > .50).

Does parent input within engagement states differ by age and developmental outcome?

The third goal of this study was to characterize parent verbal input *within* object engagement, supported JE, and coordinated JE. Descriptive statistics for parent input within engagement states are reported in Table 4; as noted above, three infants who did not have the same parent participate at both sessions were excluded from analyses examining parent input across age and outcome. Based on prior literature showing similarly rich linguistic input from parents for EL and TL infants (Swanson, 2020), we expected rates of input would be comparable across groups.

As shown in Table 4, parents provided similar rates of utterances and labels in object engagement at 12 and 18 months, with approximately 14 to 17 utterances and 3 to 5 labels on average per minute. Repeated measures mixed ANOVAs showed no significant effects of age, outcome, or interactions for parent utterances or labels in object engagement. Parents also provided similar rates of utterances and labels in supported JE across outcome groups at 12 and 18 months, with approximately 16 to 21 utterances and 4 to 7 labels on average per minute. No significant effects of age, outcome, or interactions emerged for parent utterances or labels in supported JE.

As noted above, a substantial portion of the sample spent no time in coordinated JE at either 12 months, 18 months, or both. Thus, rates of parent input *within* coordinated JE could only be calculated for infants who spent *some* time in coordinated JE. As shown in Table 4, parents provided on average 15 to 23 utterances and 3 to 7 labels per minute in coordinated JE. For parent utterances in coordinated JE, no significant effects emerged for age, outcome, or interaction between the two. However, for parent labels during coordinated JE, there was a main effect of age ($F(1,26) = 9.375$, $p = .005$), which was qualified by a significant age by outcome interaction ($F(3,26) = 22.787$, $p = .026$). As shown in Figure 3, parents of EL-ASD infants increased in the rate of labels they provided during coordinated JE from 12 to 18 months. Paired samples t-tests confirmed a significant increase in parent labels to EL-ASD infants ($p = .005$) and a trend for EL-LD infants ($p = .066$), but not for TL or EL-ND infants (*p*'s > .58).

Prior work has suggested that child language ability shapes the input received from parents (e.g., Fusaroli, Weed, Fein, & Naigles, 2019; Vigil, Hodges, & Klee, 2005), and consistent with prior studies (e.g., Franchini et al., 2018; Iverson et al., 2018), EL-LD and EL-ASD infants were beginning to differ in their expressive language skills by 18 months (Table 2). Thus, when considering increases in parent labeling behavior within coordinated JE, it may be important to consider the extent to which time spent in coordinated JE corresponds with concurrent language abilities. To examine this, we examined a post-hoc correlation between the proportion of time in coordinated JE at 18 months and concurrent expressive language scores on the MSEL. This relationship was positive ($r = 0.353$, $p = .008$), suggesting that some infants with lower expressive language skills tend to spend minimal time in coordinated JE. Thus, it may be that when infants beginning to show delays *do* spend time in coordinated JE, these salient moments are replete with labels from their parents.

How do parent labels overall and within engagement states relate to language in toddlerhood?

The final goal of this study was to examine parent labels in relation to language abilities in toddlerhood, and to test whether labels were positively associated with later language across outcome groups. Based on prior work, we expected parent input overall and during supported JE to be positively related to language ability in toddlerhood for infants with varied developmental outcomes (Adamson et al., 2009; Adamson et al., 2019, Bottema-Beutel et al., 2014, Swanson, 2020; Trautman & Rollins, 2006).

A series of four multiple linear regressions was completed with 12-month parent labels in the overall observation, object engagement, supported JE, or coordinated JE as predictors of Toddler Language, with concurrent expressive language (12-month MSEL expressive language T-scores) as a covariate. TL infants served as the reference group and outcome classification (EL-ND, EL-LD, EL-ASD) was added as a moderator. At 12 months, neither parent labels during the overall observation, nor in object engagement, supported JE, or coordinated JE predicted Toddler Language, and there were no significant interactions.

Four additional multiple linear regressions were completed with 18-month parent labels overall and in each engagement state as predictors of Toddler Language, in the same manner as above with TL infants as the reference group. Again, concurrent expressive language (18-month MSEL expressive language T-scores) was included as a covariate. [4] Results are presented in Table 5, and the moderation between outcome groups for each variable is displayed in Figure 4. Contrary to hypotheses, parent labels during supported JE were not positively associated with Toddler Language for any outcome group (Figure 4c). However, for TL infants, parent labels during the overall observation ($B = 0.156$, $p < 0.05$; Figure 4a), during object engagement ($B = 0.080$, $p < 0.05$; Figure 4b), and during coordinated JE ($B = 0.115$, $p < 0.05$; Figure 4d) positively predicted Toddler Language.

While there were positive associations between 18-month parent labels and Toddler Language for TL infants, this was not the case for EL infants. As can be seen in Figure 4, the relation between parent labels overall and in each engagement state appeared relatively flat for EL-ND infants, with a significant interaction compared to TL infants for parent labels in object engagement (Figure 4b). A post-hoc analysis rotating the reference group showed that there was not a significant association between parent labels during object engagement and Toddler Language for EL-ND infants ($B = -0.021$, $p = 0.475$). For EL-LD

[4]For both the 12-month and 18-month regressions, analyses were performed with and without controlling for concurrent expressive language. The pattern of results for each model was the same, with two exceptions: when concurrent language was not included for 18-month labels in the overall observation and for 18-month labels in coordinated JE, the EL-ND interaction terms were also significant (ps < 0.05). Additionally, post-hoc analyses rotating the reference group with and without concurrent language were equivalent unless otherwise specified, and results are presented throughout with concurrent expressive language in the model.

infants, a similarly flat pattern emerged, apart from an apparent negative association between parent labels in coordinated JE at 18 months and Toddler Language (Figure 4d). This was confirmed by a significant interaction compared to TL infants ($p < 0.01$), though a post-hoc analysis rotating the reference group showed that this negative trend for EL-LD infants was not significant ($B = -0.078$, $p = 0.095$).

As is also evident in Figure 4, there appeared to be a negative association between 18-month parent labels in the overall observation and Toddler Language for EL-ASD infants, with a similar pattern for EL-ASD infants across engagement states. Significant interaction terms showed that the relationship with Toddler Language differed between TL infants and EL-ASD infants for parent labels in the overall observation, in object engagement, and in coordinated JE (p's < 0 05). Notably, analyses with EL-ASD as the reference group *without* concurrent language as a covariate showed significant *negative* relations between parent labels and Toddler Language for EL-ASD infants (overall observation: $B = -0.155$, $p = 0.001$; object engagement: $B = -0.086$; $p = 0.017$; supported JE: $B = -0.070$; $p = 0.029$; coordinated JE: $B = -0.068$; $p = 0.042$). Thus, infants with ASD who had the lowest language scores in toddlerhood tended to receive the highest rate of labels at 18 months of age. However, when including concurrent expressive language in the model, only parent labels in the overall observation at 18 months remained a significant negative predictor of Toddler Language for EL-ASD infants (Figure 4a; $B = -0.111$, $p = 0.026$).

Discussion

Prior work has examined joint engagement, parent input, and language in young children with ASD (Adamson et al., 2009; 2019, Bottema-Beutel et al. 2014; 2018), and a growing body of research is beginning to characterize parent speech and language abilities in EL infants (Swanson, 2020). However, to our knowledge, no studies to date have examined joint engagement in children with ASD younger than two years of age. The present study represents a first step in describing the dynamic interplay between joint engagement, parent labels, and language outcomes at 12 and 18 months of age for EL infants. Systematic observation was used to characterize toy play observations in the home between parents and their infants with a range of developmental outcomes, including ASD and non-ASD language delays.

Consistent with predictions, supported JE was prevalent in interactions regardless of developmental outcome. EL infants tended to spend more time playing alone with objects than TL infants, but contrary to hypotheses, they did not differ significantly in time spent in coordinated JE. However, the moment-to-moment dynamics of these engagement states differed between groups. While parents across groups generally provided similar rates of input, of those who spent time in coordinated JE, parents of EL-ASD infants, and to a lesser extent, EL-LD infants, increased the labels they provided during coordinated JE from 12 to 18 months. Further, higher rates of labels from parents predicted better language skills in toddlerhood for TL infants, but not for EL infants, with effects in the opposite direction for infants later diagnosed with ASD. A summary of key findings is presented in Table 6, and each of these findings is discussed in turn below.

Supported JE is prevalent in parent-child interactions regardless of developmental outcome

Consistent with studies of older toddlers with ASD (Adamson et al., 2009; Bottema-Beutel et al., 2014; 2018), infants and their parents spent close to a third of toy play observations in supported JE regardless of developmental outcome. Also consistent with prior studies of neurotypical development (Adamson et al., 2004; Bakeman & Adamson, 1984), time spent in supported JE appeared relatively stable across the second year of life. Further, more time spent in supported JE was associated with higher rates of labels from parents throughout the observation at both 12 and 18 months. While EL infants tended to spend more time in object engagement at 12 months (and more time in object engagement was associated with fewer labels from parents), differences between groups in object engagement were attenuated by 18 months. Prior studies have consistently shown 2- to 4-year-old children with ASD to spend less time in coordinated JE (Adamson et al., 2009; 2019), an engagement state that requires the child to coordinate between people and objects and make eye contact with the social partner. However, significant differences did not emerge between groups of infants in the present study, and there was a wide range of individual variability, with many infants spending no time in coordinated JE at one or both time points.

Together, these findings extend prior research on young children with ASD to provide a picture of the development of JE and object engagement in the second year of life. The trend for EL-ASD infants to spend more time in object engagement at 12 months of age is consistent with prior work showing that infants and toddlers later diagnosed with ASD are less engaged with social partners (Campbell et al., 2018; Jones & Klin, 2013; Chawarska, Macari, & Shic, 2013). Interestingly, EL-ND infants also spent more time than their TL peers in object engagement, suggesting a propensity for EL infants as a group to spend more time engaged with objects than people at 12 months of age.

TL and EL-ND infants tended to increase time spent in coordinated JE from 12 to 18 months while EL-LD and EL-ASD infants did not, and the lack of significant differences between groups in this state was surprising. It may be that over time, infants later diagnosed with ASD diverge as their neurotypical peers continue to gain joint attention skills over the second year of life, but these differences are not yet apparent by 18 months. Further, the variability across groups and the fact that even some TL and EL-ND infants spent no time in coordinated JE highlights the importance of examining eye contact in contexts beyond structured lab settings. The relatively small proportion of interactions spent in coordinated JE is consistent with prior work with 18-month-old neurotypical toddlers (e.g., 16–27% in coordinated JE; Adamson et al., 2004; Bakeman & Adamson, 1984). Additionally, a growing body of work with neurotypical infants suggests that eye contact is not prevalent in early parent-infant interactions, and that infants use a variety of multimodal cues to share attention with social partners (Yu & Smith, 2013; Suarez-Rivera et al., 2019). Thus, further research with EL infants is needed to explore the variety of cues that may be used to share attention in naturalistic interactions (Jaswal & Akhtar, 2019).

Parents of EL-ASD infants increase the rate of labels provided during coordinated JE

Consistent with prior work examining parent speech with EL infants (see Swanson, 2020, for a review), parents across outcome groups generally provided similar rates of labels in the overall observation. They also provided similarly rich input within supported JE and object engagement. However, for infants who spent some time in coordinated JE, differences in parent input emerged between groups over time. Specifically, parents of EL-ASD infants, and to a lesser extent, parents of EL-LD infants, showed an increase in the rate of labels they provided in coordinated JE from 12 to 18 months. Further, infants who spent less time in coordinated JE at 18 months tended to have lower concurrent expressive language scores. Thus, while coordinated JE makes up only a small portion of interactions across groups, it may be that when infants who are beginning to show communicative delays *do* look up and make eye contact, parents take notice and fill these salient moments with labels.

Diverging associations between parent labels and language skills in toddlerhood

Finally, contrary to expectations, parent labels in supported JE did not predict better language abilities in toddlerhood, either for TL infants or for any EL outcome groups. Rather, the overall rate of parent labels at 18 months predicted language scores for TL infants, as did the rate of parent labels in coordinated JE and in object engagement. It is possible that supported JE in these brief toy play interactions is more parent-driven, as parents are scaffolding and directing the interactions in this engagement state (Adamson et al., 2019). However, it may be that as TL infants begin to develop more advanced communicative skills, labels provided within child-driven contexts become more important. Consistent with this idea, varying aspects of parent input relate to language skills at varying points in development (Rowe, 2012), and it may be that the role of labels in different engagement states change with the child's abilities as well. For example, a label targeted to the child's focus just as they are pretending to feed a teddy bear on their own in object engagement, or looking up and showing their parent an interesting toy in coordinated joint engagement, may be more tightly coupled with the child's interests and provide key moments to expand their rapidly growing vocabulary.

While higher rates of parent labels predicted better language outcomes for TL infants across several engagement states, this was not the case for EL infants. In fact, the opposite pattern emerged for EL infants later diagnosed with ASD: a higher rate of labels provided to these infants was associated with *lower* language skills later in toddlerhood, and a similar but non-significant trend emerged for EL-LD infants. However, these negative associations were somewhat attenuated when controlling for concurrent language abilities. Consistent with prior studies (e.g., Franchini et al., 2018; Iverson et al., 2018), EL-ASD and EL-LD infants scored lower than their TL peers on measures of expressive language as early as 18 months. Thus, it is possible that these parents, who already have an older child with ASD, are picking up on delays in the second year of life and adapting their input, providing *more* labels (particularly in salient moments of coordinated JE) to help their infants "catch up". Consistent with this idea, Bani Hani, Gonzalez-Barrero, and Nadig (2013) found that preschoolers with ASD who had the lowest language scores received the most labels from parents in a structured task 6 months later, suggesting that parents may be consciously or unconsciously ramping up their label input to facilitate attention to objects. Further, child language ability for EL infants and young children with ASD predicts complexity of input from parents in subsequent months, suggesting that parents of children with ASD adapt their input to their child's abilities (Choi et al., 2020; Fusaroli et al., 2019). Thus, the present study expands on literature showing that early differences in infant abilities shape the dynamic exchange between infants and their parents, and may lead to alterations in their communicative environments (e.g., Adamson et al., 2020; Iverson & Wozniak, 2016).

Limitations and Future Directions

A strength of the present study is its use of in-home observations – parent-child toy play sessions like those in which infants spend much of their time and are presumably quite comfortable. However, this approach does come with some limitations. While dyads were given a standard set of toys to play with, there is substantial variation in how infants and their parents played together – infants laid on the floor, sat in parents' laps, brought toys over to coffee tables and couches, and at times, tried to run off to another room or to a preferred toy of their own. Surprisingly, TL infants spent significantly more time unengaged than EL infants at 12 months. Many studies of parent-child interactions place infants sitting across from a social partner in a lab, but it may be that TL infants and their parents spend their time differently when observed in less structured, familiar environments. These findings would benefit from replication with a larger sample and more controlled settings, though home observations provide ecologically valid insights to how infants interact in everyday activities (e.g., Delehanty & Wetherby, 2021).

A second limitation of the current study is the relatively brief nature of the toy play observations. While many of these interactions were rich with input (i.e., several infants heard well over 100 parent utterances in a 5-minute observation), they are only a brief window into everyday interactions between infants and their parents with a small set of toys. Recent work with neurotypical infants shows that short video recordings represent "peak" periods of parent speech heard over the course of a day (Bergelson, Amatuni, Dailey, Koorathota, & Tor, 2019). In other words, infants hear 2–4 times more nouns per minute in one-hour video observations than in day-long audio recordings. The current findings must be considered with this in mind, and longer observations may be necessary to get a full picture of the communicative environment. Swanson et al. (2019) collected day-long home recordings with EL infants and found that adult word counts positively predicted language across groups. Thus, while high rates of labels were negatively related to language for EL infants later diagnosed with ASD in the present study, this may not translate to rates of input heard over the course of a day. Finally, as is common in work with EL infants, power was limited by a small sample of EL-ASD infants. Several infants across outcome groups spent no time in coordinated JE (perhaps in part due to the brief nature of the observation), yielding an even smaller sample for analyses related to parent input in coordinated JE. Therefore, findings should be replicated with a larger sample and longer observations.

Conclusions and Clinical Implications

While an extensive range of ASD literature has focused on deficits in joint attention and eye contact (e.g., Charman, 2003; Dawson et al., 2004; Jones, Carr, & Klin, 2008; Rozga et al., 2011), work with neurotypical infants has shown that eye contact is not prevalent in parent-child interactions with toys (e.g. Yu & Smith, 2013). The present findings are consistent with this work, with coordinated JE accounting for a small proportion of toy play interactions across outcome groups. In fact, some TL and EL-ND infants spent no time in coordinated JE at all. Supported JE, on the other hand, was prevalent across groups, and *all* infants spent at least some time in this state at both 12 and 18 months. Thus, supported JE may be a strength to build on for interventions with toddlers showing early signs of autism. In fact, interventions for young children with ASD have targeted joint engagement (including both coordinated and supported JE) using a parent-training model, with promising outcomes in improving joint attention skills, increasing time in JE, and decreasing time in object engagement (e.g., Kasari et al. 2010).

However, interventions for toddlers with ASD have had mixed effects with regard to specific improvements in child language (e.g., Green et al., 2017; Siller, Hutman, & Sigman, 2013; Pickles et al., 2016). The present study highlights the importance of taking a developmental perspective and considering the bi-directional nature of parent-child interactions. Higher rates of parent labels regarding the child's focus did not predict better language outcomes for EL infants, and appeared to be negatively related to language for infants later diagnosed with ASD, though this was attenuated when controlling for concurrent language abilities. It may be that providing too many labels in a brief period is an overload for those already showing delays, but that toddlers with *some* language may be able to utilize this input more effectively. EL-LD infants showed similar (if somewhat attenuated) patterns as their EL-ASD peers, with trends for increased parent labels within coordinated JE and negative associations between these labels and language. Recent meta-analyses show that in addition to an elevated likelihood of ASD, EL infants are more likely than their TL peers to have non-ASD language delays that may persist beyond the toddler years (Marrus et al., 2018; Roemer, in press), highlighting the need to monitor EL infants for language delays in addition to symptoms of ASD. Future work should build on strengths for EL infants, considering how to utilize existing moments of supported JE and object engagement by exploring what aspects of parent input in these contexts, at what points in development, *are* most effective for language learning. By examining everyday interactions in the first two years of life, we can inform and develop targeted early interventions and begin to understand how parents and their infants together shape the communicative environment.

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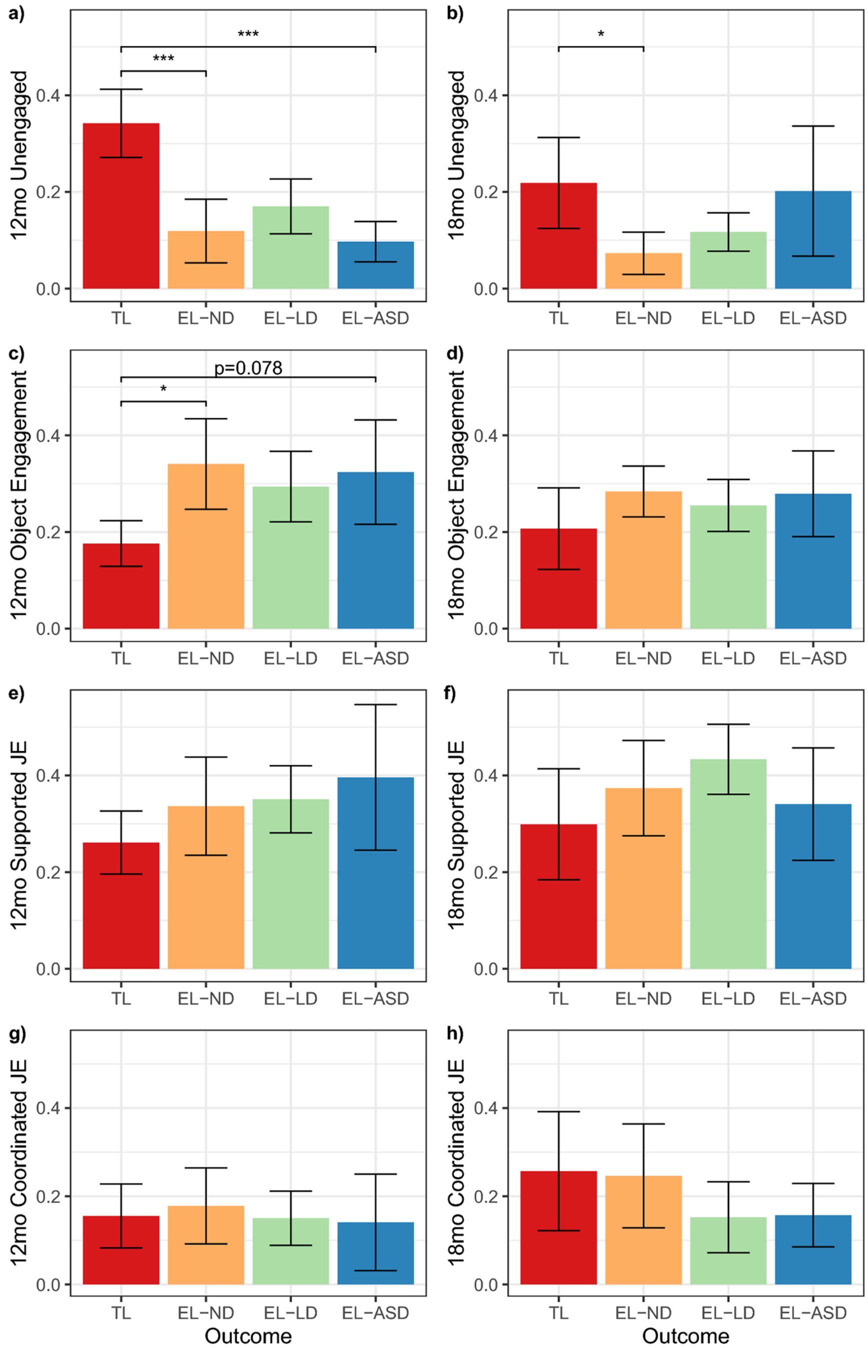

Figure 1.

Proportions of observation time at 12 (left) and 18 months (right) by outcome group are displayed for (a,b) unengaged, (c,d) object engagement, (e,f) supported joint engagement, and (g,h) coordinated joint engagement; error bars show 95% confidence intervals; * < 0.05, ** <0.01, *** < 0.001

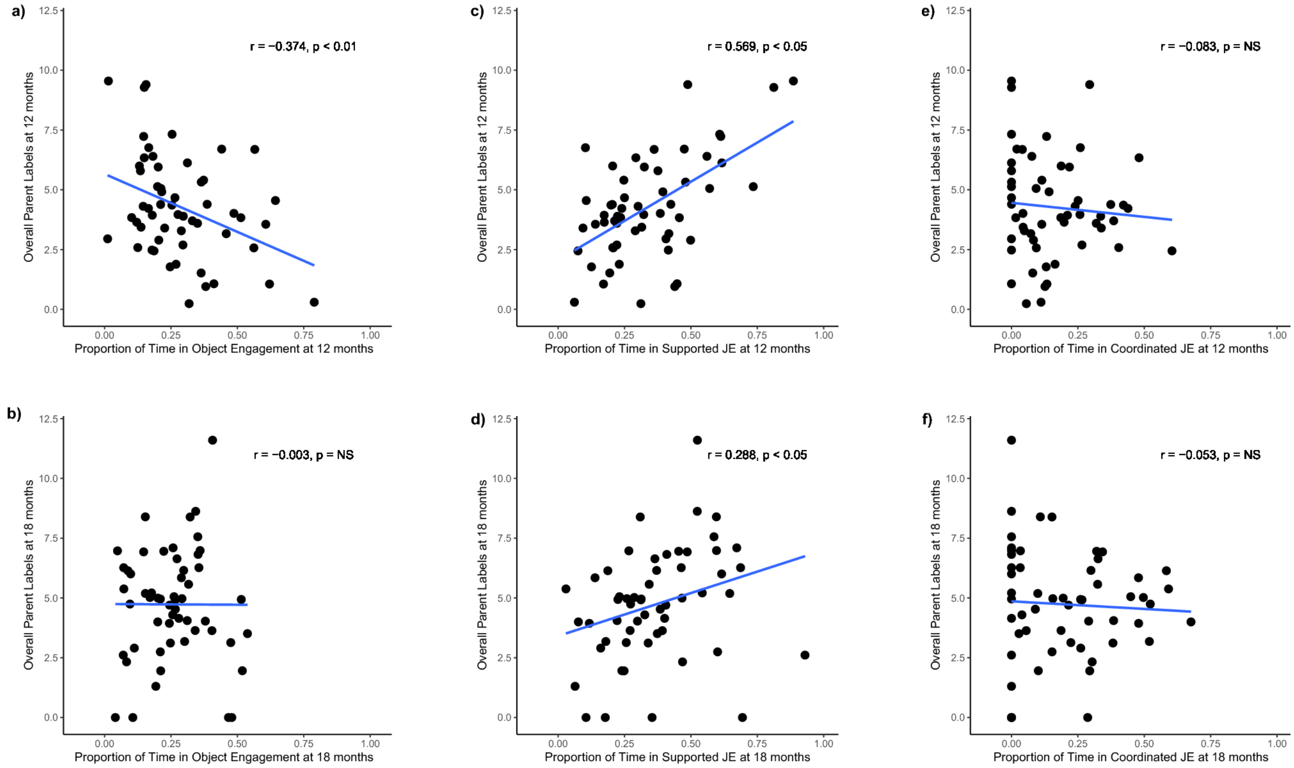

Figure 2.

Correlations between parent labels in the overall observation and proportion of observation time spent in (a,b) object engagement at 12 and 18 months, (c,d) supported joint engagement at 12 and 18 months, and (e,f) coordinated joint engagement at 12 and 18 months

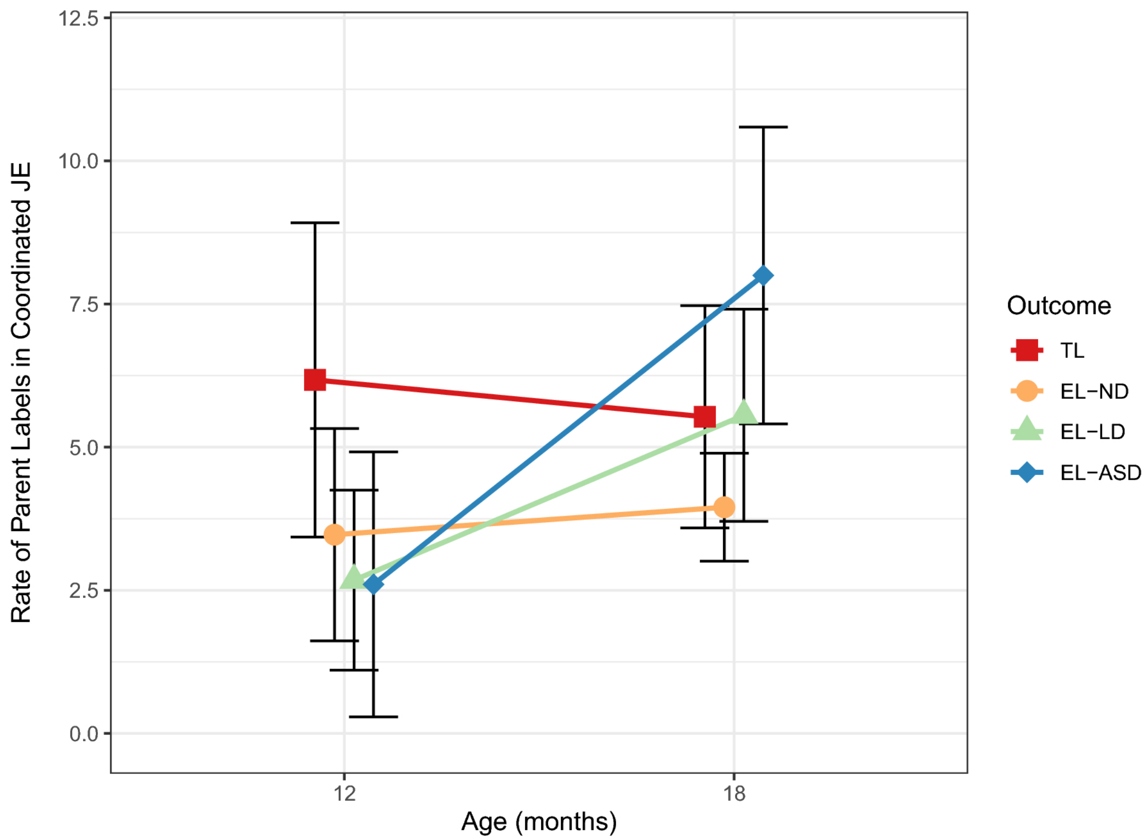

Figure 3.

Rates (number/minute) of parent labels during coordinated joint engagement, moderated by outcome group. *Note*: This figure reflects analyses which included toddlers who spent *some* time in coordinated JE and had the same parent participate at both 12 and 18 months.

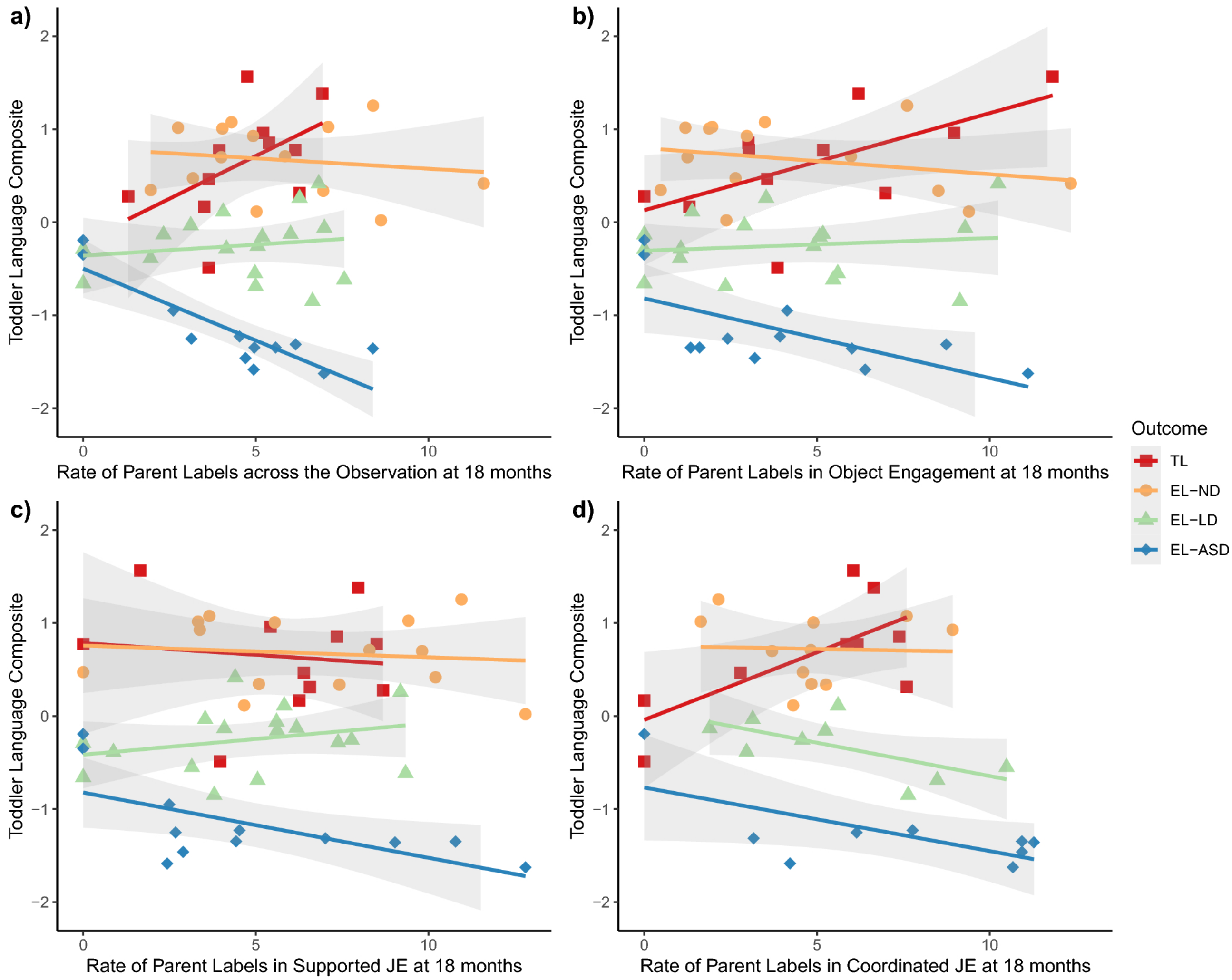

Figure 4.

Moderations by outcome group of the relation between the rate of parent labels at 18 months and Toddler Language composite at 24- and 36-months for a) parent labels across the overall observation, b) parent labels within object engagement, c) parent labels within supported joint engagement, and d) rate parent labels within coordinated JE

Table 1:

Demographic Information for Typical Likelihood (TL) infants and Elevated Likelihood (EL) infants by outcome group

	TL (n=12)	EL-ND (n=14)	EL-LD (n=17)	EL-ASD (n=12)
Sex (# Female, Male)	4, 8	7, 7	7, 10	3, 9
Mean mother age (SD)	31.33 (4.79)	33.93 (3.25)	35.35 (3.69)	32.58 (4.50)
Mean father age (SD)	32.58 (4.80)	37.43 (6.10)	38.41 (4.30)	34.92 (4.66)
Mean parent education[a] (SD)	1.46 (0.45)	1.14 (0.50)	1.29 (0.53)	1.13 (0.61)

Note: TL = Typical Likelihood, EL = Elevated Likelihood, ND = No Diagnosis, LD = Language Delay

[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.

Table 2:

Descriptive statistics characterizing each outcome group at 12, 18, 24 and 36 months

		Typical Likelihood			EL – No Diagnosis			EL – Language Delay			EL – ASD			One-way ANOVA	
Measure	**Month**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**F**	**p**
CDI: Words Understood	12	11	27.7^{a}	22.0	14	17.5^{ab}	16.6	17	17.7^{ab}	17.9	12	6.67^{b}	6.85	3.04	0.038
CDI: Words Produced	12	11	48.6^{a}	18.3	14	42.5^{a}	12.4	17	35.3^{a}	17.0	12	34.2^{a}	12.2	2.42	0.077
	18	11	30.5^{a}	23.5	14	31.4^{a}	19.9	17	7.65^{b}	12.3	12	6.67^{b}	9.37	8.99	<0.001
	24	11	49.1^{a}	21.3	12	46.7^{a}	22.2	17	16.2^{b}	17.5	11	2.73^{b}	4.67	19.16	<0.001
	36	11	24.6^{a}	19.2	13	27.3^{a}	29.6	17	4.12^{b}	4.41	11	0.00^{b}	0.00	8.098	<0.001
MSEL: Receptive Language	12	12	42.3^{a}	8.14	14	36.7^{a}	9.23	17	38.3^{a}	9.23	12	33.0^{a}	13.6	1.76	0.166
	18	12	41.0^{a}	12.6	14	42.6^{a}	16.9	17	34.5^{a}	12.0	12	28.4^{a}	14.6	2.72	0.054
	24	11	54.5^{a}	10.8	13	56.3^{a}	5.12	17	41.2^{b}	14.3	9	25.6^{c}	8.23	18.17	<0.001
	36	11	54.6^{a}	6.59	14	55.1^{a}	8.87	17	45.0^{b}	7.60	9	29.6^{c}	10.3	21.11	<0.001
MSEL: Expressive Language	12	12	52.9^{a}	11.6	14	44.1^{ab}	11.0	17	38.6^{b}	10.4	12	35.9^{b}	9.52	6.26	0.001
	18	12	52.3^{a}	8.54	14	47.7^{ab}	7.46	17	38.7^{bc}	6.72	12	34.3^{c}	13.0	10.61	<0.001
	24	11	55.4^{a}	8.58	13	55.1^{a}	5.33	17	43.9^{b}	8.65	11	28.8^{c}	10.7	25.06	<0.001
	36	11	58.4^{a}	10.6	14	59.7^{a}	8.45	17	50.2^{a}	7.47	10	31.1^{b}	11.3	21.96	<0.001
MSEL: Visual Reception	12	12	54.0^{a}	11.9	14	53.1^{a}	9.43	17	52.4^{a}	8.70	12	47.8^{a}	14.5	0.75	0.530
	18	12	49.0^{a}	9.34	14	47.6^{a}	6.93	17	40.9^{ab}	8.76	12	36.3^{b}	12.7	4.93	0.004
	24	11	53.3^{a}	11.8	13	50.5^{a}	9.41	17	45.6^{ab}	7.93	10	38.7^{b}	8.42	4.55	0.007
	36	n	68.4^{a}	6.31	14	60.4^{ab}	9.37	17	53.1^{b}	13.2	9	31.6^{c}	13.3	16.54	<0.001

Note: CDI = MacArthur-Bates Communicative Development Inventory, CDI percentile scores are reported; MSEL = Mullen Scales of Early Learning, MSEL standardized T-scores are reported. EL = Elevated Likelihood of ASD. Superscripts denote Gabriel post-hoc comparisons for each variable; groups that do not share a letter (a,b,c) differ significantly from one another ($p < 0.05$).

Table 3.

Engagement State Coding

Engagement State	Definition
Unengaged	Child is not engaged with a specific person or object, and may be unoccupied, scanning the environment, or flitting between different foci. *Examples*: child is munching a cookie while looking around the room, having a tantrum without a focus on a specific object, or wandering around the room without a particular focus.
Object engagement	Child is exploring or playing with object(s) by him/herself. While the parent may attempt to engage the child, the child ignores him/her. This state requires active engagement with objects (i.e., does not include absent-mindedly holding a toy while scanning the room). *Examples*: Child brushes the bear, parent looks on but is not actively involved; child plays with the bowl and spoon, parent picks up the teddy bear and says it's hungry, trying to engage the child, but child pulls away and continues playing alone with bowl and spoon.
Supported JE	Parent and child are actively involved with the same object, but the child does not visually acknowledge the parent (i.e., s/he does not glance up at the parent to coordinate attention between objects and people). *Examples*: Parent and child take turns feeding the teddy bear with the bowl and spoon; child drums on the bowl with the spoon, gives parent the spoon and they drum together. Child does not look at parent's face in either scenario.
Coordinated JE	Parent and child are actively involved with the same object, and the child coordinates their attention between objects and people, visually acknowledging the parent's role in the interaction. *Example*: Parent and child set up a picnic together for the teddy bear, child looks back and forth between the bear and parent's face.
Other	*Person engagement* (i.e., child's attention to only the parent; may include physical contact with parent but no objects) and *Onlooking* (i.e., child looking at the parent's activities without being actively involved) were coded to ensure accurate distinction between categories but collapsed for analyses.
Uncodable	Segments of the observation were considered uncodable if the movement of the child or camera gave an inadequate view of the child's activities.

Table 4.

Rates (number/minute) of Parent Input across the Overall Observation and within Object Engagement, Supported Joint Engagement, and Coordinated Joint Engagement

		TL		EL-ND		EL-LD		EL-ASD		Mixed ANOVAs		
		M	**SD**	**M**	**SD**	**M**	**SD**	**M**	**SD**	**Age**	**Outcome**	**Age by Outcome**
Overall Obs.	Age	(n=12)		(n=13)		(n=16)		(n=11)				
Utterances	12	17.77	5.91	16.75	6.51	16.72	5.76	17.90	6.91	ns	ns	ns
	18	17.97	5.61	17.80	5.71	16.70	6.35	16.99	5.66			
Labels	12	4.16	1.75	3.97	1.76	4.01	2.01	4.63	2.88	ns	ns	+
	18	4.47	1.61	5.67	2.76	4.28	2.25	3.96	2.31			
Object Eng.		(n=12)		(n=13)		(n=16)		(n=11)				
Utterances	12	14.07	9.03	16.90	8.55	15.80	6.53	15.43	6.47	ns	ns	ns
	18	14.00	7.00	14.28	6.58	16.36	6.40	17.40	7.21			
Labels	12	3.90	3.38	2.91	2.01	3.44	2.56	3.89	2.78	ns	ns	ns
	18	4.49	3.56	4.55	3.80	3.85	3.42	3.90	3.56			
Supported JE		(n=12)		(n=13)		(n=16)		(n=11)				
Utterances	12	18.75	6.55	16.57	5.70	16.49	6.81	20.52	6.54	ns	ns	ns
	18	20.11	7.83	19.56	6.05	16.70	6.09	18.34	4.37			
Labels	12	5.88	3.13	4.77	2.58	5.03	2.82	6.48	3.55	ns	ns	+
	18	5.37	2.90	7.01	3.65	4.53	2.65	4.55	4.12			
Coordinated JE		(ns=9; 10)		(ns=10;10)		(ns=15; 9)		(ns=7; 8)				
Utterances	12	19.63	6.26	15.06	7.86	17.04	10.00	22.95	7.53	ns	ns	ns
	18	19.68	5.17	20.19	9.56	20.96	3.16	16.67	5.53			
Labels	12	5.45	4.24	3.47	2.87	2.51	2.78	4.03	3.95	**	ns	*
	18	5.09	3.07	4.38	1.66	5.56	2.84	6.73	4.08			

Note: Rates during Coordinated JE are based on the sample of infants who spent *some* time in coordinated JE at 12 or 18 months. Three infants who had mother participate at one visit and father at the other are excluded. The main effects of age (12 to 18 months), outcome (TL = Typical Likelihood; EL = Elevated Likelihood; ND = No Diagnosis; LD = Language Delay; ASD = autism spectrum disorder), and the age by outcome interaction effect are displayed as follows: ns = $p > 0.10$

+ $p < 0.10$

* $p < 0.05$

** $p < 0.01$

Table 5.

Moderation of the Relations Between Parent Labels during the Overall Observation and within Engagement States at 18 months, and Toddler Language Composite

	Parent Labels in Overall Obs. (n=54)		Parent Labels in Object Engagement (n=54)		Parent Labels in Supported JE (n=54)		Parent Labels in Coordinated JE (n=38)	
Variable	**Coeff.**	***SE***	**Coeff.**	***SE***	**Coeff.**	***SE***	**Coeff.**	***SE***
Constant	−0.877 +	0.469	−0.483	0.396	−0.317	0.490	−0.662	0.415
18mo MSEL expressive language	0.015 *	0.007	0.014 +	0.008	0.019 **	0.007	0.014 +	0.008
Labels (TL)	0.156 *	0.074	0.080 *	0.038	−0.012	0.045	0.115 *	0.046
EL-ND	0.809 +	0.437	0.590 *	0.269	−0.004	0.367	0.679 +	0.373
EL-LD	0.042	0.417	−0.292	0.267	−0.790 *	0.376	0.180	0.365
EL-ASD	−0.324	0.416	−0.950 **	0.273	−1.320 **	0.354	−0.782 *	0.347
EL-ND *(Labels)	−0.152 +	0.086	−0.101 *	0.049	0.021	0.055	−0.119	0.072
EL-LD *(Labels)	−0.156 +	0.083	−0.083 +	0.046	0.034	0.058	−0.192 **	0.063
EL-ASD *(Labels)	−0.267 **	0.091	−0.131 *	0.059	−0.027	0.054	−0.157 *	0.061
Model Summary	$R^2 = 0.836$ ***		$R^2 = 0.825$ ***		$R^2 = 0.810$ ***		$R^2 = 0.880$ ***	

Note. Data are presented as Unstandardized coefficients with standard errors in parentheses. MSEL expressive language is a T-score

+ $p < .10$

* $p < .05$

** $p < .01$

*** $p < .001$

Table 6.

Summary of Results

Study Question	Key findings
How does joint engagement develop across outcome groups?	- Unengaged: TL > EL-ND and TL > EL-ASD at 12mo; TL > EL-ND at 18mo - Object Engagement: EL-ND > TL (and trend for EL-ASD > TL) at 12mo - Supported JE: no significant differences - Coordinated JE: no significant differences
How does parent labeling relate to time in engagement states?	- Time in object engagement negatively related to overall parent labels at 12mo - Time in supported JE positively related to overall parent labels at 12 and 18mo
Does parent input within engagement states vary by age and outcome?	- No age/outcome effects for parent utterances - No age/outcome effects for parent labels in object engagement or supported JE - Effect of age and age*outcome interaction for parent labels in coordinated JE Increase from 12 to 18 months for EL-ASD (and trend for EL-LD)
How do parent labels overall and within engagement states relate to language in toddlerhood?	- No significant effects for 12mo parent labels - TL: 18mo parent labels overall, in object engagement, and in coordinated JE (but not in supported JE) positively predict toddler language - EL-ND: significant interaction compared to TL for labels in object engagement; no association between labels and toddler language - EL-LD: significant interaction compared to TL for labels in coordinated JE; non-significant trend for a negative association between labels in coordinated JE and toddler language - EL-ASD: significant interaction compared to TL for labels overall, in object engagement, and in coordinated joint engagement; negative association between labels (overall and within all engagement states) and toddler language