J Autism Dev Disord (2014) 44:1946–1958
DOI 10.1007/s10803-014-2069-y

ORIGINAL PAPER

Parent–Child Gesture Use During Problem Solving in Autistic Spectrum Disorder

Kristen Medeiros · Adam Winsler

Published online: 18 February 2014

Abstract This study examined the relationship between child language skills and parent and child gestures of 58 youths with and without an autism spectrum disorder (ASD) diagnosis. Frequencies and rates of total gesture use as well as five categories of gestures (deictic, conventional, beat, iconic, and metaphoric) were reliably coded during the collaborative Tower of Hanoi task. Children with ASD had lower Peabody Picture Vocabulary Test scores and gestured less and at lower rates compared to typically developing children. Gesture use was unrelated to vocabulary for typically developing children, but positively associated with vocabulary for those with ASD. Demographic correlates of gesturing differed by group. Gesture may be a point of communication intervention for families with children with ASD.

Keywords Autism spectrum disorder · Gesture · Receptive communication · Parent–child interaction

Introduction

Autism spectrum disorder (ASD) is an umbrella term for three developmental disabilities with similar symptoms: autism, Asperger's syndrome, and pervasive developmental disorder—not otherwise specified (PDD-NOS). Individuals with autism exhibit deficits in three core areas: language (both verbal and non-verbal), social interaction and communication, and restricted or repetitive behaviors and interests (APA 2000). Individuals with Asperger's Syndrome typically have intact language, but have difficulty with social communication and often exhibit restricted interests and perseveration on specific topics. Individuals diagnosed with PDD–NOS typically show less severe signs of the three core deficits or have later onset (after 3 years of age) (American Psychiatric Association 2000). Given heterogeneity in the topography and severity of symptoms, the notion of a single spectrum may fit the disorder better than categories (Betancur 2011; Geschwind and Levitt 2007). However, a core deficit underlying all types of ASD is communication.

The DSM-IV lists four criteria for communication impairment in autism: (1) delayed or lack of spoken language, (2) obvious impairment in initiating or sustaining conversation (in verbal children), (3) stereotypic and repetitive use of language, and (4) lack of developmentally-appropriate, varied, spontaneous make-believe play or social imitative play (American Psychiatric Association 2000). Social impairments are distinct from, yet closely intertwined with, communication impairments, and they include nonverbal behaviors such as gaze modulation, facial expressions, body gestures, and social regulatory gestures. These social skills can be critically helpful in the development of communication by providing additional cues about the speaker's intent or interests, and clarification or emphasis of ideas (Landa 2007).

ASD can be particularly taxing for individuals and their families because of social and communication deficits often leading to a failure to develop friendships and deep emotional bonds or reciprocity (Riby et al. 2012). Individuals with ASD may have difficulty making eye contact and

K. Medeiros (✉)
State University of New York at New Paltz, 600 Hawk Dr, JFT 306, New Paltz, NY 12561, USA
e-mail: medeirok@newpaltz.edu

A. Winsler
Applied Developmental Psychology, Department of Psychology-3F5, George Mason University, Fairfax, VA 22030-4444, USA
e-mail: awinsler@gmu.edu

trouble interpreting facial affect. Several lines of research have shown that children with ASD have a preference for nonsocial stimuli over faces, potentially from birth (Freeth et al. 2010; Kikuchi et al. 2009). Additional communication impairments that are seen in early ASD development include asynchronous babbling or atypical intonations (Sheinkopf et al. 2000), poor quality of shared affective expressions with parents (Yirmiya et al. 2006), and deficits in responding to other's nonverbal cues (Baranek 1999).

Intensive behavioral interventions have proven to be successful for individuals with ASD (Eikeseth et al. 2012), and research on alternative communication systems has been encouraging, such as with sign language (Carbone et al. 2010), Picture Exchange Communication Systems (Ganz et al. 2012; Tincani and Devis 2011), and visual schedules (Cihak and Ayres 2010; Ganz 2007). Sign language communication training paired simultaneously with speech instruction produces positive communication outcomes for children diagnosed with autism and other developmental disabilities (Valentino and Shillingsburg 2011). A recent study found varying predictors for gesture use, language abilities, and communication skills in the ASD population (Kjellmer et al. 2012). Specifically, cognitive level was associated with receptive and expressive language development, whereas severity of autism symptoms and socio-emotional deficits were associated with non-verbal communication development (e.g., gestures and actions).

Individualized education plans for children with ASD often involve training in alternative methods of communication, since even with intensive early speech instruction, around 50 % of children diagnosed with ASD early on will fail to acquire functional speech (Peters and Gillberg 1999). Gesture may be useful as a supplemental mode of communication with children with ASD; however, relations between gesture, language, and communication have yet to be explored fully in individuals with ASD. If eye gaze is not a natural component of communication for those with ASD, perhaps a direct guide with an arm or finger (i.e., a gesture) would present a more salient stimulus to attract attention. Research on the younger siblings of children with ASD (toddlers at high risk for ASD) has found impairments in responding to joint attention, initiating joint attention, and initiating behavioral requests (Ibañez et al. 2013). The level of these joint attention deficits is predictive of later ASD diagnosis and later degree of social impairment (Yoder et al. 2009). Presmanes et al. (2007) showed that this high-risk group had deficits in joint attention tasks compared to toddlers not at risk for ASD, but they performed at typical levels when provided with a pointing gesture in addition to other verbal and nonverbal cues. Walton and Ingersoll (2013) have successfully used verbal cues to supplement eye gaze in the fast-mapping language development of children with and without ASD. Gestures could aide in communication or task performance for an individual who prefers not to make eye contact or does not understand subtle communication cues. The present study examines gesture use of children with ASD and their parents during a collaborative task.

ASD and Gesture Use in Infants and Toddlers

Increasingly, parent–child interactions are being considered in the communicative development of ASD (Wan et al. 2012). The majority of research in this area has investigated parent–child interactions in infancy and toddlerhood. A major piece of this research has been identifying precursors for ASD in infant atypical behavior and unusual parent–child interactions (Landa and Garrett-Mayer 2006, 2007; Mitchell et al. 2006; Zwaigenbaum et al. 2005). Rozga et al. (2011) found that joint attention and child requesting at 12 months were lower between caregivers and their infants who were later diagnosed with ASD. The interactions of parents with their infants who are later diagnosed with ASD tend to use less gesture but have higher physical contact and longer stimulation during play (Saint-Georges et al. 2011). Wan et al. (2012) saw that these transactional patterns of communication and directive interaction can have effects on later-born siblings. There were differences in global interaction characteristics of parent–child unstructured play between infants who had an older sibling diagnosed with ASD and infants without any family history of ASD, where at-risk infants were less lively, and their parents were more directive and less sensitive. Recent retrospective research finds that infants later diagnosed with autism are less likely to use social interaction, behavior regulation, and joint attention gestures between 9 and 18 months than infants with typical development (Watson et al. 2013).

Mitchell et al. (2006) collected data on early word comprehension, word production, and gesture use of at-risk infants (i.e. younger siblings of children already diagnosed with ASD) at 12 and 18 months of age. At both time points, the children who were later diagnosed with ASD at 24 months had produced fewer gestures and had delays in both comprehension and production of phrases. Findings similar to this have created momentum in the literature to target gesture in screening instruments and interventions for infants at risk for ASD to improve cognitive and language development (Kelly et al. 2008).

One of the possible reasons for deficits in gestures is a difficulty with sensorimotor coordination between the hands and mouth, and this may be measurable in infant's motor and vocal interdependence and synchrony (Iverson 2010). Initially, speech and gesture appear to be two independent systems which then merge together temporally and semantically early in language development (Sowden et al. 2008).

For children with ASD, this developmental transition of merging the two modes of communication may be a prospective target area or period for intervention, in addition to efforts to improve each system independently. Some research claims that children with ASD have a reverse pattern of language acquisition compared to typically developing children, where they initially have better word production and expression than comprehension, reception, and gesture skills (Hudry et al. 2010; Miniscalco et al. 2012). Other research has found that children with ASD show a delayed, yet typical trajectory of development for gesture and speech (Sowden et al. 2008). Although this research is promising in the areas of early assessment, early intervention, and dynamic communicative transactions, a limitation of the current literature base is its preoccupation on the infant and toddler developmental years. These complex parent–child interactions change over time, creating dynamic relationships at different ages, and warrant the need to investigate their effects throughout development.

ASD and Gesture Use in Young Children

Although young children with specific language impairment use gestures at a higher rate than typically developing peers (Iverson and Braddock 2011), young children with ASD show a lack of or atypical gesture use during social interactions, delayed use of gestures (Baranek 1999), and less competence in recognizing gestures compared to typically developing peers (Ham et al. 2010; Smith and Bryson 2007). Young children with ASD produce fewer deictic gestures (i.e., gestures that indicate a referent in the immediate environment such as pointing or reaching) and less synchronous gestures (i.e., hand signs and motions that match simultaneous verbal speech) than typically developing peers (De Marchena and Eigsti 2010).

Other research has shown that deficits in ASD gesture are only found in intransitive gestures (i.e., symbolically communicative, e.g., hitch-hiking), with performance of children with ASD being similar to typically developing children on transitive gestures (i.e., describing actual tool use, e.g., illustrating the use of a hammer with a grip and a swinging motion) and pantomime gestures (i.e., using a body part to represent object use, e.g., using a finger as a toothbrush when miming the act of brushing teeth) (Ham et al. 2010). Children with ASD may also have trouble imitating gestures, as seen in their errors during a commanding replication task when instructed with gestures (Mostofsky et al. 2006). Young children with ASD also show difficulty with the individual components of gesture communication, such as pointing, showing, sharing interests, and coordinating gaze, expressions, and gestures (Wetherby et al. 2004).

Still some studies have found that parents of preschoolers and early school-age children with ASD tend to use more gestures and nonverbal prompts during interactions, compared to typically developing controls (Doussard-Roosevelt et al. 2003; Lemanek et al. 1993; Nassan El-Ghoroury and Romanczyk 1999), creating a more dictated and directive way of playing (Wan et al. 2012). Similarly, research has shown that children with autism are more likely to make requests and directly manipulate the hands of those they are engaging with rather than make comments, point, or gaze to communicate with a partner (Stone et al. 1997). In addition, children with delayed language are more likely to use conventional gestures and distal hand gestures than children with PDD–NOS, and this distinction becomes more apparent with age (Wetherby et al. 1998).

ASD and Gesture Use After Childhood

There is little research on gesture use and comprehension in individuals with ASD after the early school years. Some research on children with autism between 4 and 13 years old has found deficits in symbolic gesture use, gesture comprehension, and joint attention tasks (Loveland and Landry 1986; Stone and Caro-Martinez 1990); whereas other research has found children with autism in this age range to rely more on gestures when comprehending communication but have deficits in producing symbolic communication like speech and signs (McHale et al. 1980). However, most of these earlier studies relied on small sample sizes and teacher report.

More recent research has found deficits in gesture imitation, but not in gesture comprehension, for children and adolescents with autism, where nonverbal requests are more easily followed than verbal requests compared to typically developing children (Kurt 2011; Smith and Bryson 2007). Some research has looked at particular types of gesture use and found that adolescents with ASD show deficits in recognizing and imitating transitive, intransitive, and pantomime gestures compared to typically developing adolescents (Ham et al. 2011). Research on the personal use of gesture while narrating a story found that the gestures of adolescents with ASD tended to be less synchronized with their speech and less helpful in engaging listeners and improving the quality of their stories (de Marchena and Eigsti 2010). In typically developing children, gesture use has been shown to improve language and memory aspects of narration (Demir et al. 2013).

Demographic Correlates of Parental Gestures

Finally, a variety of child and family characteristics may be associated with parental gesture use, as has been found to be

the case for parental oral language responsivity and language stimulation. Early observational studies by Gutman and Turnure (1979) found that mothers gestured more to their young children during an object description task than during a toy manipulation task, and mothers gestured more often and more complexly to older children than to younger children. A longitudinal study by Hart and Risley (1992) saw that socioeconomic status was related to the quality of verbal parenting (with less privileged parents speaking less meaningful utterances to their young children), which was later related to the IQ of the child (partially measured by language abilities). Research by Evans et al. (1999) found that parents with more children spoke less complexly and were less verbally responsive to their children than parents in less crowded homes (controlling for socioeconomic status). A meta-analysis by Leaper et al. (1998) found that mothers tend to talk more, use more supportive and negative speech, and use less directive and informing speech than fathers. Also, mothers tend to talk more and use more supportive speech with their daughters than with their sons. It is possible that there are similar demographic correlates of parental gesture use with older children with ASD, which is why we also explore the extent to which gesture use between parent and child is related to a variety of family factors, such as number of children in the home, child age and gender, and parental education, income, and age.

The Present Study

From the reviewed literature, it appears that nonverbal communication skills, such as gestures, may be a valuable tool for intervention, but these abilities in children with ASD may be too atypical or deficient to utilize well in communication training. There is a need to understand the relationship between parent–child gesture, communication, and language skills beyond infancy and toddlerhood. This study examined parent and child gesture use during a collaborative problem-solving task involving both typically developing youth and children with high functioning autism between the ages of 7 and 18. In addition to exploring group differences in gesture use, we were also interested in understanding the demographic correlates of parental and child gesture use, as this information could be useful for designing and tailoring interventions. The following research questions were addressed: (1) How do children with ASD and the parents differ from typically developing children in their gesture use (their rate of gesturing and the types of gestures they use) during joint problem solving? (2) To what extent are parent and child gestures related to children's receptive language skills, and are relations the same for typically developing children and children with ASD? and (3) Which parent, child, or family characteristics are associated with parent and child gesturing, and are these the same for typical children and those with ASD?

Method

Participants

The sample included 58 children ranging in age from 7 to 18 years old ($M = 10.97$, $SD = 3.03$), with 49 males and 9 females, and their primary caregiver or guardian. This sample included 26 typically developing children with no diagnosis and 32 children diagnosed with ASD. Participants were required to have documentation of their DSM-IV diagnosis, which included rigorous neuropsychological assessments, child observations, a child interview, and a parent interview. The ASD diagnoses included High Functioning Autism ($n = 9$), Asperger's syndrome ($n = 19$), and PDD-NOS ($n = 4$).

The participating caregivers (hereby referred to as parents) were 86.2 % female and 13.8 % male, and ranged in age from 30 to 62 years ($M = 42.19$, $SD = 5.83$). The ethnic background of the sample was generally Caucasian (89.7 %). Family size varied, with 39.7 % having one child, 29.3 % having 2 children, 19 % having 3 children, and 10.3 % having 4 children. Parents were generally well educated, with 51.7 % having at least some college education and 48.3 % having at least some graduate school education. The majority of parents were married (86.2 %) and a fraction were either divorced (12.1 %) or never married (1.7 %). The average total family income fell in the $126,000–$150,000 range, which is typical for the geographic location of the study. Typically developing children and children with ASD were not statistically different in terms of child age, parent age, parent gender, or total family income. The groups did differ in terms of child gender ($\chi^2(1) = 8.36, p < .01$), where children with ASD were more likely to be male (97 %) compared to typically developing children (69 %). Also, children with ASD, as a group, performed lower (M percentile $= 61.2$, $SD = 37.8$) than the typically developing children (M percentile $= 86.5, SD = 11$) on PPVT vocabulary, $t(32.04) = 3.39, p < .01$.

Procedure

Participants were recruited through an ASD clinic within a major children's hospital, and comparison children were recruited through advertisements, local schools, and family organizations. Families participated in a larger study (**; deleted for blind review) involving the child completing other executive functioning tasks that are irrelevant to the goals of the current study. Data were collected in two small university laboratory rooms by two graduate research assistants. Researchers first engaged in a 5-min

rapport-building session, where they explained the contents of the session to the parent and child. They obtained informed consent from the parent (and assent from the child) for both the child and parent to participate and to be videotaped. The data collection sessions consisted of the parent completing several questionnaires, the child completing several computerized cognitive tasks and in-person assessments (for the larger study, not relevant here), and a problem-solving task (described below) that was completed twice—once collaboratively by parent and child together, and subsequently by the child individually.

Tasks

Tower of Hanoi—Revised (TOH-R; Welsh et al. 1991)

In the TOH-R task, participants were shown a picture display of three pegs with four colored discs on one peg in order of ascending size. Their objective was to rearrange the physical discs on their own pegs in the same way as in the picture, in the fewest moves possible. This problem-solving task involves transferring the entire tower of discs to one of the other pegs, moving only one disc at a time and never placing a larger disc on a smaller disc. The TOH-R task was video recorded in a small room with the parent and child as a dyad. Directions to the parent and child stated that the researchers, "Would like you to work on this task together as you would normally," and they were told that after they completed the task together, the child would complete it alone. They were told to take as much time as needed, but to try to complete it in the fewest number of moves. The average amount of time taken to complete the dyad TOH-R task was 3.31 min ($SD = 2.47$), with a range of 50 s to 15 min.

Peabody Picture Vocabulary Test—III (PPVT-3; Dunn and Dunn 1997)

The PPVT-3 is a widely used, normed and standardized, receptive vocabulary test for individuals from 2 to 90 years old. The test takes about 20 min to administer and provides raw scores, age equivalent scores, and percentile ranks. The examiner presents a series of pages that contain four numbered pictures, and the child is asked to find the picture that illustrates a certain word, either by verbally identifying the number of the picture or by pointing to the picture. The PPVT-3 has high internal consistency and test–retest reliability (Dunn and Dunn 1997), convergent validity with the Wechsler Adult Intelligence Scale—Third edition (Bell et al. 2001), and concurrent validity (Campbell et al. 2001). Percentile scores, comparing the child's vocabulary to the national standardization table for others of the same age, were used in this study, since raw PPVT scores were highly correlated with child age ($r = .87$).

Gesture Coding

Gestures were defined as actions between the time when a moving hand entered the "gesture space" in front of a person's body and when the hand was "retracted into neutral space or changed trajectory or location" (Iverson and Braddock 2011, p. 77). The graduate student coder was blind to the diagnoses of the children at the time of coding from the videotapes. Coding was accomplished after the completion of data collection by a different research assistant than those who participated in data collection. In accordance with definitions described by Goldin-Meadow (2009a), the parent and child were each coded for the frequency of five forms of gestures: deictic, conventional, beat, iconic, and metaphoric. The total number of each of the following gestures displayed by the parent or the child during the dyad task was recorded. (1) *Deictic gestures* were defined as those that indicated a referent in the immediate environment (e.g., pointing at a disc or peg, holding up a disc for the partner to see, reaching for a disc, handing a disc to the partner). (2) *Conventional gestures* were defined as those whose meaning would be recognizable by others in the absence of accompanying language (e.g., nodding the head "yes," putting the arms out and palms up while shrugging shoulders for "I don't know," clapping in praise, putting hands out with palms and fingers flat for "stop" or "wait," fist in the air for "victory"). (3) *Beat gestures* were defined as any formless movements of the hands or arms that followed the rhythm of emphasizing accompanying speech (e.g., flicking the hand up and down, rolling the wrist or fingers while repeating, "What to do" in a melodic pattern and cadence). (4) *Iconic gestures* were defined as those that described the physical characteristics of an item or object (e.g., referring to a big or small disc with the distance of hands, holding fingers steady illustrating a certain disc size and demonstrating a bouncing motion of moving the disc from peg to peg or a sliding movement of dropping the disc onto a peg). (5) *Metaphoric gestures* were defined as those that captured abstract meaning (e.g., placing fingers on the forehead and throwing them forward while spreading out the fingers for "thinking"). A total gesturing variable was created by summing the deictic, conventional, beat, iconic, and metaphoric gestures exhibited during the dyad TOH-R task by each participant. Thus, for both parent and child, five separate gesture frequencies and a total gesture score were created. These raw scores were then divided by the amount of time taken to complete the dyad TOH-R task, thus creating gesture rates for each of the five types of gestures and total gesturing rate for the parent and for the child. To control for the length of time taken to complete the TOH-R task (i.e. the different amounts of opportunity to gesture during the dyad

Table 1 Descriptive statistics on gesture rates

	Typically developing				Autism spectrum disorder			
	M	SD	Range	% No gestures	*M*	SD	Range	% No gestures
Child								
Total gesture rate*	2.66	2.87	0–12.5	7.69	.89	1.08	0–4.91	34.37
Deictic*	1.55	2.38	0–11.36	23.08	.40	.83	0–4.27	62.5
Conventional*	.85	.80	0–3.31	11.54	.29	.47	0–1.57	62.5
Beat	.17	.30	0–.89	69.23	.19	.41	0–2.0	68.75
Iconic	.09	.26	0–1.17	84.62	.07	.04	0–.21	96.88
Metaphoric	0	0	0	100	0	0	0	100
Parent								
Total gesture rate	7.58	3.48	1.69–2.95	0	7.35	4.54	.87–20	0
Deictic	4.85	3.08	0–10.8	7.69	4.03	3.33	0–12.95	17.39
Conventional	1.80	1.83	0–6.91	3.85	2.05	2.43	0–10.86	21.74
Beat	.60	.56	0–1.89	30.77	.93	1.26	0–4.92	43.48
Iconic	.23	.36	0–1.26	57.69	.31	.69	0–3.75	82.61
Metaphoric	.10	.22	0–.82	76.92	.03	.11	0–.43	90.63

* $p < .05$

task), gesture rates were used rather than raw gesture counts.

Results

Question 1. Group Differences in Gesture Use

Child Gestures

Table 1 provides descriptive statistics on the gesture rates (per minute) for dyads involving children with ASD and typically developing children. To control for gender, we entered gender (0 = girl, 1 = boy) and group (comparison = 0, ASD = 1) into multiple regressions with the total gesture rate and the rate for each individual type of gesture included as the dependent variables in turn. Whether or not a child was diagnosed with ASD explained 5.8 % of the variance in total gesture rate, controlling for gender ($F(2, 57) = 5.46$, $p = .007$). In terms of the types of gestures used, children with ASD were significantly less likely to use deictic ($b = -1.08$, $p = .03$) and conventional ($b = -.49$, $p = .01$) gestures than children without ASD. There were no group differences in use of beat ($b = .06$, $p = .57$) or iconic gestures ($b = -.09$, $p = .08$); albeit both groups rarely used these gestures, and no child ever used metaphoric gestures. Child gender was unrelated to total gesture rate and most of the particular categories of gesture. However, the rate of conventional gestures was significantly higher ($F(1, 56) = 4.93$, $p = .03$) for girls ($m = 1.0$, $SD = .84$) than boys ($m = .46$, $SD = .64$), but all of the girls were typically developing. In terms of total gesture rate, there were group differences in children's overall rate of gesturing, with typically developing children gesturing an average of 2.66 gestures per minute and children with ASD gesturing an average of .89 gestures per minute, $t(30.78) = 1.77$, $p < .01$.

Parent Gestures

Parents of children with and without ASD did not differ in their total gesture rate ($t(56) = .21, p = .83$) or in their rate of gesturing in any of the five categories: deictic ($t(56) = .96$, $p = .34$), conventional ($t(56) = -.44$, $p = .66$), beat ($t(44.61) = -1.30, p = .20$), iconic ($t(56) = -.52, p = .61$), or metaphoric ($t(35.17) = 1.32$, $p = .20$), according to independent samples t tests. Worth noting is the rarity of expressing iconic and metamorphic gestures for either group. Regression models were also run controlling for child gender, as was done above for child gesturing, with the same lack of significant findings for child diagnosis or for child gender on parent gestures.

Question 2. Relations Between Gesture Use and Child Receptive Language Skill

We addressed our second research question having to do with relations between parent and child gesture use and child language competence in two ways. First we correlated total gesture use rates with child PPVT performance, overall, and for each group separately. These correlations can be in seen Table 2 for parent gestures and in Table 3

Table 2 Correlates of parent total gesture rate

	Typically developing	ASD	Total sample
Parent's age	.02	−.16	−.11
Number of children[a]	−.20	.42*	.20
Education	.23	−.19	−.01
Family income	.27	−.26	−.07
Child Age	−.41*	−.36*	−.37**
Child birth order	−.07	.36*	.19
Child gender (male)	−.22	−.06	−.13
Child vocabulary	−.05	−.21	−.15
Child's gesture rate[a]	−.12	.40*	.07
Joint TOH performance	−.19	−.22	−.21
Child TOH performance	.41*	.13	.17

* $p < .05$; ** $p < .01$

[a] Fisher test for difference in correlations $p < .05$

Table 3 Correlates of child total gesture rate

	Typically developing	ASD	Total sample
Parent's age	.06	.36*	.04
Number of children	.10	.38*	.24
Education	−.22	−.30	−.20
Family income	−.20	−.37*	−.22
Child age	.26	.07	.09
Child birth order	.14	.06	.11
Child gender (male)	−.14	.09	−.24
Child vocabulary	.14	.28	.27*
Joint TOH performance	−.05	−.28	−.13
Child TOH performance	.09	−.05	−.07

* $p < .05$

for child gestures. Recall that we are using PPVT percentile scores that control for child age and compare the child to the national standardization sample for his or her age group. Child overall gesture rate was positively and significantly related to child PPVT vocabulary, but parent overall gesture rate was not associated with child vocabulary. We also ran the same correlations on the five subtypes of gestures. Patterns of interest were noted for the two most common gesture types (deictic and conventional). Deictic gestures by parents (but not by child) were negatively correlated, $r = -.25$, $p = .07$, with child vocabulary for the total sample and this association was stronger for children with ASD, $r = -.43$, $p < .05$, than it was for typical children, $r = -.18$, *ns.* Conventional gestures by the child (but not by parent) were more common among children with higher vocabularies, $r = .28$, $p < .05$ among the total sample, and the same pattern was seen for both groups ($r = .29$ for typical and $r = .14$ for ASD).

Given that some of the correlations above between vocabulary and gesture use differed by group, our second way of answering research question 2 was through moderated multiple regression. We predicted parent or child gesture rate by entering gender, group, and vocabulary in the first step and then adding the interaction term between group and vocabulary in a second block. We did this for overall gesture use and for deictic and conventional gestures. In no cases did the interaction between group and vocabulary become statistically significant.

Question 3. Demographic Correlates of Gesture Use

To understand other correlates of gesture use, correlation matrixes were produced separately by group, showing relations between child and family demographic variables (parent age, number of children in family, parent education, family income, child age, child birth order) and total parent gesture rates (Table 2) and total child gesture rate (Table 3). In addition to evaluating the correlations for statistical significance by comparing them to 0, they were also compared between groups using Fisher's test for the difference between two correlations. The correlates of parent gesturing appeared to be somewhat different, depending on the diagnosis of the child (Table 2). Parents of both the comparison group and children with ASD gestured at higher rates with younger children. For parents of typical children, there were no other significant correlations between parent gesturing and the other child or parent background characteristics. However, parent gesturing involving children with ASD was related to a few more variables. Parents of children with ASD gestured at higher rates when they had more children at home, and with their later-born children. The only dimension, however, where the correlations differed significantly between the ASD and non-ASD group according to Fisher's test was for the number of children in the family. Parents of children with ASD had higher rates of gesturing when they had more children; whereas, parents of typically developing children had lower rates of gesturing when they had more children (Table 2).

Also included at the bottom of Table 2 are the associations between parent gesture and child gesture rates during the joint session. It is notable that parent and child gesture use were unrelated to each other for the typical group but positively correlated among dyads involving a child with ASD. So, the more the parent gestured, the more the child with ASD gestured, and vice versa. The difference between these two correlations was significant, $p < .05$. Also included at the bottom of Table 2 are the correlations between parent gesture and dyadic and individual performance on the TOH task (total number of moves, so that bigger numbers indicate poorer performance). Table 2 shows that parent gesture was not

significantly correlated with performance on the joint nor the individual TOH for children with ASD. However, parent gesture was positively correlated with typically developing children's performance on the TOH task by themselves afterward ($r = .41$, $p < .05$), meaning children whose parents gestured more during the dyadic session performed worse (took more moves to complete) later on the individual TOH task.

Table 3 shows the correlates of child gesture use. Here again, there were more significant associations between background variables and child gesture rate among the children with ASD than among typically developing controls. Children with ASD used more gestures as the age of their parent increased, and as the size of their family increased. ASD child gesture use was negatively associated with family income. These associations were not significant among the typically developing group. For the overall sample, child gestures were positively associated with PPVT vocabulary, indicating that, in general, children with more language skills gestured more than those with less receptive language skills. In addition, the bottom of Table 3 shows that there were no significant correlations between child gesture rate and their performance on either the dyadic or the individual TOH task for either typically developing children or children with ASD.

Discussion

This research investigated parent and child gesture use during a joint problem-solving task for children with and without ASD, and examined relations between gesture use, child language skills, and demographic variables. In support of the current understanding of the deficits of ASD, we found that receptive language skills, as measured by the PPVT-3, were lower for children with ASD than for typically developing children. Children with ASD were also more likely to be male; however, there were no gender differences in gesture use for either group. Children with ASD were less likely to gesture and gestured at lower rates during the dyad TOH-R task with their parents and were specifically less likely to use deictic (i.e. pointing and reaching) or conventional (i.e. nodding) gestures compared to typically developing children. This reduced use of deictic and conventional gestures may relate directly to the social communication deficits seen in ASD, as signs of poor joint attention. Although there have been successful interventions recently for parents and teachers facilitating joint attention skills in toddlers and young children with ASD (Kasari et al. 2012; Landa et al. 2011; Schertz et al. 2013; Wong 2013), the present research shows that deictic and conventional gestures specifically may be a new potential target skill for communication programs.

Several language training programs for children with ASD, such as the Picture Exchange Communication System (PECS), attempt to train children on iconic or metaphoric gestures to provide them with a means of expressing their needs and desires. Children with ASD gestured similarly to typically developing children in regards to iconic gestures, which supports research by Ham et al. (2010) that showed no ASD deficit for pantomime gestures about the use of objects. This also supports the research which shows that infants and younger children with ASD gesture less than typical children, but that those deficits may in fact be for intransitive communicative gestures only (De Marchena and Eigsti 2010; Hudry et al. 2010). Metaphoric and beat gestures were almost never displayed by children in either group in this study. This may suggest that the tower task does not elicit all categories of gesture and that other tasks and parent–child scenarios should be explored to assess the roles of various types of gestures. Although the TOH task has been used previously to study gesture use in relation to problem solving, subcategories of gesture were not examined (Garber and Goldin-Meadow 2002).

It is also possible that certain types of gestures are generally rarer in older children, such as those examined here. Little research has investigated the incidence of different categories of gesture beyond the toddler years. One study by Roth and Lawless (2002) found that children between the ages of 9 and 18 used more metaphoric gestures and fewer beat or deictic gestures when explaining abstract physics concepts that they had not fully comprehended. However, when explaining abstract concepts that they had mastered, the students used more beat and deictic gestures than metaphoric gestures. This shows that the type of gesture used in problem-solving situations certainly varies depending on the task and child competence.

Capone and McGregor (2004) highlighted the importance of extending gesture research to older children and young adults. Research on infants and toddlers clearly shows that gesture serves as a scaffold for cognitive development while verbal skills are being acquired. This means that infants replace gestures with words over time (Namy and Waxman 2002), and early gesture use is related to subsequent vocabulary (Mayberry and Nicoladis 2000) and school-readiness (Goldin-Meadow 2009b). Specifically, deictic gestures predict noun vocabulary development (Iverson and Goldin-Meadow 2005), and, once some basic verbs are acquired, iconic gestures can predict later verb vocabulary (Ozcaliskan et al. 2013). Cartmill et al. (2013) showed that the quality of parent gestures toward their infants predicted the size of their child's vocabulary 3 years later. Perhaps gesture use with older children also scaffolds the development of other cognitive and linguistic skills, especially among children with intellectual disabilities. Linking parental gesture use to older children's language and

cognitive growth is more complex, requiring different methods and designs than that used in the current study. In the current study, we did not examine the "quality" of parental gestures with respect to the moment-to-moment cognitive demands of the task, however the lack of a correlation between the global frequency of parental gestures and children with autism's later individual performance on the TOH task suggests that parental gesture use in ASD is not importantly related to child cognitive competence. That is, it was *not* the case that parents used more gesture with lower functioning ASD children who would go on to struggle with the TOH task, nor was it the case that gesture use by parents was reserved for the children who were more competent with the task. There was simply no association between amount of parent gesture use and child task performance for dyads involving children with ASD. Interestingly, among the typical children, increased parental gesture was found for the children who tended to struggle with the TOH individually. This suggests that the supplemental nonverbal communication tool of gesture might be used, at least by parents of typically developing children, in the context of task difficulty or cognitive challenges, not unlike how children use private speech (self talk) as a tool for problem solving during difficult tasks (Winsler et al. 2007).

Interestingly in the present study, parents gestured at the same rate to their child, regardless of whether the youth was typically developing or diagnosed with ASD. Thus, it does not appear to be the case that older children with ASD are receiving impoverished gesture input from their parents during joint activities, nor does it appear that parents of children with ASD are overcompensating for their child's verbal communication deficits by using extra gestures. Our finding of no group differences in parent gesture is in contrast to Wan et al. (2012), who found that parents of younger children with ASD tended to use more directive gestures during interactions compared to controls. This brings to light the potential contribution of communicative growth and development in parent–child interactions. Perhaps initially more directive parents assist their child's language development and communication skills through extra gesturing and then ultimately fade their nonverbal prompts to a typical level and rate. Research by Goldin-Meadow (2009b) supports this notion of the indirect reciprocity effects of gesturing, where the communicative environment between parent and child adapts to gesture and verbal cues to promote language development. A strength of the current study was that it involved an older sample for investigating parent–child interactions and gesture, since the bulk of previous research in this area has focused on early gesture and intervention in infants and toddlers. Clearly longitudinal research is needed to examine whether the above-hypothesized developmental changes in parent gesture use over time with children with ASD is true. It is important to point out in this connection, however, that the children with ASD included in the current study were relatively high functioning and quite verbal. The patterns of gesture use described here by parents and children might not be similar to those observed with lower-functioning children on the spectrum. Further research will need to explore parent and child gesture use across a wide range of age and verbal ability levels.

It was interesting that specifically for dyads involving a child on the spectrum, parent and child gesture rates were positively correlated—the more one member of the dyad gestured, the more the other one did as well, suggesting that both were using gesture for adaptive communicative purposes. This was not the case for dyads involving typical children, in which a small negative correlation was found. Perhaps gesture plays a special role in the problem-solving communication that occurs between parents and their children with autism.

Another goal of this study was to determine the correlates of parent and child gesture during joint problem solving and see whether they were the same for children with ASD and typical children. First, it was notable that for the overall sample and somewhat stronger for children with ASD, children with higher receptive language skills tended to gesture more than those with weaker vocabularies, and this was particularly true for conventional gestures (i.e., nodding). This suggests that, rather than being used as a compensatory tool for those with poor oral language skills, gesture use by children during joint problem solving appears to be a mature communication strategy covarying with stronger language skills in general. Parents of both groups of children, however, tended to gesture more with younger children than with older children, and parents (especially parents of children with ASD) used more deictic (i.e., pointing) gestures with children who had weaker receptive language skills. Since deictic gestures are only useful in referring to immediate surroundings, this type of communication may be useful for directing behavior and cognition during moment-to-moment situations. Children with poor receptive language skills may need more instantaneous and concise language guidance from their parents. Grimminger et al. (2010) showed that maternal gestures toward their late talkers were qualitatively different than those with typically developing talkers. Specifically, gestures toward late talkers were more deictic, more frequent, and longer in duration, and these aspects were fine-tuned to the level of their child's speech deficit.

Several unanticipated demographic correlates of gesture were found specifically among dyads involving children with ASD. Parents of children with ASD gestured more with the target child when there were more children/siblings in the home and when the target child was later-born,

a pattern not observed in the typically developing group. Similarly, specifically autistic children with older parents and more siblings gestured at higher rates than autistic children from smaller families with fewer siblings. This suggests that communication dynamics and gesture use in families with an autistic child vary depending on the size of the family and presence of older siblings. This is an area that deserves research attention in the future.

Although, this study provides much-needed information on the dynamics of parent-adolescent gesture use during joint problem solving among families with a child on the spectrum, there are several limitations worth noting. First, the analyses are correlational and global in nature. Future studies may wish to use microanalytic, qualitative methods, and/or sequential analysis to examine in more detail the moment-to-moment dynamics of parent–child communication during joint activity and determine how particular gestures or communicative strategies by one member of the dyad influence gesture use in the other. Second, we only investigated high functioning, highly verbal children with ASD. Gesture use and communication strategies during joint problem solving likely differ for lower functioning children with ASD, and this should be explored in future studies. Our relatively small sample sizes also made it difficult to find statistically significant differences, even in the presence of moderate effect sizes. Third, we were limited to using the PPVT as the only measure of child language ability, when a more comprehensive assessment of language competence, including language production, would have been better. Similarly, we did not have a standardized way of measuring autism severity, which also restricts the strength of our conclusions. Fourth, the participants in this study were not matched on language; however, matching on language would have been difficult to achieve because of the subtle ways in which children with ASD differ from typically developing children with respect to language. Furthermore, since gesture was the dependent variable of interest and also a prominent area in which children with ASD and typically developing children differ, matching well on language seemed ill-advised to us. Finally, we only examined gesture use in one planning task, and gesture use is likely to vary depending on the nature and complexity of the task (and the individual's skill) (Roth and Lawless 2002). In addition, the iconic and metaphoric types of gestures were rarely seen during this task, so research with other parent–child collaborative activities would be welcome.

In summary, this study investigated the relationship between gesture, communication, and language in a parent–child collaborative task among school-age and adolescent children with and without ASD. Although there does not appear to be anything different about the gestural input that children with ASD receive when collaborating with their parents on tasks, there were several differences in the way gestures were used by children with ASD and typically developing children, which suggest potential avenues for intervention.

References

American Psychiatric Association. (2000). *Diagnostic and statistical manual of mental disorders* (4th ed.). Washington, DC: American Psychiatric Association.

Baranek, G. T. (1999). Autism during infancy: A retrospective video analysis of sensory-motor and social behaviors at 9–12 months of age. *Journal of Autism and Developmental Disorders, 29*, 213–224. doi:10.1023/A:1023080005650.

Bell, N. L., Lassiter, K. S., Matthews, T. D., & Hutchinson, M. B. (2001). Comparison of the Peabody Picture Vocabulary Test—Third edition and Wechsler Adult Intelligence Scale-Third edition with university students. *Journal of Clinical Psychology, 57*, 417–422. doi:10.1002/jclp.1024.

Betancur, C. (2011). Etiological heterogeneity in autism spectrum disorders: More than 100 genetic and genomic disorders and still counting. *Brain Research, 22*, 42–77. doi:10.1016/j.brainres.2010.11.078.

Campbell, J. M., Bell, S. K., & Keith, L. K. (2001). Concurrent validity of the Peabody Picture Vocabulary Test—Third edition as an intelligence and achievement screener for low SES African American children. *Assessment, 8*, 85–94. doi:10.1177/107319110100800108.

Capone, N. C., & McGregor, K. K. (2004). Gesture development: A review for clinical and research practices. *Journal of Speech, Language, and Hearing Research, 47*, 173–186.

Carbone, V. J., Sweeney-Kerwin, E. J., Attanasio, V., & Kasper, T. (2010). Increasing the vocal responses of children with autism and developmental disabilities using manual sign mand training and prompt delay. *Journal of Applied Behavior Analysis, 43*(4), 705–709. doi:10.1901/jaba.2010.43-705.

Cartmill, E. A., Armstrong, B. F., Gleitman, L. R., Goldin-Meadow, S., Medina, T. N., & Trueswell, J. C. (2013). Quality of early parent input predicts child vocabulary 3 years later. *Proceedings of the National Academy of Sciences of the United States of America, 110*, 11278–11283. doi:10.1073/pnas.1309518110.

Cihak, D. F., & Ayres, K. M. (2010). Comparing pictorial and video-modeling activity schedules during transitions for students with autism spectrum disorders. *Research in Autism Spectrum Disorders, 4*(4), 763–771. doi:10.1016/j.rasd.2010.01.017.

De Marchena, A., & Eigsti, I. M. (2010). Conversational gestures in autism spectrum disorders: Asynchrony but not decreased frequency. *Autism Research, 3*(6), 311–322. doi:10.1002/aur.159.

Demir, O. E., Fisher, J. A., Goldin-Meadow, S., & Levine, S. C. (2013). Narrative processing in typically developing children and children with early unilateral brain injury: Seeing gesture matters. *Developmental Psychology*, (no pagination specified). doi:10.1037/a0034322.

Doussard-Roosevelt, J. A., Joe, C. M., Bazhenova, O. V., & Porges, S. W. (2003). Mother–child interaction in autistic and nonautistic children: Characteristics of maternal approach behaviours and child social responses. *Development and Psychopathology, 15*, 277–295. doi:10.1017/S0954579403000154.

Dunn, L. M., & Dunn, L. M. (1997). *The Peabody Picture Vocabulary Test* (3rd ed.). Circle Pines, MN: American Guidance Service.

Eikeseth, S., Klintwall, L., Jahr, E., & Karlsson, P. (2012). Outcome for children with autism receiving early and intensive behavioral intervention in mainstream preschool and kindergarten settings. *Research in Autism Spectrum Disorders, 6*(2), 829–835. doi:10.1016/j.rasd.2011.09.002.

Evans, G. W., Maxwell, L. E., & Hart, B. (1999). Parental language and verbal responsiveness to children in crowded homes. *Developmental Psychology, 35*, 1020–1023. doi:10.1037/0012-1649.35.4.1020.

Freeth, M., Ropar, D., Chapman, P., & Mitchell, P. (2010). The eye-gaze direction of an observed person can bias perception, memory and attention in adolescents with and without autism spectrum disorders. *Journal of Experimental Child Psychology, 105*, 20–37. doi:10.1016/j.jecp.2009.10.001.

Ganz, J. B. (2007). Classroom structuring methods and strategies for children and youth with autism spectrum disorders. *Exceptionality, 15*(4), 249–260. doi:10.1080/09362830701655816.

Ganz, J. B., Davis, J. L., Lund, E. M., Goodwyn, F. D., & Simpson, R. L. (2012). Meta-analysis of PECS with individuals with ASD: Investigation of targeted versus non-targeted outcomes, participant characteristics, and implementation phase. *Research in Developmental Disabilities, 33*(2), 406–418. doi:10.1016/j.ridd.2011.09.023.

Garber, P., & Goldin-Meadow, S. (2002). Gesture offers insight into problem-solving in adults and children. *Cognitive Science, 26*, 817–831.

Geschwind, D. H., & Levitt, P. (2007). Autism spectrum disorders: Developmental disconnection syndromes. *Current Opinion in Neurobiology, 17*, 103–111.

Goldin-Meadow, S. (2009a). From gesture to word. In E. L. Bavin (Ed.), *The Cambridge handbook of child language* (pp. 145–160). New York, NY: Cambridge University Press. doi:10.1017/CBO9780511576164.009.

Goldin-Meadow, S. (2009b). How gesture promotes learning throughout childhood. *Child Development Perspectives, 3*, 106–111.

Grimminger, A., Rohlfing, K., & Stenneken, P. (2010). Children's lexical skills and task demands affect gestural behavior in mothers of late-talking children and children with typical language development. *Gesture, 10*, 251–278. doi:10.1075/gest.10.2-3.07gri.

Gutmann, A. J., & Turnure, J. E. (1979). Mothers' production of hand gestures while communicating with their preschool children under various task conditions. *Developmental Psychology, 15*, 197–203. doi:10.1037/0012-1649.15.2.197.

Ham, H. S., Bartolo, A., Corley, M., Rajendran, G., Szabo, A., & Swanson, S. (2011). Exploring the relationship between gestural recognition and imitation: Evidence of dyspraxia in autism spectrum disorders. *Journal of Autism and Developmental Disorders, 41*, 1–12. doi:10.1007/s10803-010-1011-1.

Ham, H. S., Bartolo, A., Corley, M., Swanson, S., & Rajendran, G. (2010). Case report: Selective deficit in the production of intransitive gestures in an individual with autism. *Cortex: A Journal Devoted to the Study of the Nervous System and Behavior, 46*(3), 407–409. doi:10.1016/j.cortex.2009.06.005.

Hart, B., & Risley, T. R. (1992). American parenting of language-learning children: Persisting differences in family-child interactions observed in natural home environments. *Developmental Psychology, 28*, 1096–1105. doi:10.1037/0012-1649.28.6.1096.

Hudry, K., Leadbitter, K., Temple, K., Slonims, V., McConachie, H., Aldred, C., et al. (2010). Preschoolers with autism show greater impairment in receptive compared with expressive language abilities. *International Journal of Language and Communication Disorders, 45*(6), 681–690. doi:10.3109/13682820903461493.

Ibañez, L. V., Grantz, C. J., & Messinger, D. S. (2013). The development of referential communication and autism symptomatology in high-risk infants. *Infancy, 18*, 687–707. doi:10.1111/j.1532-7078.2012.00142.x.

Iverson, J. M. (2010). Multimodality in infancy: Vocal-motor and speech-gesture coordinations in typical and atypical development. *Enfance, 62*(3), 257–274. doi:10.4074/S0013754510003046.

Iverson, J. M., & Braddock, B. A. (2011). Gesture and motor skill in relation to language in children with language impairment. *Journal of Speech, Language, and Hearing Research, 54*(1), 72–86. doi:10.1044/1092-4388.

Iverson, J. M., & Goldin-Meadow, S. (2005). Gesture paves the way for language development. *Psychological Science, 16*, 368–371. doi:10.1111/j.0956-7976.2005.01542.x.

Kasari, C., Gulsrud, A., Freeman, S., Paparella, T., & Hellemann, G. (2012). Longitudinal follow-up of children with autism receiving targeted interventions on joint attention and play. *Journal of the American Academy of Child and Adolescent Psychiatry, 51*(5), 487–495. doi:10.1016/j.jaac.2012.02.019.

Kelly, S. D., Manning, S. M., & Rodak, S. (2008). Gesture gives a hand to language and learning: Perspectives from cognitive neuroscience, developmental psychology and education. *Language and Linguistics Compass, 2*(4), 569–588. doi:10.1111/j.1749-818X.2008.00067.x.

Kikuchi, Y., Senju, A., Tojo, Y., Osanai, H., & Hasegawa, T. (2009). Faces do not capture special attention in children with autism spectrum disorder: A change blindness study. *Child Development, 80*, 1421–1433. doi:10.1111/j.1467-8624.2009.01342.x.

Kjellmer, L., Hedvall, A., Fernell, E., Gillberg, C., & Norrelgen, F. (2012). Language and communication skills in preschool children with autism spectrum disorders: Contribution of cognition, severity of autism symptoms, and adaptive functioning to the variability. *Research in Developmental Disabilities, 33*(1), 172–180. doi:10.1016/j.ridd.2011.09.003.

Kurt, O. (2011). A comparison of discrete trial teaching with and without gestures/signs in teaching receptive language skills to children with autism. *Kuram ve Uygulamada Eğitim Bilimleri, 11*, 1436–1444.

Landa, R. J. (2007). Early communication development and intervention for children with autism. *Mental Retardation and Developmental Disabilities Research Reviews, 13*(1), 16–25. doi:10.1002/mrdd.20134.

Landa, R. J., & Garrett-Mayer, E. (2006). Development in infants with autism spectrum disorders: A prospective study. *Journal of Child Psychology and Psychiatry, 47*, 629–638. doi:10.1111/j.1469-7610.2006.01531.x.

Landa, R. J., Holman, K. C., & Garrett-Mayer, E. (2007). Social and communication development in toddlers with early and later diagnosis of autism spectrum disorders. *Archives of General Psychiatry, 64*, 853–864. doi:10.1001/archpsyc.64.7.853.

Landa, R. J., Holman, K. C., O'Neill, A. H., & Stuart, E. A. (2011). Intervention targeting development of socially synchronous engagement in toddlers with autism spectrum disorder: A randomized controlled trial. *Journal of Child Psychology and Psychiatry, 52*, 13–21. doi:10.1111/j.1469-7610.2010.02288.x.

Leaper, C., Anderson, K. J., & Sanders, P. (1998). Moderators of gender effects on parents' talk to their children: A meta-analysis. *Developmental Psychology, 34*, 3–27. doi:10.1037/0012-1649.34.1.3.

Lemanek, K. L., Stone, W. L., & Fishel, P. T. (1993). Parent–child interactions in handicapped preschoolers: The relation between parent behaviors and compliance. *Journal of Clinical Child Psychology, 22*, 68–77. doi:10.1207/s15374424jccp2201_7.

Loveland, K., & Landry, S. H. (1986). Joint attention and language in autism and developmental language delay. *Journal of Autism and Developmental Disorders, 16*, 335–349.

Mayberry, R. I., & Nicoladis, E. (2000). Gesture reflects language development: Evidence from bilingual children. *Current Directions in Psychological Science, 9*(6), 192–196.

McHale, S., Simeonsson, R., Marcus, L., & Olley, J. (1980). The social and symbolic quality of autistic children's communication. *Journal of Autism and Developmental Disorders, 10*, 299–310.

Miniscalco, C., Fränberg, J., Schachinger-Lorentzon, U., & Gillberg, C. (2012). Meaning what you say? Comprehension and word production skills in young children with autism. *Research in Autism Spectrum Disorders, 6*(1), 204–211. doi:10.1016/j.rasd.2011.05.001.

Mitchell, S., Brian, J., Zwaigenbaum, L., Roberts, W., Szatmari, P., Smith, I., et al. (2006). Early language and communication development of infants later diagnosed with autism spectrum disorder. *Journal of Developmental and Behavioral Pediatrics, 27*, 69–78. doi:10.1097/00004703-200604002-00004.

Mostofsky, S. H., Dubey, P., Jerath, V. K., Jansiewicz, E. M., Goldberg, M. C., & Denckla, M. B. (2006). Developmental dyspraxia is not limited to imitation in children with autism spectrum disorders. *Journal of the International Neuropsychological Society, 12*(3), 314–326. doi:10.1017/S1355617706060437.

Namy, L. L., & Waxman, S. R. (2002). Patterns of spontaneous production of novel words and gestures within an experimental setting in children ages 1; 6 and 2; 2. *Journal of Child Language, 29*, 911–921. doi:10.1017/S0305000902005305.

Nassan El-Ghoroury, N., & Romanczyk, G. (1999). Play interactions of family members towards children with autism. *Journal of Autism and Developmental Disorders, 29*, 249–258. doi:10.1023/A:1023036223397.

Ozcaliskan, S., Gentner, D., & Goldin-Meadow, S. (2013).s's early verbs? *Applied Psycholinguistics, First View,* 1–20. doi:10.1017/S0142716412000720.

Peters, T., & Gillberg, C. (1999). *Autism: Medical and educational aspects*. London, England: Whurr.

Presmanes, A. G., Walden, T. A., Stone, W. L., & Yoder, P. J. (2007). Effects of different attentional cues on responding to joint attention in younger siblings of children with autism spectrum disorders. *Journal of Autism and Developmental Disorders, 37*, 133–144. doi:10.1007/s10803-006-0338-0.

Riby, D., Doherty-Sneddon, G., & Whittle, L. (2012). Face-to-face interference in typical and atypical development. *Developmental Science, 15*, 281–291. doi:10.1111/j.1467-7687.2011.01125.x.

Roth, W. M., & Lawless, D. (2002). Scientific investigations, metaphorical gestures, and the emergence of abstract scientific concepts. *Learning and Instruction, 12*, 285–304.

Rozga, A., Hutman, T., Young, G. S., Rogers, S. J., Ozonoff, S., Dapretto, M., et al. (2011). Behavioral profiles of affected and unaffected siblings of children with autism: Contribution of measures of mother–infant interaction and nonverbal communication. *Journal of Autism and Developmental Disorders, 41*(3), 287–301. doi:10.1007/s10803-010-1051-6.

Saint-Georges, C., Mahdhaoui, A., Chetouani, M., Cassel, R. S., Laznik, M. C., & Apicella, F. (2011). Do parents recognize autistic deviant behavior long before diagnosis? Taking into account interaction using computational methods. *Public Library of Science, 6*, 1–13.

Schertz, H. H., Odom, S. L., Baggett, K. M., & Sideris, J. H. (2013). Effects of joint attention mediated learning for toddlers with autism spectrum disorders: An initial randomized controlled study. *Early Childhood Research Quarterly, 28*, 249–258. doi:10.1016/j.ecresq.2012.06.006.

Sheinkopf, S., Mundy, P., Oller, K., & Steffens, M. (2000). Vocal atypicalities of preverbal autistic children. *Journal of Autism and Developmental Disorders, 30*, 345–354. doi:10.1023/A:1005531501155.

Smith, I. M., & Bryson, S. E. (2007). Gesture imitation in autism: II. Symbolic gestures and pantomimed object use. *Cognitive Neuropsychology, 24*, 679–700. doi:10.1080/02643290701669703.

Sowden, H., Perkins, M., & Clegg, J. (2008). The co-development of speech and gesture in children with autism. *Clinical Linguistics and Phonetics, 22*, 804–813. doi:10.1080/02699200801919745.

Stone, W. L., & Caro-Martinez, L. M. (1990). Naturalistic observations of spontaneous communication in autistic children. *Journal of Autism and Developmental Disorders, 20*, 437–453.

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.

Tincani, M., & Devis, K. (2011). Quantitative synthesis and component analysis of single-participant studies on the picture exchange communication system. *Remedial and Special Education, 32*(6), 458–470. doi:10.1177/0741932510362494.

Valentino, A. L., & Shillingsburg, M. A. (2011). Acquisition of mands, tacts, and intraverbals through sign exposure in an individual with autism. *Analysis of Verbal Behavior, 27*, 95–101.

Walton, K. M., & Ingersoll, B. R. (2013). Expressive and receptive fast-mapping in children with autism spectrum disorders and typical development: The influence of orienting cues. *Research in Autism Spectrum Disorders, 7*, 687–698. doi:10.1016/j.rasd.2013.02.012.

Wan, M. W., Green, J., Elsabbagh, M., Johnson, M., Charman, T., & Plummer, F. (2012a). Parent–infant interaction in infant siblings at risk of autism. *Research in Developmental Disabilities, 33*(3), 924–932. doi:10.1016/j.ridd.2011.12.011.

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*, 25–39. doi:10.1044/1058-0360(2012/11-0145.

Wan, M. W., Green, J., Elsabbagh, M., Johnson, M., Charman, T., & Plummer, F. (2012b). Parent–infant interaction in infant siblings at risk of autism. *Research in Developmental Disabilities, 33*(3), 924–932. doi:10.1016/j.ridd.2011.12.011.

Welsh, M. C., Pennington, B. F., & Groisser, D. B. (1991). A normative-developmental study of executive function: A window of prefrontal function in children. *Developmental Neuropsychology, 7*, 131–149. doi:10.1080/87565649109540483.

Wetherby, A. M., Prizant, B. M., & Hutchinson, T. A. (1998). Communicative, social/affective, and symbolic profiles of young children with autism and pervasive developmental disorders. *American Journal of Speech-Language Pathology, 7*(2), 79–91.

Wetherby, A. M., Woods, J., Allen, L., Cleary, J., Dickinson, H., & Lord, C. (2004). Early indicators of autism spectrum disorders in the second year of life. *Journal of Autism and Developmental Disorders, 34*(5), 473–493.

Winsler, A., Abar, B., Feder, M., Rubio, D. A., & Schunn, C. (2007). Private speech and executive functioning among high functioning children with autistic spectrum disorders. *Journal of Autism and Developmental Disabilities, 37*, 1617–1635. doi:10.1007/s10803-006-0294-8.

Wong, C. S. (2013). A play and joint attention intervention for teachers of young children with autism: A randomized controlled pilot study. *Autism, 17*, 340–357.

Yirmiya, N., Gamliel, I., Pilowsky, T., Feldman, R., Baron-Cohen, S., & Sigman, M. (2006). The development of siblings of children with autism at 4 and 14 months: Social engagement, communication, and cognition. *Journal of Child Psychology*

and Psychiatry, 47, 511–523. doi:10.1111/j.1469-7610.2005.01528.x.

Yoder, P., Stone, W. L., Walden, T., & Malesa, E. (2009). Predicting social impairment and ASD diagnosis in younger siblings of children with autism spectrum disorder. *Journal of Autism and Developmental Disorders, 39*, 1381–1391. doi:10.1007/s10803-009-0753-0.

Zwaigenbaum, L., Bryson, S., Rogers, T., Roberts, W., Brian, J., & Szatmari, P. (2005). Behavioral manifestations of autism in the first year of life. *International Journal of Developmental Neuroscience, 23*, 143–152. doi:10.1016/j.ijdevneu.2004.05.001.