Communication Initiation and Effectiveness in Infants with Elevated Likelihood for ASD

by

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Infants initiate interactions in order to get their wants and needs met; but sometimes infants are not effective in their communication and they are misunderstood by caregivers. When this happens, they must recognize the breakdown in their communication and make repairs. Experimental literature suggests that neurotypically developing infants acquire these skills during their first two years. However, little work has investigated communication breakdowns and repairs in populations of infants with known social communication difficulties, e.g., infants with elevated likelihood for autism spectrum disorder (ASD). Here we explored early social communication initiations, breakdowns, and repair strategies in naturalistic videos of infants with elevated likelihood (EL) for ASD and other developmental delays and infants with typical likelihood (EL) for ASD. EL infants, including those diagnosed with ASD, initiated with caregivers, experienced breakdowns, and made repairs at similar rates to TL infants. However, the types of behaviors used differed, such that EL infants appeared to have a relative strength in behavior regulation bids. Additionally, EL infants later diagnosed with ASD used a large proportion of developmentally appropriate repair behaviors (i.e., addition and substitution), even though their repertoire of strategies was smaller. On the other hand, EL-ASD infants also used a larger proportion of simplification repairs, which are less developmentally advanced and less helpful to interlocutors. Identifying patterns in how EL infants communicate with caregivers and capitalizing on their strengths could improve interventions focused on social communication.

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1.0 Introduction

Infants engage in complex dyadic interactions with caregivers daily. During these interactions, infants initiate social communication in order to get their wants and needs met and to engage in social exchanges (Golinkoff, 1993; Harding & Golinkoff, 1979) that are particularly salient for learning (Tamis-LeMonda et al., 2014). Sometimes infants are not effective in their communication and their messages are misunderstood by caregivers. When this happens, they must recognize the breakdown and adjust their message in order to be successful. A body of experimental literature suggests that typically developing (TD) infants develop these skills during the first two years of life (Fagan, 2008; Liszkowski et al., 2004; Marrus et al., 2018; Shatz & O'Reilly, 1990). However, little work has investigated communication breakdowns and repairs in populations of infants with known social communication difficulties, such as infants with elevated likelihood for autism spectrum disorder (ASD).

Autism spectrum disorder is a neurodevelopmental disorder characterized by challenges in social communication and a pattern of restrictive and repetitive behaviors (American Psychiatric Association (APA), 2013) that impacts 1 in 44 school-age children (Maenner et al., 2021). Later-born infant siblings of children with ASD have an elevated likelihood (EL) of being diagnosed with ASD, and EL infants who do not receive an ASD diagnosis display a wide range of developmental trajectories and outcomes, providing a unique opportunity to study variations in the development of social communication. Both EL infants later diagnosed with ASD and those who are not have higher rates of language delay (LD; Landa et al., 2012; Ozonoff et al., 2014). In naturalistic interactions with caregivers, EL infants, particularly those who go on to be diagnosed with ASD, show lower rates of spontaneous social communication than infants with typical

likelihood (TL) for ASD who are neurotypically developing (Winder et al., 2013). Understanding how EL infants initiate communication is a promising avenue for identifying early differences in social communication skills.

Infants' communication must also be understood by their caregivers in order for it to be effective. While there is evidence that EL infants show delays in communication, it is unclear how well they are able to utilize the skills they have to convey information to caregivers. It is possible that there is variation in how effectively these infants use their communication skills, especially among those eventually identified with LD or ASD. When infants' social bids are not effective (i.e., not understood by caregivers), they also have the opportunity to repair the breakdown in communication. There is very limited research suggesting that children with ASD and other developmental disorders are less successful at making these repairs.

How infants communicate with caregivers is essential to their early development, as they are the main source of social interaction and provide input for learning during the first two years of life (Miller & Lossia, 2013; Naigles, 2013; Swanson et al., 2019; Tamis-LeMonda et al., 2014). Given the known variability in communication skills in EL infants, investigating initiation and effectiveness of communication may provide new information about developmental differences in infants identified with LD or ASD. This study will explore early infant social communication initiation, the effectiveness of infant initiated social bids, and communication breakdown repair strategies in infants with elevated likelihood for ASD and other developmental delays.

1.1 Literature Review

1.1.1 Communication in Neurotypically Developing Infants

1.1.1.1 Initiations in TD Infants

Infant initiated communication can be classified into three broad categories of social communication bids: joint attention, behavior regulation, and social interaction (Bates, 1976; Mundy & Acra, 2006). J*oint attention* (JA) bids utilize gaze orientation to communicate to a social partner that an infant wants the social partner to look at an object. Infants both respond to joint attention bids from others and initiate joint attention with others starting as young as 9 months of age (Mundy et al., 2007). B*ehavior regulation* (BR) bids occur when an infant is requesting the social partner do something (e.g., give them a toy). Infants produce behavior regulation bids at 9 months of age, with a significant increase in frequency by 12 months (Mundy et al., 2007). Lastly, infants produce *social interaction* (SI) bids when they want the attention of their social partner, unrelated to a joint attention or behavior regulation goal. During the second year of life infants appear to communicate for the sake of communicating and interacting, and not just to manipulate another person's behavior (Golinkoff, 1993). The majority of studies looking at these forms of infant initiation have utilized structured interactions with experimenters, and there is little research describing how infants use these three types of initiations in everyday interactions during the first two years.

1.1.1.2 Effective Communication, Breakdowns, and Repairs in TD Infants

While research on infant communication has focused heavily on the frequency with which communicative behaviors are produced, it is also important to understand *how* infants use their

communicative repertoires to interact with social partners. Communication must be understood in order to be effective. Additionally, infants must be able to determine when their communication is not effective and make changes to their message in order to be understood. For example, during a playtime routine, an infant may look at an object out of reach and vocalize to request it. The caregiver, not sure where the infant was looking, misunderstands the request and offers an incorrect object, indicating a communication breakdown. In response, the infant recognizes the misunderstanding and enters into a negotiation with the caregiver. The infant makes eye contact with the caregiver, looks at the desired toy, points and vocalizes, and looks back at the caregiver, illustrating a repair attempt via addition to the original request with new gesture and eye gaze. The caregiver understands the request and gives the infant the requested object (i.e., the repair was successful).

Very young TD children are motivated to repair their communication, particularly requests, when they are misunderstood, in order to get their needs met (Shatz & O'Reilly, 1990). They utilize a variety of repair strategies, such as repeating the utterance or gesture, intensifying the original communication, adding to their original single modality communication by combining vocalizations and gestures, or changing the gesture or vocal utterance (Fagan, 2008; Marcos, 1991). Infants as young as 12 months old repair their requests when misunderstood, even if they have already received the target of the request, and they will modulate their repair strategy based on the type of communication failure and their interlocutor's response (Fagan, 2008; Golinkoff, 1986; Grosse et al., 2010; Marcos & Chanu, 1992). Eighteen month-olds utilize communication repairs when their social partner requests clarification, but in instances where the social partner refuses to comply, they repeat their request instead of reformulating (Marcos & Bernicot, 1994).

While the majority of research investigating communication breakdowns and repairs has focused on instances of behavior regulation (e.g., requests), a similar phenomenon has been observed in joint attention interactions (Liszkowski et al., 2004). Twelve-month-old infants' rates of pointing, numbers of joint attention attempts, duration of pointing, and numbers of looks to the social partner vary depending on whether the partner engages in joint attention (looking between infant and object) or in other behaviors (looking only at the object, looking only at the infant's face, or ignoring the bid altogether). Infants display a higher frequency of points in the conditions where their partner does not engage in joint attention than in the condition where the bid is successful. This suggests that infants appreciate when their message is not understood (or is being ignored) and repeat their behavior in an attempt to make the joint attention bid successful.

Much of what is known about communication success and repairs in TD infants and young children comes from highly structured experiments that are designed to elicit requests and standardize the adult's behavior. These experiments vary widely in procedure and do not necessarily represent how infants use communication on a daily basis at home and with their caregivers. However, there is one longitudinal naturalistic study that observed infants and caregivers during a snack-time routine from 12- to 19-months-old. Golinkoff (1986) reported results similar to those reported in the experimental literature—when caregivers do not understand infants' requests, infants will persist in trying to repair the communication. Additionally, she found that infants and caregivers improved their communication over time, increasing the proportion of successful requests and decreasing the proportion of breakdowns and repairs. While this study only looked at three infants at three timepoints, it lays the groundwork for naturalistic studies of infant-caregiver communication breakdowns and repairs. Since Golinkoff's (1986) publication, there has been a dearth of observational studies of these negotiation sessions in everyday naturalistic

settings. Additionally, relatively little attention has been devoted to this topic in populations with social communication delays, such as ASD.

1.1.2 Communication in EL Infants

Given its low base rate in the general population (1.85%; Maenner et al., 2020), research on the earliest emergence of ASD has focused on infant siblings of older children with ASD, who have a higher likelihood of developing ASD themselves (EL infants). Nearly one in five infants with familial history of ASD receive a diagnosis themselves (EL-ASD; 18.7%; Ozonoff et al., 2011). Additionally, EL infants not ultimately diagnosed with ASD have higher rates of language delay (EL-LD), other developmental delays, and subclinical autism symptoms (Charman et al., 2017; Ozonoff et al., 2014; Rozga et al., 2011). It is also important to note that a large portion of EL infants develop typically (estimated 54.4%; Ozonoff et al., 2014). Therefore, EL infants provide a unique, heterogeneous group in which to study variations in the development of social communication and relationships to later outcomes.

Previous studies investigating the development of language and social communication in EL infants have relied heavily on caregiver report (e.g., questionnaires asking which sounds and words infants produce) and structured assessments administered by a trained researcher. These methodologies may not provide a complete picture of infants' social communication. Caregiver reports are often vocabulary inventories that quantify the number of words an infant can produce and understand, but do not describe how they use language in a social context. Similarly, traditional standardized assessments of communication capture infants' performance on a particular day on a particular set of tasks, but do not measure their everyday use of communication. Indeed, recent research has shown that infant communication in a structured setting represents the infant's best

possible performance, and not their typical communication as measured in a naturalistic setting (Tamis-LeMonda et al., 2017). Research on EL infants to date has relied heavily on these standardized measures, potentially missing true differences in infants' social communication, particularly in how infants use communication and language in everyday interactions with caregivers.

Recently there have been calls for research to make use of naturalistic language sampling to better understand how infants with ASD use communication socially (Barokova & Tager-Flusberg, 2018). Research with EL infants utilizing naturalistic communication samples with observational coding has primarily focused on rates of vocalization production (e.g., frequency of vocalizations in a given timespan). While findings are mixed, the overall consensus is that compared to both TL and EL infants with no diagnosis, EL infants later diagnosed with ASD tend to exhibit a lower frequency of vocalizations, particularly speech-like vocalizations such as words and babbles, between 6 and 24 months of age (EL-ND; Chenausky et al., 2017; Paul et al., 2011; Plate et al., 2021; Warlaumont et al., 2014). However, it is unclear whether EL-ND infants produce vocalizations at lower rates than TL infants during the first two years of life (Chenausky et al., 2017; Northrup & Iverson, 2015; Paul et al., 2011; Plate et al., 2021; Warlaumont et al., 2014). This may be because very few studies have been able to separate EL-LD infants from EL-ND infants, making it difficult to determine whether low vocalization rates in EL infants are driven by a subset of infants with language difficulties.

There is also evidence that, compared to TL infants, EL infants, and particularly those later diagnosed with ASD, have poorer social communication skills, as evidenced by lower rates of directing their vocalizations to a social partner via nonverbal behaviors such as gestures and eye gaze (Garrido et al., 2017; Winder et al., 2013; Yankowitz et al., 2019). Although existing studies

of social communication in EL infants have provided valuable information about the frequencies with which they communicate, we still know little about *how* EL infants communicate. This information is critical for understanding how the development of EL-ASD, EL-LD, and EL-ND infants diverge.

1.1.2.1 Initiations in EL Infants

An important dimension of early infant communication is *infant initiated* communication. Initiations are essential to communicating wants and needs to caregivers, and part of the diagnostic criteria for ASD includes failure to initiate social interactions (APA, 2013). EL infants as a group engage in lower rates of spontaneous communication (i.e., not prompted or elicited by the social partner) during naturalistic play with a caregiver (Winder et al., 2013).

From as early as the second year of life, children with ASD have significant deficits in initiating and engaging in joint attention (Bruinsma et al., 2004; Clifford & Dissanayake, 2008; Franchini et al., 2019; Heymann et al., 2018; Rozga et al., 2011). One study also identified decreased rates of initiating joint attention in EL-LD infants at 12 months, but by 18 months, EL-LD infants performed similarly to EL-ND and TL infants. By contrast, EL-ASD infants continued to display decreased joint attention initiations at 18 months (Franchini et al., 2019).

Similar to joint attention, there is a large body of research indicating that EL-ASD infants produce behavior regulation behaviors at lower rates than TD peers (Goldberg et al., 2005; Rozga et al., 2011; Wetherby et al., 1998). However, it has also been noted that for infants with ASD, behavior regulation may be a relative strength, and it is often produced at higher rates than other types of communication (Wetherby et al., 1998). Additionally, one study has shown that like EL-ASD infants, EL-ND infants exhibit low rates of behavior regulation bids in comparison to TL

infants (Goldberg et al., 2005). This evidence suggests that difficulties with production of behavior regulation bids may not be ASD specific, but rather a challenge for EL infants more broadly.

Lastly, infants diagnosed with ASD show challenges in social and affective communication (Landa et al., 2007; Wetherby et al., 1998), and difficulties in social communication are essential to an ASD diagnosis (APA, 2013). However, most research on early initiation behaviors has focused on joint attention and behavior regulation and has not included social interaction bids. Additionally, most studies of infant initiated communication in EL groups have focused on EL-ASD vs. TL or EL-ND comparisons. There is relatively little known about how EL infants without ASD (i.e., EL-ND, EL-LD) initiate communication using these three types of bids.

1.1.2.2 Effective Communication, Breakdowns, and Repairs in EL Infants

We are not aware of any studies to date that have looked *prospectively* at communication effectiveness, breakdowns, and repairs in infants with elevated likelihood for ASD. The existing literature focuses on preschool and school-age children with ASD (Geller, 1998; Keen, 2003; Meadan et al., 2006) and there is additional research focusing on children with other developmental disabilities (Brady et al., 2005; Halle et al., 2004).

The study of communication breakdowns and repairs in ASD has yielded mixed results. Research with small samples suggests that school-aged children with ASD attempt to clarify their requests when initially unsuccessful (73% of the time); however, these repairs are only successful 35% of the time, with a large portion of repair attempts being ambiguous or unintelligible (Geller, 1998). Even young minimally verbal children will engage in repair behaviors; however, they tend to use repetitions and problem behaviors (e.g., harming self or others) over more adaptive strategies like addition, which involves adding new vocalizations or gestures to the original communication bid (Keen, 2005). A 2003 review of the small body of work on communication

breakdowns in ASD suggests that children with ASD experience more breakdowns, have fewer strategies to repair those breakdowns, and engage in more problem behaviors in the face of breakdowns than TD peers (Keen, 2003).

However, a case study of two young children with ASD reported that the children repaired 70% of their requests and modulated their repair strategies based on the task and type of breakdown, as do typically developing children (Meadan et al., 2006). It is worth noting that this study examined only two children, both of whom had significant language impairments, and had no comparison group. Additionally, the children in this study were 32 and 39 months old, whereas studies of typical development have looked at these skills primarily in 12- to 24-month-olds. This pattern has also been seen cross-culturally. A small study of school-aged verbal autistic children in Japan found that children with ASD repaired breakdowns over 80% of the time and the strategies they used differed by the kind of breakdown that occurred (Ohtake et al., 2011).

It is possible that delayed language contributes to the challenges children with ASD face with communication breakdowns and repairs. Young children with other developmental disabilities and delayed expressive language show similar difficulties in these domains (Brady et al., 2005). For example, higher expressive language scores are predictive of more commenting and requesting communication behaviors in settings designed to elicit requests (Brady et al., 2005). It has also been suggested that children with developmental disabilities display more ambiguous and idiosyncratic forms of communication, which interlocutors may have difficulty interpreting, leading to more communication breakdowns and fewer successful repair attempts (Halle et al., 2004). This raises the question of whether children with ASD display unique difficulties with communication effectiveness and repair strategies, or whether this challenge can be explained by

delayed expressive language skills. A sample with varying language abilities and both ASD and LD outcomes is needed in order to address this question.

1.2 The Present Study

While the study of communication initiation and effectiveness (e.g., bid success, breakdowns, and repairs) is a promising avenue for understanding the development of social communication in EL infants, some critical gaps remain in the literature. First, infants are known to engage in three types of social communication initiations, but research on communication breakdowns has focused almost entirely on infant requesting (behavior regulation). Additionally, most studies of infant social communication have relied on structured experimental measures to elicit initiations and repairs and do not tap into infants' everyday communication with caregivers. Finally, there is no prospective research investigating the early development of effective communication in EL infants, despite promising findings in older children with ASD reporting differences in success, breakdowns, and repair strategies relative to TD children. Investigation of how EL infants initiate communication with caregivers and make repairs when communication is not successful may provide a novel means for identifying social communication differences in infancy that are related to later developmental outcomes (ASD, LD).

The present study will address these three gaps by: (1) identifying all three types of infant initiations (behavior regulation, joint attention, and social interaction) and examining the effectiveness of each bid type; (2) employing naturalistic observation; and (3) utilizing a prospective sample of infants with familial history of ASD to investigate the development of these

skills in infancy (18 months-old) and their relationship to ASD and language outcomes assessed at three years of age. There are four primary aims:

1. To examine social communication initiation in 18-month-old EL and TL infants during naturalistic interactions with caregivers and determine whether there are group differences (EL-ASD, EL-LD, EL-ND, and TL) in rates of initiations and types of bids used. *Based on the existing literature (Rozga et al., 2011; Wetherby et al., 1998), we hypothesized that EL-ASD infants would initiate communication (particularly joint attention bids) at lower rates compared to infants in the other three groups. We also expected that EL-LD infants would have lower rates of initiations due to less advanced communication skills.*
2. To explore communication success rates across groups and whether these vary in relation to initiation bid type. *The literature with older children with ASD and developmental delays (Brady et al., 2005; Keen, 2003) suggests that both EL-ASD and EL-LD infants would have lower percentages of communication success than EL-ND and TL infants. As noted above, no studies to date have examined communication success in all three types of communication bids; therefore, we had no a priori hypotheses about how success rate may differ by communication type.*
3. To investigate rates of communication repairs and types of repair strategies across groups. *We expected that all infants would engage in a high rate of repair attempts, with no group differences (Fagan, 2008; Geller, 1998; Meadan et al., 2006; Shatz & O'Reilly, 1990). However, we hypothesized that EL-ASD infants would have a lower rate of repair success than the three comparison groups (Geller, 1998).*

4. To assess the relationship between expressive language and rates of initiation, success, and repairs in EL infants. *We predicted that all behavior rates would be correlated with both MSEL and CDI expressive language scores.*

2.0 Method

2.1 Participants

The present study included 49 (19 female) infants with an older sibling with ASD (elevated likelihood, EL) and 15 (8 female) infants with a neurotypically developing older sibling and no immediate family history of ASD (typical likelihood, TL). EL infants participated in a longitudinal research study where they were visited in their homes monthly from 5 to 14 months of age, with follow-up visits at 18, 24, and 36 months (Heymann et al., 2018). The TL infants participated in a separate longitudinal study with visits at home every two weeks from 2 to 19 months. Data collected at the 18-month visit were used in the present study and data from 24- and 36-month follow-up visits were used to assign EL infants to outcome groups (described below).

At 36 months, EL infants were classified into three outcome groups: autism spectrum disorder (EL-ASD), language delay (EL-LD), and no diagnosis (EL-ND). ASD determination was made by a clinician, naïve to previous study data, who administered the Autism Diagnostic Observation Schedule (ADOS; Lord et al., 2012) and made a clinical best estimate diagnosis based on DSM-IV criteria (N = 9, 3 female). Infants without ASD who met one of the following two criteria were classified as language delayed: (1) standardized scores on the MacArthur-Bates Communication Development Inventory (CDI; Fenson et al., 2007) at or below the 10th percentile at least twice between 18 and 36 months; *or* (2) standardized score on the CDI at or below the 10th percentile and a standardized score on the Mullen Scales of Early Learning (MESL; Mullen, 1995) Expressive and/or Receptive Language subscales at least 1.5 standard deviations below the mean at 36 months (N = 15, 6 female). Infants who were not classified as having ASD or as having a

language delay were considered to have no diagnosis (*N* = 25, 10 female). TL infants did not have follow-up visits, but there were no developmental concerns reported by parents or researchers by the last visit (19 months).

Table 1. Participant Demographic Information

	TL	EL-ND	EL-LD	EL-ASD	
Sex (M, F)	7, 8	15, 10	9, 6	6, 3	*n.s.*
Race/Ethnicity	*N* = 15	*N* = 25	*N* = 15	*N* = 9	*n.s.*
White	14	25	11	6	
Black	0	0	0	1	
Asian	0	0	1	0	
Multiracial	1	0	0	1	
Hispanic/Latino	0	0	3	1	
Mother's Education	*N* = 15	*N* = 25	*N* = 15	*N* = 9	*n.s.*
High School	1	0	1	4	
Certification	0	2	1	0	
Some College	0	3	2	0	
Associate Degree	1	1	0	1	
Bachelor's Degree	7	9	5	2	
Master's Degree	5	7	4	1	
Occupation Prestige	*N* = 11	*N* = 20	*N* = 12	*N* = 9	*n.s.*
Mean (SD)	56.63 (15.59)	55.43 (15.94)	61.44 (15.39)	60.46 (17.69)	

Note. Demographic variable differences calculated using Fisher's Exact Tests for Count Data.

Sample characteristics are provided in Table 1. The sample was primarily white and groups did not differ in sex, maternal education, occupation prestige (highest used when two parent occupations provided), and race/ethnicity.

2.2 Measures

2.2.1 CDI

The MacArthur-Bates Communication Development Inventory (Fenson et al., 2007) is a caregiver-report measure of infant communication. Caregivers completed the Words and Sentences form (CDI-II) at 18 months, which includes a vocabulary checklist of 680 words, as a measure of infant expressive language skills. Caregivers of EL infants also completed the CDI-II at 24 months and the CDI-III at 36 months. Caregiver report of expressive language on the CDI is highly correlated with child performance on an expressive language task (Ring & Fenson, 2000). Percentile scores were used to determine LD classification. Percentile scores at 18 months were also used as a measure of expressive language for analyses.

2.2.2 MSEL

The Mullen Scales of Early Learning (MSEL) is a standardized assessment of visual reception, fine motor, gross motor, expressive language, and receptive language skills (Mullen, 1995). The MSEL has shown construct, convergent, and divergent validity in both non-autism and autism samples (Swineford et al., 2015). EL infants were assessed by a trained researcher at all

three visits. The Expressive and Receptive Language subscales at 36 months were used for language delay outcome determination and the Expressive Language subscale at 18 months was used as a measure of expressive language for analyses.

2.2.3 ADOS

The Autism Diagnostic Observation Schedule (ADOS; Lord et al., 2012) is considered the gold-standard for assessing autism spectrum disorder in both research and clinical settings (Kamp-Becker et al., 2018). The ADOS is a play-based assessment of social communication skills and restrictive and repetitive behaviors. A clinician naïve to likelihood status and prior study data completed diagnostic assessments at 36 months with all EL infants.

2.3 Procedure

At 18 months of age, infants were visited in their homes. The visit lasted approximately 45 minutes for TL infants and included multiple structured and unstructured play sessions. EL infants were also administered the MSEL and had a semi-structured interaction with a researcher, making the visit approximately an hour and 30 minutes. For all infants, caregivers were asked to engage their infant in play as they normally would for 15 minutes. This free play session was video recorded, and infants wore vests containing a wireless microphone in order to capture vocalizations. These video-audio recordings were used for behavioral coding of infant initiated communication, breakdowns, and repairs. Caregivers also completed the CDI as a measure of infant expressive language abilities. EL infants were visited at home again at 24 and 36 months, at

which time caregivers completed the CDI and infants were administered the MSEL. At 36 months of age EL infants were administered the ADOS either at home or at the University of Pittsburgh.

2.3.1 Coding

All videos were coded using the video coding software Datavyu (Datavyu Team, 2014). The coding scheme is described below and illustrated in *Figure 1*, with an extended manual in Appendix A. All coders were naïve to infant likelihood group membership and outcome status.

2.3.1.1 Initiation

To be considered an initiation, the infant must have engaged in at least one of the following: vocalization, gesture, or eye gaze (directed at an object or the caregiver) while clearly directing the communication to the caregiver, and the behavior must have been unprompted.

Instances of infant initiation of social communication with the caregiver were coded into one of three mutually exclusive categories: Behavior Regulation (BR), Joint Attention (JA), and Social Interaction (SI; Wetherby et al., 1998). Instances of *Behavior Regulation* included requests for the caregiver to do something (open a container, get a toy, etc.). Instances of *Joint Attention* included bids by the infant to get the caregiver to look at an object with them. Instances of *Social Interaction* included bids by the infant to get the caregiver to look at or touch them (hug, high-five), without a shared object of interest.

2.3.1.2 Caregiver Response

If caregivers immediately understood the bid from the infant and complied (e.g., infant point at an object to request it and the caregiver gives it to them), the initiation of social

communication was considered a success. Otherwise, there was a breakdown of communication (e.g., infant points at an object to request it and the caregiver responds with "What do you want?") and the dyad entered into a negotiation.

2.3.1.3 Repair

After caregivers responded to indicate a communication breakdown, infants had the opportunity to repair the communication (Meadan & Halle, 2004; Price et al., 2018). Repair attempts were coded as: Repetition (repeating exact behavior); Addition (augmenting the original bid with an additional behavior, e.g., repeating the original vocalization and adding a pointing gesture); Simplification (reducing the original bid to simpler message, e.g., "Want milk" becomes "Milk"); Substitution (replacing the bid with a new behavior); Yes/No (responds to caregiver with affirmation or rejection); Emotional Response (e.g., hitting, throwing, crying); and No Response (did not attempt to repair). All repair behaviors were mutually exclusive.

2.3.1.4 Success

Repair behaviors were then considered successes or failures based on the subsequent caregiver response. If the bid failed again, the series of breakdowns and repairs continued to be coded until success was reached or the infant gave up (e.g., infant accepted incorrect response from caregiver and did not attempt to repair).

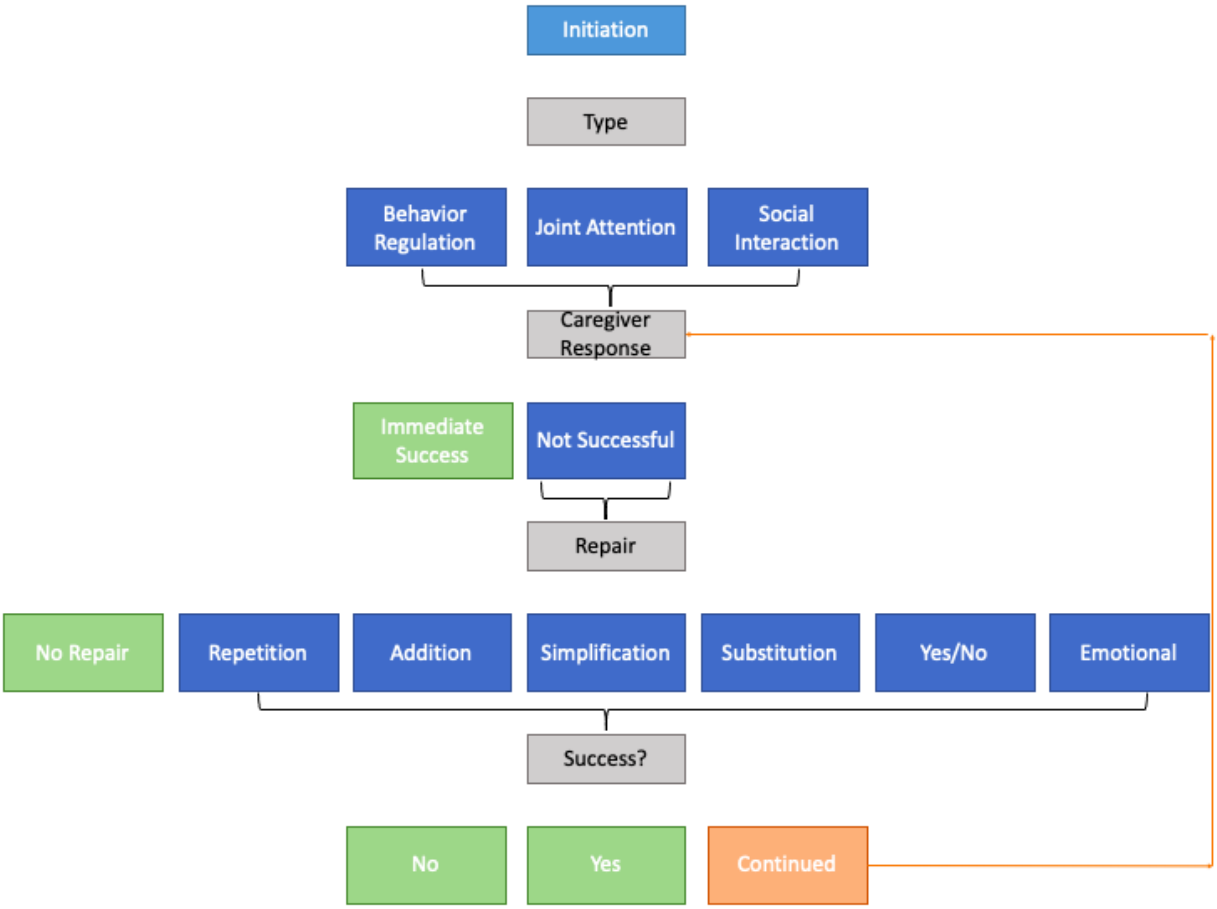

Figure 1. Coding Scheme Flow Chart

2.3.1.5 Reliability

Prior to initiating independent coding, coders were trained to a criterion of 70% inter-rater reliability on three successive training videos for bid initiation identification and all behavior codes, with an average of 83%. Video coding of the sample was completed by a pair of coders. First, coders viewed the video independently to identify initiations, and then the pair met and the entire video was consensus coded. Both coders then coded the behaviors related to the initiations and again completed consensus coding. Agreement for Initiation Type (K = 0.88, percent agreement = 92%), Caregiver Response (K = 0.7, percent agreement = 87%), Repair Type (K =

0.55, percent agreement = 76%), and Success (K = 0.64, percent agreement = 81%), ranged from moderate to almost perfect (Landis & Koch, 1977).

3.0 Results

The goal of this study was to identify initiations of social communication in infants with and without elevated likelihood for autism and compare groups on communication breakdowns, use of repair strategies, and success of bids in a naturalistic interaction. Primary analyses used ANOVAs to compare groups on variables that were calculated as rates or percentages, with Tukey HSD tests use as post-hoc pairwise comparisons. For proportional data where variables were dependent on one another, nonparametric Kruskal-Wallis H tests were conducted, with Mann-Whitney U tests used as post-hoc pairwise comparisons. Lastly, Spearman and Pearson correlations were used to explore the relationships between expressive language skills and communication behaviors.

3.1 How do infants initiate communication with caregivers?

The first aim of this study was to examine communication initiation in 18-month-old EL-ASD, EL-LD, EL-ND, and TL infants during naturalistic interactions with caregivers. To do this, we calculated rates of communication initiation per 15 minutes of recording (initiation rate = number of initiations/total recording time in minutes * 15) and proportions of initiations that fell in each communication type (proportion BR/JA/SI = number of bids in a category/number of initiations).

Table 2. Rates of initiations and proportions of initiation types for TL and EL infants.

	TL	EL-ND	EL-LD	EL-ASD	Difference
Initiation Rate	10.71 (9.95)	13.07 (12.50)	10.54 (7.26)	6.43 (3.45)	*n.s.*
Proportion Behavior Regulation[a]	0.17 (0-1)	0.51 (0.06-1)	0.50 (0.13-1)	0.33 (0-1)	$H(3) = 8.73$* TL < EL-ND
Proportion Joint Attention[b]	0.50 (0-1)	0.25 (0-0.94)	0.25 (0-0.67)	0.00 (0-0.86)	$H(3) = 8.47$* TL > EL-ASD
Proportion Social Interaction[c]	0.10 (0-1)	0.00 (0-0.5)	0.20 (0-0.75)	0.33 (0-1)	*n.s.*

Note. For initiations per 15 minutes, means and standard deviations are reported. For proportions, medians, ranges are reported.

[a]58 of the 64 infants produced at least one behavior regulation initiation. Six infants had a proportion of zero. [b]46 infants produced at least one joint attention initiation. [c]36 infants produced at least one social interaction initiation. *$p < .05$, **$p < .01$, ***$p < .001$

On average, infants produced 10.99 initiations per 15 minutes of recording (SD = 9.97), composed of behavior regulation (47.07%), joint attention (33.31%), and social interaction (19.62%) bids in that order. While EL-ASD infants had the lowest rate of initiations (M = 6.43, SD = 3.45), initiation rates did not differ by group, $F(3, 54) = 0.93$, $p = 0.44$, $\eta^2 = 0.05$ (Table 2). As seen in *Figure 2*, even though the groups had similar rates of initiations, the types of bids they used differed. While all three EL groups used behavior regulation bids the most, the majority of bids produced by the TL group were joint attention bids. Kruskal-Wallis H tests revealed moderate group differences in joint attention, $H(3) = 8.47$, $p = 0.037$, $\eta^2 = 0.08$, $\varepsilon^2 = 0.13$, and behavior regulation, $H(3) = 8.73$, $p = 0.033$, $\eta^2 = 0.08$, $\varepsilon^2 = 0.14$, where TL infants used proportionally fewer

behavior regulation bids than EL-ND infants and proportionally more joint attention bids than EL-ASD infants (Table 2; Figure 2). Descriptively, the EL-ASD group used a higher proportion of social interaction bids than the other three groups, but there was no significant difference.

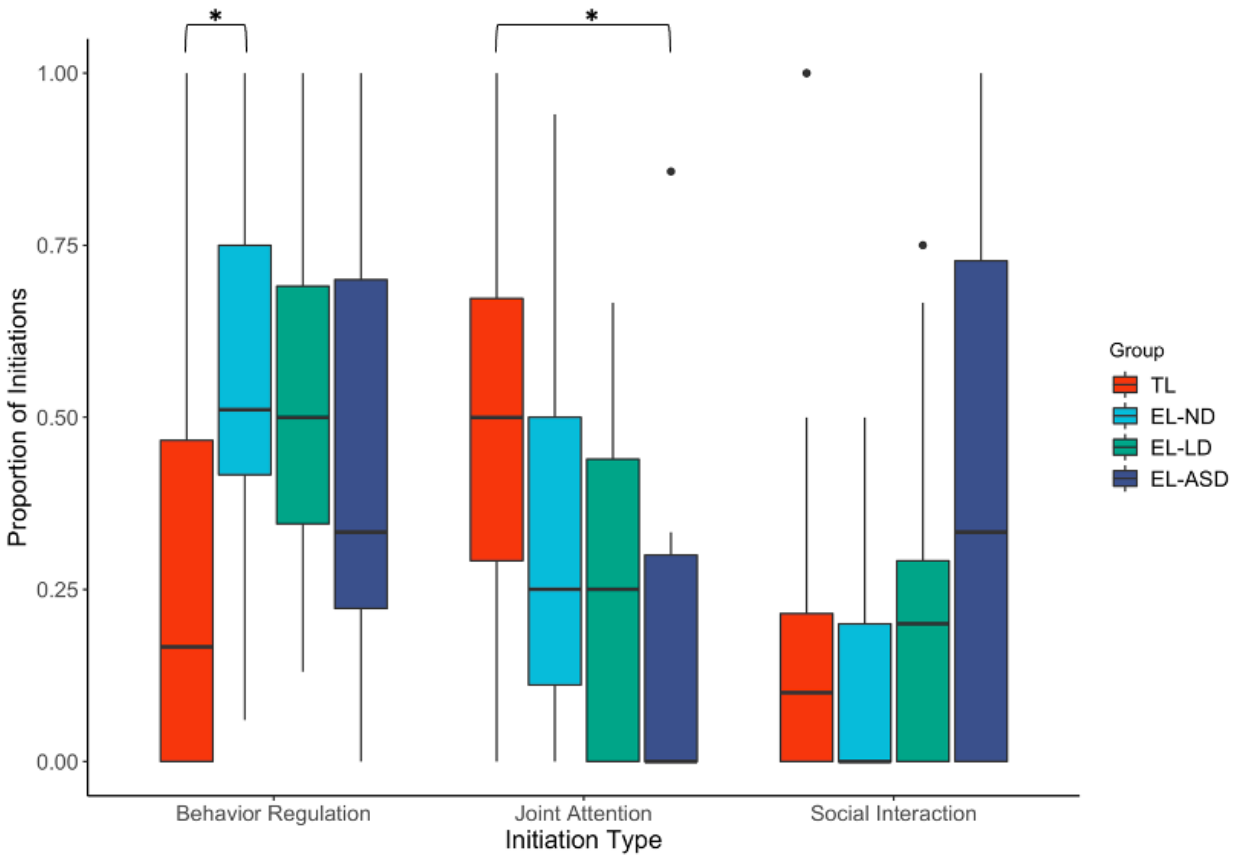

Figure 2. Proportions of bid type used by the four groups of infants

3.2 How successful were infants' communication bids?

The second aim of this study was to explore potential differences in communication success across EL-ASD, EL-LD, EL-ND, and TL infants. We calculated the percentage of communication initiations that were immediately successful (percent immediate success = number of successful

initiations/number of initiations) to examine group differences. We also tested whether success rate differed by communication type.

On average, 67.74% (*SD* = 0.21) of initiations were immediately successful (i.e., the caregiver understood the bid and complied immediately). Outcome groups did not differ in the percentages of bids with immediate success, $F(3, 60) = 0.57$, $p = 0.64$, suggesting that all caregivers readily understood their infants' communication (Table 3). Additionally, when we collapsed across groups, bid type was not related to whether the bid was immediately successful, $F(2, 44) = 0.81$, $p = 0.453$ (e.g., BR: $M = 0.61$, $SD = 0.30$; JA: $M = 0.72$, $SD = 0.30$; SI: $M = 0.73$, $SD = 0.37$). This suggests that the type of social communication bid that infants used was not related to whether or not their caregivers understood them, despite group differences in the types of bids used.

3.3 How do infants repair communication breakdowns?

We next investigated repair strategies used by EL-ASD, EL-LD, EL-ND, and TL infants when communication bids were not immediately successful. We first calculated the rate of repair attempts in response to a communication breakdown (percent repair attempt = number of repairs/number of breakdowns) and the percentage of bids with a repair attempt that were successful (percent repair success = successful repair attempts/total repair attempts).

Dyads experienced communication breakdowns following about a third of infant initiations. In response to these breakdowns, infants made attempts to repair more than half of the time (*M* = 58%) and even persisted, repairing multiple times until successful (range: 1-4). This was true across all four groups, and there was no significant difference in the percent of

breakdowns that infants attempted to repair ($F(3, 54) = 1.46$, $p = 0.235$). Additionally, infants overall were successful in their repairs 43% of the time and this did not differ by outcome group ($F(3, 48) = 0.33$, $p = 0.802$; Table 3). Thus, despite expected difficulties with social communication, EL infants, including those later diagnosed with ASD, had similar communication profiles to their TL peers.

Table 3. Rates of initiation successes and repairs in TL and EL infants

	TL	EL-ND	EL-LD	EL-ASD	Difference?
Percent Immediate Success	0.67 (0.21)	0.65 (0.25)	0.69 (0.17)	0.75 (0.14)	*n.s.*
Percent Repair Attempt	0.49 (0.31)	0.69 (0.28)	0.52 (0.33)	0.53 (0.39)	*n.s.*
Percent Repair Success	0.42 (0.46)	0.47 (0.35)	0.33 (0.37)	0.47 (0.45)	*n.s.*
Number of Unique Repair Strategies	1.62 (0.31) 0-4	2.17 (0.28) 1-5	1.57 (0.33) 0-4	1.13 (0.30) 0-2	*n.s.*

Note. Means and standard deviations are reported for all variables. Ranges for number of unique strategies are also reported.

We also calculated the proportion of repairs that fell into each category (repair proportion = number of attempts in a category/number of repair attempts) and the number of unique repair strategies produced by each infant to examine group differences in the type of repairs strategies used. We hypothesized that EL-ASD infants would use higher proportions of Repetitions and Emotional Response and lower proportions of Addition and Substitution repairs (Geller, 1998; Keen, 2005). A previous review also suggested that EL-ASD infants would have fewer unique repair strategies (Keen, 2003).

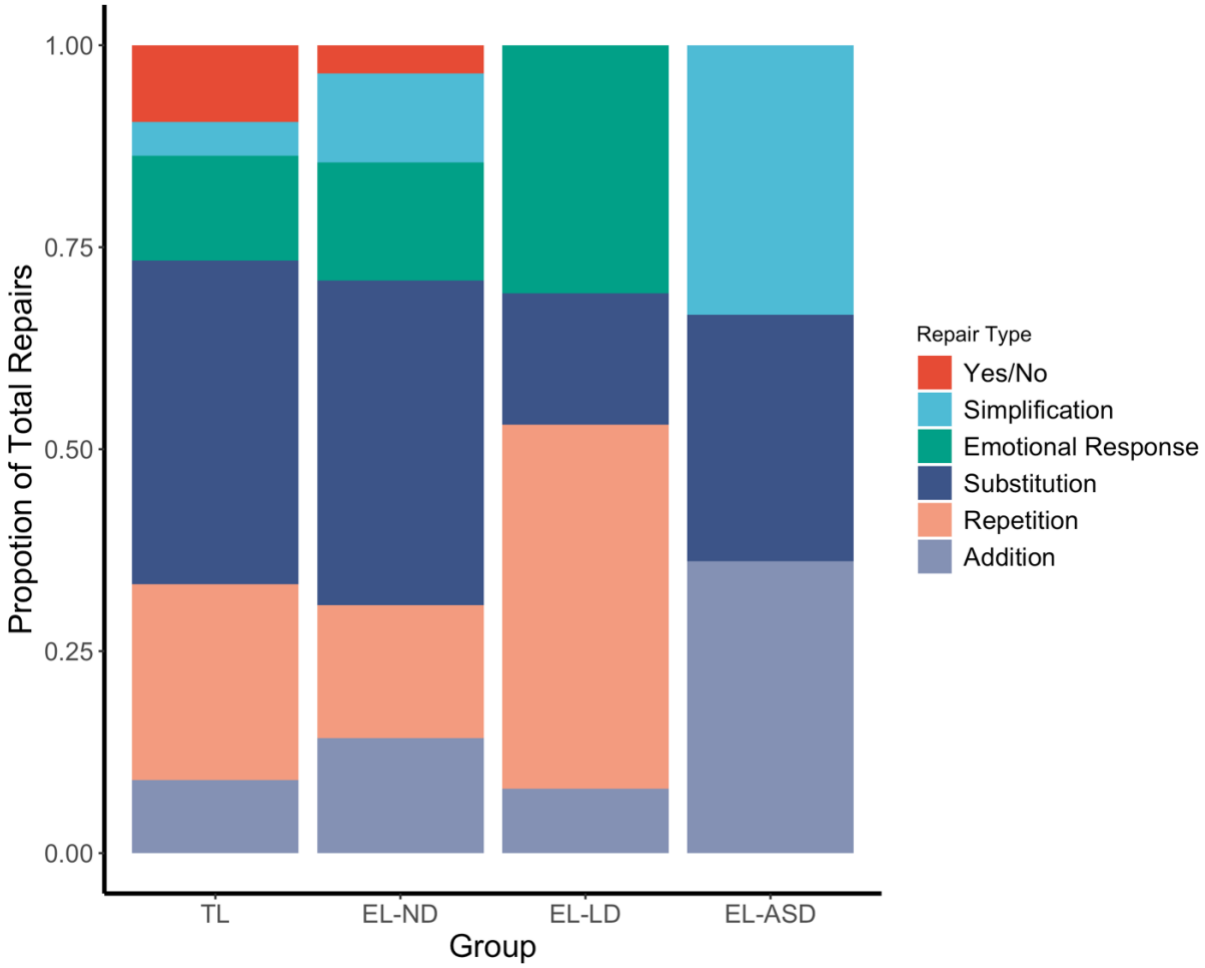

Figure 3. Types of repairs used by each group as proportions of total repairs

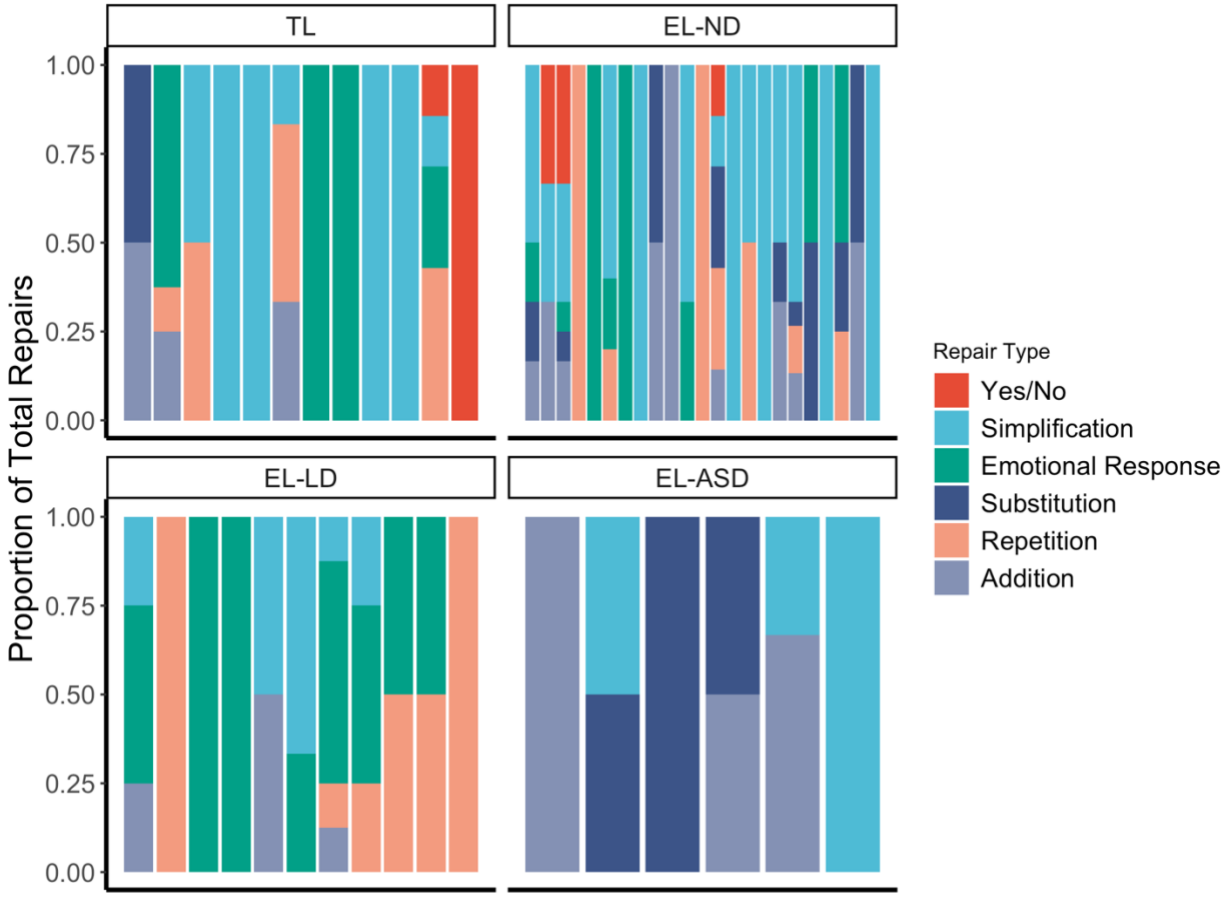

Figure 4. Types of repairs used by each infant as proportions of total repairs

While all four groups made repairs at similar rates, they differed in the types and numbers of repair strategies they used (Figure 3). There was wide individual variability in the numbers of unique strategies infants used in a 15-minute play session (Figure 4). The maximum number of repair strategies any EL-ASD infant used was two, whereas TL and EL-LD infants used up to four and EL-ND infants used up to five. This suggests that outcome groups varied in the diversity of repair strategies they employed, although the differences in average number of unique strategies were nonsignificant, $F(3, 54) = 1.82$, $p = 0.155$ (Table 3).

To better understand the types of repair strategies infants used, we employed Kruskal-Wallis H tests to compare groups on proportions of repair attempts that used each strategy. Groups

differed on the proportion of repetitions (e.g., repeating the original bid exactly), H (3) = 9.66, p = 0.022, η^2= 0.11, ε^2 = 0.15, and simplifications (e.g., repeating only part of the original bid, such as repeating a vocalization but not repeating the gesture) used, H (3) = 9.85, p = 0.020, η^2= 0.11, ε^2 = 0.16. Specifically, EL-ASD infants used no repetitions, whereas EL-LD infants used repetitions the most (*Median* = 0.5, *Range* = 0-1). Descriptively, the EL-ASD group used simplification repairs the most (*Median* = 0.25, *Range* = 0-1) and the EL-LD group never used simplification repairs (Figure 3). However, despite the moderate main effect of group on proportion of simplification repairs used, post-hoc Mann-Whitney U tests did not reveal significant pair-wise differences between groups.

3.4 Does expressive language relate to communication skills?

The final aim of this research was to assess whether expressive language was associated with rates of communication initiation, success, and repairs. We ran correlations between CDI expressive language percentile scores (caregiver report of words the infant says at 18 months) and all rate measures. Only EL infants were administered a standardized assessment of language at 18 months (MSEL), so we also ran correlations between MSEL expressive language t-scores and all rate measures in EL infants only.

We first confirmed that, as expected, caregiver report of expressive language (CDI) was strongly positively correlated with standardized expressive language scores (MSEL) in the EL infants, r(46) = 0.66, p < 0.001, R^2 = 0.44 (Table 4). There was no significant correlation between expressive language measures and communication initiation rate (p's > 0.05). Infants' expressive

vocabulary size (CDI words produced percentile scores) was negatively associated with the percent of infant bids fulfilled by caregivers with immediate success, r = -0.26, p = 0.036, R^2 = 0.07. In other words, caregivers who credited their infants with larger word vocabularies were less likely to immediately fulfill their infants' bids. However, the effect size was quite small. This pattern was not seen with the standard assessment of language (MSEL expressive language) in the EL group ($p > 0.05$).

The percent of breakdowns that infants attempted to repair was correlated with CDI words produced percentile scores in the full sample, r = 0.31, p = 0.018, R^2 = 0.10, and was marginally correlated with MSEL expressive language t-scores in the EL sample, r = 0.25, p = 0.097, R^2 = 0.06. Additionally, the number of unique repair strategy types infants used was also correlated with CDI words produced percentile in the full sample, r = 0.33, p = 0.011, R^2 = 0.11, and marginally correlated with MSEL expressive language t-scores in the EL sample, r = 0.26, p = 0.082, R^2 = 0.07. Infants with better expressive language tended to try to repair breakdowns more and used more variety in their repair strategies, suggesting adaptability in communication.

Table 4. Descriptive Statistics and Correlations for Language and Observed Communication Variables

Variable	*n*	*M*	*SD*	1	2	3	4	5	6
1. MSEL Expressive Language t-score[a]	48	42.50	10.39	—					
2. CDI Words Produced Percentile	63	27.54	25.64	0.66***	—				
3. Initiation Rate	64	10.99	9.97	0.16	0.14	—			
4. Percent Immediate Success	64	0.68	0.21	-0.19	-0.26*	.14	—		
5. Percent Repair Attempt	58	0.58	0.32	0.25†	0.31*	-0.21	-0.12	—	
6. Number of Unique Repair Strategies	58	1.76	1.23	0.26†	0.33*	0.28*	-0.09	0.54**	—

Note. [a]Only EL infants had a MSEL assessment at 18 months. [†]$p<.10$, *$p < .05$, **$p < .01$, ***$p < .001$

4.0 Discussion

This study examined how infants with and without an elevated likelihood for ASD initiate communication with their caregivers, handle breakdowns in communication, and make repairs. We used previously collected videos and identified all instances of behavior regulation, joint attention, and social interaction bids from infants to their caregivers during 15 minutes of naturalistic play at home. We then identified whether caregivers immediately fulfilled the bid, or whether a breakdown in communication occurred. In the case of breakdowns, we classified infant repair behaviors by type (i.e., addition, simplification, repetition, substitution, yes/no, emotional response). Findings for each of these behaviors (e.g., initiations, success/breakdowns, and repairs) will be discussed in turn.

Results indicated that the four groups of infants did not differ in the rates at which they initiated communication, but they did differ in the types of bids they used. TL infants produced a higher proportion of joint attention bids than EL-ASD infants and a lower proportion of behavior regulation bids than EL-ND infants. Infant initiations were successful 67.74% of the time and groups did not differ in their rates of communication success. Initiation type was not related to bid success. Rates of repair attempts, and the success of those repairs, were similar across groups. However, the numbers of different repair strategies that infants employed varied by group (though not significantly so). EL-ASD infants used between zero and two strategy types, whereas EL-ND infants used up to five different strategy types in a single 15-minute play session. EL-ASD infants also used proportionally more simplification repairs than the other groups (although this did not reach significance) and proportionally fewer repetition repairs than the EL-LD group. Lastly, infant expressive vocabulary scores on the CDI (as rated by caregivers) were negatively correlated

with rates of initiations and positively correlated with the percent of breakdowns infants attempted to repair and the number of unique repair strategies. These findings will be discussed below with regard to similarities and differences among groups in production of communication and repair behaviors, and in terms of associations between measures of expressive language and observational measures of communication.

4.1 The rates at which infants initiated and repaired communication were similar

With regard to similarities across groups, infants in all three EL groups and those in the TL group initiated communication, had breakdowns, and made repairs at similar rates. Previous literature suggested that EL-ASD infants would have lower rates of initiations (Franchini et al., 2019; Rozga et al., 2011; Wetherby et al., 1998; Winder et al., 2013) than their TL peers, and that EL infants without ASD would also show lower initiation rates (Franchini et al., 2019; Goldberg et al., 2005; Winder et al., 2013). However, these studies have focused either on infant vocalizations overall (rather than initiations specifically), or on just one type of initiation (e.g., behavior regulation or joint attention). Additionally, most looked at these behaviors during an assessment or during play in a laboratory setting. Research has suggested that these methods measure what infants *can* do, but not necessarily what they *actually* do on a day-to-day basis, which may be particularly important for EL-ASD infants (see Tamis-LeMonda et al., 2017 for further discussion). Our study suggests that EL-ASD infants do in fact engage frequently with caregivers and initiate communication. However, it is important to note that although EL-ASD infants' initiation rates did not differ significantly from those of the other three groups, they did have the lowest average rate of initiations, as well as a smaller standard deviation.

To our knowledge, this is the first prospective study of EL infants that examined communication breakdowns and repairs. Our data provide evidence that 18-month-old EL infants, including infants later diagnosed with ASD, exhibit relatively similar patterns of breakdowns and repairs as TL infants. Given the limited previous literature in older children with ASD and language impairments (Brady et al., 2005; Keen, 2003), we had expected that EL-ASD and EL-LD infants would be less successful in their initiation attempts. This prediction was not supported by our data. Across all groups, infants' communicative bids were successful two-thirds of the time, suggesting that in the context of everyday play at home, caregivers are accustomed to their infants' communication styles and readily identify and fulfill their bids. Additionally, all infants frequently made repair attempts (58% of the time a breakdown occurred), which is consistent with previous research indicating that children are persistent and will attempt to make repairs until their request is fulfilled (Fagan, 2008; Geller, 1998; Meadan et al., 2006; Shatz & O'Reilly, 1990).

4.2 The strategies infants used to initiate and repair communication differed by group

While infants in all four groups demonstrated similar overall rates of communication behaviors, they differed in the types of initiations and in the variety of repair types they used. In line with previous research, production of joint attention bids appeared to be a relative weakness for EL-ASD infants; a smaller proportion of their initiations were JA bids compared to TL infants (Rozga et al., 2011; Wetherby et al., 1998). TL infants, on the other hand, used a smaller proportion of BR bids compared to EL-ND infants. There appeared to be a clear pattern of TL infants preferring JA bids over BR bids, and vice versa for the EL groups. This pattern may be driven by other delays EL infants experience that require them to request help more frequently. Previous

research has discussed lower *rates* of BR in EL infants but has not looked at how EL infants use BR bids in relation to other types of initiations. BR bids tend to appear earlier in development than JA bids, and Wetherby and colleagues (1998) have suggested that they are a relative strength for children with ASD. Our results indicate that this may also be the case for 18-month-old EL-LD and EL-ND infants, whereas TL infants have begun to use more JA bids to initiate communication at this age.

While EL infants later diagnosed with ASD made repairs at similar rates as other infants, they used smaller repertoires of repair strategies. This suggests that EL-ASD infants may have less flexibility in their communication patterns. By contrast, infants without ASD can select from a larger repertoire of repairs to fit different situations and may be more able to make adaptations when the strategy they are using is not working.

Previous research suggested that EL-ASD infants would use more repetition repairs (Geller, 1998; Keen, 2005), but we found that they used lower proportions of these repairs than EL-LD infants. EL-ASD infants instead made greater use of simplification when repairing communication breakdowns, a strategy that is less helpful to the interlocutor than other repair types because it does not add new information and only repeats a portion of the original unclear bid. Simplification repairs have been described as occurring earlier in development and later being replaced with more advanced strategies such as addition and substitution (Prather et al., 1989). Repetitions, while not as advanced as addition or substitution repairs, are often appropriate responses when caregivers make requests for clarification, such as by asking the child *"What?"* (Marcos, 1991). Our study suggests that EL-ASD infants rely more on a less mature repair method, whereas EL-LD infants who have language delays, but more advanced social communication skills, utilize repetitions.

4.3 Communication behaviors are related to expressive language

We collected two measures of infants' concurrent expressive language, a standardized assessment (MSEL) and a parent report measure (CDI) and expected that both would be correlated with observed infant communication behaviors. This prediction was partially supported by our data. In the EL infants, MSEL Expressive Language scores were positively correlated with percent of initiations that infants attempted to repair and number of unique repair strategies, but these associations were only marginally significant with small effect sizes.

Language abilities as assessed on the CDI were moderately and positively correlated with infant repair behaviors (e.g., percent repair attempts and unique repair strategies), such that infants who had more advanced expressive language produced larger numbers of repairs following communication breakdowns. By contrast, CDI scores were negatively correlated with the percent of infant bids that were immediately successful (i.e., immediately fulfilled by the caregiver). The small negative correlation between caregiver reports of infant language and caregiver behavior was somewhat surprising, but one potential interpretation is that it reflects caregivers' expectations regarding infant bid quality. More specifically, the negative relation may be driven by caregivers who perceive their infants as having better expressive language setting higher standards for infant bids. For example, if the infant points at a book on a shelf and the caregiver knows the infant can say the word *book*, they may not immediately give the infant the book because they expect the infant to add the word to the bid. On the other hand, if a caregiver knows their infant cannot say the word *book*, they may be more likely to immediately fulfill the infant's request in response to a pointing gesture only. This possibility is supported by previous research indicating that as infants' language develops, mothers begin to respond more frequently to more advanced vocalizations (e.g., consonant sounds), and less frequently to less developmentally advanced vocalizations (e.g.,

vowel sounds; Gros-Louis et al., 2006; Leezenbaum et al., 2014). Caregivers appear to scaffold their infants' learning, encouraging them to use the skills they have as they develop.

The weaker relationship between expressive language and repair behaviors in the EL sample only may have been due to the type of expressive language measure (standardized assessment vs. caregiver report) or may indicate that the relationship between expressive language and observed communication behaviors is weaker in EL than in TL infants. Taken together, our data indicate that while infants' expressive language abilities are related to how often they attempt to repair breakdowns and the variety of strategies they use, studying dyadic communication and breakdowns captures more about infant social communication skills than measures of expressive language abilities.

4.4 Limitations and Future Directions

This study has a number of strengths in regard to characterizing infant initiations, breakdowns, and repairs, including using a natural play setting and a sample of EL infants before the age of ASD diagnosis. However, there are also some limitations to note. First, across the sample, initiations and breakdowns were relatively low frequency behaviors, with some infants producing only one initiation in 15 minutes. Therefore, we may not have captured the full range of breakdown and repair behaviors that dyads exhibit on a daily basis. Additionally, this study used videos of naturalistic play sessions in the home. While this has the benefit of providing a snapshot of everyday infant-caregiver interactions, the play session was relatively low stakes, where caregivers were highly attentive to their infants. A more controlled study where infants are presented with situations where they needed to make requests to caregivers (e.g., asking for help

opening containers containing exciting toys) or where caregivers were distracted by another task may offer more opportunity to capture how infants respond to situations where breakdowns are more common. Lastly, as with many studies of infant behavior, our sample was highly heterogeneous, with large individual differences in behavior. Our small sample size likely limited our power to detect group differences, given that our four outcome groups were both small and highly variable. With a larger sample we may have been better able to identify differences across the four groups of infants. However, we were able to detect small to moderate effects in this sample, and all non-significant analyses had very small effect sizes.

To address these limitations, future studies should consider using both naturalistic observation *and* semi-structured interactions that may elicit breakdowns and repairs. For example, in two studies, Marcos and colleagues constructed situations where children were expected to make requests (e.g., toys or cookies were placed out of reach) and mothers were instructed to act as if they had not understood the child (Marcos, 1991; Marcos & Chanu, 1992). Utilizing a similar paradigm in the home, in conjunction with naturalistic observation, could provide more information about the skills that infants *have* and *how* they use them on a day-to-day basis. We are not aware of any studies to date that have used a similar paradigm in a sample of EL infants.

4.5 Conclusions and Implications

The present study addressed three gaps in the literature by identifying communication breakdowns and repairs in response to behavior regulation, joint attention, and social interaction initiations made by infants, in a naturalistic setting, with a prospectively followed sample of infants with elevated likelihood for ASD. We used this design to investigate the development of

initiations, breakdowns, and repair skills in infancy and their relationship to ASD and language outcomes assessed at three years old.

Taken together, the findings from this study suggest that infants and their caregivers often understand one another's communications, recognize when breakdowns do occur, and negotiate communication to resolve misunderstandings. However, the ways in which infants engage in these behaviors differs in relation to familial history of ASD and developmental outcomes. Assessing the skills infants use to get their wants and needs met may be beneficial for setting intervention targets. If infants with communication delays and early signs of ASD have fewer strategies and less flexibility in the ways in which they engage in dyadic interactions, interventions that focus on expanding their repertoire of ways to initiate and repair communication could improve everyday interactions for infants and caregivers.

Appendix A Coding Manual

Adapted from coding procedures described by Meadan & Halle (2004) and Price et al. (2018). All behaviors will be coded in point cells. When an interaction has multiple iterations of repairs, multiple point cells will be coded with initiation type, bid behavior type, and caregiver response left blank.

1. Initiation Type <type>

Onsets and offsets of all instances of infant initiated social communication bids will be identified. Infant initiated means that the infant is not responding to vocalization or gesture from the caregiver (within 2 seconds). An initiation bid can include vocalizations, gestures, and/or shifting eye gaze orientation. Initiation bids will be coded into 3 mutually exclusive types. Because these 3 types have overlapping behaviors, they will be selected hierarchically.

(b) Behavior Regulation: Request for the caregiver to do something (e.g., open a container, give infant a toy, etc.). Usually involves an object.

(j) Joint Attention: Request for the caregiver to look at an object with the infant. Usually includes gaze orientation shift between object and caregiver. Must involve an object. Joint attention can also be coded when the infant appears to give an object to the caregiver but then retracts it, as if changing their mind. In this case, joint attention is more appropriate to code than behavior regulation is.

(s) Social Interaction: Request for the caregiver to interact with the infant (e.g., look at infant, give infant a hug, talk to infant). The request should not include an object.

2. Bid behavior type <behavior>

Communication behaviors used in initiation bids will be coded. Codes are not mutually exclusive multiple codes can be included (type in alphabetical order).

(v) Vocalization: The infant makes a vocalization (cannot be vegetative) to communicate. Does not need to be a word, but must contain clear morphemes/speech-like utterances.

(g) Gesture: The infant utilizes a gesture to communicate a message (e.g., give, reach, show, wave, etc.)

(e) Eye Gaze/Orientation: The infant's gaze is directed towards the caregiver. Base this on the direction of the child's face, direct eye contact is not required.

3. Caregiver Response <caregiver_response>

Parent response will be coded as one of the following four mutually exclusive categories. For analyses, caregiver responses will be collapsed to represent immediately successful and not successful.

(i) Immediate Success: The infant's request is immediately met. Caregiver may still ask a clarification question (e.g., repeating the infant's phrase as a question), but if they first or simultaneously fulfill the bid, this would be considered an immediate success.

(rs) Request for Clarification, Specific: Caregiver asks a specific question to identify what the infant is requesting. For example, the caregiver may ask questions to clarify an infant's request (e.g., "Do you want the ball?", "Which one?") or repeat what they thought the infant was saying with a questioning tone (e.g., "Want milk?"). Caregivers may also provide one-word suggestions (e.g., "Open?") to clarify.

(rn) Request for Clarification, Non-Specific: Caregiver asks a 'w' question (e.g., "What?", "Where?") or makes a vague indication that they do not understand (e.g., "huh," "hmm"). Other non-specific requests for clarification include "I don't understand"

and “Pardon.” Any request for the infant to make a repair to the communication that does not specifically ask for the infant to do or say something is coded as <rn>. Asking “What did you say?” is non-specific but asking the infant “Say it again” is a specific request.

(p) Purposefully Not Successful: Caregiver purposefully offers the wrong response (e.g., offers a different object because they don’t want the infant to have the object being requested) or ignores the bid.

(m) Missed/Misunderstood Bid: Caregiver misses the bid or attempts to fulfill the infant’s request but is incorrect. (e.g., looks at the wrong thing). The caregiver gives no verbal or non-verbal response or provides a seemingly unrelated response.

4. Repair <repair>

When initiation bids are not successful, infant repair attempts will be coded as follows. These categories are mutually exclusive and therefore listed hierarchically. If no repair attempt is made code no response and the interaction ends. If the infant changes the request (new goal), that must be coded as a new initiation

(a) Addition: Augmenting the original bid with another communicative behavior. The infant produces the same verbal and non-verbal behaviors and adds a new communicative behavior.

(s) Substitution: Replacing the original bid with a new communicative behavior. The infant produces new communicative behaviors that were not in the original bid and does not repeat any of the previous behaviors.

(i) Simplification: Reducing the original bid to a simpler form. The infant produces the same bid but does not repeat at least one of the verbal or non-verbal behaviors, or reduces the complexity of the behaviors.

(r) Repetition: Repeating the exact communicative bid. The infant produces the same verbal and non-verbal behaviors, once or more than once.

(y) Yes/No: Responds to caregiver with affirmation or rejection. This can come in the form of head shaking/nodding and/or verbal "yes" or "no." This is often in response to a caregiver's specific clarifying question, but is not necessary.

(e) Emotional Behavior: Engaging in frustration behaviors such as crying, throwing, or hitting. Neutral actions like dropping a toy or walking away are not considered emotional behaviors. The infant must display some level of frustration or distress in their behavior.

(u) Unintelligible: An unclear response that can't be categorized. The infant makes a vocalization that is muffled so it cannot be determined if they were repeating a previous vocalization or making a new one. Unclear gestures are also considered unintelligible (e.g., closed fist 'point').

(n) No Response: No attempt to repair the breakdown is made. If a change in the activity or topic occurs (by caregiver or infant) and the infant does not attempt to return to the original bid, code as no response. All interactions end with either success or no response.

5. Repair Successful? <success>

Repairs will be determined successful or not. If a repair is successful, the interaction is over. If a breakdown occurs again the interaction continues and a new point cell is made (leaving the first 2 arguments blank).

(y) Yes: The request of the infant's bid is met. The caregiver does the requested behavior, engages in joint attention with the infant and intended object, or participates in social interaction.

(n) No: The request of the bid is not met and the interaction ends. This typically happens

when the infant provides no repair attempt.

(c) Continue: The interaction continues if the parent provides a response and the caregiver and infant continue to try to repair the interaction.

Examples.

1. Behavior Regulation with No Repair: Infant reaches for a toy out of reach <b>. The caregiver does not notice the infant's reach and the infant does not get the toy. Because the caregiver missed the reach, code as <m>. The infant does not engage in any repair behaviors <n>. The infant does not have their request met and does not continue requesting, so repair success is coded as <n>. In actuality this interaction looks like an infant reach with no other behavior's, but can be coded to describe a breakdown.

2. Joint Attention with Addition: Infant vocalizes "ball" while looking across the room and then looking to the caregiver <j>. The caregiver is unclear where the infant is looking and makes a non-specific request for clarification, asking "Where?" <rn>. The infant then points to a ball that had rolled under a table and repeats the vocalization, alternating gaze between the ball and caregiver <a>. The caregiver sees the ball and alternates between looking at the infant and the ball saying "Oh yes I see, the ball rolled under the table" <y>.

3. Social Interaction with Immediate Success: Infant reaches arms out to caregiver for a hug <s>. Caregiver immediately responds by giving the infant a hug <i>.

4.Behavior Regulation with Emotional Response: Infant shakes baby gate and turns to parent <b>. Caregiver refuses to open gate and tries to redirect infant <p>. Infant begins crying <e> and the interaction continues <c>. Caregiver refuses again and redirects infant, bringing them away from the gate <p>. Infant starts playing with new toy <n> and the original bid is not

successful <n>.

5. Behavior Regulation with Multiple Repairs: Infant attempts to give toy horse to caregiver (requesting caregiver put the horse on a track) <b>. Caregiver refuses, pointing to infant and saying “No, you do” <p>. Infant throws the toy in response <e>. Caregiver ignores again, picks up toy and says “You can do it” <p>. Infant shakes head ‘no’ <y> and caregiver places toy horse on track as requested <y>.

6. Behavior Regulation with Multiple Repairs 2: Infant attempts to reach up and take object out of caregiver’s hand <b>. Caregiver refuses <p> and infant repeats the exact behavior, trying to reach again <r>. The behavior continues <c> wherein caregiver then asks what the infant’s intent with the object is (“are you gonna play with it?”) <rs>. The infant substitutes a new behavior, walking away to do something else, apparently losing interest <s>. The behavior ends <n>.

7. Behavior regulation with no response: Infant attempts to give rail road piece to caregiver <b>. Caregiver does not take rail road from infant, missing the bid <m>. The infant does not provide a response <n> and the interaction ends there <n>.

8. Successful repair behavior regulation (6078_18): Infant asks caregiver to activate a toy <b>. Caregiver asks “need help?” <rs> and the infant makes a few vocalizations and gestures in response <s>. Caregiver successfully activates the toy.

Rules and Clarifications.

1. Asking to be picked up is always social, so long as there is no object-oriented goal.

2. Joint attention must have a clear parent response to indicate that they are attending to the object.

3. Offscreen pointing will not be counted as joint attention unless there is explicit context.

4. In the case of <p, n, n> repair: when not immediately successful, the infant does an action to resolve a request that doesn't involve communication to their caregiver, such as taking an object back from their caregiver instead of repairing.

5. If a caregiver asks their infant to choose, the following gesture/voc does not count, but it SHOULD be coded as behavioral regulation.

6. Emotional responses can be initiations as long as they are very clear requests for something.

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