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Coordinated social communication in toddlers with and without autism spectrum disorder during a home observation

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Abstract

Background & Aims: Social communication and language skills have been found to be important predictors of long-term outcomes in individuals with autism spectrum disorder (ASD). However, the development of coordinated social communication (i.e., gestures and sounds or words) remains relatively understudied in young children with ASD and developmental delays (DD). This study used a prospective, longitudinal design and granular observational coding to document the coordination of gestures, sounds, and words in a large, heterogeneous sample of toddlers identified with ASD, DD, or typical development (TD) during a naturalistic home observation. Specific aims were: (1) to compare rates per minute and proportions of coordinated child communicative acts across groups; (2) to examine concurrent relationships between coordinated communication and measures of social communication and autism symptoms; and (3) to examine prospective relationships between coordinated communication, receptive and expressive language skills, and autism symptoms collected at 3 years of age.

Methods: At a mean age of 20.3 months (SD = 2.0), 211 children ($n_{ASD} = 121$; $n_{DD} = 46$; $n_{TD} = 44$) participated in everyday activities with a parent during an hourlong home observation. Rates per minute and proportions of gestures, sounds and words, as well as temporally overlapping gesture + sound, gesture + word, and gesture + phrase combinations, were compared using one-way ANOVA. Pearson product moment correlations between coordinated communicative acts and measures of social communication, language, and autism symptoms were examined.

Results: On average, children with ASD used sounds and gesture + sounds at significantly lower rates than DD and TD groups, who did not differ. Children with ASD and DD coordinated gesture + single words and gesture + phrases at significantly lower rates than the TD group. Groups did not differ with respect to the rate per minute at which they used gestures alone. Children with TD used a smaller proportion of sounds alone and higher proportions of words and phrases, with and without coordinated gestures, than ASD and DD groups. Children with ASD and DD used a significantly higher proportion of gestures alone than children with TD. Rates per minute and proportions of single words and gesture + words had significant correlations with measures of social communication, language skills, and autism symptoms.

Conclusions: Results suggest that a significantly lower rate per minute of sounds and gesture + sound combinations was a distinguishing feature of ASD in our sample. Further, limited use of single words and gesture + single words was observed in children ASD and DD. Significant prospective relationships between single words and gesture + words with language skills measured over a year later underscores the importance of acquiring these forms.

Implications: Results support the idea that clinicians should include opportunities to observe and encourage coordinated social communication while screening and assessing young children for DD and ASD in the home environment. The significant associations between rate of single words and gesture + word combinations with language development over a year later have implications for incorporating intervention targets that encourage the use of gesture-speech combinations.

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Young children's gestures are predictive of both spoken language and language comprehension (Butterworth & Morissette, 1996; Goldin-Meadow & Butcher, 2003). In children with typical development (TD), gesture use predicts growth in vocabulary and provides indication of a child's readiness to advance to a new grammatical stage (Goldin-Meadow & Butcher, 2003; Igualada et al., 2015; Iverson & Goldin-Meadow, 2005; Rowe & Goldin-Meadow, 2009; Rowe et al., 2008). At approximately 15 months of age, children acquire the ability to coordinate their communication across verbal and nonverbal modalities, and the individual use of gestures and sounds (i.e., nonword vocalizations) begins to decrease (Carpenter et al., 1998; Wetherby et al., 1988). These coordinated communicative acts, including pointing + speech combinations at twelve months, are important predictors of vocabulary and syntax at 18 months (Igualada et al., 2015). In another example, the ability to use gestures as lexical place fillers by combining a spoken word with a supplementary gesture of a different meaning (e.g., "Dada" + points at hat to communicate "Dada's hat") has been found to predict the onset of two-word utterances, sentence complexity at age 3½, and subsequent syntax skills (Goldin-Meadow & Butcher, 2003; Iverson & Goldin-Meadow, 2005; Rowe & Goldin-Meadow, 2009).

As spoken word combinations increase, gesture + word pairings begin to decline (Iverson & Thal, 1998). However, children do not lose their gestures as their language development advances. Instead, gestures serve as supports to language comprehension, to extend and disambiguate messages by making them more meaningful to communication partners, and to support speakers in instances during which they are having difficulty explaining a concept with words alone (Demir-Lira et al., 2018; Iverson et al., 1994; Özçalışkan & Dimitrova, 2013).

Coordinated social communication in children with autism spectrum disorder

Children with autism spectrum disorder (ASD) have long been observed to use a restricted inventory of gestures and to communicate at lower rates per minute than children with TD (TD; Colgan et al., 2006; Delehanty & Wetherby, 2021; Iverson et al., 2018; Manwaring et al., 2018; Wetherby et al., 2007). Difficulty with the flexible coordination of multiple social communication behaviors, including gestures, words, eye gaze, and facial expressions, is a core feature of the diagnostic criteria for ASD (APA, 2013). Even still, social communication skills have been found to be important predictors of short- and long-term outcomes in individuals with ASD (Bal et al., 2015; Charman et al., 2005; Delehanty & Wetherby, 2021). Delehanty and Wetherby (2021) found that rate per minute of social communication, including gestures, sounds, and words at 20 months was a significant predictor of receptive and expressive language skills at age 3. Even more striking were the findings of Charman et al. (2005) indicating that rate of nonverbal communication at age 2 was a significant predictor of social communication and language skills at age 7. Finally, Bal et al. (2015) reported that social communication at 2 years of age predicted attainment of daily living skills at age 21. Thus, researchers have begun to examine coordinated verbal and nonverbal communication in young children with ASD to identify patterns of development, points at which developmental trajectories may diverge from children with TD, and whether the acquisition of gesture-word combinations predicts language development in children with ASD, as observed in children with TD (Choi et al., 2019; Heymann et al., 2018; Özçalışkan et al., 2018; Parladé & Iverson, 2015; Talbott et al., 2018).

Results of recent research suggest that children who are identified with ASD acquire coordinated social communication in a developmental sequence similar to children with TD (e.g., Bates et al., 1979). Talbott et al. (2018), for example, studied 42 children with ASD ($M_{age} = 24.1$ months) participating in a randomized controlled trial of a caregiver implemented intervention. They found that gesture + word pairings largely preceded, and were strongly associated with the acquisition of, word combinations. The only disruption was that the onset of single words was observed to precede pointing in 40% of children with ASD.

A small number of studies, however, has found that toddlers with ASD coordinate gestures + sounds and gestures + words at reduced rates compared to children with TD between 12–31 months (Choi et al., 2019; Heymann et al., 2018; Özçalışkan et al., 2018; Parladé & Iverson, 2015). Among these, three studies included comparison groups of children with language or developmental delays without autism (DD; Heymann et al., 2018; Özçalışkan et al., 2018; Parladé & Iverson, 2015). Parladé and Iverson (2015) examined growth in coordinated communication in 13 younger siblings of children with ASD (who were later diagnosed with ASD) and found that they used gesture + sound/word combinations at lower rates than elevated-likelihood peers with language delays and low-likelihood peers by 12 months, and that this gap widened by 18 months. In another study of children at elevated

likelihood of developing ASD, Heymann et al. (2018) studied the coordination of reach, point, and show gestures with vocalizations in 36 children between the ages of 14–24 months during administration of the Early Social Communication Scales (Mundy et al., 2003). Again, they found that infants with ASD integrated gestures with speech less frequently than infants without ASD. Finally, Özçalışkan et al., 2018 found that children with ASD ($n = 23$; $M_{age} = 2;6$) and children with TD ($n = 23$; $M_{age} = 1;6$), matched by expressive language, did not differ with respect to the frequency or proportion of complementary and supplementary gesture + speech combinations they produced. However, children with Down Syndrome (DS; $n = 23$; $M_{age} = 2;6$) used significantly fewer gesture + speech combinations than children with TD.

Taken together, published findings thus far suggest that the development of coordinated social communication in young children with ASD may be delayed, but not significantly divergent compared to patterns observed in those with TD. In addition, despite these observed delays, several studies have reported significant concurrent and prospective relationships between social communication and language production and comprehension (Choi et al., 2019; Luyster et al., 2008; Mitchell et al., 2006). Still, the development of coordinated social communication remains relatively understudied in young children with ASD and DD. Few studies have included comparison groups of children with ASD, DD, and TD, although it can be difficult to distinguish ASD and DD at early ages. Research that examines patterns of coordinated social communication between groups and the associations between social communication and language skills is needed to determine factors that predict the transition from prelinguistic communication to more sophisticated language use in children with DD and ASD. Also, a limited number of studies have examined coordinated social communication in the natural environment in young children with ASD (e.g., Parladé & Iverson, 2015). It is important to extend the current literature base to larger, heterogeneous samples ascertained using different methods and studied in varied contexts, including caregiver-child interaction in a home-based setting. Results can be integrated to provide a more complete picture of the development of coordinated social communication in children with ASD, DD, and TD, promote earlier identification, aid the efforts of clinicians screening and assessing young children in the home environment, and inform the design of language intervention strategies.

Purpose of this study

The present study used a prospective, longitudinal design and granular observational coding to document the coordination of gestures, sounds, and words in a large sample of toddlers identified with ASD, DD, and TD during an hour-long, naturalistic video-recorded home observation. This study builds on the findings of Delehanty & Wetherby (2021), who reported overall rates of communication as well as the rates and proportions of gesture types and communicative functions used by this sample. Given the important links between early social communication and language development that have been reported in previous research, we also examined associations between coordinated social communication and direct assessments of social communication, receptive and expressive language, and autism symptoms. Specific aims of this study were: (1) to compare rates per minute and proportions of coordinated child communicative acts across groups; (2) to examine relationships between rate of coordinated communication and concurrent measures of social communication and autism symptoms; and (3) to examine prospective relationships between rate of coordinated communication and measures of developmental level and autism symptoms collected at 3 years of age.

Method

Participants

Participants were selected from the archival database of the FIRST WORDS® Project (Wetherby et al., 2008). To be included in this study, all children completed a video recorded Communication and Symbolic Behavior Scales Behavior Sample (CSBS; Wetherby & Prizant, 2002) and a home observation at a mean age of 20.3 months ($SD = 2.0$). The American Academy of Pediatrics (AAP) recommends screening for ASD in primary care in children 18–24 months of age (Hyman et al., 2020), and children are commonly referred for an evaluation to determine eligibility for early intervention at this age. Further, 18–24 months is the age at which a stable diagnosis of ASD may be made in many children (Chawarska et al., 2007; Guthrie et al., 2013).

A clinical best estimate diagnosis, using all available information, was made at a developmental evaluation at 36.6 months ($SD = 4.8$) that included the Mullen Scales of Early Learning (MSEL; Mullen, 1995). All children with DD (*T* score greater than or equal to 1.25 *SD* below the mean on any subscale of the MSEL), and/or for whom there were concerns about ASD, completed the Autism Diagnostic Observation Schedule (ADOS; Lord et al., 1999). Children in the TD group had MSEL *T* scores within 1.25 *SD* of the mean and the diagnostician noted no concerns about ASD. Diagnostic outcomes and other developmental characteristics of the children in this sample were reported in Delehanty & Wetherby (2021) for all children included in this study. This information is included in Supplemental Table S1. Approximately 81% of the children were male, as the larger project oversampled males to match the sample of children with ASD. Sixty-eight percent of children were white, 20% were Black, 10% were more than one

race, 2% were Asian, and 8% reported Hispanic ethnicity. Additional demographic information was reported by Delehanty & Wetherby (2021) and may be found in Supplementary Table S2. All parents gave written informed consent, and this study was approved by the Institutional Review Board at Florida State University.

Measures

Communication and symbolic behavior scales behavior sample (CSBS). The CSBS is a standardized observational measure of social communication designed for use with children between 12–24 months. The CSBS yields composite scores in three domains: social, speech, and symbolic ($M = 10$; $SD = 3$). The social composite measures expression of emotions, use of eye gaze, communication, and gestures. The speech composite measures the use of sounds and words. The symbolic composite measures language comprehension and object use in play. The CSBS was administered at a mean age of 19.4 months ($SD = 3.1$).

Systematic observation of red flags of autism spectrum disorder (SORF). The SORF is an observational screening measure developed to identify early signs of ASD in young children, with higher scores indicating a larger number of signs observed (Dow et al., 2020; 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). The SORF was scored at mean age of 20.3 months ($SD = 2.0$).

Mullen scales of early learning (MSEL). The MSEL is a standardized cognitive assessment appropriate for use with children 1–68 months. *T* scores are calculated for receptive language, expressive language, visual reception, and fine motor scales ($M = 50$, $SD = 10$). The Early Learning Composite (ELC) is expressed as a standard score ($M = 100$, $SD = 15$) based on the sum of the T scores. The MSEL was administered at 36.6 months ($SD = 4.8$).

Autism diagnostic observation schedule (ADOS). The ADOS is a standardized measure of communication, social interaction, and play used in the assessment of individuals suspected of having ASD. Calibrated severity scores (CSS), developed to standardize scores across modules, were used in analyses (Gotham et al., 2009). The ADOS was administered at a mean age of 37.5 months ($SD = 4.6$).

Observational coding scheme for the home observation

During the hourlong ($M = 56.1$ min, $SD = 6.3$) video-recorded home observation, families were asked to interact with their child while participating in as many of the following activities as possible: play with toys, play with people, meals or snacks, caregiving, book sharing, and family chores. Child communicative acts were identified using criteria from the CSBS as interactive behaviors that (1) included a gesture, sound, word, or word combination (phrase); (2) were directed toward the adult; and (3) served a communicative function (Wetherby & Prizant, 2002). All communicative acts that occurred during the home observation were coded for whether they included a gesture alone, sound alone, word alone or phrase alone; or a temporally overlapping, coordinated gesture-speech combination: gesture + sound, gesture + word, or gesture + phrase. Gesture + word acts were then coded as gesture + word complement (gesture and word have the same meaning; e.g., pointing at a cup and saying "cup") or gesture + word supplement (gesture communicates additional meaning; pointing at a cup and saying "more" to request more milk; Iverson & Goldin-Meadow, 2005; Özçalışkan et al., 2018). All codes were mutually exclusive and exhaustive.

Videos were coded by one undergraduate research assistant and the first author, blind to participant diagnoses, using Noldus Pro© Observer XT v12.5. Cohen's kappa coefficients (Cohen, 1960) were used to assess inter-rater reliability. Fifty videos (24%) were double-coded. The kappa for coding the type of communicative act was .81, 95% CI [.80, .83], indicating substantial agreement (Cohen, 1960; McHugh, 2012).

Analytic plan

Group means were compared using one-way ANOVA. Post hoc, pairwise comparisons were interpreted using the Dunnett T3 correction to control for violations of the assumption of homogeneity of variance that may occur with unequal sample sizes. Cohen's *d* was calculated and interpreted using the following conventions for effect sizes: .20 = small, .50 = medium, and .80 = large (Cohen, 1988). Pearson product-moment correlation coefficients were calculated to examine linear relationships among variables. Statistical significance was adjusted using a Bonferroni correction due to the large number of associations examined. Cohen's (1988) conventions for effect sizes were used to interpret results, where $r = .10$ is considered a small effect, .30 is medium, and $\geq .50$ is large.

Results

Rates per minute of coordinated social communication

On average, in absolute terms, children in all three groups used sounds alone at their highest rates per minute, followed by gesture + sound (Table 1, upper section).

Table 1. Rates per minute and proportions of coordinated social communication used during the home observation.

	ASD ($n = 121$)		DD ($n = 46$)		TD ($n = 44$)			Effect size (d)[c] of group differences		
	M	*SD*	*M*	*SD*	*M*	*SD*	*F* (2, 208)	ASD-DD	ASD-TD	DD-TD
Rate per Minute										
Gestures Alone	0.36	0.27	0.39	0.22	0.46	0.34	2.04	0.12	0.33	0.24
Coordinated Gestures										
Gesture + Sound	0.61_a	0.44	0.91_b	0.60	1.17_b	0.70	18.52***	0.57	0.96	0.40
Gesture + Word	0.07_a	0.14	0.10_a	0.12	0.43_b	0.44	40.94***	0.23	1.10	1.02
Gesture + Word Complement	0.05_a	0.12	0.06_a	0.09	0.26_b	0.28	29.48***	0.09	0.97	0.96
Gesture + Word Supplement	0.02_a	0.05	0.03_a	0.05	0.17_b	0.19	38.80***	0.20	1.08	1.00
Gesture + Phrase	0.01_a	0.03	0.01_a	0.02	0.06_b	0.12	14.15***	0.00	0.57	0.58
Vocal or Verbal Acts										
Sound	1.42_a	0.82	1.80_b	0.86	2.01_b	0.74	9.97***	0.45	0.76	0.26
Single Word	0.21_a	0.42	0.27_a	0.29	0.91_b	0.65	40.09***	0.17	1.28	1.27
Phrase	0.03_a	0.12	0.02_a	0.05	0.16_b	0.30	10.34***	0.11	0.57	0.65
Proportion										
Gestures Alone	$.15_a$	.11	$.13_{a,b}$	.10	$.09_b$	.06	6.38**	0.19	0.68	0.49
Coordinated Gestures										
Gesture + Sound	.22	.12	.25	.10	.22	.12	0.91	0.27	0.00	0.27
Gesture + Word	$.02_a$	.03	$.02_a$	.03	$.08_b$	.06	36.50***	0.00	1.26	1.26
Gesture + Word Complement	$.01_a$	.03	$.02_a$	.02	$.05_b$	.04	24.15***	0.39	1.13	0.95
Gesture + Word Supplement	$.01_a$	.01	$.01_a$	.01	$.03_b$	.03	32.73***	0.00	0.89	0.00
Gesture + Phrase	$.00_a$	.01	$.00_a$	.01	$.01_b$	.02	10.40***	0.00	0.53	0.53
Vocal or Verbal Acts										
Sound	$.54_a$	.14	$.52_a$	.12	$.40_b$	.12	18.54***	0.15	1.07	1.00
Single Word	$.06_a$	.08	$.07_a$	.07	$.17_b$	.11	28.44***	0.13	1.14	1.08
Phrase	$.01_a$	.02	$.01_a$	.02	$.03_b$	.06	8.22***	0.00	0.45	0.45

Note: Means in the same row with different subscripts (a,b) differ significantly at $p < .05$. ASD = Autism spectrum disorder; DD = Developmental delay without ASD; TD = Typical development. Proportions represent total count/all communicative acts.
[c]Effect size based on Cohen's $d = .20$ is small, .50 is medium, and .80 is large.
*$p < .05$, **$p < .01$, ***$p < .001$.

Children with ASD used sounds at a significantly lower rate than children with DD and TD with medium effect sizes, F (2, 208) = 9.97, $p < .001$, $d = 0.45$ and 0.76, respectively. DD and TD groups did not differ in the rate per minute at which they used sounds ($p = .53$, $d = 0.26$). Children with ASD also used gesture + sounds at a significantly lower rate than both DD and TD groups, F (2, 208) = 18.52, $p < .001$, $d = 0.57$ and 0.97, respectively. Again, DD and TD groups did not differ ($p = .08$, $d = 0.40$).

Children with ASD and DD coordinated gestures with single words at significantly lower rates than those in the TD group, with large effect sizes, F (2, 208) = 40.94, $p < .001$, $d = 1.10$ and 1.02, respectively. This included both gesture + word complements (F (2, 208) = 29.48, $p < .001$) and gesture + word supplements (F (2, 208) = 38.80, $p < .001$). Children with ASD and DD also used the following communicative acts at significantly lower rates than TD children: gesture + phrase (F (2, 208) = 14.15, $p < .001$), single words (F (2, 208) = 40.09, $p < .001$), and phrases (F (2, 208) = 10.34, $p < .001$). For each of these variables, no significant differences were noted between ASD and DD groups. Finally, the three groups did not differ with respect to the rate per minute at which they used gestures in isolation ($p = .13$).

Proportions of coordinated communicative acts

Children in the TD group communicated using sounds for approximately 40% of their overall communicative acts (Table 1, lower section). They used gesture + sounds about 22% of the time and single words 17% of the time. Children with ASD and DD used sounds for over half of their communicative acts and gesture + sounds about a quarter of the time. In contrast to the TD group, the third most common mode of communication for children with ASD and DD was gestures alone (used 15% and 13% of the time, respectively).

Children with TD used a smaller proportion of sounds than the ASD and DD groups, F (2, 208) = 18.54, $p < .001$, $d = 1.07$ and 1.00, respectively. We did not observe differences with respect to the proportion of gesture + sounds used by our three groups, F (2, 208) = 0.91, $p = .41$. Children with ASD used a significantly higher proportion of gestures alone than children with TD (F (2, 208) = 6.38, $p < .01$, $d = 0.68$), but did not differ from DD. Children in the TD group used significantly higher proportions of communicative acts that included coordinated gesture + words and gesture + phrases than children with ASD and DD (gesture + word: F (2, 208) = 36.50, $p < .001$, $d = 1.26$; gesture + phrase: F (2, 208) = 10.40, $p <$

.001, $d = 0.53$). With regard to proportions of verbal communicative acts that were not coordinated with gestures, the TD group used a significantly higher proportion of words and phrases than ASD and DD groups (single words: F (2, 208) = 28.44, $p < .001$, $d = 1.14$ and 1.08; phrases: F (2, 208) = 8.22, $p < .001$, $d = 0.45$ and 0.45). It should be noted that children in all groups used phrases and gesture + phrases only 1%–3% of the time.

Concurrent and prospective relationships

Finally, we examined concurrent associations between rate and proportion of nonverbal and verbal communication and the CSBS and SORF (measured at 20 months) and prospective associations with MSEL receptive and expressive language scales and the ADOS CSS (measured at age 3). Although the focus of this study was coordinated social communication, results for all variables are included to present the most complete picture of early development possible. Correlations with social communication and language measures are displayed in Table 2, and correlations with measures of autism symptoms are displayed in Table 3. Group-level scores for each of these measures (reported by Delehanty & Wetherby, 2021) are included in Supplemental Table 1 to assist with the interpretation of these correlational analyses.

Rates per minute and proportions of single words and coordinated gesture + words, both complementary and supplementary combinations, had statistically significant, medium and large correlations with the social, speech, and symbolic composites of the CSBS, the SORF Total Score, and the MSEL Receptive and Expressive Language T scores. Using a larger proportion of gestures alone, sounds alone, and coordinated gesture + sound was related to lower CSBS and the MSEL scores and higher SORF scores. Notably, using a larger proportion of sounds had medium sized negative relationships with all CSBS composites and MSEL scales. A larger proportion of gestures alone had a significant, medium sized negative relationship with the CSBS Speech composite. All coordinated social communication variables had small correlations with the ADOS CSS.

Table 2. Concurrent and prospective correlations between rate and proportion of coordinated social communication, social communication, and language.

	CSBS			MSEL	
	Social[a]	Speech[a]	Symbolic[a]	Receptive Language[b]	Expressive Language[b]
Rate per Minute					
Gesture Alone	.24	.07	.21	.23	.19
Coordinated Gesture					
Gesture + Sound	.35*	.23	.19	.26	.21
Gesture + Word	.49*	.51*	.52*	.50*	.48*
Gesture + Word Complement	.47*	.49*	.50*	.47*	.47*
Gesture + Word Supplement	.43*	.45*	.44*	.39*	.44*
Gesture + Phrase	.26	.30	.30*	.21	.23
Vocal or Verbal Acts					
Sound	.25	.29*	.14	.27	.21
Word	.46*	.57*	.46*	.46*	.47*
Phrase	.24	.33*	.26	.21	.26
Proportion					
Gesture Alone	−.18	−.33*	−.13	−.18	−.18
Coordinated Gesture					
Gesture + Sound	−.02	−.12	−.10	−.13	−.12
Gesture + Word	.50*	.55*	.54*	.49*	.53*
Gesture + Word Complement	.47*	.50*	.51*	.49*	.47*
Gesture + Word Supplement	.42*	.48*	.44*	.44*	.38*
Gesture + Phrase	.26	.31*	.29	.22	.20
Vocal or Verbal Acts					
Sound	−.40*	−.36*	−.40*	−.34*	−.31*
Single Word	.45*	.59*	.45*	.47*	.45*
Phrase	.24	.36*	.26	.26	.20

Note: $N = 211$. The Communication and Symbolic Behavior Scales Behavior Sample (CSBS) was administered at $M = 20.3$ months. The Mullen Scales of Early Learning (MSEL) was administered at $M = 36.6$ months.

[a]Standard Scores based on M of 10 and SD of 3 were used in analyses.

[b]T Scores based on a M of 50 and SD of 10 were used in analyses.

*$p < .001$ (Bonferroni).

Table 3. Concurrent and prospective correlations between rate and proportion of coordinated social communication, and autism symptoms.

	SORF ($N = 211$)	ADOS ($n = 184$)
	Total score	Calibrated severity score[c]
Rate per Minute		
Gesture Alone	−.18	−.04
Coordinated Gesture		
Gesture + Sound	−.35*	−.24
Gesture + Word	−.38*	−.27
Gesture + Word	−.35*	−.16
Complement		
Gesture + Word	−.35*	−.20
Supplement		
Gesture + Phrase	−.27	−.10
Vocal or Verbal Acts		
Sound	−.43*	−.27
Word	−.39*	−.15
Phrase	−.14	−.03
Proportion		
Gesture Alone	.24	.20
Coordinated Gesture		
Gesture + Sound	−.01	−.05
Gesture + Word	−.39*	−.27
Gesture + Word	−.34*	−.20
Complement		
Gesture + Word	−.35*	.23
Supplement		
Gesture + Phrase	−.26	−.12
Vocal or Verbal Acts		
Sound	.28	.05
Word	−.38*	−.14
Phrase	−.16	−.06

Note: The Systematic Observation of Red Flags for Autism Spectrum Disorder (SORF) was administered at $M = 20.3$ months. The Autism Diagnostic Observation Schedule (ADOS) was administered at $M = 37.4$ months.
*$p < .001$ (Bonferroni).

Discussion

In this report, we documented the coordination of social communication (i.e., gestures plus sounds or words) in toddlers identified with ASD, DD, and TD who were observed during a home observation. Previously published findings revealed that the overall rate per minute of communication for children with ASD in this sample was significantly lower than the rates at which children with DD and TD communicated (Delehanty & Wetherby, 2021). The current study examined coordinated social communication at a more fine-grained level. We also explored a number of associations with direct assessments and observational measures of social communication, autism symptoms, and language skills to build on studies that have examined factors that predict language development in children with ASD and DD. Results extend earlier work in this area by including a large, heterogeneous sample of toddlers with ASD, DD, and TD, observed within the age range that the AAP recommends universal screening for ASD, in a home-based setting during caregiver-child interaction.

Rates and proportions of coordinated communicative acts

All three groups, in absolute terms, used sounds alone, followed by gesture + sound combinations, as their most common modes of communication with respect to frequency and proportion. However, children with ASD used both of these modes of communication at significantly lower rates per minute than children with DD and TD, who did not differ. Children with ASD and children with DD, together, used all other modes of communication at significantly lower rates than TD children, except gestures used alone. Patterns in the proportions of coordinated communicative acts used by our toddlers with ASD and DD largely mapped onto those observed in the TD group, with one exception. We found that a significantly larger proportion of communicative acts used by toddlers with ASD and DD, compared to TD, were gestures alone. Children with ASD and DD used gestures alone as their third most common mode of communication, whereas single words were the third most common mode for children with TD.

These findings follow previous published studies indicating that children with DD (without ASD) may have social communication and language skills that are less robust than those with TD (e.g., Delehanty et al., 2018; Veness et al., 2014; Ventola et al., 2007), which complicates efforts to distinguish DD and ASD at young ages. Results of this study also suggest that the ability to coordinate verbal and nonverbal communication may be impacted in children with DD. However, rates of coordinated social communication among children with ASD were still significantly lower than those with DD and TD.

Further, our three groups did not differ in the rate at which they used gestures alone. Deficits in the ability to coordinate verbal and nonverbal communication are a diagnostic feature of ASD (APA, 2013). However, in the toddler years, a significantly lower rate per minute of sounds and gesture + sound combinations may be a distinguishing feature of ASD rather than the rate of gestures used in isolation. Further, limited use of single words and gesture + single words at this age may be an early sign of ASD or DD. Results support the recommendation that clinicians include opportunities to observe and encourage coordinated social communication while screening and assessing young children for DD and ASD in the home environment.

Concurrent and prospective relationships

An important finding of this study was that, despite significantly lower rates of communication in our ASD and DD groups, rates of coordinated social communicative had statistically significant concurrent associations with social communication and autism symptoms and prospective associations with receptive and expressive language skills. We found that the coordination of gestures and words at 20 months had significant relationships with communication and language, as did the use of single words alone. Gesture + word complement and gesture + word supplement combinations each had medium sized significant correlations with outcome variables. These finding underscore the importance of acquiring single words and coordinated gestures and words (both complementary and supplementary combinations) to language outcomes over a year later.

The ability to combine gestures with sounds and words is an important milestone that predicts more advanced forms of expressive language (Goldin-Meadow & Butcher, 2003; Iverson & Goldin-Meadow, 2005; Rowe & Goldin-Meadow, 2009). Findings suggest that intervention strategies that include modeling coordinated gestures and single words (complementary or supplementary), as well as directly targeting two-word combinations, could advance language comprehension and promote the production of word combinations in children with ASD and DD. Furthering our knowledge of the characteristics of children who might benefit from treatment strategies that target gesture enhancement is an important avenue for future research.

Moreover, while caregivers might miss a gesture or a sound used in isolation, they may be more likely to attend to a clearer communicative act that includes both a gesture and a sound, and then respond by providing the child with the language input needed to support learning in that moment (Leezenbaum et al., 2014; Olson & Masur, 2013; Wu & Gros-Louis, 2015). These responses provide the child with frequent, rich language input and facilitate social attention, which are important for language development (Adamson et al., 2004; Delehanty & Wetherby, 2021). Next steps in our research will be to examine parents' responses to child coordinated communicative acts in this sample.

Limitations

Limitations to this study are important to consider. Although our sample was large and showed wide variability in developmental profiles, additional studies of coordinated communication in the home environment are needed before results may be generalized to a larger population of children with ASD, DD, and TD. Next, due to the nature of the home video footage used in this study, we were not able to code for eye gaze to faces or shared expression of affect. It is possible that studying the coordination of gestures and speech in concert with eye gaze and facial expressions could provide more information about the mechanisms underlying the links between early social communication and language development in toddlers. Effective integration of all these aspects of communication could promote even richer parental responses and sustained child attention during social exchanges. A third limitation of this study is that we examined only the outcomes of children who returned for the diagnostic evaluation. Wetherby et al. (2008), who included families from the same geographic region, reported demographic characteristics of children from their larger screening sample who did and did not return for a follow-up evaluation. They found that 41% of the screened sample of children identified as racial and/or ethnic minorities, compared to 29% of the sample who completed a follow-up evaluation. We estimate that attrition rates would be similar in the sample of children who participated in the current study. Finally, observing children and families in the home environment promotes ecological validity, but also introduces a reduced level of control over the activities the families engaged in during their home observations. Future research examining coordinated social communication across everyday activities will be an additional, important next step (e.g., Binns et al., 2022).

Implications

While it is important to study children in carefully controlled settings, there is also great value in understanding how findings obtained in the lab extend to interactions in the natural environment. Observing and measuring the coordination of verbal and nonverbal communication, at home during everyday activities, provides useful information about social communication and language development and early signs of ASD and DD. Our results augment a growing research base indicating that coordinated social communication, like overall social communication development, is delayed but not necessarily divergent from TD in children with ASD and DD. However, the finding that children with ASD use sounds and coordinate gestures with sounds at significantly lower rates than those with DD can inform the development of screening and assessment measures that are feasible for use in a home-based setting. Identifying the children who are most in need of swift referral to early intervention is critical but remains challenging as an increasing number of children may show early signs of ASD while not exhibiting significant, co-occurring developmental delays.

Conclusion

Our findings build upon a small number of studies that have examined the coordination of social communication in young children with and without ASD and DD (Choi et al., 2019; Parladé & Iverson, 2015; Özçalışkan et al., 2018; Talbott et al., 2018). Language is a robust predictor

of long-term developmental outcomes in individuals with ASD and DD. Given the national priority for early identification and intervention, it is important to continue searching for early markers of social communication and language delays and developing intervention strategies that will promote language development. Experimental treatment research is needed to address the question of whether directly teaching gestures and coordinated social communication may play a causal role in fostering language skills in toddlers with ASD and DD. This study adds to a growing research base examining rates and patterns of coordinated communication as important measures for improving early detection.

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Supplemental material

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