

## Research Article

# Rate of Communicative Gestures and Developmental Outcomes in Toddlers With and Without Autism Spectrum Disorder During a Home Observation

Abigail D. Delehanty<sup>a</sup>  and Amy M. Wetherby<sup>b</sup>

**Purpose:** Most toddlers with autism spectrum disorder and other developmental delays receive early intervention at home and may not participate in a clinic-based communication evaluation. However, there is limited research that has prospectively examined communication in very young children with and without autism in a home-based setting. This study used granular observational coding to document the communicative acts performed by toddlers with autism, developmental delay, and typical development in the home environment.

**Method:** Children were selected from the archival database of the FIRST WORDS Project ( $N = 211$ ). At approximately 20 months of age, each child participated in everyday activities with a caregiver during an hour-long, video-recorded, naturalistic home observation. Inventories of unique gestures, rates per minute, and proportions of types of communicative acts and communicative functions were coded and compared using a one-way analysis of variance. Concurrent and prospective relationships between rate of communication and measures

of social communication, language development, and autism symptoms were examined.

**Results:** A total of 40,738 communicative acts were coded. Children with autism, developmental delay, and typical development used eight, nine, and 12 unique gestures on average, respectively. Children with autism used deictic gestures, vocalizations, and communicative acts for behavior regulation at significantly lower rates than the other groups. Statistically significant correlations were observed between rate of communication and several outcome measures.

**Conclusion:** Observation of social communication in the natural environment may improve early identification of children with autism and communication delays, complement clinic-based assessments, and provide useful information about a child's social communication profile and the family's preferred activities and intervention priorities.

**Supplemental Material:** <https://doi.org/10.23641/asha.14204522>

Gestures are intentional, communicative movements of the hands, arms, face, or head that children learn during reciprocal social exchanges as caregivers use them to refer to objects, events, and people around them (Acredolo & Goodwyn, 1988). Infants use gestures to communicate before they begin to talk, with the earliest gestures emerging by 7–9 months of age (Bates et al., 1979; Crais et al., 2004). The number of unique gestures in a child's inventory and the rate at which they use gestures have

been found to be significantly related to language development, leading researchers to theorize that language and gesture share a common symbolic communication system and neurological underpinnings (Bates & Dick, 2002; Bernardis & Gentilucci, 2006; Iverson & Thelen, 1999; Wetherby et al., 1988).

Delays in young children's gesture development and a reduced rate of communication may signal risk for a developmental delay (DD), including autism spectrum disorder (ASD; Crais et al., 2009; Wetherby et al., 2007). Deficits in nonverbal communication in the context of social interactions, including the understanding and use of gestures and the integration of gestures and verbal communication, are core components of the *Diagnostic and Statistical Manual of Mental Disorders* criteria for diagnosis of ASD (American Psychiatric Association [APA], 2013). There is great potential for incorporating measures of gesture use into early communication

<sup>a</sup>Department of Speech-Language Pathology, Duquesne University, Pittsburgh, PA

<sup>b</sup>Department of Clinical Sciences, College of Medicine, Florida State University, Tallahassee

Correspondence to Abigail D. Delehanty: [delehantya@duq.edu](mailto:delehantya@duq.edu)

Editor-in-Chief: Julie Barkmeier-Kraemer

Editor: Mary K. Fagan

Received December 9, 2019

Revision received April 27, 2020

Accepted December 5, 2020

[https://doi.org/10.1044/2020\\_AJSLP-19-00206](https://doi.org/10.1044/2020_AJSLP-19-00206)

**Disclosure:** Amy M. Wetherby receives royalties from the *Communication and Symbolic Behavior Scales* but not from this study. Abigail D. Delehanty has no conflicts of interest.

screening and evaluation, as prelinguistic social communication skills such as gestures are observable and measurable months before words are expected to emerge.

### ***Gestures in Young Children Who Are Typically Developing***

Gestures may be divided into two categories: deictic and representational (Iverson & Thal, 1998). Deictic gestures are contextual, referring to an object or event that is physically present, and begin to emerge between 7 and 10 months of age. Contact gestures, including pulling an adult by the hand, are the earliest developing deictic gestures, appearing between 7 and 9 months of age (McLean et al., 1991). Distal deictic gestures, such as reaching and pointing, require no physical contact with an object or person. They emerge between 10 and 12 months (Crais et al., 2004). Deictic gestures have been found to make up approximately 88% of toddlers' gesture repertoires (Thal & Tobias, 1992).

Representational gestures do not require the presence of a referent and develop around 12–16 months of age, after deictic gestures are at least somewhat established (Acredolo & Goodwyn, 1988; Bates et al., 1979; Iverson & Thal, 1998). They may be either iconic, depicting the properties of an object (e.g., holding hands out to represent the size of an object), or conventional, refined by sociocultural contexts (e.g., placing a finger to the lips to gesture “quiet” or waving goodbye). Representational gestures tend to appear just prior to the “vocabulary burst” that occurs at 18 months, which has led to speculation that an overall increase in symbolic understanding may launch this naming explosion (Rowe & Goldin-Meadow, 2009).

Another method used to describe children's early communicative acts is to determine the communicative function being expressed (Bruner, 1981; Wetherby & Prizant, 2002). Bruner's (1981) functional categories include acts for (a) behavior regulation: requesting or protesting actions and objects; (b) social interaction: greeting or drawing attention toward oneself; and (c) joint attention: directing attention toward an entity or event by showing, pointing, commenting, or requesting information. Communicative acts for joint attention are, by definition, triadic and thus more sophisticated than acts for behavior regulation or social interaction. Over time, researchers have documented a general order of emergence of these communicative functions, with behavior regulation appearing first, followed closely by social interaction and then joint attention (Bates et al., 1979; Crais et al., 2004; Wetherby et al., 1988). Bruner's taxonomy is particularly useful in the assessment of gestures, as they may be used to express varying functions depending on the context.

### ***Gestures in Young Children With ASD***

There are similarities between gesture acquisition patterns of children with typical development (TD) and those with ASD. Extant research suggests that gesture inventories and the rate per minute at which children communicate and use gestures are significantly related to later language development in both populations (Charman et al., 2005; Özçalışkan

et al., 2017; Watt et al., 2006; Wetherby et al., 2007). A second similarity is that children both with and without ASD have been found to use a higher proportion of deictic than representational gestures (Özçalışkan et al., 2016; Thal & Tobias, 1992).

Despite these parallels, differences in the quality and quantity of gesture usage have been observed in children with ASD from a very early age. Veness et al. (2012), for example, found that overall gesture scores on the MacArthur-Bates Communicative Development Inventories (Fenson et al., 2007) differentiated 12-month-old children with ASD from those with non-ASD DDs and with TD. In a study of retrospective home videos (Watson et al., 2013), 9- to 12-month-old infants with ASD were less likely than infants with TD and DD to use gestures for behavior regulation and joint attention. At 15–18 months, toddlers with ASD were less likely than those with DD and TD to use gestures for social interaction and joint attention.

In the second half of the second year of life, these patterns remain largely consistent. Wetherby et al. (2007) compared Communication and Symbolic Behavior Scales (CSBS) Behavior Sample (Wetherby & Prizant, 2002) scores of 18- to 24-month-old children with ASD, DD, and TD. Children with ASD were observed to use a significantly smaller inventory of gestures, a reduced rate of communication, and fewer communicative acts used for the purpose of joint attention compared to children with DD and TD. Rate of communication, acts for behavior regulation, and inventory of gestures predicted nonverbal developmental level on the Mullen Scales of Early Learning (MSEL; Mullen, 1995) and were also significant predictors of scores on the Autism Diagnostic Observation Schedule (ADOS; Lord et al., 1999) at 3 years of age. Shumway and Wetherby (2009) further analyzed this sample using an observational coding scheme applied to the CSBS. They found that children with ASD used deictic gestures at a significantly lower rate per minute and in smaller proportions than those with DD and TD as well as a significantly higher proportion of contact gestures (i.e., reaching to touch an adult for comfort) than both groups. Group differences in representational gesture use were not observed, with all three groups using a relatively small proportion of this gesture type. With regard to communicative function, acts for joint attention were used significantly less frequently by children with ASD compared to those with DD and TD. Finally, rate of communication was observed to be significantly correlated with verbal and nonverbal developmental level at around the age of 3 years.

Turning to research conducted with slightly older toddlers and preschool-aged children, Özçalışkan et al. (2016) observed a group of twenty-three 31-month-old children with ASD (range: 21–37 months) who were matched by expressive vocabulary to a younger sample of 23 children with TD as they interacted with a caregiver during a 20-min play sample in a laboratory playground. Generally, results were in agreement with studies of younger toddlers. They found that children with ASD used deictic gestures at lower frequencies than those with TD, although deictic gestures accounted for 78% of all gestures in the ASD group and 87% of all gestures

in the TD group. Of interest, although children with ASD were found to have expressed the same amount of speech as children with TD during play samples, they were observed to gesture less frequently. Again, deictic gesture production was noted to be a significant predictor of expressive vocabulary 1 year later for both groups. Requesting for the purpose of behavior regulation was the strongest predictor of expressive vocabulary in the ASD group, and deictic gestures for commenting predicted vocabulary for children with TD.

### ***Observing Child Gestures in the Home Environment***

Taken together, research findings suggest that restricted gesture inventories and reduced rates of communication are important early red flags for ASD (Zwaigenbaum et al., 2015). Still, additional research examining early social communication skills is recommended to clarify delays and deficits that are specific to children with ASD and advance efforts to improve early identification. One area of interest is the study of social communication in toddlers with ASD during caregiver–child interaction in a home-based setting. Few researchers have examined the rates and types of communicative acts and communicative functions that occur in the natural environment in young children with ASD (LeBarton & Iverson, 2016; Parladé & Iverson, 2015). The consideration of information from multiple sources across contexts, including standardized assessments, observation, and parent report, is critical for a comprehensive evaluation of language development and for making a diagnosis of ASD (APA, 2013; Barokova & Tager-Flusberg, 2020; Kim & Lord, 2012; Risi et al., 2006). Furthermore, the Individuals with Disabilities Education Act Part C (IDEA, 2004) mandates that children receive services in the natural environment to the maximum extent possible, and approximately 88% of children who receive early intervention services do so at home (U.S. Department of Education, 2016).

Observation of caregiver–child interaction in the home offers a naturalistic, ecologically valid context to augment the results of standardized assessments and may provide useful information about a child’s strengths and needs and the family’s preferred activities and intervention priorities (Woods & Brown, 2011). Research on infants and toddlers with TD suggests that they may initiate communication at higher rates and use a higher quality of vocal communicative acts (i.e., consonant–vowel combinations vs. nonspeechlike sounds) in a familiar environment (Lewedag et al., 1994). It is possible that the same pattern may be observed in children with ASD. Finally, measurement of toddlers’ communicative acts in the home environment using granular coding with a scheme that is informed by findings of previous research (e.g., Özçalışkan et al., 2016; Shumway & Wetherby, 2009) could add important information to studies that have utilized standardized assessment measures (Wetherby et al., 2007), parent report tools (e.g., Iverson et al., 2018; Veness et al., 2012), and retrospective home video analysis (e.g., Colgan et al., 2006; Watson et al., 2013). The results of studies using a variety of methods could be integrated to

provide a more complete picture of communication development in young children with ASD and aid efforts to identify ASD earlier.

### ***Purpose of This Study***

The purpose of this study was to document the communicative acts performed by toddlers diagnosed with ASD, DD, and TD during a naturalistic home observation. Given the important links between early communication and language development that have been reported in previous research, associations among child communication in the home environment and developmental outcomes were also examined. Specific aims guiding this study were to (a) describe and compare inventories of unique gestures, mean rates of communication, and proportions of communicative acts by type and communicative function; (b) examine relationships between communicative acts performed during the home observation and concurrent measures of social communication and autism symptoms; and (c) examine prospective relationships between communicative acts and standardized measures of developmental level and autism symptoms collected around 3 years of age.

## **Method**

### ***Participants***

Participants included 211 children who were selected from the archival database of the prospective, longitudinal FIRST WORDS Project (Wetherby et al., 2008). As part of the larger project, families were recruited through screening for communication delay in primary care settings. Children were initially screened with the Infant–Toddler Checklist (ITC; Wetherby & Prizant, 2002), a parent report broadband screener for communication delay, between 9 and 18 months. Children who scored below the 10th percentile on the ITC, those whose parents indicated concerns about their child’s development, and randomly selected children who screened negative for communication delay on the ITC were invited to participate in a communication evaluation.

To be included in this study, children must have subsequently completed (a) a video-recorded CSBS Behavior Sample in the second year of life; (b) a video-recorded home observation, also collected during the second year, that was scored using the Systematic Observation of Red Flags for ASD (SORF; Wetherby et al., 2016); and (c) a developmental evaluation around 3 years of age that included the MSEL. The 18- to 24-month age window was chosen, as this is the age at which the American Academy of Pediatrics recommends screening for ASD in primary care (Hyman et al., 2020), the age at which a stable diagnosis of ASD may be made in many children (Chawarska et al., 2007; Guthrie et al., 2013), and the age at which children may be referred for an evaluation to determine eligibility for early intervention.

Each participant in this study received a clinical best estimate diagnosis of ASD, DD, or TD using all available

information collected at the developmental evaluation by an experienced team of diagnosticians. For children with a DD on the MSEL and/or for whom ASD was suspected, additional measures were collected during the developmental evaluation to confirm or rule out ASD, including the ADOS and the Vineland Adaptive Behavior Scales (Sparrow et al., 2005). Children identified as having a DD received a *T* score of < 38 (1.25 *SDs* below the mean) on any subscale of the MSEL, and ASD was ruled out following the full diagnostic battery. Children were classified as having TD if all MSEL *T* scores  $\geq 38$  and a judgment of no concern about autism symptoms was made by the diagnostician. Due to limited resources of diagnostic time, the ADOS was completed on a subset of children in the TD group ( $n = 17$ , 39%). ASD was ruled out in these children, supporting group assignment. Children from three groups (ASD, DD, and TD) were included in an effort to clarify social communication delays and deficits specific to children with ASD that may differentiate them from children with DD and TD.

Diagnostic outcomes, CSBS scores, and/or SORF scores have previously been reported in Delehanty et al. (2018) for 70 children included in the current study, 95 who were included in Dow et al. (2017), and 141 in Dow et al. (2020). Thirty-nine children with ASD included in this study participated in a randomized controlled trial of the Early Social Interaction (ESI) intervention model (Wetherby et al., 2014). Parents of all children gave written informed consent before their children were enrolled and evaluated. Before participants were selected for inclusion, this study was approved by the institutional review board at Florida State University.

## **Archival Measures**

### **CSBS Behavior Sample**

The CSBS Behavior Sample (Wetherby & Prizant, 2002) is a standardized observational measure of communication for use with children between 12 and 24 months of age. The CSBS is designed to elicit spontaneous communication within a supportive interaction with a caregiver and an examiner. The social composite measures emotion and eye gaze, communication, and gestures; the speech composite includes sounds and words; and the symbolic composite measures language comprehension and object use in play.

### **SORF**

The SORF is an observational screening measure developed to quantify red flags of ASD in toddlers and to identify children who should be referred for a diagnostic evaluation by a professional with experience in ASD (Wetherby et al., 2016). The SORF includes items from each diagnostic domain for ASD—impairments in social communication and social interaction and restricted and repetitive behaviors (APA, 2013). Item-level SORF is rated on a scale of 0–3 according to item-level definitions. Scores of 2 or 3 indicate clear symptom presence and are pooled to yield a total number of red flags. Higher SORF scores indicate a higher

number of red flags for ASD. Results of two initial studies of the SORF, scored from the CSBS (Dow et al., 2017), and a video-recorded home observation (Dow et al., 2020) suggested that the SORF demonstrated utility and efficacy as a measure of ASD symptoms.

### **MSEL**

The MSEL is a standardized assessment of cognitive functioning, normed for children between the ages of 1 and 68 months (Mullen, 1995). The Early Learning Composite (ELC) is expressed as a standard score ( $M = 100$ ,  $SD = 15$ ) based on the sum of the *T* scores ( $M = 50$ ,  $SD = 10$ ) of cognitive scales (Receptive Language, Expressive Language, Visual Reception, and Fine Motor).

### **ADOS**

The ADOS is a semistructured, standardized measure of communication, social interaction, and play used in the assessment of individuals suspected of having ASD. The ADOS provides domain scores in Social Affect and Restricted and Repetitive Behaviors as well as a total score. Five modules are available that are appropriate for use with individuals of all ages and developmental levels. In this study, Module 1 or 2 was administered by a research-reliable clinician. Calibrated severity scores (CSSs), developed to standardize ADOS scores across modules, approximate a metric of the severity of autism-specific symptoms, and facilitate longitudinal comparison of assessments and modules over time, were reported (Gotham et al., 2009).

### **Home Observation**

A baseline home observation of each child, lasting approximately 1 hr, was video-recorded around the time point at which the CSBS was administered. The home observation allowed for the collection of information about child communication, social interaction, and play during everyday activities with a caregiver or caregivers. Families received a set of standardized instructions in advance of the recording. They were asked to interact with their child as they typically would while participating in activities from six categories: (a) play with toys, (b) play with people, (c) meals and snacks, (d) caregiving, (e) book sharing, and (f) family chores. Examples of each activity category were provided. Caregivers were asked to engage in as many different activities as possible; however, in an attempt to collect an observation that was as naturalistic as possible, they were not instructed to participate in any activity for a specified amount of time.

### **Observational Coding Scheme for Home Observation**

A branch-chain observational coding scheme, in which multiple codes are assigned to each event, was developed to measure child communicative acts that occurred during video-recorded home observations (Bakeman & Quera, 2011). A communicative act was identified using criteria from the CSBS as an interactive behavior that (a) included a gesture, nonword vocalization, or verbalization (word or

word combination); (b) was directed toward the adult; and (c) was used as a communicative signal to serve a communicative function (Wetherby & Prizant, 2002). Noldus Pro Observer XT v.12.5 software was utilized for coding. All child communicative acts were coded as mutually exclusive and exhaustive events (Bakeman & Quera, 2011), meaning that only one outcome was possible for each communicative act coded.

Nonword vocalizations, single words, and word combinations that did not overlap with gestures were coded as vocal communicative acts. If a communicative act included a gesture, one of 22 gesture types was assigned as contact, deictic, or representational (conventional or iconic). Contact gestures, the earliest developing deictic gestures, included communicative acts that were used to direct an adult's attention but may not have been used to reference an object. Examples included pushing or pulling a person, use of another person's hand as a tool, or a communicative self-injurious act (Phillips et al., 1995; Shumway & Wetherby, 2009; Wetherby & Prutting, 1984). Deictic gestures included give, push/pull away, open-handed reach for a person or an object, show, tap/pat, point to touch, and distal point. Conventional gestures included shake head, wave, clap, blow kiss, "shh," nod head, thumbs-up, shrug, hand up for "wait," and high five. Examples of iconic gestures were depictive gestures and signs.

With regard to mode of communication, the overall rate of vocal-only acts that we present in this study includes nonword vocalizations, single words, and phrases. Gestures were coded for whether they had temporal overlap with a vocalization, single word, or word combination. The overall rate per minute of gesture use reflects the following modes of communication: gesture alone, gesture + vocalization, gesture + single word, and gesture + word combination. Finally, coders determined the communicative function of each act (behavior regulation, social interaction, joint attention, or unclear).

### **Training and Interrater Reliability**

A trained undergraduate research assistant, blind to participant diagnosis and the aims of the study, and the first author (also blind to diagnoses) served as coders. Practice sessions of consensus coding of home videos of children not included in this study were conducted for one academic semester. Ten home observations of children not included in this study were then selected for use as training videos, and interrater reliability was assessed using Cohen's kappa coefficients (Cohen, 1960). An agreement criterion of  $\kappa > .60$  (substantial or acceptable agreement; Landis & Koch, 1977; McHugh, 2012) was set for practice videos and for the corpus of coded video recordings that was included in the study for analyses. The research team participated in coding meetings multiple times per week to minimize drift from definitions and procedures. Fifty videos (24%) were double-coded. The overall kappa for identification of child communicative acts by type was .80, 95% CI [.72, .88], and the overall

kappa for frequency of communicative functions was .84, 95% CI [.84, .85].

### **Analytic Plan**

Group comparisons of participant demographic and developmental characteristics, aspects of the video-recorded home observations, rate per minute of communicative acts, and proportions of communicative acts were conducted using chi-square tests of independence for categorical variables and one-way analyses of variance (ANOVAs) for continuous variables. In order to conservatively control for potentially inflated risk of Type I error due to violations of the assumption of homogeneity of variance that may occur with unequal sample sizes, post hoc, pairwise comparisons of continuous variables were interpreted using Dunnett's T3 correction. Cramér's  $V$  ( $\phi_c$ ) was calculated to estimate the effect sizes of group differences for categorical demographic variables (Acock & Stavig, 1979; McHugh, 2013). Values of  $\phi_c$  range from 0 to 1, with the strength of association increasing as values approach 1. Cohen's  $d$  was calculated for group comparisons of continuous variables using the following conventions for effect sizes: .20 is small, .50 is medium, and .80 is large (Cohen, 1988). For concurrent and prospective bivariate relationships among variables, Pearson product-moment correlation coefficients were calculated. Results were interpreted using Cohen's (1988) conventions for effect sizes for  $r$ , where .10 is considered a small association, .30 is medium, and .50 or greater is large. Visual inspection of histograms suggested that rates of child communicative acts were not always normally distributed. However, parametric statistics including ANOVA and bivariate Pearson product-moment correlations are considered to be generally robust to violations of normality (Blanca et al., 2017; Schmider et al., 2010). All measures were included in analyses.

A power analysis for one-way ANOVA was conducted a priori using G\*Power 3.1 (Faul et al., 2013) to estimate the sample size needed to detect group differences. Using an  $\alpha$  of .05, a medium effect size ( $f = 0.25$ ), and three diagnostic groups, the power to detect group differences would be approximately 80% with a sample size of 159. Exploring further, given our unbalanced design, results of this power analysis were confirmed using SAS with GROUPNS and GROUPWEIGHTS options to specify overall sample size and group allocation.

## **Results**

### **Participant Demographics at 20 Months**

Demographic characteristics for each group are displayed in Table 1. As part of the larger project's recruitment strategy, boys with TD were oversampled in an attempt to represent proportions similar to the group with ASD. In the current study, a higher proportion of children in the DD group was Black compared to the other groups,  $\chi^2(8, N = 211) = 24.93, p < .01$ . A larger proportion of parents in the TD group had a graduate degree,  $\chi^2(12, N = 211) = 27.06, p < .01$ . Mothers of children in the DD group were

**Table 1.** Participant demographic characteristics.

Demographic	ASD ( <i>n</i> = 121)	DD ( <i>n</i> = 46)	TD ( <i>n</i> = 44)	$\chi^2$	<i>df</i>	$\Phi_c^a$
Sex (%)				8.53*	2	.20
Female	14	17	34			
Male	86	83	66			.20
Race (%)				24.93**	8	
White	73	44	80			
Black	18	37	7			
Asian	3	2	0			
More than one race	7	15	14			
Ethnicity (%)				6.40	4	.17
Hispanic	12	7	5			
Parent's education						
Mother (%)				33.36**	12	.18
Finished eighth grade	1	9	2			
High school degree	24	35	7			
Associate degree	17	9	14			
Some college	6	4	0			
College degree	23	13	27			
Graduate degree	22	20	48			
Missing ( <i>n</i> )	8	11	2			
Father (%)				27.06**	12	.16
Finished eighth grade	3	4	0			
High school degree	32	39	18			
Associate degree	13	7	9			
Some college	5	2	2			
College degree	18	13	18			
Graduate degree	17	15	48			
Missing ( <i>n</i> )	12	20	5			
Parent's age at child's birth (years)				<b><i>F</i>(2, 205)</b>		<b><i>d</i><sup>b</sup></b>
Mother ( <i>M</i> [ <i>SD</i> ])	30.6 (6.3)	29.1 (5.8)	32.3 (4.7)	3.24*		.61
Missing ( <i>n</i> )	0	3	0			
Father ( <i>M</i> [ <i>SD</i> ])	33.6 (6.8)	32.0 (8.4)	33.7 (6.5)	0.91		.30
Missing ( <i>n</i> )	4	5	0			

Note. ASD = autism spectrum disorder; DD = developmental delay without ASD; TD = typical development.

<sup>a</sup>Values of Cramér's  $V$  ( $\Phi_c$ ) range from 0 to 1, with the strength of association increasing as values approach 1. <sup>b</sup>Effect size is based on Cohen's *d*: .20 is small, .50 is medium, and .80 is large.

\* $p < .05$ . \*\* $p < .01$ .

significantly younger than those of children in the TD group,  $F(2, 205) = 3.24, p < .05$ .

### Participant Developmental Characteristics at 20 Months and 3 Years

Participant developmental characteristics are displayed in Table 2. At 20 months, children in all three groups were observed to score significantly differently from one another on the social composite of the CSBS, with children with TD scoring the highest, followed by children with DD and ASD,  $F(2, 208) = 79.12, p < .001$ . On the speech and symbolic composites, ASD and DD groups scored significantly lower than the TD group, speech:  $F(2, 208) = 42.27, p < .001$ ; symbolic:  $F(2, 208) = 57.97, p < .001$ . All three groups differed on the SORF total score, with the ASD group scoring highest, followed by the DD and TD groups,  $F(2, 208) = 29.84, p < .001$ . With regard to the measures taken at the age of 3 years, children with ASD and DD scored significantly lower than children with TD on the MSEL Receptive

Language,  $F(2, 208) = 45.04, p < .001$ , and Expressive Language,  $F(2, 208) = 50.56, p < .001$ , scales. Children with TD were observed to have MSEL ELC scores that were greater than 1 *SD* above the mean, on average. Finally, children with ASD scored significantly higher than children with DD and TD on the ADOS total score,  $F(2, 208) = 99.90, p < .001$ .

### Characteristics of the Video-Recorded Home Observations at 20 Months

On average, the calculated duration of the home observations was 56.1 min ( $SD = 6.3$ ). Video length was not observed to differ significantly among diagnostic groups,  $F(2, 208) = 3.01, p = .05$ . Families engaged in a mean of 5.4 activities ( $SD = 1.3$ , range: 2–6). The three groups were not observed to differ with respect to the number of activities in which they participated,  $F(2, 208) = 1.71, p = .18$ . In 61% of videos, one adult interacted with the child. Thirty-seven percent of videos included two adults, and 2% included three

**Table 2.** Participant developmental characteristics.

Measure	ASD (n = 121)		DD (n = 46)		TD (n = 44)		F(2, 208)	Effect size (d) <sup>a</sup> of group differences	
	M	SD	M	SD	M	SD		ASD-DD	ASD-TD
CSBS Behavior Sample									
Age in months	19.4	2.2	19.4	1.9	19.2	1.8	0.27	0.01	0.13
Social composite <sup>b</sup>	5.6 <sub>c</sub>	2.5	7.6 <sub>d</sub>	2.8	11.4 <sub>e</sub>	2.9	79.12***	0.76	2.15
Speech composite <sup>b</sup>	6.4 <sub>c</sub>	2.4	7.1 <sub>c</sub>	2.1	10.1 <sub>d</sub>	2.3	42.27***	0.33	1.59
Symbolic composite <sup>b</sup>	6.7 <sub>c</sub>	2.6	7.1 <sub>c</sub>	2.4	11.9 <sub>d</sub>	3.5	57.97***	0.16	1.68
Systematic Observation of Red Flags for ASD									
Age in months	20.2	2.2	20.5	1.8	20.1	1.7	0.37	0.11	0.07
Total score	20.3 <sub>c</sub>	8.0	16.7 <sub>d</sub>	6.0	10.9 <sub>e</sub>	4.5	29.84***	0.51	1.46
Mullen Scales of Early Learning									
Age (months)	37.8 <sub>c</sub>	4.3	36.0 <sub>c,d</sub>	3.7	33.8 <sub>d</sub>	5.8	12.78***	0.44	0.78
Receptive Language <sup>f</sup>	37.2 <sub>c</sub>	14.5	36.3 <sub>c</sub>	12.7	58.0 <sub>d</sub>	8.6	45.04***	0.06	1.74
Expressive Language <sup>f</sup>	38.6 <sub>c</sub>	14.4	35.9 <sub>c</sub>	12.5	59.8 <sub>d</sub>	8.2	50.56***	0.19	1.81
Visual Reception <sup>f,g</sup>	40.9 <sub>c</sub>	17.5	38.4 <sub>c</sub>	13.2	63.3 <sub>d</sub>	11.6	38.63***	0.17	1.49
Fine Motor <sup>f</sup>	35.8 <sub>c</sub>	13.4	32.5 <sub>c</sub>	11.6	53.1 <sub>d</sub>	7.0	40.38***	0.25	1.57
Early Learning Composite <sup>g</sup>	79.2 <sub>c</sub>	24.2	74.1 <sub>c</sub>	16.9	116.0 <sub>d</sub>	12.9	62.49***	0.24	1.94
ADOS									
			(n = 121)	(n = 46)	(n = 17)		F(2, 179)		
Age (months)	38.0	4.3	36.2	3.7	38.0	7.8	2.78	0.45	0.01
Total <sup>h</sup>	6.6 <sub>c</sub>	1.9	2.7 <sub>d</sub>	1.9	2.3 <sub>d</sub>	1.4	99.90***	2.05	2.58

Note. Means in the same row with different subscripts (c, d, and e) differ significantly ( $p < .05$ ). ASD = autism spectrum disorder; DD = developmental delay; TD = typical development; CSBS = Communication Symbolic and Behavior Scales; ADOS = Autism Diagnostic Observation Schedule.

<sup>a</sup>Effect size is based on Cohen's  $d$ : .20 is small, .50 is medium, and .80 is large. <sup>b</sup>Standard scores based on  $M = 10$  and  $SD = 3$ . <sup>f</sup> $T$  scores based on  $M = 50$  and  $SD = 10$ . <sup>g</sup>Standard scores based on  $M = 100$  and  $SD = 15$ . <sup>h</sup>ADOS total score is reported as a calibrated severity score. \*\*\* $p < .001$ .

or more adults. In 25% of videos, an additional child or children were present. In 7% of videos, the adult spoke more than one language to the child, including Spanish, Korean, or Mandarin. Groups were not found to differ on these three variables, number of adults:  $F(2, 208) = 0.27, p = .76$ ; other children present:  $F(2, 208) = 0.42, p = .66$ ; more than one language:  $F(2, 208) = 0.38, p = .69$ .

### Gestures Used During the Home Observation

A total of 40,738 communication acts were coded. Children in the TD group used a mean of 11.7 out of 22 possible gestures ( $SD = 2.3$ , range: 6–17). The ASD and DD groups produced a mean of 8.4 ( $SD = 2.5$ , range: 1–14) and 9.3 ( $SD = 2.4$ , range: 4–14) gestures, respectively. Proportions of children with ASD, DD, and TD who performed each gesture on at least one occasion during the home observation may be found in Supplemental Material S1. Within gesture inventories, three significant group differences emerged with regard to deictic gestures: (a) A significantly higher proportion of children in the TD group relative to those in the ASD and DD groups used a deictic gesture,  $F(2, 208) = 14.58, p < .001$ ; (b) a higher proportion of children in the TD group used a point-to-touch gesture relative to those in the ASD and DD groups,  $F(2, 208) = 7.39, p < .01$ ; and (c) all three groups differed on the proportion of children who used a distal point, with 100% of the TD group using this gesture, 74% of the DD group, and 50% of children with ASD,  $F(2, 208) = 22.10, p < .001$ . Children in the TD

group used some conventional gestures in higher proportions than those in the ASD and TD groups, that is, head shake:  $F(2, 208) = 9.91, p < .001$ ; head nods:  $F(2, 208) = 30.38, p < .001$ ; wave:  $F(2, 208) = 2.01, p < .05$ ; and thumbs-up:  $F(2, 208) = 3.92, p < .05$ , as well as iconic gestures,  $F(2, 208) = 8.52, p < .001$ .

### Rate of Communication During the Home Observation

Children with ASD, DD, and TD were significantly different with respect to both overall rate of communication and the rate at which they used deictic gestures during the home observation, with children with TD having the highest rate, followed by those with DD and then those with ASD,  $F(2, 208) = 45.17, p < .001$ , and  $F(2, 208) = 28.99, p < .001$ , respectively (see Table 3). Other significant differences between groups emerged, with the ASD and DD groups using conventional gestures at a lower rate than the TD group,  $F(2, 208) = 14.70, p < .001$ , and the ASD group using iconic gestures at lower rates than the TD group,  $F(2, 208) = 5.16, p < .01$ . Contact gestures were used at low rates by all three groups. Examination of communicative functions revealed that all three groups differed from one another on rate of communication for the purpose of behavior regulation, again with the TD group having the highest and then the DD and ASD groups,  $F(2, 208) = 28.01, p < .001$ . Groups did not differ on rate of acts for social interaction. With regard to joint attention, the rate of the TD group was

**Table 3.** Rate and proportion of communicative acts performed during the home observation at 20 months.

Communicative act	ASD (n = 121)		DD (n = 46)		TD (n = 44)		F(2, 208)	Effect size (d) <sup>a</sup> of group differences		
	M	SD	M	SD	M	SD		ASD-DD	ASD-TD	
Rate per minute by type										
Overall	2.7 <sub>b</sub>	1.5	3.5 <sub>c</sub>	1.5	5.2 <sub>d</sub>	1.4	45.17***	0.52	1.70	
Contact	0.02	0.03	0.02	0.04	0.02	0.1	0.02	0.00	0.00	
Deictic	0.9 <sub>b</sub>	0.6	1.2 <sub>c</sub>	0.7	1.8 <sub>d</sub>	0.8	28.99***	0.57	1.24	
Conventional	0.1 <sub>b</sub>	0.2	0.1 <sub>b</sub>	0.1	0.3 <sub>c</sub>	0.3	14.70***	0.00	0.74	
Iconic	0.02 <sub>b</sub>	0.1	0.03 <sub>b</sub>	0.1	0.1 <sub>c</sub>	0.1	5.16**	0.13	0.49	
Vocal	1.7 <sub>b</sub>	1.1	2.1 <sub>b</sub>	1.0	3.1 <sub>c</sub>	1.1	27.50***	0.40	1.30	
Proportion by type										
Contact	.01	.02	.01	.02	.00	.01	1.74	0.00	0.00	
Deictic	.3	.1	.4	.1	.3	.1	0.41	0.16	0.00	
Conventional	.1	.1	.04	.1	.1	.1	1.38	0.20	0.00	
Iconic	.01	.02	.01	.02	.01	.02	1.13	0.00	0.00	
Vocal	.6	.2	.6	.1	.6	.1	0.08	0.08	0.00	
Rate per minute by function										
Behavior regulation	1.1 <sub>b</sub>	0.7	1.5 <sub>c</sub>	0.7	2.1 <sub>d</sub>	0.9	28.01***	0.53	1.20	
Social interaction	0.8	0.5	0.9	0.5	0.9	0.5	1.69	0.27	0.24	
Joint attention	0.9 <sub>b</sub>	1.0	1.2 <sub>b</sub>	0.9	2.3 <sub>c</sub>	1.0	36.08***	0.32	1.44	
Unclear	0.01	0.01	0.01	0.01	0.01	0.01	0.88	0.00	0.00	
Proportion by function										
Behavior regulation	.4	.2	.4	.2	.4	.1	0.61	0.00	0.25	
Social interaction	.3 <sub>b</sub>	.2	.3 <sub>b</sub>	.1	.2 <sub>c</sub>	.1	13.50***	0.21	1.02	
Joint attention	.3 <sub>b</sub>	.2	.3 <sub>b</sub>	.2	.4 <sub>c</sub>	.1	14.98***	0.12	1.02	
Unclear	.003	.01	.002	.01	.001	.01	2.43	0.10	0.20	

Note. Proportions represent total count/all communicative acts. Means in the same row with different subscripts (b, c, and d) differ significantly ( $p < .05$ ). ASD = autism spectrum disorder; DD = developmental delay without ASD; TD = typical development.

<sup>a</sup>Effect size is based on Cohen's  $d$ : .20 is small, .50 is medium, and .80 is large.

\*\* $p < .01$ . \*\*\* $p < .001$ .

significantly higher than those of the ASD and DD groups,  $F(2, 208) = 14.98, p < .001$ .

### Proportions of Communicative Acts and Functions Used During the Home Observation

Proportions of each type of communicative act used were not observed to differ significantly among groups. Vocal communicative acts were used in the largest proportions, followed by deictic gestures. Conventional, iconic, and contact gestures made up a relatively small proportion (about 6%, together) of communicative acts used by all children, on average. Turning to communicative functions, children in all groups communicated for the function of behavior regulation for 40%–43% of all communicative acts; however, some significant differences were noted. Children with TD communicated for the purpose of social interaction in lower proportions than children with DD and ASD,  $F(2, 208) = 13.50, p < .001$ . Meanwhile, the TD group used a higher proportion of acts for joint attention than the ASD and DD groups,  $F(2, 208) = 14.98, p < .001$ , while the ASD and DD groups did not differ.

### Concurrent Relationships—Rate of Communication, CSBS, and SORF

For the entire sample, overall rate per minute of all communicative acts, deictic gestures, conventional gestures,

and vocal acts were observed to have significant positive correlations with the CSBS social and symbolic composites (see Table 4; range  $r$ : .24–.52). Significant negative correlations were noted between overall rate, rates of deictic and conventional gestures, and vocal acts with the SORF total score (range  $r$ : –.29 to –.57). With regard to communicative function, three relationships were notable. Significant associations were observed between rate of acts for behavior regulation and joint attention with the three CSBS composites (range  $r$ : .24–.56). Rates of all three communicative functions were observed to be significantly negatively correlated with the SORF (range  $r$ : –.30 to –.52). Lastly, inventory of gestures was observed to be significantly correlated with the CSBS and the SORF (see Table 5; range  $r$ : .42–.49).

### Prospective Relationships—Rate of Communication, MSEL, and ADOS

Significant correlations were observed between MSEL Receptive Language and Expressive Language scales administered around the age of 3 years and overall rate per minute of communication, rates of deictic and conventional gestures, rate of vocal acts, and rates of communication for behavior regulation and joint attention at 20 months (see Table 4; range  $r$ : .29–.49). Rates of deictic gesture, vocal communicative acts, and rate of acts for all three communicative

**Table 4.** Bivariate correlations between communicative acts, functions, and archival measures.

Rate per minute of communication during the home observation at 20 months	Communication and Symbolic Behavior Scales Behavior Sample			Systematic Observation of Red Flags for ASD	Mullen Scales of Early Learning		Autism Diagnostic Observation Schedule
	Social <sup>a</sup>	Speech <sup>a</sup>	Symbolic <sup>a</sup>	Total score	Receptive Language <sup>b</sup>	Expressive Language <sup>b</sup>	Total score <sup>c</sup>
Overall	.52*	.52*	.42*	-.55*	.49*	.45*	-.29
Communicative acts							
Contact	-.11	-.10	-.10	.03	-.12	-.16	.05
Deictic	.47*	.36*	.35*	-.42*	.38*	.34*	-.27
Conventional	.36*	.20	.32*	-.29*	.37*	.35*	-.08
Iconic	.21	.23	.20	-.17	.18	.17	-.10
Vocal	.41*	.49*	.24*	-.50*	.42*	.39*	-.25
Communicative functions							
Behavior regulation	.35*	.28*	.24*	-.30*	.35*	.29*	-.31
Social interaction	.12	.14	.05	-.38*	.17	.14	-.17
Joint attention	.53*	.56*	.47*	-.51*	.46*	.45*	-.17

Note. Communication and Symbolic Behavior Scales Behavior Sample and Systematic Observation of Red Flags for ASD were administered at around 20 months ( $N = 211$ ). Mullen Scales of Early Learning ( $N = 211$ ) and Autism Diagnostic Observation Schedule ( $n = 184$ ) were administered at around the age of 3 years. ASD = autism spectrum disorder.

<sup>a</sup>Composite standard scores based on  $M = 10$  and  $SD = 3$  were used for analyses. <sup>b</sup> $T$  scores based on  $M = 50$  and  $SD = 10$  were used for analyses. <sup>c</sup>Autism Diagnostic Observation Schedule calibrated severity score was used for analyses.

\* $p < .001$ .

functions were observed to have small, nonsignificant negative associations with the ADOS. Finally, significant correlations were observed between number of unique gestures used at 20 months and the MSEL (see Table 5; range  $r: .47-.50$ ).

**Table 5.** Bivariate correlations between inventory of unique gestures at 20 months and archival measures.

Assessment measure	Inventory of gestures
Communication and Symbolic Behavior Scales Behavior Sample ( $N = 211$ )	
Social composite <sup>a</sup>	.50*
Speech composite <sup>a</sup>	.42*
Symbolic composite <sup>a</sup>	.47*
Systematic Observation of Red Flags for ASD ( $N = 211$ )	
Total score	-.49*
Mullen Scales of Early Learning ( $N = 211$ )	
Receptive Language <sup>b</sup>	.47*
Expressive Language <sup>b</sup>	.50*
Autism Diagnostic Observation Schedule ( $n = 184$ )	
Total score <sup>c</sup>	-.28

Note. The Communication and Symbolic Behavior Scales Behavior Sample and Systematic Observation of Red Flags for ASD were administered at around 20 months. Mullen Scales of Early Learning and Autism Diagnostic Observation Schedule were administered at around the age of 3 years. ASD = autism spectrum disorder.

<sup>a</sup>Standard scores based on  $M = 10$  and  $SD = 3$  were used in analyses.

<sup>b</sup> $T$  scores based on  $M = 50$  and  $SD = 10$  were used in analyses.

<sup>c</sup>Autism Diagnostic Observation Schedule total score, reported as a calibrated severity score, was used in this analysis.

\* $p < .001$ .

In order to examine how the children included in the randomized controlled trial of the ESI intervention may have influenced these prospective relationships, they were removed from analyses. The strongest prospective correlations were re-examined (i.e., overall rate, rate of joint attention, and rate of vocal acts), and  $r$  coefficients were reduced by between 3 and 8 points but remained significant and medium in effect size. Additionally, given group differences in maternal education, a conservative SPSS procedure using Spearman's rho to calculate partial correlations using ordinal data was employed to examine relationships while controlling for maternal education, an ordinal variable in this study. Controlling for maternal education did not change the significance of reported results, with  $r$  values changing  $|4-7|$  points.

## Discussion

This study documented the inventories, rates, and proportions of communicative acts, with a special focus on gestures, used by 211 toddlers diagnosed with ASD, DD, and TD who participated in everyday activities with a caregiver in the context of a video-recorded home observation. Decades of research have documented impairments in early social communication in children with ASD. Few studies have used granular coding of naturalistic home observations to examine the types and functions of communication expressed by toddlers diagnosed with ASD. Our detailed analysis of a large number of child communicative acts collected prospectively contributes information to studies that have collected data in clinical or laboratory settings or via retrospective home video analysis. Finally, this study extends earlier work by including a larger sample of children with and

without ASD than has been previously published, within the age range that the American Academy of Pediatrics recommends screening for ASD.

### ***Inventory of Gestures and Overall Rate of Communication***

In this study, children with ASD used fewer unique gestures than those with TD, including deictic gestures that are often used to establish joint attention. They also communicated at significantly lower rates than children with DD and TD (Shumway & Wetherby, 2009; Wetherby et al., 2007), specifically, at about half the rate of children in the TD group. Inventory of gestures and overall rate of communication were observed to have significant concurrent and prospective relationships with developmental outcomes. Taken together, these findings are largely in agreement with patterns reported in previous research. We extend these results to a large sample of toddlers of varying developmental levels and diagnoses who were observed in the home environment.

Differences with respect to the rates per minute of communication reported here raise additional questions. The rate for children with ASD (2.71) was higher than rates that have been previously reported. Rates of communication in the literature have ranged from fewer than one act per minute (Stone et al., 1997) to 1.23 and 1.90 acts per minute (Charman et al., 2005; Shumway & Wetherby, 2009). It is possible that children in this study communicated at higher rates given that they were observed in a familiar environment while interacting with their primary caregiver(s). If children do communicate at higher rates in the home environment, as results of this study indicate, data gathered during a home observation could be a valuable complement to other measures, facilitating consensus-building with families on their child's communication strengths and needs, as well as any observed red flags for ASD.

The relatively higher rates documented here may also be related to the higher developmental level of our sample, compared to other samples. Stone et al. (1997), for example, reported a developmental quotient (DQ) of 52.6 for their ASD group. The nonverbal and verbal DQs of the ASD group reported by Shumway and Wetherby (2009) were 76 and 68, respectively, while Charman et al. (2005) reported a nonverbal IQ of 74.7. Calculating DQs from MSEL *T* scores revealed that our ASD group had a mean nonverbal DQ of 91 and a verbal DQ of 76. Epidemiological trends suggest that fewer children with ASD over time are being diagnosed with co-occurring DD and intellectual disabilities (Maenner et al., 2020). The continued study of communication development of children with ASD of varying developmental levels separately will be important to enhance our ability to interpret and generalize these findings. Taken together, results do suggest that measuring the overall rate of initiating and responding to communication in the home, as well as the number of unique gestures used, provides a useful index of social communication skill. Rate of communication at a young age is related to language development in children with TD (Wetherby et al., 1988) and has been found to be an important

predictor of outcomes at the age of 7 years in children with ASD (Charman et al., 2005).

### ***Types of Communicative Acts***

Examining different types of communicative acts separately showed that all three groups, on average, used high rates of vocal-only communicative acts, followed by acts that included deictic gestures. Importantly, there were no significant group differences on the proportions of each type of communicative act. Children with ASD, DD, and TD used vocal acts about 60% of the time. Deictic gestures were used for about a third of communicative acts, followed by conventional, iconic, and contact gestures. In TD, deictic gestures are the most commonly used gesture type in the first 2 years of life (Thal & Tobias, 1992). Our results add to a growing body of evidence suggesting that the same is true for children with DD and ASD (Choi et al., 2019; Özçalışkan et al., 2016).

Among gesture types, the strongest concurrent and prospective relationship with measures of social communication, autism symptoms, and receptive and expressive language was the rate of acts that included deictic gestures, a finding that is also in agreement with previous studies. However, rate of conventional gesture use was also found to be a significant predictor of language development. The importance of conventional gestures to predicting language was found to differ from findings reported by Özçalışkan et al. (2016), who found that only deictic gesture production was a significant predictor of expressive vocabulary 1 year later for children with ASD and TD. In TD, conventional gestures emerge around the time that words are expected. They do not require the presence of a referent and are therefore symbolic in their own right. It is not surprising that the ability to use a higher rate of this advanced gesture type would be associated with language development. In this study, a longer sampling time and the context of the home environment may have provided more opportunities for children to use conventional gestures, an interesting area for future research.

In contrast to the notable relationships that were observed with language outcome measures, significant correlations between early communicative acts and the ADOS CSS were not observed. Use of the CSS is recommended for comparing overall autism symptom severity across individuals of different developmental levels (Gotham et al., 2009). However, the CSS incorporates information about social communication and restricted and repetitive behaviors. Individuals with the same CSS may exhibit patterns of symptoms in both areas that vary widely. Future studies should examine these prospective relationships using a more precise measure of social communication.

### ***Communicative Functions***

Examination of the rate at which communicative functions were used revealed that children with DD and ASD communicated at lower rates than children with TD for the

purpose of joint attention. Deficits in joint attention are a core feature of ASD, and young children with DD have also been found to lack robust skills in gaze shifts between objects and people (Delehanty et al., 2018; Slonims & McConachie, 2006). In contrast to previous research in this area, however, we did not find a difference in rate of acts for joint attention between our ASD and DD groups. It may be important to examine vocalizations and gestures in concert with eye gaze and the expression of affect when assessing the risk of ASD in very young children with DD, to identify attributes that enhance the quality of these communicative acts in the home environment.

Of interest, the TD group used a significantly smaller proportion of acts for social interaction than the ASD and DD groups. The high proportion of acts for joint attention and low proportion of acts for social interaction expressed by children with TD may reflect their developmental level as evidenced by their above-average scores on the ELC of the MSEL. By the second half of the second year of life, children with TD included in this study appeared to have progressed from the earlier developing, dyadic skill of social interaction toward mastery of the initiation of triadic communication for joint attention. Our findings around communicative functions do underscore the importance of joint attention as a predictor of developmental outcomes. Significant correlations between rate of acts for joint attention and all communication and language outcomes were observed for our entire sample. Still, rate of acts for behavior regulation was also found to be significantly associated with these same measures. Triadic acts for behavior regulation during which children are requesting or protesting objects, actions, or experiences could be considered precursors to joint attention that can be used as a bootstrapping mechanism to scaffold the more advanced skill of drawing another person's attention to share enjoyment or interest (Wetherby et al., 2007).

### **Limitations**

Our results must be considered in the context of certain limitations. First, our DD and TD groups were smaller than the ASD group. Furthermore, the composition of the sample varied across the analyses reported with regard to prospective relationships with the ADOS, which was not administered to every child in the TD group. Relative to the size of the entire sample, however, the amount of missing data was small. Next, although families were given examples of everyday activities to participate in during their video-recorded home observation, they were permitted to choose among activities and we did not specify an amount of time to spend, introducing a lack of control over these variables. A potential moderating variable that may have altered the prospective correlations documented in this study was the inclusion of children who participated in the randomized controlled trial of ESI (Wetherby et al., 2014). However, this was examined and was nonsignificant. Additionally, information about intervention that children in the DD group may have received was not available. Very

little research has been conducted that examines the intensity of intervention needed to significantly impact developmental outcomes in children with ASD and DD, and additional investigation is needed (Barbaro & Dissanayake, 2017; Woolfenden et al., 2012). Finally, more studies of communication in the home environment are necessary before results may be generalized to the larger population. Although our sample showed wide variability in developmental profiles, individuals with ASD exhibit a heterogeneous clinical phenotype.

### **Clinical Implications**

Collectively, the observed patterns of communication and relationships with developmental outcomes indicate that clinicians who are screening and assessing young children's communication in the home environment should place an emphasis on gesture development as well as on sounds and words (Crais et al., 2009). The precise coding of communicative acts that was conducted for this study required a significant time investment that may not be feasible in the field. On the other hand, some research suggests that a brief observation may not capture a child's full range of communication skill or adequately detect ASD risk (Gabrielsen et al., 2015; Haebig et al., 2013). Additional work is needed to determine a sufficient length of time to accomplish both of these goals and to create a valid, systematic, and practical method by which to measure communication in the natural environment.

Researchers are becoming increasingly proficient at detecting group differences earlier between children with ASD, DD, and TD. At the same time, given the changing landscape of ASD in which increasing numbers of children do not have significant cognitive delays, deficits in core domains may be more subtle. It is important for clinicians to be aware that toddlers with ASD do use gestures and that the sequence in which they are acquired may not be markedly divergent from children with TD. Also, toddlers with ASD may not present with a total lack of joint attention when observed at home. However, their communication skills may not be as robust as those of children with TD. They may be delayed in their acquisition of gestures and may communicate at lower-than-expected rates.

### **Future Directions**

Continued study of the role of a naturalistic home observation as part of a comprehensive evaluation of language and communication is warranted to determine best practices for implementation with children at risk for ASD and DD. Observing parent-child interactions in the home may help clinicians and families build consensus on signs and symptoms of ASD and DD, which could propel access to critical intervention earlier. A second direction for this work will be to examine trajectories of gesture development over multiple time points in the home environment to determine the earliest points of divergence between children with

and without ASD. Finally, investigation of mediating variables may provide insight into the mechanisms underlying the relationships we documented in this study. Evidence thus far suggests that parental responsivity and language comprehension mediate the link between gestures and language development in children with ASD (Dimitrova et al., 2016; Roemer et al., 2019).

## Conclusions

Given the limited availability of autism-specific diagnostic and intervention resources in the community, the continued search for early markers specific to ASD is imperative. This study adds information about patterns of social communication that may be observed during a home observation and describes relationships with measures of social communication, language development, and autism symptoms administered in a clinical setting. The examination of the communication that young children with ASD and DD use in the natural environment can inform the development of targeted intervention strategies. Increasing inventories of types and functions of communication, as well as the rates at which children communicate, creates additional opportunities for caregivers to respond contingently, leading to enhanced social interactions and language learning that may ultimately improve their long-term developmental outcomes.

## Acknowledgments

This study is based on the first author's dissertation, completed at Florida State University. This research was supported in part by Eunice Kennedy Shriver National Institute of Child Health and Human Development Grants R01HD078410 and R01HD065272; National Institute on Deafness and Other Communication Disorders Grant R01DC007462; Centers for Disease Control and Prevention Cooperative Agreements U01DD000304 and 1U10DD000064; and U.S. Department of Education, Office of Special Education Programs Grant H325D120062, all awarded to Amy M. Wetherby. The content is solely the responsibility of the authors and does not necessarily represent the official views of these federal agencies. We thank the families and FIRST WORDS Project staff for their time in this study, as well as Katherine Lohr, the undergraduate research assistant who served as the primary observational coder for this study.

## References

- Acock, A. C., & Stavig, G. R. (1979). A measure of association for nonparametric statistics. *Social Forces*, 57(4), 1381–1386. <https://doi.org/10.1093/sf/57.4.1381>
- Acredolo, L., & Goodwyn, S. (1988). Symbolic gesturing in normal infants. *Child Development*, 59(2), 450–466. <https://www.jstor.org/stable/1130324>
- American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders (DSM-5®)*. American Psychiatric Association Publishing. <https://doi.org/10.1176/appi.books.9780890425596>
- Bakeman, R., & Quera, V. (2011). *Sequential analysis and observational methods for the behavioral sciences*. Cambridge University Press. <https://doi.org/10.1017/CBO9781139017343>
- Barbaro, J., & Dissanayake, C. (2017). Diagnostic stability of autism spectrum disorder in toddlers prospectively identified in a community-based setting: Behavioural characteristics and predictors of change over time. *Autism*, 21(7), 830–840. <https://doi.org/10.1177/1362361316654084>
- Barokova, M., & Tager-Flusberg, H. (2020). Commentary: Measuring language change through natural language samples. *Journal of Autism and Developmental Disorders*, 50(7), 2287–2306. <https://doi.org/10.1007/s10803-018-3628-4>
- Bates, E., Benigni, L., Bretherton, I., Camaioni, L., & Volterra, V. (1979). *The emergence of symbols*. Academic Press.
- Bates, E., & Dick, F. (2002). Language, gesture, and the developing brain. *Developmental Psychobiology*, 40(3), 293–310. <https://doi.org/10.1002/dev.10034>
- Bernardis, P., & Gentilucci, M. (2006). Speech and gesture share the same communication system. *Neuropsychologia*, 44(2), 178–190. <https://doi.org/10.1016/j.neuropsychologia.2005.05.007>
- Blanca, M., Alarcón, R., Arnau, J., Bono, R., & Bendayan, R. (2017). Non-normal data: Is ANOVA still a valid option? *Psicothema*, 29(4), 552–557.
- Bruner, J. (1981). The social context of language acquisition. *Language & Communication*, 1(2–3), 155–178. [https://doi.org/10.1016/0271-5309\(81\)90010-0](https://doi.org/10.1016/0271-5309(81)90010-0)
- Charman, T., Taylor, E., Drew, A., Cockerill, H., Brown, J. A., & Baird, G. (2005). Outcome at 7 years of children diagnosed with autism at age 2: Predictive validity of assessments conducted at 2 and 3 years of age and pattern of symptom change over time. *The Journal of Child Psychology and Psychiatry*, 46(5), 500–513. <https://doi.org/10.1111/j.1469-7610.2004.00377.x>
- Chawarska, K., Klin, A., Paul, R., & Volkmar, F. (2007). Autism spectrum disorder in the second year: Stability and change in syndrome expression. *The Journal of Child Psychology and Psychiatry*, 48(2), 128–138. <https://doi.org/10.1111/j.1469-7610.2006.01685.x>
- Choi, B., Shah, P., Rowe, M. L., Nelson, C. A., & Tager-Flusberg, H. (2020). Gesture development, caregiver responsiveness, and language and diagnostic outcomes in infants at high and low risk for autism. *Journal of Autism and Developmental Disorders*, 50(7), 2556–2572. <https://doi.org/10.1007/s10803-019-03980-8>
- Cohen, J. (1960). Coefficient of agreement for nominal scales. *Educational and Psychological Measurement*, 20(1), 37–46. <https://doi.org/10.1177/001316446002000104>
- Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Erlbaum.
- Colgan, S. E., Lanter, E., McComish, C., Watson, L. R., Crais, E. R., & Baranek, G. T. (2006). Analysis of social interaction gestures in infants with autism. *Child Neuropsychology*, 12(4–5), 307–319. <https://doi.org/10.1080/09297040600701360>
- Crais, E. R., Douglas, D. D., & Campbell, C. C. (2004). The intersection of the development of gestures and intentionality. *Journal of Speech, Language, and Hearing Research*, 47(3), 678–694. [https://doi.org/10.1044/1092-4388\(2004\)052](https://doi.org/10.1044/1092-4388(2004)052)
- Crais, E. R., Watson, L. R., & Baranek, G. T. (2009). Use of gesture development in profiling children's prelinguistic communication skills. *American Journal of Speech-Language Pathology*, 18(1), 95–108. [https://doi.org/10.1044/1058-0360\(2008\)07-0041](https://doi.org/10.1044/1058-0360(2008)07-0041)
- Delehanty, A. D., Stronach, S., Guthrie, W., Slate, E., & Wetherby, A. M. (2018). Verbal and nonverbal outcomes of toddlers with and without autism spectrum disorder, language delay, and global developmental delay. *Autism & Developmental Language Impairments*, 3, 1–19. <https://doi.org/10.1177/2396941518764764>
- Dimitrova, N., Özçalışkan, Ş., & Adamson, L. B. (2016). Parents' translations of child gesture facilitate word learning in children

- with autism, Down syndrome and typical development. *Journal of Autism and Developmental Disorders*, 46(1), 221–231. <https://doi.org/10.1007/s10803-015-2566-7>
- Dow, D., Day, T. N., Kutta, T., Nottke, C., & Wetherby, A. M.** (2020). Screening for autism spectrum disorder in a naturalistic home setting using the Systematic Observation of Red Flags (SORF) at 18–24 months. *Autism*, 13(1), 122–133. <https://doi.org/10.1002/aur.2226>
- Dow, D., Guthrie, W., Stronach, S. T., & Wetherby, A. M.** (2017). Psychometric analysis of the Systematic Observation of Red Flags for autism spectrum disorder in toddlers. *Autism*, 21(3), 301–309. <https://doi.org/10.1177/1362361316636760>
- Faul, F., Erdfelder, E., Buchner, A., & Lang, A. G.** (2013). *G\* Power (Version 3.1.7)* [Computer software]. Universität Kiel.
- Fenson, L., Bates, E., Dale, P. S., Marchman, V. A., Reznick, J. S., & Thal, D. J.** (2007). *MacArthur–Bates Communicative Development Inventories*. Brookes.
- Fenson, L., Dale, P. S., Reznick, J. S., Bates, E., Thal, D. J., Pethick, S. J., Tomasello, M., Mervis, C. B., & Stiles, J.** (1994). Variability in early communicative development. *Monographs of the Society for Research in Child Development*, 59(5), 1–173. <https://www.jstor.org/stable/1166093>
- Gabrielsen, T. P., Farley, M., Speer, L., Villalobos, M., Baker, C. N., & Miller, J.** (2015). Identifying autism in a brief observation. *Pediatrics*, 135(2), e330–e338. <https://doi.org/10.1542/peds.2014-1428>
- Gordon, R. G., & Watson, L. R.** (2015). Brief report: Gestures in children at risk for autism spectrum disorders. *Journal of Autism and Developmental Disorders*, 45(7), 2267–2273. <https://doi.org/10.1007/s10803-015-2390-0>
- Gotham, K., Pickles, A., & Lord, C.** (2009). Standardizing ADOS scores for a measure of severity in autism spectrum disorders. *Journal of Autism and Developmental Disorders*, 39(5), 693–705. <https://doi.org/10.1007/s10803-008-0674-3>
- Gulsrud, A. C., Hellemann, G. S., Freeman, S. F., & Kasari, C.** (2014). Two to ten years: Developmental trajectories of joint attention in children with ASD who received targeted social communication interventions. *Autism Research*, 7(2), 207–215. <https://doi.org/10.1002/aur.1360>
- Guthrie, W., Swineford, L. B., Nottke, C., & Wetherby, A. M.** (2013). Early diagnosis of autism spectrum disorder: Stability and change in clinical diagnosis and symptom presentation. *The Journal of Child Psychology and Psychiatry and Allied Disciplines*, 54(5), 582–590. <https://doi.org/10.1111/jcpp.12008>
- Haebig, E., McDuffie, A., & Weismer, S. E.** (2013). The contribution of two categories of parent verbal responsiveness to later language for toddlers and preschoolers on the autism spectrum. *American Journal of Speech-Language Pathology*, 22(1), 57–70. [https://doi.org/10.1044/1058-0360\(2012\)11-0004](https://doi.org/10.1044/1058-0360(2012)11-0004)
- Hyman, S. L., Levy, S. E., Myers, S. M., & Council on Children With Disabilities, Section on Developmental and Behavioral Pediatrics.** (2020). Identification, evaluation, and management of children with autism spectrum disorder. *Pediatrics*, 145(1), Article e20193447. <https://doi.org/10.1542/peds.2019-3447>
- Individuals with Disabilities Education Improvement Act of 2004, 20 U.S.C. § 1400 *et seq.* (2004).
- Ingersoll, B.** (2010). Brief report: Pilot randomized controlled trial of Reciprocal Imitation Training for teaching elicited and spontaneous imitation to children with autism. *Journal of Autism and Developmental Disorders*, 40(9), 1154–1160. <https://doi.org/10.1007/s10803-010-0966-2>
- Iverson, J. M., & Goldin-Meadow, S.** (2005). Gesture paves the way for language development. *Psychological Science*, 16(5), 367–371. <https://doi.org/10.1111/j.0956-7976.2005.01542.x>
- Iverson, J. M., Northrup, J. B., Leezenbaum, N. B., Paradé, M. V., Koterba, E. A., & West, K. L.** (2018). Early gesture and vocabulary development in infant siblings of children with autism spectrum disorder. *Journal of Autism and Developmental Disorders*, 48, 55–71. <https://doi.org/10.1007/s10803-017-3297-8>
- Iverson, J. M., & Thal, D.** (1998). Communicative transitions: There's more to the hand than meets the eye. In A. Wetherby, S. Warren, & J. Reichle (Eds.), *Transitions in prelinguistic communication* (pp. 59–86). Brookes.
- Iverson, J. M., & Thelen, E.** (1999). Hand, mouth and brain: The dynamic emergence of speech and gesture. *Journal of Consciousness Studies*, 6(11–12), 19–40.
- Kim, S. H., & Lord, C.** (2012). Combining information from multiple sources for the diagnosis of autism spectrum disorders for toddlers and young preschoolers from 12 to 47 months of age. *The Journal of Child Psychology and Psychiatry*, 53(2), 143–151. <https://doi.org/10.1111/j.1469-7610.2011.02458.x>
- Landis, J. R., & Koch, G. G.** (1977). The measurement of observer agreement for categorical data. *Biometrics*, 33(1), 159–174. <https://www.jstor.org/stable/2529310>
- LeBarton, E. S., & Iverson, J. M.** (2016). Gesture development in toddlers with an older sibling with autism. *International Journal of Language & Communication Disorders*, 51(1), 18–30. <https://doi.org/10.1111/1460-6984.12180>
- Lewedag, V. L., Oller, D. K., & Lynch, M. P.** (1994). Infants' vocalization patterns across home and laboratory environments. *First Language*, 14(40), 49–65. <https://doi.org/10.1177/014272379401404004>
- Lord, C., Rutter, M., DiLavore, P. C., & Risi, S.** (1999). *Autism Diagnostic Observation Schedule (ADOS)*. Western Psychological Services.
- Maenner, M. J., Shaw, K. A., & Baio, J.** (2020). Prevalence of autism spectrum disorder among children aged 8 years—Autism and Developmental Disabilities Monitoring Network, 11 sites, United States, 2016. *MMWR Surveillance Summaries*, 69(4), 1–12. <https://doi.org/10.15585/mmwr.ss6904a1>
- Mastrogioseppe, M., Capirci, O., Cuva, S., & Venuti, P.** (2015). Gestural communication in children with autism spectrum disorders during mother–child interaction. *Autism*, 19(4), 469–481. <https://doi.org/10.1177/1362361314528390>
- McHugh, M. L.** (2012). Interrater reliability: The kappa statistic. *Biochemia Medica*, 22(3), 276–282. <https://hrcak.srce.hr/89395>
- McHugh, M. L.** (2013). The chi-square test of independence. *Biochemia Medica*, 23(2), 143–149. <https://doi.org/10.11613/BM.2013.018>
- McLean, J. E., McLean, L. K., Brady, N. C., & Etter, R.** (1991). Communication profiles of two types of gesture using nonverbal persons with severe to profound mental retardation. *Journal of Speech and Hearing Research*, 34(2), 294–308. <https://doi.org/10.1044/jshr.3402.294>
- Mitchell, S., Brian, J., Zwaigenbaum, L., Roberts, W., Szatmari, P., Smith, I., & Bryson, S.** (2006). Early language and communication development of infants later diagnosed with autism spectrum disorder. *Journal of Developmental & Behavioral Pediatrics*, 27(Suppl. 2), S69–S78. <https://doi.org/10.1097/00004703-200604002-00004>
- Mullen, E.** (1995). *The Mullen Scales of Early Learning*. American Guidance Service.
- Özçalışkan, Ş., Adamson, L. B., & Dimitrova, N.** (2016). Early deictic but not other gestures predict later vocabulary in both typical development and autism. *Autism*, 20(6), 754–763. <https://doi.org/10.1177/1362361315605921>

- Özçalışkan, Ş., Adamson, L. B., Dimitrova, N., & Baumann, S.** (2017). Early gesture provides a helping hand to spoken vocabulary development for children with autism, Down syndrome, and typical development. *Journal of Cognition and Development, 18*(3), 325–337. <https://doi.org/10.1080/15248372.2017.1329735>
- Parladé, M. V., & Iverson, J. M.** (2015). The development of coordinated communication in infants at heightened risk for autism spectrum disorder. *Journal of Autism and Developmental Disorders, 45*(7), 2218–2234. <https://doi.org/10.1007/s10803-015-2391-z>
- Phillips, W., Gómez, J. C., Baron-Cohen, S., Laá, V., & Rivière, A.** (1995). Treating people as objects, agents, or “subjects”: How young children with and without autism make requests. *The Journal of Child Psychology and Psychiatry, 36*(8), 1383–1398. <https://doi.org/10.1111/j.1469-7610.1995.tb01670.x>
- Risi, S., Lord, C., Gotham, K., Corsello, C., Chrysler, C., Szatmari, P., Cook, E. H., Jr., Leventhal, B. L., & Pickles, A.** (2006). Combining information from multiple sources in the diagnosis of autism spectrum disorders. *Journal of the American Academy of Child & Adolescent Psychiatry, 45*(9), 1094–1103. <https://doi.org/10.1097/01.chi.0000227880.42780.0e>
- Roemer, E. J., West, K. L., Northrup, J. B., & Iverson, J. M.** (2019). Word comprehension mediates the link between gesture and word production: Examining language development in infant siblings of children with autism spectrum disorder. *Developmental Science, 22*(3), Article e12767. <https://doi.org/10.1111/desc.12767>
- Rowe, M. L., & Goldin-Meadow, S.** (2009). Early gesture selectively predicts later language learning. *Developmental Science, 12*(1), 182–187. <https://doi.org/10.1111/j.1467-7687.2008.00764.x>
- Schmider, E., Ziegler, M., Danay, E., Beyer, L., & Bühner, M.** (2010). Is it really robust. *Methodology, 6*, 147–151. <https://doi.org/10.1027/1614-2241/a000016>
- Shumway, S., & Wetherby, A. M.** (2009). Communicative acts of children with autism spectrum disorders in the second year of life. *Journal of Speech, Language, and Hearing Research, 52*(5), 1139–1156. [https://doi.org/10.1044/1092-4388\(2009/07-0280\)](https://doi.org/10.1044/1092-4388(2009/07-0280))
- Slonims, V., & McConachie, H.** (2006). Analysis of mother–infant interaction in infants with Down syndrome and typically developing infants. *American Journal on Mental Retardation, 111*(4), 273–289. [https://doi.org/10.1352/0895-8017\(2006\)111\[273:AOMIII\]2.0.CO;2](https://doi.org/10.1352/0895-8017(2006)111[273:AOMIII]2.0.CO;2)
- Sparrow, S., Cicchetti, D. V., & Balla, D. A.** (2005). *Vineland Adaptive Behavior Scales* (2nd ed.). AGS.
- Stone, W. L., Ousley, O. Y., Yoder, P. J., Hogan, K. L., & Hepburn, S. L.** (1997). Nonverbal communication in two- and three-year-old children with autism. *Journal of Autism and Developmental Disorders, 27*(6), 677–696. <https://doi.org/10.1023/A:1025854816091>
- Thal, D. J., & Tobias, S.** (1992). Communicative gestures in children with delayed onset of oral expressive vocabulary. *Journal of Speech and Hearing Research, 35*(6), 1281–1289. <https://doi.org/10.1044/jshr.3506.1289>
- U.S. Department of Education, Office of Special Education Programs.** (2016). *38th Annual Report to Congress on the Implementation of the Individuals with Disabilities Education Act*. Retrieved from <https://www2.ed.gov/about/reports/annual/osep/2016/parts-b-c/38th-arc-for-idea.pdf>
- Veness, C., Prior, M., Bavin, E., Eadie, P., Cini, E., & Reilly, S.** (2012). Early indicators of autism spectrum disorders at 12 and 24 months of age: A prospective, longitudinal comparative study. *Autism, 16*(2), 163–177. <https://doi.org/10.1177/1362361311399936>
- Watson, L. R., Crais, E. R., Baranek, G. T., Dykstra, J. R., & Wilson, K. P.** (2013). Communicative gesture use in infants with and without autism: A retrospective home video study. *American Journal of Speech-Language Pathology, 22*(1), 25–39. [https://doi.org/10.1044/1058-0360\(2012/11-0145\)](https://doi.org/10.1044/1058-0360(2012/11-0145))
- Watt, N., Wetherby, A., & Shumway, S.** (2006). Prelinguistic predictors of language outcome at 3 years of age. *Journal of Speech, Language, and Hearing Research, 49*(6), 1224–1237. [https://doi.org/10.1044/1092-4388\(2006/088\)](https://doi.org/10.1044/1092-4388(2006/088))
- Wetherby, A. M., Brosnan-Maddox, S., Peace, V., & Newton, L.** (2008). Validation of the Infant–Toddler Checklist as a broadband screener for autism spectrum disorders from 9 to 24 months of age. *Autism, 12*(5), 487–511. <https://doi.org/10.1177/1362361308094501>
- Wetherby, A. M., Cain, D. H., Yonclas, D. G., & Walker, V. G.** (1988). Analysis of intentional communication of normal children from the prelinguistic to the multiword stage. *Journal of Speech and Hearing Research, 31*(2), 240–252. <https://doi.org/10.1044/jshr.3102.240>
- Wetherby, A. M., Guthrie, W., Woods, J., Schatschneider, C., Holland, R. D., Morgan, L., & Lord, C.** (2014). Parent-implemented social intervention for toddlers with autism: An RCT. *Pediatrics, 134*(6), 1084–1093. <https://doi.org/10.1542/peds.2014-0757>
- Wetherby, A. M., & Prizant, B. M.** (2002). *Communication and Symbolic Behavior Scales: Developmental Profile* (1st normed ed.). Brookes.
- Wetherby, A. M., & Prutting, C. A.** (1984). Profiles of communicative and cognitive–social abilities in autistic children. *Journal of Speech and Hearing Research, 27*(3), 364–377. <https://doi.org/10.1044/jshr.2703.364>
- Wetherby, A. M., Watt, N., Morgan, L., & Shumway, S.** (2007). Social communication profiles of children with autism spectrum disorders late in the second year of life. *Journal of Autism and Developmental Disorders, 37*(5), 960–975. <https://doi.org/10.1007/s10803-006-0237-4>
- Wetherby, A. M., Woods, J., Nottke, C., Stronach, S., Dow, D., & McCoy, D.** (2016). *Systematic Observation of Red Flags of autism spectrum disorder* [Unpublished manual]. Florida State University.
- Woods, J. J., & Brown, J. A.** (2011). Integrating family capacity-building and child outcomes to support social communication development in young children with autism spectrum disorder. *Topics in Language Disorders, 31*(3), 235–246. <https://doi.org/10.1097/TLD.0b013e318227fde4>
- Woolfenden, S., Sarkozy, V., Ridley, G., & Williams, K.** (2012). A systematic review of the diagnostic stability of autism spectrum disorder. *Research in Autism Spectrum Disorders, 6*(1), 345–354. <https://doi.org/10.1016/j.rasd.2011.06.008>
- Zwaigenbaum, L., Bauman, M. L., Stone, W. L., Yirmiya, N., Estes, A., Hansen, R. L., McPartland, J. C., Natowicz, M. R., Choueiri, R., Fein, D., Kasari, C., Pierce, K., Buie, T., Carter, A., Davis, P. A., Granpeesheh, D., Mailloux, Z., Newschaffer, C., Robins, D., . . . Wetherby, A.** (2015). Early identification of autism spectrum disorder: Recommendations for practice and research. *Pediatrics, 136*(Suppl. 1), S10–S40. <https://doi.org/10.1542/peds.2014-3667C>