How Child Gestures Relates To Parent Gesture Input in Older Children with Autism and Typical Development

HOW CHILD GESTURES RELATES TO PARENT GESTURE INPUT IN OLDER CHILDREN WITH AUTISM AND TYPICAL DEVELOPMENT

by

STEPHANIE DUNSTAN BAUMANN

Under the Direction of Şeyda Özçalışkan, PhD

ABSTRACT

Young children with autism spectrum disorder (ASD) differ from typically developing (TD) children in their overall production of gesture, producing fewer deictic gestures and supplemental gesture-speech combinations. In this study, we ask whether older children with ASD continue to differ from TD children in the types of gestures and gesture-speech combinations they produce, and whether this reflects differences in parental gesture input. Our study examined the gestures and speech produced by 42 children (20 ASD, 22 TD), comparable in expressive vocabulary, and their parents, and showed that children with ASD were similar to TD children in the amount and types of gestures that they produced, but differed in their gesture-speech combinations, using gesture primarily to complement their speech. Parents, however, did not show the same group differences in their gesture-speech combinations, suggesting that differences observed in children's gesture use may not reflect parental input, but rather the child's communicative needs.

INDEX WORDS: Child gesture, Parent gesture, Autism Spectrum Disorder, Parent-child interaction, Language development, Nonverbal communication

HOW CHILD GESTURES RELATES TO PARENT GESTURE INPUT IN OLDER CHILDREN WITH AUTISM AND TYPICAL DEVELOPMENT

by

STEPHANIE DUNSTAN BAUMANN

A Thesis Submitted in Partial Fulfillment of the Requirements for the Degree of

Master of Arts

in the College of Arts and Sciences

Georgia State University

2017

HOW CHILD GESTURES RELATES TO PARENT GESTURE INPUT IN OLDER CHILDREN WITH AUTISM AND TYPICAL DEVELOPMENT

by

STEPHANIE DUNSTAN BAUMANN

Committee Chair: Şeyda Özçalışkan

Committee: Amy Lederberg

Rose Sevcik

Electronic Version Approved:

Office of Graduate Studies

College of Arts and Sciences

Georgia State University

December 2017

DEDICATION

I would like to thank my husband, Chris Baumann, for his unwavering support in allowing me to pursue my dream. This journey would not have been possible without his endless encouragement, affirming words, and patience.

ACKNOWLEDGEMENTS

First and foremost, I would like to thank my advisor and committee chair, Dr. Şeyda Özçalışkan, for her invaluable guidance and support throughout this process, and for providing the data that made this project possible. I would also like to thank my other committee members, Dr. Amy Lederberg and Dr. Rose Sevcik, for their feedback and guidance along the way. I am especially grateful to all the parents and children who took the time to participate in this study over the last year, as well as the National Science Foundation (BCS 1251337, Özçalışkan) for providing a grant that made the study possible. Finally, I want thank my wonderful research assistants, Kadijah Hamki, Melinda Reed, and Alice Guo, who assisted tremendously on the transcription and coding of the data, and my colleagues and friends Samantha Emerson, Leslie Hodges, Valery Limia, Lauren Stites, and Anita Hasni for their feedback and support throughout this process.

TABLE OF CONTENTS

ACKNOWLEDGEMENTS ..... **v**

LIST OF TABLES **3**

LIST OF FIGURES **4**

1 INTRODUCTION **1**

1.1 Gesture-speech system of typically developing children **1**

1.2 Gesture-speech system of children with ASD **4**

1.3 Gesture-speech system of parents **7**

1.4 Present study **9**

2 METHODS **12**

2.1 Participants **12**

2.2 Data collection **14**

2.3 Data transcription and coding **14**

2.3.1 Speech ***15***

2.3.2 Gesture ***15***

2.3.3 Gesture+Speech ***15***

2.3.4 Reliability ***15***

2.4 Data Analysis **16**

3 RESULTS **17**

3.1 Speech **17**

3.2 Gesture 18

3.3 Gesture+Speech 19

4 CONCLUSIONS 22

4.1 Limitations 27

4.2 Implications 28

REFERENCES 30

APPENDICES 38

Appendix A 38

Appendix B 39

Appendix C 40

LIST OF TABLES

Table 1 Summary of children's and parents' production of speech..... 38

Table 2 Summary of children's and parent's production of gesture..... 39

Table 3 Summary of children's and parents' production of gesture-speech combinations..... 40

LIST OF FIGURES

Figure 3.1Mean proportion of deictic, conventional and iconic gestures produced by typically developing (TD) children and children with autism spectrum disorder (ASD; Panel A), and their parents (Panel B). Error bars represent standard error..... 19

Figure 3.2 Mean proportion of complementary, disambiguating and supplementary gesture-speech combinations produced by typically developing (TD) children and children with autism spectrum disorder (ASD; Panel A), and their parents (Panel B). Error bars represent standard error..... 21

1 INTRODUCTION

Gesture plays an important role in early language acquisition across different learners. Young typically developing (TD) children, as well as children with autism spectrum disorder (ASD), use gesture to express what they cannot yet convey in speech before they produce similar words and sentences in speech (Iverson & Goldin-Meadow, 2005; Özçalışkan, Adamson, Dimitrova, & Baumann, 2017a; Özçalışkan & Goldin- Meadow, 2005a). Parents are also highly responsive to their young children's nonverbal communicative signals, providing models for the types of gestures and gesture-speech combinations that their children produce (Iverson, Capirci, Longobardi, & Caselli, 1999; Özçalışkan & Goldin- Meadow, 2005b)—a pattern that remains robust in parents of children with ASD (Özçalışkan, Adamson, Dimitrova, & Baumann, 2017b). We take these findings one step further and ask whether the gesture-speech system continues to be a part of the language learning process at the later ages in children with ASD in a manner similar to TD children, and if so, whether the patterns that we observe in the gestures of older children with ASD can be traced back to the gestures that their parents produce.

1.1 Gesture-speech system of typically developing children

From an early age, infants are able to communicate with gestures before they are able to communicate with speech (Acredolo & Goodwyn, 1985; Bates, 1976; Özçalışkan & Goldin-Meadow, 2005a). Children begin to produce their first gestures—typically deictic gestures that indicate or request referents (e.g., point at book)—shortly before age1;0, before the onset of their first words (Bates, 1976; Bates, Benigni, Bretherton, Camaioni, & Volterra, 1979). These gestures have a range of meanings, similar to those of spoken words, allowing children to communicate about different referents before the onset of speech (Acredolo & Goodwyn, 1985).

Children typically begin by using deictic gestures (i.e., pointing) in order to indicate objects. These early deictic gestures also predict children's future vocabularies in speech; children indicate a referent in gesture on average 3 months before they produce the word for the same referent in speech (Iverson & Goldin-Meadow, 2005).

Gesturing does not subside once speech begins to emerge. As children begin to produce speech, they combine speech with gesture in order to expand their communicative repertoire beyond single words. At first, their co-speech gestures often reinforce the meaning found in their speech (e.g., point to dog + "dog"; Butcher & Goldin-Meadow, 2000; Greenfield & Smith, 1976). As children develop and their speech becomes more advanced, so do their gestures. One- to two-year-old children are able to produce gestures that extend their speech, by clarifying or adding new information to what they express in speech. For example, they might point to a cookie while saying "that" in order to clarify the pronominal referent in speech (i.e., disambiguating combinations), or they might point to a bottle while saying "mommy," conveying a sentence-like meaning across gesture and speech (i.e., supplementary combinations). Importantly, supplementary gesture-speech combinations both precede and predict the onset of two-word combinations in children's speech (Goldin-Meadow & Butcher, 2003; Iverson, Capirci, Volterra & Goldin-Meadow, 2008; Iverson & Goldin-Meadow, 2005; Özçalışkan & Goldin Meadow, 2005a).

Even after children begin to use a variety of two-word combinations in speech around age 2, they continue to use gesture-speech combinations to further expand their communicative repertoires (Behne, Carpenter, & Tomasello, 2014; Nicoladis, Mayberry, & Genesee, 1999; Özçalışkan & Goldin Meadow, 2009). One unique aspect of this later period is the increased frequency of iconic gestures that convey actions or attributes associated with objects (e.g.,

flapping arms to represent bird flying). Children show their first spurt in iconic gesture production somewhere between ages 2 and 3 (Özçalışkan & Goldin-Meadow, 2011)—an increase that seems to be closely tied to children's greater use of relational words, such as verbs (Özçalışkan, Gentner, & Goldin-Meadow, 2014).

Between ages of 3 and 4, children show a "gesture explosion," where children's overall use of gesture nearly doubles and reaches almost adult-like frequencies (McNeill, 2005). While deictic gestures remain the most frequent gesture type even at ages 3-4, children also increase their use of other gesture types, producing greater variety of conventional gestures that convey culturally-prescribed meanings (e.g., thumbs up to convey "good") and iconic gestures that convey characteristic actions or features associated with objects (e.g., flapping arms to represent a bird; Nicoladis et al., 1999; Özçalışkan, 2007).

As children show steady gains in language development in school years, TD children continue to use gesture to provide additional information that they cannot yet express easily in speech (McNeill, 1992). More specifically, studies examining children's use of gestures in more extended speech contexts, such as narratives and explanations, at the later ages show that 4- to 10-year-old children continue to produce gesture-speech combinations, particularly combinations in which gestures either disambiguate or supplement the information conveyed in speech (e.g., Church & Goldin-Meadow, 1986; Colletta, Pellenq & Guidetti, 2010; Colletta et al., 2015; Demir, Levine, and Goldin- Meadow, 2015); and these combinations precede and predict their emerging spoken language abilities in their narratives and explanations (Church & Goldin-Meadow, 1986; Stites & Özçalışkan, 2017; Özçalışkan, 2007).

In summary, research examining developmental changes in TD children's use of gesture shows that children show steady gains in gesture use over time, producing a greater number and

variety of gesture types as they get older. With increasing verbal abilities, children also begin to use gesture not only to reinforce what they conveyed in speech, but also to further clarify or supplement their speech. The use of such gesture-speech combinations, particularly supplementary ones, play an important role in the achievement of different language milestones—from sentences to more extended speech forms—signaling children's burgeoning spoken language abilities.

1.2 Gesture-speech system of children with ASD

In comparison to their typically developing (TD) peers, children with autism spectrum disorder (ASD) often show delays or deviations in both verbal and nonverbal communication (Tager-Flusberg, 1999). These delays can often been seen at an early age. Although children are not typically diagnosed with ASD until around the age of 3, studies have suggested that further analysis of early atypical or disrupted gesture patterns in infants could be used to identify children at-risk for an autism diagnosis (Gordon & Watson, 2015).

While children with ASD use gesture as a means of communication, it is often at lower rates than their TD peers, and the extent of their gesture use may be linked to the severity of their diagnosis (Kjellmer, Hedvall, Fernell, Gillberg, & Norrelgen, 2012; Mitchell et al., 2006; Mundy, Sigman, Ungerer, & Sherman, 1986). Not only do children with ASD produce fewer gestures overall, but also differ from TD children in their relative use of the different gesture types. The overarching finding across several studies is that, compared to their mental-age matched TD peers, children with ASD (ages 2-17) produce significantly fewer deictic gestures (e.g., point at book) and use gesture more to request than to indicate objects (Baron-Cohen, 1989; Camaioni, Perucchini, Muratori, & Milone, 1997; Goodhart & Baron-Cohen, 1993; Mundy et al., 1990; Stone, Ousley, Yoder, Hogan, & Hepburn, 1997). More recent work further

showed that young children with ASD (M_{age} = 2;6) produce fewer deictic gestures than TD children, even when they produced comparable amounts of speech as TD children (Özçalışkan et al., 2016). Importantly, however, even if young children with ASD produce fewer deictic gestures, they nonetheless show similarities to TD children in the variety of gestures that they produce, using all three of the gesture types (deictic, conventional, iconic) commonly observed in TD children's communicative repertories (Özçalışkan et al., 2016).

One possible explanation for the lower production of deictic gestures that indicate referents may be the co-occurring difficulty with joint engagement in children with ASD. Joint engagement is often defined as the ability to direct another person's attention toward an object or event in order to share interest. Children with ASD have been shown to have deficits in joint engagement when compared not only to mental-age or language-matched TD peers, but also children with other intellectual disabilities, as well as children with language delays, suggesting that lower joint engagement is not solely related to language ability but might also be unique to autism (Adamson, Bakeman, Deckner, & Romski, 2009; Loveland & Landry, 1986; Mundy et al., 1990). Gestures that require some level of joint engagement, such as deictic gestures where a child points to, comments on, or directs a parent's attention to a specific object, may be more difficult for children with ASD who struggle with the ability to share attention with others. More recent work (Özçalışkan et al., 2017b) that focused on children's production of gesture-speech combinations, also found that young children with ASD (M_{age} = 2;6), produced fewer gesture-speech combinations than TD children, even if they were similar in the amount of speech that they produced. At the same time, children in the two groups did not differ in their relative production of different types of gesture-speech combinations. They both produced greater

amount of complementary and supplementary gesture-speech combinations than disambiguating ones in their early interactions with their parents.

Previous work on gesture in children with ASD primarily focused on younger children (ages 1-5; Camaioni et al., 1997; Mundy et al., 1986; Özçalışkan et al., 2016, 2017a, 2017b; Stone et al., 1997), leaving gesture production in older children with ASD relatively unexplored. The few existing studies with older children with ASD focused on either earlier (ages 6-12) or later school years (ages 11-16), and showed that children in both age groups gesture less than their language- or IQ-matched TD peers (Capps, Kehres, & Sigman, 1998; So, Wong, Lui, & Yip, 2015). Some of this earlier work also examined differences in children's production of different gesture types and found strengths in iconic gesture use among older school-age children with ASD (ages 11-16) in narrative elicitation contexts, compared to language-matched children with developmental delays (Braddock, Gabany, Shah, Armbrecht, & Twymana, 2016; Capps et al., 1998). Studies focusing on younger school-age children (ages 6-12) in parent-child interaction contexts, on the other hand, showed no differences between children with ASD and mental-age matched TD children in their production of deictic and iconic gestures, but a difference in the production of conventional gestures, in that children with ASD produced fewer conventional gestures than TD children (So et al., 2015).

Earlier work also suggests that children with ASD may have more difficulty in integrating gesture and speech, both semantically and temporally, particularly at the early ages (de Marchena and Eigsti, 2010; So et al., 2015). Research with younger school-age children with ASD (ages 6-11) showed lower production of such supplementary combinations in this group compared to their IQ-matched TD peers, but no difference in the use of complementary or disambiguating gestures (So et al., 2015). In contrast, research with older school-age children

(ages 11-16) with ASD showed that children with ASD produced primarily supplementary gesture-speech combinations in their narratives—where gesture adds additional information not found in speech, and at rates similar to their TD peers (Braddock et al., 2016).

These findings thus suggest that from a young age, children with ASD lag behind their TD peers in overall production of gesture. While they do produce a similar variety of gestures as TD children (deictic, conventional, and iconic), young children with ASD (ages 1-3) show greater difficulty in their use of deictic gestures and primarily use gesture to request, as opposed to indicate, a referent. The research on gesture production in younger school-age children with ASD (ages 6-11) is sparse and point to continued weaknesses in overall amount of gesture use and in the production of supplementary gesture-speech combinations—a difference that seems to dissipate in late school years. This study, by providing a comprehensive account of gesture and speech development in early-school-age children with ASD compared to their language-similar TD peers, will shed further light on the similarities and differences in children's use of gesture in the early school years.

1.3 Gesture-speech system of parents

Parents influence language development of their TD children not only through their verbal input, but also through the use of gesture (Acredolo & Goodwyn, 1988). In fact, research shows a tight link between production of gesture in children and their parents: children who gesture more also have parents who gesture more (Acredolo & Goodwyn, 1988; Namy, Acredolo, & Goodwyn, 2000; Rowe, Özçalışkan, & Goldin- Meadow, 2008). There is also evidence that, similar to speech, parents produce a gestural "motherese" when interacting with their young children, using fewer and simpler gestures and gesture-speech combinations (Bekken, 1989; Iverson et al., 1999; Özçalışkan& Goldin-Meadow, 2005b). For example,

Özçalışkan and Goldin-Meadow (2005b) found that during spontaneous interactions with their children between ages 1 to 2, parents used predominantly deictic gestures in complementary gesture-speech combinations, and at significantly greater rates than other types of gestures and gesture-speech combinations. Moreover, Özçalışkan and Goldin-Meadow found that parents provided models to their young children for the different types of gestures and gesture- speech combinations. However, at the same time, gesture also served a different function for the children who are learners of a language, as compared to their parents who are expert speakers of the language. Young TD children used gesture primarily to supplement their speech, conveying information not found in their speech, while their parents used gestures primarily to reinforce what is already conveyed in their speech.

Research on parental gesture input to children with ASD, on the other hand, remains relatively sparse. Of the few existing studies, one examined parental nonverbal input to younger children with ASD (Mage=2;6) and with TD (Mage=1;6) comparable in language ability and found similarities between the two groups, in parent-child interaction contexts (Özçalışkan et al., 2017b). Parents of children with ASD were not only comparable to parents of TD children in the amount of their gesture production, but also in their relative use of the different types of gestures and gesture-speech combinations when addressing their children in semi-naturalistic play contexts, suggesting that parental gesture input remains the same regardless of variations in the gesture production of the children. A few other studies focused on parental nonverbal input—including gesture—to older children with ASD (ages 7-18; Medeiros & Winsler, 2014), and showed that parents of older TD children and children with ASD (ages 7-18) gesture at the same rate to their children regardless of diagnosis during a collaborative problem-solving task. The few other studies that focused on a broader set of nonverbal parental behaviors (e.g., Wan et al.,

2012; Doussard-Roosevelt, Joe, Bazhenova, and Porges, 2003) showed that parents of children with ASD used more high-intensity approaches and directive behaviors, including a greater number of gestural prompts compared to parents of TD children.

In summary, earlier work on parental nonverbal input to younger children with ASD (age 2;6), showed no differences between parents of children with ASD and with TD in either the amount or the types of gestures and gesture-speech combinations that they produced when interacting with their children. The one earlier study that examined parental gestural input to *older children with ASD* (ages 7-18) also pointed to lack of a group difference in the overall rate of gestures parents produced in the two groups, further suggesting that parents might not follow the diagnosis-specific differences in gesture use that their children exhibit.

1.4 Present study

Previous work has shown that gesture and speech development go hand-in-hand in TD children and that parents contribute to this process by providing models for the types of gestures that their children produce. However, we know little about the nature of the gesture-speech system in older children with ASD, and the role their parents might play in this process. In this study, we focus on early school-age children with ASD, and examine whether these children use gesture in similar ways as TD children and whether parents continue to tune their gestures to the needs of their children as their children develop more complex language skills. More specifically, we ask whether early school-age children with ASD would differ from language-comparable TD children in the types of gestures and gesture-speech combinations that they produce in structured play interactions with their parents; and if so, whether these differences can be traced back to the gestures and gesture-speech combinations that their parents produce. We examine these questions by studying the speech and gestures produced by 20 children with ASD

(M_{age} = 7;6; range = 5-11 years) and 22 TD children (M_{age} = 5;4; range = 5-6 years)—comparable in language ability, as well as their parents. We first ask (1) whether older children with ASD differ from TD children in their production of gestures and gesture-speech combinations, and if so, we next ask (2) whether we can find evidence of such differences in the gestures and gesture-speech combinations that their parents produce.

We predict that older children with ASD will continue to produce fewer gestures and gesture-speech combinations than TD children; and we expect these differences to be particularly pronounced for deictic gestures and supplementary gesture-speech combinations, but not for other types of gestures or gesture-speech combinations, based largely on earlier work with younger children with ASD (Mitchell et al., 2006; Mundy et al., 1986; Özçalışkan et al., 2016; 2017).

We predict that parents of children with ASD will be comparable to parents of TD children in their overall production of gesture, based on earlier work with both young children with ASD (Özçalışkan et al., 2017b) and adolescents with ASD (age 7-18; Medeiros & Winsler, 2014). We also predict that parental production of different types of gestures and gesture-speech combinations may follow one of two patterns. If parents' gesture production is largely driven by the parents themselves, but not by the gesture production of the children, we would predict that parents of children in both groups would not differ in their relative production of the different types of gestures and gesture-speech combinations. However, if parents of children with ASD use more directive behaviors during interactions (as observed in Doussard-Roosevelt et al., 2003 and Wan et al., 2012) and tune their gestures to the needs of their children through a gestural "motherese," then parents of older children with ASD might differ from parents of TD children, making greater use of deictic gestures, mostly in complementary gesture-speech combinations

('bottle'+point at bottle) to compensate for the difficulties that children with ASD might have with joint attention.

2 METHODS

2.1 Participants

The sample for this study came from a longitudinal study that focuses on the role of gesture in the later language development of children with ASD and TD children (Özçalışkan et al., in progress). The current study focuses on the third observation session of the larger longitudinal project, during which parent-child observations were recorded. The participants included 20 children with ASD (16 boys; M_{age} = 7;7; range = 5;2-11;1) and 22 TD children (13 boys; M_{age} = 5;4; range = 5;0-6;2), along with their parents, which included all children who completed the third observation. The children in each group were selected so that the two groups were comparable in their productive vocabulary during the selected observation period, for both word types (M_{TD} = 100.68, SD = 42.67, M_{ASD} = 119.20, SD = 51.50, $F(1, 41) = 1.62$, $p = .21$) and word tokens (M_{TD} = 246.23, SD = 142.49, M_{ASD} = 319.55, SD = 198.74, $F(1, 41) = 1.91$, $p = .17$). We made the two groups comparable in language production instead of age or IQ, because we were interested in identifying patterns of similarities and differences in gesture production in the two groups that are not driven by group differences in speech production. The sample size was based on a similar earlier study, comparing gesture use in TD children and children with ASD (So et al., 2015), which indicated that 16 subjects per group were adequate to detect reliable effects at $p < .05$ ($\eta 2 = 0.44$).

All children were monolingual English speakers and had the verbal ability to produce sentences, as part of the selection criteria for the larger study. None of the TD children had any cognitive or linguistic impairments based on parental report. All children with ASD had a clinical diagnosis of Autism Spectrum Disorder, as assessed by a clinician. The autism diagnosis

included a comprehensive clinical evaluation by a licensed clinical psychologist, using the ADI-R (Le Couteur, Lord, & Rutter, 2003)—a parent interview that assesses child behavior in three core domains of social interaction, communication, and restricted or repetitive behaviors. To further confirm the diagnosis of autism, all participants were administered the *Social Responsiveness Scale* (SRS-2; Constantino & Gruber, 2012) and *The Social Communication Questionnaire* (SCQ; Rutter, Bailey & Lord, 2003). None of the TD children fell within the autism range on either the SRS-2 (M_{TD} = 44.92; range = 35-55, autism range = <60) or the SCQ (M_{TD} = 4.83; range = 1-12, autism range = >15), while all children with ASD fell within the autism range (with the exception of one child) on both of tests (SRS: M_{ASD} = 75.61; ASD range = 60-90; SCQ: M_{ASD} = 22.50; ASD range = 14-35). One child in the ASD group had a score of 51 on the SRS and 11 on the SQC; given the proximity of the child's scores to the autism range, along with the confirmed diagnosis of ASD by a clinician, we included this child also in the ASD group.

The participating families in the two groups were comparable in education and household income. All families had at least one parent with a college or a postgraduate degree in both groups (mothers: TD: 88%, ASD: 95%; fathers: TD: 84%, ASD: 72%) and majority of the families reported household annual incomes of $50,000 or above (TD: 89%, ASD: 85%). The parents were also comparable in racial backgrounds, with majority of mothers reporting Caucasian (TD: 65%, ASD: 70%) or African American (TD: 23%, ASD: 20%) backgrounds—a pattern that remained similar for fathers (Caucasian: TD: 73%, ASD: 63%; African American: TD: 15%, ASD: 21%). The majority of the parent-child interactions consisted of mother-child dyads (TD: 86%, ASD: 79%).

2.2 Data collection

All child-parent dyads observed in their homes, except for two children with ASD, who were observed in the laboratory, following the parents' request. The observation consisted of a 10-minute structured play with 3 different toys (picture book, toy doctor's kit, puzzle) provided by the experimenter. The parents were asked to interact with their children as naturally as possible, playing with each toy for about 3-4 minutes. All sessions were video-recorded.

2.3 Data transcription and coding

All verbal responses were transcribed for child and parent speech, using the Codes for Human Analysis Transcript (CHAT) system (CHILDES; MacWhinney, 2000). Sounds that were used to refer to an object, property of an object, or an event ('cat', 'pretty', 'gone'), onomatopoetic (e.g. 'vroom vroom') or conventionalized evaluative sounds (e.g. 'uh-oh') were treated as words. The observations were further coded for child and parent gestures. Gesture was defined as a communicative hand movement that did not involve direct manipulation of an object (e.g. moving a toy truck back and forth) or a ritualized game (e.g. patty cake), following earlier work (Özçalışkan & Goldin- Meadow, 2005a). Transcripts were divided into communicative acts, defined as a sequence of words that was preceded and followed by a change in conversational turn, intonation or pause, following the CHAT system guidelines (MacWhinney, 2000). All communicative acts were further categorized as *gesture only* (i.e., utterances in which gestures are produced without speech; e.g. pointing to picture of a snowflake), *speech only* (i.e., utterances in which speech is produced without gesture; e.g. 'It is snowing'), or *gesture+speech* (utterances that include both speech and gesture; e.g. 'It is snowing'+point to picture of a snowflake).

2.3.1 Speech

All verbal responses produced by the children and their parents during the interaction were tallied for token (i.e., number of words) and type (i.e., number of unique words) frequency of word production.

2.3.2 Gesture

All gestures produced by each child and their parent were coded for gesture types, which included: *deictic gestures* that indicate referents (e.g., point to puzzle piece), *conventional gestures* that convey culturally-prescribed meanings (e.g., nodding the head to mean yes), and *iconic gestures* that represent characteristic actions or features associated with objects (e.g., wiggling outstretched fingers to represent snowing). We did not include any beat gestures (i.e., hand movements that are rhythmically related to speech but that do not convey any semantic information; McNeill, 1992) produced by either the parents or the children.

2.3.3 Gesture+Speech

Each gesture-speech combination was further coded for the informational relation gesture held to the accompanying speech, defined as: (1) *complementary gesture+speech*, in which gesture conveys the same meaning as speech (e.g. 'It's snowing'+point at picture of snowflake), (2) *disambiguating gesture+speech*, in which gesture clarifies a pronominal referent in speech (e.g. 'that one'+point at picture of a snowflake, or (3) *supplementary gesture+speech*, in which gesture adds new information not found in speech (e.g., 'and then another one'+point at picture of snowflake).

2.3.4 Reliability

Intercoder reliability was assessed for gesture with additional coders who independently

coded a randomly selected 20% of the videos in each group for gesture type and gesture-speech combination type. For the children, agreement between coders was 82%, κ = .86 (TD: 83%, ASD: 81%) for identifying gestures, 100%, κ = 1.00 (TD: 100%, ASD: 100%) for classifying gestures into types, and 93%, κ = .90 (TD: 94%, ASD: 92%) for classifying gesture-speech combinations into types. For the parents, agreement between coders was 87% κ = .91 (TD: 88%, ASD: 87%) for identifying gestures, 99%, κ = .95 (TD: 99%, ASD: 98%) for classifying gestures into types, and 87%, κ = .81 (TD: 86%, ASD: 88%) for classifying gesture-speech combinations into types.

2.4 Data Analysis

The total number of words, gestures, and gesture-speech combinations were tallied for each participant, separately for the children and their parents, and analyzed, using one-way ANOVAs or Kruskal-Wallis tests—where the assumption of homogeneity of variance or normality was violated—with group (TD, ASD) as a between-subjects factor. We next computed the total number of each type of utterance (gesture-only, speech-only, gesture+speech), *gesture* (deictic, conventional, iconic), and *gesture+speech combination* (reinforcing, disambiguating, supplementary) produced by each child and parent. Children's production of different types of communicative acts, gestures and gesture-speech combinations showed considerable within- and between-group variability (see Tables 1-3); all raw scores produced by each child and parent were converted into proportions, and arcsine transformed to attenuate any deviations from normality. Differences were then analyzed with mixed two-way ANOVAs, with *group* (TD, ASD) as between-subjects and *type of communication* as within-subject factors, separately for the children and their parents.

3 RESULTS

3.1 Speech

Children did not show group differences for either the amount (i.e., word tokens, $F(1, 41) = 1.91$, $p = .17$) or the diversity of the words (i.e., word types, $F(1, 41) = 1.62$, $p = .21$) that they produced (see Table 1, upper half). The comparability of the groups on word production reflected our selection criteria for participants that created groups comparable on the amount and diversity of word production (see sample description). The children also did not show group differences in in their production of communicative acts with speech ($F(1, 41) = 2.64$, $p = .11$). All children in the sample were producing single words, and all but one TD child produced word-word combinations during the observation (see Table 1, upper half).

The parents of children with ASD and with TD were also comparable in their speech production, using similar number of word tokens ($F(1, 41) = .01$, $p = .91$) and word types ($F(1, 41) = .77$, $p = .39$), even though comparability of parent word production was not used as criteria for participant selection. Parents also did not show group differences in their production of communicative acts with speech ($F(1, 41) = .18$, $p = .68$) during the interaction (see Table 1, lower half).

In summary, children did not show group differences in their production of speech, which was by design. Parents also did not show group differences in their production of speech, suggesting that parents of children with ASD and with TD provide comparable amounts of verbal input to their children.

3.2 Gesture

Children with ASD and with TD did not differ in their overall production of gesture (U = 168.00, p = .19), or in their production of communicative acts with gesture (U = 161.50, p = .14). All but one child with ASD produced at least one gesture during our observation (see Table 2, upper half).

We next looked at children's proportional use of different gesture types, excluding the one child with ASD who did not produce any gesture. Children's proportional use of each gesture type did *not* show an effect of group (F(1,39) = .02, p = .90) or a group x gesture type interaction (F(1.28, 49.73) = .22, p = .70), but did show a main effect of gesture type (F(1.28, 49.73) = 159.16, p < .001, partial η^2 = .80).[1] Children in both groups produced significantly greater proportion of deictic gestures than conventional gestures (Bonferroni, p < .001) and greater proportion of conventional than iconic gestures (Bonferroni, p < .001; see Fig. 1, left panel).

Similar to their children, parents of children with ASD did not differ from parents of TD children in either their overall amount of gesture production (F(1,41) = .30, p = .59) or in their production of communicative acts with gesture (F(1,41) = .16, p = .70). All parents were producing gestures during our observation (see Table 2, lower half). This pattern was also evident in the parents' proportional use of each gesture type, which showed no effect of group (F(1,39) = .01, p = .93), no interaction between group and gesture type (F(1.52, 60.74) =.74, p = .45), but an effect of gesture type (F(1.52, 60.74) = 331.37, p < .001, partial η2 = .89). Similar to their children, parents produced significantly greater proportion of deictic gestures than

[1] When comparing the proportional use of each gesture type between groups, Mauchly's test indicated that the assumption of sphericity had been violated (χ2(2) = .43, p < .001), therefore degrees of freedom were corrected using Greenhouse-Geisser estimates of sphericity (ε = 0.98).

conventional gestures (Bonferroni, $p < .001$) and greater proportion of conventional than iconic gestures (Bonferroni, $p < .001$).

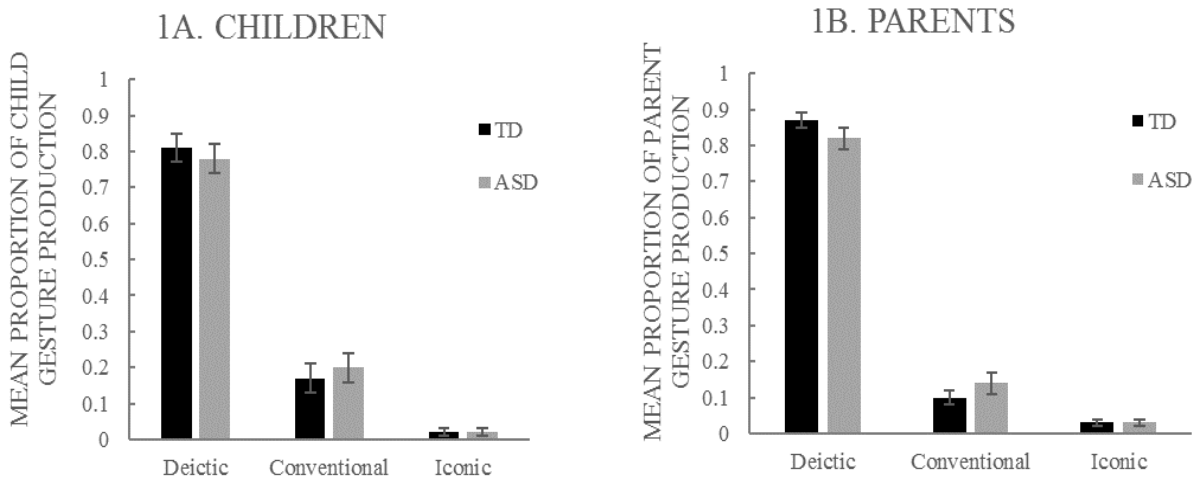

Figure 3.1Mean proportion of deictic, conventional and iconic gestures produced by typically developing (TD) children and children with autism spectrum disorder (ASD; Panel A), and their parents (Panel B). Error bars represent standard error.

In summary, children with ASD and with TD did not differ either in their overall production of gesture and their relative production of each gesture type, producing primarily deictic gestures, followed by conventional and iconic gestures. Parents followed a similar pattern to their children, showing no group differences in their gesture production, and producing predominantly deictic gestures, followed by conventional and iconic gestures.

3.3 Gesture+Speech

Children with ASD and TD children did not differ in the number of gesture-speech combinations that they produced ($U = 214.00$, $p = .88$) or in the number of communicative acts that contained both gesture and speech ($U = 189.50$, $p = .44$). Almost all of the TD children

(21/22) and children with ASD (18/20) were producing gesture-speech combinations at the time of our observation (See table 3, upper half).

We next turned to children's proportional use of each gesture-speech combination type, excluding the 3 children (1 TD, 2 ASD) who did not produce any gesture-speech combinations during our observation. Our analysis showed no main effect of group ($F(1, 37) = 3.35$, $p = .08$), but a main effect of gesture-speech combination type ($F(2, 74) = 8.17$, $p < .01$, partial $\eta^2 = .18$) and a significant interaction between group and combination type ($F(2, 74) = 9.63$, $p < .001$, partial $\eta^2 = .21$). Since there was a main effect of gesture-speech combinations, we conducted a simple main effects analysis. As can be seen in Figure 2 (left panel), children with ASD tended to use a greater proportion of complementary gesture-speech combinations than disambiguating (Bonferroni, $p = .05$) and used significantly more complementary than supplementary combinations (Bonferroni, $p < .01$), while TD children's production of the different gesture-speech combinations was not significantly different between types. A majority of the children produced complementary and disambiguating gesture-speech combinations both in the ASD group (complementary: 19/20; disambiguating: 16/20) and the TD group (complementary: 18/22; disambiguating: 21/22). However, only 50% of the ASD group produced supplementary gesture-speech combinations (supplementary: 10/20), which differed from the TD group (supplementary: 19/22).

Similar to their children, parents did not did not show group differences in their overall production of gesture-speech tokens ($U = 204.00$, $p = .69$) or communicative acts that contained both gesture and speech ($F(1, 41) = .06$, $p = 80$). All parents were producing gesture-speech combinations at the time of our observation, and all parents produced at least one instance of each of the two combination types (see Table 3, lower half). The parents of children with ASD

and with TD were similar in their proportional use of each gesture-speech combination type—with no effect of group ($F(1, 40) = .001$, $p = .97$), a main effect of combination type ($F(2,80) = 21.44$, $p < .001$) and no interaction between group and combination type ($F(2,80) = 2.29$, $p = .11$). Overall, parents produced a greater proportion of complementary gesture-speech combinations than disambiguating combinations (Bonferroni, $p < .01$) and a greater proportion of disambiguating combinations than supplementary ones (Bonferroni, $p < .01$).

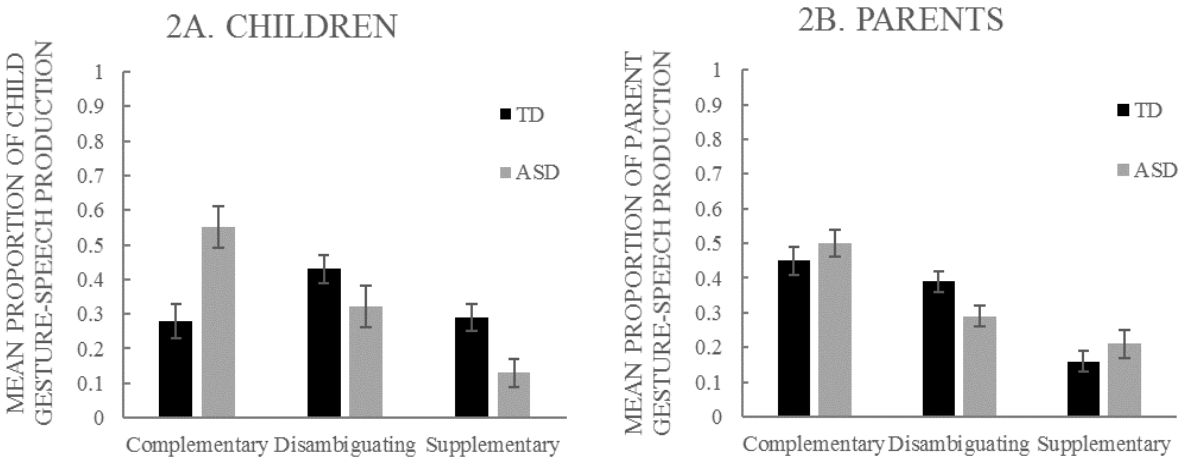

Figure 3.2 Mean proportion of complementary, disambiguating and supplementary gesture-speech combinations produced by typically developing (TD) children and children with autism spectrum disorder (ASD; Panel A), and their parents (Panel B). Error bars represent standard error.

In summary, despite the fact that children in both groups produced similar amounts of gesture-speech combinations, children with ASD primarily used gesture to complement their speech, while TD children used all three types at comparable rates. Unlike their children, parents in both groups produced gesture-speech combinations in a similar pattern, producing primarily complementary gesture-speech combinations, followed by disambiguating and then supplementary combinations.

4 CONCLUSIONS

Earlier research has found that young children with ASD and with TD, but *not* their parents, show group differences in their relative production of different types of gestures and gesture-speech combinations (Özçalışkan et al., 2017b). In this study, we asked whether the patterns observed for younger children remain similar in older children with ASD and their parents. More specifically, we asked whether children with ASD continue to differ from TD children in their gesture production, and if so whether we can find evidence of such differences in the gestural input provided by their parents. Comparing the speech and gestures produced by 20 children with ASD (M_{age} = 7;6; range = 5;2-11;1) and 22 TD children (M_{age} = 5;4; range = 5;0-6;2), we found that children with ASD *did not* differ from TD children in either their overall use of gesture or in their relative production of different gesture types. They *did* differ, however, in their use of gesture-speech combinations, in that children with ASD relied on gesture primarily to complement their speech, whereas TD children used all types of gesture-speech combinations at comparable rates, suggesting that gesture assumes a different informational role in the two groups. Parents produced similar types of gestures and gesture-speech combinations as their children in each group. However, unlike their children, parents did not show group differences in their rate of production of different types of gesture-speech combinations, thus suggesting that gesture-speech combinations might be serving a different communicative function for their children.

In our study, we found that children with ASD did not differ from TD children in their overall production of gesture, a finding that is different from earlier work that has found that children with ASD often produce fewer gestures than TD children (Kjellmer et al., 2012; Mundy

et al., 1986; Özçalışkan et al., 2016). One explanation for the discrepancy in the findings could be the sample characteristics in our study. All children with ASD in our study were verbal, reported by their parents to be producing word-word combinations. This is in contrast to most of the earlier work, which included children with more varied verbal abilities or matched samples based on age or IQ instead of language. Our selection of expressive language-matched groups was based on our interest in similarities and differences in patterns of gesture production in groups who were at similar levels of speech production, which is often not the case in age- or IQ-matched groups. As a result, the children with ASD in our sample were also slightly older (ages 7-11) than the TD developing children (ages 5-6).

Children with ASD also did not differ from TD children in their proportional use of different gesture types. Across groups, children produced a greater proportion of deictic gestures (TD: 81%, ASD: 78%), followed by conventional (TD: 16%, ASD: 20%) and iconic gestures (TD: 2%, ASD: 2%). The prevalence of deictic gesture use in both groups might be explained by the design of the study, where parent-child dyads were observed during a play context with a set of concrete referents. As such, the presence of such referents might have elicited more deictic gestures, which are the most commonly produced gestures to indicate or request a specific referent. This is also different from several previous studies with older children with ASD, which examined the production of gesture during cartoon narration or conversational interaction contexts that did not include concrete referents, and found that children with ASD rarely, if ever, used deictic gestures during these tasks (Braddock et al., 2016; Capps et al., 1998).

More importantly, children also showed diagnosis-specific group differences in their use of different gesture-speech combinations. Children with ASD primarily used gesture to complement what they conveyed in speech (55%), and rarely used gesture to supplement their

speech (13%). TD children, on the other hand, used gesture to supplement (29%), disambiguate (43%) or complement (30%) their speech. This group difference follows a similar pattern to that found in older school-age children with ASD, where children with ASD rarely used gesture to add additional information to their speech (So et al., 2015). However, this finding is different from earlier work with younger children with ASD which has suggested that young children, regardless of diagnosis, produce a great number of complementary gesture-speech combinations than supplementary or disambiguating combinations (Özçalışkan et al., 2017b).

One explanation for the group difference in the use of each gesture-speech combination type may be that gesture may serve a different communicative function for older, verbal children with ASD than for TD children. Supplementary gesture-speech combinations frequently require a triadic relationship (child, adult, and referent) in order to convey information, as an integration of both speech and gesture are required in order to understand the sentence-like meaning. Complementary gestures, on the other hand, convey similar information in speech and gesture, and the meaning can be understood with only one of those modalities. As children with ASD have been shown to have difficulties with joint engagement (Adamson et al., 2009; Loveland & Landry, 1986; Mundy et al., 1990), which frequently require a triadic relationship, the reliance on primarily complementary gesture-speech relationships may be representative of their difficulty in creating and maintaining triadic joint attention. This reliance on complementary gesture-speech combinations, as opposed to the more complex supplementary gesture-speech combinations, may further point to children's continued difficulty with integrating multi-modal information when the two pieces convey different semantic information, an area of difficulty displayed in younger children with ASD (de Marchena and Eigsti, 2010).

Parents of children with ASD did not differ from parents of TD children in their use of total gestures or in verbal communicative acts, suggesting that children in both groups receive similar input across modalities. This finding is similar to previous research on parents of young children with ASD (Özçalışkan et al., 2017b). Parents in both groups also did not differ in the proportional use of different gesture types, following a similar pattern to their children. They produced primarily deictic gestures (TD: 87%, ASD: 82%), followed by conventional (TD: 10%, ASD: 14%) and iconic gestures (3TD: 3%, ASD: 3%). This robust main effect of gesture type across both parents and children further suggests that the use of deictic gestures may be an easier form of communication when interacting jointly in relation to concrete referents. The use of a variety of different gesture types by parents, a pattern that was also found with parents of young children (Özçalışkan & Goldin-Meadow, 2005b), also suggests that parents of older children continue to serve as a model to their children in the use of different gesture types.

Parents not only looked similar across groups in their use of different gesture types, but also in their use of different gesture-speech combinations. Unlike the group differences seen in children, parents showed no group differences in their use of different gesture-speech combinations, using mostly complementary gesture-speech combinations (47%; TD: 45%, ASD: 49%), followed by disambiguating (34%; TD: 39%, ASD: 29%), and supplementary gesture-speech combinations (18%; TD: 16%, ASD: 21%). This suggests that parents were serving as models for the use of all gesture types. However, when we compared the child and parental gesture production, there were no relationships between parental gesture use and child gesture use across overall gesture production, gesture types, or gesture-speech combinations. This suggests that the group differences that were observed in children's production of gesture,

particularly gesture-speech combinations, were not driven by parental input but instead were largely an outcome of the communicative needs of the children themselves.

Because these group differences appear to come from the child and not parental input, it might suggest that gesture serves a different function for older, verbal children with ASD than for TD children. In young children, the use of supplementary gesture-speech combinations has been shown to play an important role in language development, allowing the child to convey complex, additional information in gesture that they are not yet able to convey exclusively in speech, which appears to hold true for both younger TD children and children with ASD (Iverson & Goldin-Meadow, 2005; Özçalışkan & Goldin-Meadow, 2005b, 2009; Özçalışkan et al., 2017). The TD children in our study primarily use gesture in combination with speech to provide supplementary information, using gesture as an extension of verbal language to convey sentence-like content. However, the fact that children with ASD use gesture most frequently to complement the information that they have already presented in speech may suggest that they are relying more heavily on the content of their verbal speech to provide communicative information.

In both groups, a majority of communicative acts produced during the interaction were speech-only, and only a small proportion of utterances included gesture or were produced in gesture-only. This suggests that, for older children in both groups, speech may have become the main communicative medium, which differs from studies with younger children where gesture is often used as a means of adding in additional information that children are not yet able to produce in speech alone. Thus, gestures at the older ages may no longer be a demonstration of developmental growth in language, like in the younger ages, but rather may serve as a medium

through which to convey more complex information, a trend that is only being seen in older, TD children.

In summary, this study shows that older, verbal children with ASD resemble TD children in their overall production of gesture and in their use of different gesture types, but differ from the TD children in the way that they integrate their gestural and verbal information. This may suggest that gesture serves a different communicative function for older, verbal children with ASD, who rely primarily on gesture to reinforce what they already express in speech. Parents of children with ASD, however, do not follow a similar pattern to their children, but instead show strong similarities to parents of TD children in their overall production of gesture and in their proportional use of different gesture types and gesture-speech combinations. This suggests that parents are providing similar verbal and gestural input to their children, regardless of diagnosis, and are continuing to serve as models for different types of gestures and gesture-speech combinations, as they did for their children at the younger ages. Thus, any differences in the use of gesture seen in children is not a result of differing parental input, but rather suggests that these diagnosis-specific differences may be driven by the communicative needs of the children. However, because this difference is only seen in children in their use of gesture-speech combinations, and not with the production of total gesture or gesture types, this suggests that children with ASD may be relying less on gesture than TD children to provide content to their communication, and rather rely more heavily on the informational content of their speech.

4.1 Limitations

While our study provides insight into the use of gesture in older children with ASD and their parents, an age range that has not been explored in previous work, our selected sample does place limitations on the generalizability of findings to all children with ASD. Currently, studies

have suggested that anywhere between 30-50% of children with ASD are non- or minimally verbal (National Research Council, 2001; Tager-Flusberg, Paul, & Lord, 2005). Our selected sample was highly verbal, which is only a small portion of children with ASD, and thus may only provide insight into this subset of children with ASD.

4.2 Implications

The number of children with diagnosed with ASD in the United States had risen to 1 in 68 children (1 in 42 boys, 1 in 189 girls) by 2012 (Christensen, 2016). Due to the language delays and social development deficits that are often associated with the diagnosis of ASD, there is a growing need for early intervention and school-based services to support language and cognitive development in this group. However there is currently limited research that examines how early school-age children use gesture when communicating with others.

The findings from this study will have important implications for parents, educators and clinicians by shedding new light on how children with ASD use gesture in interactive contexts, and how parents and teachers may be able to use gesture to support learning. Previous studies on typically-developing children have found that gesture can be used as a tool to help teach scientific concepts such as math equivalence to those who are on the cusp of understanding similar concepts in speech by providing additional strategies in gesture beyond those provided in speech (Singer & Goldin-Meadow, 2005). Similarly, educators can gather information from students' gestures and respond differently based on an individual student's needs (Goldin-Meadow & Singer, 2003). However, less is currently known about how gesture can be used as a tool to support in atypical populations who show differences in their use of gesture. Understanding the link between gesture in children with ASD and parental gestural input has the

potential to inform intervention and school- based practices to encourage both expressive and receptive language development and consequently more positive learning outcomes.

REFERENCES

Acredolo, L. P., & Goodwyn, S. W. (1985). Symbolic gesturing in language development: A case study. *Human Development, 28*(1), 40-49.

Acredolo, L. P., & Goodwyn, S. (1988). Symbolic gesturing in normal infants. *Child Development, 59*(2), 450-466.

Adamson, L. B., Bakeman, R., Deckner, D. F., & Romski, M. (2009). Joint engagement and the emergence of language in children with autism and Down syndrome. *Journal Of Autism And Developmental Disorders, 39*(1), 84-96.

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders*. (5th ed.). Arlington, VA: American Psychiatric Publishing.

Baron-Cohen, S. (1989), Perceptual role taking and protodeclarative pointing in autism. *British Journal of Developmental Psychology, 7*: 113–127.

Bates E. Language and context. Orlando, FL: Academic Press; 1976.

Bates E, Benigni L, Bretherton I, Camaioni L, Volterra V. The emergence of symbols: Cognition and communication in infancy. New York: Academic Press; 1979.

Behne, T., Carpenter, M., & Tomasello, M. (2014). Young children create iconic gestures to inform others. *Developmental Psychology*, *50*(8), 2049-2060.

Bekken, K. (1989). Is there motherese in gesture? Unpublished doctoral dissertation, University of Chicago, Chicago.

Braddock, B. b., Gabany, C., Shah, M., Armbrecht, E. S., & Twymana, K. A. (2016). Patterns of Gesture Use in Adolescents With Autism Spectrum Disorder. *American Journal Of Speech-Language Pathology*, *25*(3), 408-415.

Butcher, C., & Goldin-Meadow, S. Gesture and the transition from one- to two-word speech: When hand and mouth come together. In D. McNeill (Ed.), *Language and gesture* (pp. 235-257). New York: Cambridge University Press, 2000.

Camaioni, L., Perucchini, P., Muratori, F., & Milone, A. (1997). Brief report: A longitudinal examination of the communicative gestures deficit in young children with autism. *Journal Of Autism And Developmental Disorders*, *27*(6), 715-725.

Capps, L., Kehres, J., & Sigman, M. (1998). Conversational abilities among children with autism and children with developmental delays. *Autism*, *2*(4), 325-344.

Christensen, D. L. (2016). Prevalence and characteristics of autism spectrum disorder among children aged 8 years—autism and developmental disabilities monitoring network, 11 sites, United States, 2012. *MMWR. Surveillance Summaries*, *65*.

Church, R. B. & Goldin-Meadow, S. (1986). The mismatch between gesture and speech as an index of transitional knowledge. *Cognition*, *23*, 43-71.

Colletta, J. (2009). Comparative analysis of children's narratives at different ages: A multimodal approach. *Gesture*, *9*(1), 61-69.

Colletta, J., Guidetti, M., Capirci, O., Cristilli, C., Demir, O. E., Kunene-Nicolas, R. N., & Levine, S. (2015). Effects of Age and Language on Co-Speech Gesture Production: An Investigation of French, American, and Italian Children's Narratives. *Journal Of Child Language*, *42*(1), 122-145.

Colletta, J., Pellenq, C., & Guidetti, M. (2010). Age-related changes in co-speech gesture and narrative: Evidence from French children and adults. *Speech Communication*, *52*(Speech and Face-to-Face Communication), 565-576.

Constantino, J. N., & Gruber, C. P. (2012). *Social Responsiveness Scale–Second Edition (SRS-2*. Torrance, CA: Western Psychological Services.

de Marchena, A., & Eigsti, I. (2010). Conversational gestures in autism spectrum disorders: Asynchrony but not decreased frequency. *Autism Research*, *3*(6), 311-322.

Demir, O.E., Levine, S., & Goldin-Meadow, S. (2015). A tale of two hands: Children's gesture use in narrative production predicts later narrative structure in speech, *Journal of Child Language*, *42*(3), 662-681.

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 behaviors and child social responses. *Development And Psychopathology*, *15*(2), 277-295.

Fernald, A., & Simon, T. (1984). Expanded intonation contours in mothers' speech to newborns. *Developmental Psychology*, *20*(1), 104-113.

Goldin-Meadow, S. & Butcher, C. Pointing toward two-word speech in young children. In S. Kita (Ed.), *Pointing: Where language, culture, and cognition meet* (pp. 85-107). Mahwah, NJ: Earlbaum Associates, 2003.

Goldin-Meadow, S., & Singer, M. A. (2003). From children's hands to adults' ears: Gesture's role in the learning process. *Developmental Psychology*, *39*(3), 509-520.

Goodhart, F., & Baron-Cohen, S. (1993). How many ways can the point be made? Evidence from children with and without autism. *First Language*, *13*(38, Pt 2), 225-233.

Goodwyn, S. W., & Acredolo, L. P. (1993). Symbolic gesture versus word: Is there a modality advantage for onset of symbol use?. *Child Development*, *64*(3), 688-701.

Gordon, R. G., & Watson, L. R. (2015). Brief report: Gestures in children at risk for autism spectrum disorders. *Journal Of Autism And Developmental Disorders*, *45*(7), 2267-2273.

Greenfield, P., & Smith, J. (1976). The structure of communication in early language development. New York: Academic Press

Iverson, J. M., Capirci, O., Longobardi, E., & Caselli, M. C. (1999). Gesturing in mother–child interactions. *Cognitive Development*, *14*(1), 57-75.

Iverson, J. M., Capirci, O., Volterra, V., & Goldin-Meadow, S. (2008). Learning to talk in a gesture-rich world: Early communication in Italian vs. American children. *First Language*, *28*, 164 - 181.

Iverson, J. M., & Goldin-Meadow, S. (2005). Gesture Paves the Way for Language Development. *Psychological Science*, *16*(5), 367-371.

Kjellmer, L., Hedvall, Å., 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*172-180.

Krauss, R. M. (1998). Why Do We Gesture When We Speak?. *Current Directions In Psychological Science*, *7*(2), 54-60.

Le Couteur, A., Lord, C., & Rutter, M. (2003). Autism diagnostic interview-revised. Los Angeles, CA: Western Psychological Services.

Loveland, K. A., & Landry, S. H. (1986). Joint attention and language in autism and developmental language delay. *Journal Of Autism And Developmental Disorders*, *16*(3), 335-349.

MacWhinney, B. (2000). The CHILDES Project: Tools for Analyzing Talk. 3rd Edition. Mahwah, NJ: Lawrence Erlbaum Associates.

McNeill, David. (1992). *Hand and Mind: What Gestures Reveal About Thought*. Chicago: University of Chicago Press.

McNeill, D. (2005). *Gesture and Thought*. Chicago: University of Chicago Press.

Medeiros, K., & Winsler, A. (2014). Parent–child gesture use during problem solving in autistic spectrum disorder. *Journal Of Autism And Developmental Disorders, 44*(8), 1946-1958.

Mitchell, S., Brian, J., Zwaigenbaum, L., Roberts, W., Szatmari, P., Smith, I., & Bryson, S. (2006). Early Language and Communication Development of Infants Later Diagnosed with Autism Spectrum Disorder. *Journal Of Developmental And Behavioral Pediatrics, 27*(Suppl2), S69-S78

Mundy, P., Sigman, M., & Kasari, C. (1990). A longitudinal study of joint attention and language development in autistic children. *Journal Of Autism And Developmental Disorders, 20*(1), 115-128.

Mundy, P., Sigman, M., Ungerer, J., & Sherman, T. (1986). Defining the social deficits of autism: The contribution of non- verbal communication measures. *Journal of child psychology and psychiatry, 27*(5), 657-669.

Namy, L. L., Acredolo, L., & Goodwyn, S. (2000). Verbal labels and gestural routines in parental communication with young children. *Journal Of Nonverbal Behavior, 24*(2), 63-79.

National Research Council. Educating children with autism. Washington DC: NRC; 2001.

Nicoladis, E. (2002). Some gestures develop in conjunction with spoken language development and others don't: Evidence from bilingual preschoolers. *Journal Of Nonverbal Behavior, 26*(4), 241-266.

Nicoladis, E., Mayberry, R. I., & Genesee, F. (1999). Gesture and early bilingual development. *Developmental Psychology, 35*(2), 514-526.

Özçalişkan, Ş. (2007). Metaphors we move by: Children's developing understanding of metaphorical motion in typologically distinct languages. *Metaphor And Symbol, 22*(2), 147-168.

Özçalışkan, Ş., Adamson, L. B., & Dimitrova, N. (2016). Early deictic but not other gestures predict later vocabulary in both typical development and autism. *Autism, 20*(6), 754-763.

Özçalışkan, Ş., Adamson, L. B., Dimitrova, N., & Baumann, S. (2017a). Early gesture provides a helping hand to spoken vocabulary development for children with autism, Down syndrome and typical development. *Journal of Cognition and Development.* Accepted with minor pending revisions.

Özçalışkan, Ş., Adamson, L. B., Dimitrova, N., & Baumann, S. (2017b). Do parents model gestures differently when children's gestures differ? *Journal of Autism and Developmental Disorders,* under review.

Özçalişkan, S., Gentner, D., & Goldin-Meadow, S. (2014). Do iconic gestures pave the way for children's early verbs? *Applied Psycholinguistics*, *35*(6), 1143-1162.

Özçalişkan, Ş., & Goldin-Meadow, S. (2005a). Gesture is at the cutting edge of early language development. *Cognition, 96*(3), B101-B113.

Özçalişkan, Ş., & Goldin-Meadow, S. (2005b). Do parents lead their children by the hand?. *Journal Of Child Language, 32*(3), 481-505.

Özçalişkan, S. & Goldin-Meadow, S. (2009). When gesture-speech combinations do and do not index linguistic change. *Language and Cognitive Processes, 24(2),* 190-217.

Özçalişkan, S., & Goldin-Meadow, S. Is there an iconic gesture spurt at 26 months? In G. Stam & M. Ishino (Eds.), *Integrating gestures: The interdisciplinary nature of gesture* (pp. 163-174). Amsterdam, NL: John Benjamins, 2011.

Rowe, M. L., Özçalişkan, Ş., & Goldin-Meadow, S. (2008). Learning words by hand: Gesture's role in predicting vocabulary development. *First Language, 28*(2), 182-199.

Rutter, M., Bailey, A. & Lord, C. (2003). *The Social Communication Questionnaire.* Los Angeles: Western Psychological Services.

Singer, M. A., & Goldin-Meadow, S. (2005). Children Learn When Their Teacher's Gestures and Speech Differ. *Psychological Science, 16*(2), 85-89.

So, W., Wong, M. K., Lui, M., & Yip, V. (2015). The development of co-speech gesture and its semantic integration with speech in 6- to 12-year-old children with autism spectrum disorders. *Autism, 19*(8), 956-968.

Stites, L. J. & Özçalışkan, Ş. (2017). Who does what to whom: Children track story referents first in gesture. *Journal of Psycholinguistic Research, 46*(4), 1019-1032.

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.

Tager-Flusberg, H. (1996). Brief report: Current theory and research on language and communication in autism. *Journal of Autism and Developmental Disorders, 26*(2), 169-172.

Tager-Flusberg H, Paul R, Lord CE. Language and communication in autism. In: Volkmar F, Paul R, Klin A, Cohen DJ, editors. Handbook of autism and pervasive developmental disorder. 3. Vol. 1. New York: Wiley; 2005.

Wan, M. W., Green, J., Elsabbagh, M., Johnson, M., Charman, T., & Plummer, F. (2012). Parent–infant interaction in infant siblings at risk of autism. *Research In Developmental Disabilities*, *33*(3), 924-932.

APPENDICES

Appendix A

Table 1 Summary of children's and parents' production of speech

	TD	ASD
Children	**Mean (SD)**	**Mean (SD)**
Word Types	100.68 (42.67)	119.20 (51.50)
Word Tokens	246.23 (142.49)	319.55 (198.74)
Communicative acts with speech	77.59 (35.88)	96.60 (39.92)
Parents		
Word Types	196.55 (41.26)	184.90 (44.61)
Word Tokens	626.86 (179.21)	633.80 (216.15)
Communicative acts with speech	149.36 (44.60)	155.20 (45.51)

Appendix B

Table 2 Summary of children's and parent's production of gesture

	TD	ASD
Children	**Mean (SD)**	**Mean (SD)**
Gesture (All)	18.95 (15.50)	13.90 (12.06)
Communicative acts with gesture	17.27 (11.85)	12.45 (9.74)
Deictic Gestures	15.77 (14.32)	11.10 (11.15)
Conventional Gestures	2.09 (1.69)	2.40 (2.54)
Iconic Gestures	.68 (2.01)	.20 (.52)
Parents		
Gesture (All)	39.59 (24.14)	35.60 (23.21)
Communicative acts with gesture	37.45 (20.27)	34.95 (20.93)
Deictic Gestures	35.32 (23.57)	30.55 (21.71)
Conventional Gestures	3.23 (3.28)	3.55 (3.00)
Iconic Gestures	1.00 (1.38)	1.10 (1.48)

Appendix C

Table 3 Summary of children's and parents' production of gesture-speech combinations

	TD	ASD
Children	**Mean (SD)**	**Mean (SD)**
Gesture+speech (all)	14.00 (16.17)	10.90 (9.28)
Communicative acts with gesture+speech	12.32 (11.85)	8.60 (7.75)
Complementary gesture+speech	4.18 (5.93)	4.90 (4.32)
Disambiguating gesture+speech	5.68 (5.50)	3.10 (3.77)
Supplementary gesture+speech	4.82 (6.75)	1.85 (3.30)
Parents		
Gesture+speech (all)	36.86 (23.69)	33.45 (21.14)
Communicative acts with gesture+speech	32.05 (18.07)	30.60 (19.09)
Complementary gesture+speech	18.32 (15.21)	16.15 (10.61)
Disambiguating gesture+speech	12.27 (6.07)	10.45 (7.68)
Supplementary gesture+speech	5.50 (5.11)	6.80 (6.51)