JSLHR

Research Article

The Use of Hand Gestures to Communicate About Nonpresent Objects in Mind Among Children With Autism Spectrum Disorder

Wing-Chee So,[a] Ming Lui,[b] Tze-Kiu Wong,[a] and Long-Tin Sit[a]

Purpose: The current study examined whether children with autism spectrum disorder (ASD), in comparison with typically developing children, perceive and produce gestures to identify nonpresent objects (i.e., referent-identifying gestures), which is crucial for communicating ideas in a discourse.
Method: An experimenter described the uses of daily-life objects to 6- to 12-year-old children both orally and with gestures. The children were then asked to describe how they performed daily activities using those objects.
Results: All children gestured. A gesture identified a nonpresent referent if it was produced in the same location that had previously been established by the experimenter. Children with ASD gestured at the specific locations less often than typically developing children. Verbal and spatial memory were positively correlated with the ability to produce referent-identifying gestures for all children. However, the positive correlation between Raven's Children Progressive Matrices score and the production of referent-identifying gestures was found only in children with ASD.
Conclusions: Children with ASD might be less able to perceive and produce referent-identifying gestures and may rely more heavily on visual–spatial skills in producing referent-identifying gestures. The results have clinical implications for designing an intervention program to enhance the ability of children with ASD to communicate about nonpresent objects with gestures.

Children gesture when they talk. *Gestures* are spontaneous hand movements that co-occur with speech (McNeill, 1992, 2005), and they are called upon to serve multiple functions. In addition to expressing culture-specific meanings, making requests, and describing objects, gesture conveys visual–spatial information (McNeill, 1992, 2005), which is useful for identifying referents (Cassell & McNeill, 1991; McNeill, 1992). Speakers can thus exploit the spatial character of their gestures to associate spatial locations with corresponding entities that are not present in the physical context (Gullberg, 1998, 2003, 2006; So, Coppola, Liccidarello, & Goldin-Meadow, 2005; So, Kita, & Goldin-Meadow, 2009; Yoshioka, 2008). This can be done by assigning a particular nonpresent referent to a specific area in the frontal space. For example, when describing the layout of furniture in a room, a speaker makes a series of statements: "There is a couch" (with index finger pointing to the left), "There is a dining table" (with index finger pointing to the right), and "The cabinet is over there" (with index finger pointing to the upper right). These pointing gestures accompanying speech locate referents in space, and, more important, their spatial locations represent different nonpresent referents (e.g., the speaker's left side is associated with the couch and his right side is associated with the dining table; Alibali, 2005; McNeill, 1992; McNeill, Cassell, & Levy, 1993). These gestures are classified as *referent-identifying gestures* (So et al., 2009). Listeners derive the meaning of referent-identifying gestures by integrating them with the co-occurring speech and forming the association between the nonpresent referents and their corresponding spatial locations. Once locations are assigned to specific nonpresent referents, they are often maintained throughout the discourse (Gullberg, 1998, 2006). That is, both speakers and listeners gesture at the same locations when the same referents are mentioned later.

The ability to use gestures to identify nonpresent referents is crucial for communication of ideas during a conversation. Studies on gestures have revealed that during a narration a speaker creates coherent discourse by using not only linguistic devices but also speech-accompanying gestures (Gullberg, 2006; McNeill, 1992, 2005; McNeill & Levy, 1993; Yoshioka, 2008). Gestures can contribute to cohesion by repeating the location where the gesture is produced in

[a]The Chinese University of Hong Kong
[b]Hong Kong Baptist University, China
Correspondence to Wing-Chee So: wingchee@cuhk.edu.hk

Editor: Rhea Paul
Associate Editor: Joanne Volden
Received August 7, 2014
Revision received November 3, 2014
Accepted November 29, 2014
DOI: 10.1044/2015_JSLHR-L-14-0213

Disclosure: *The authors have declared that no competing interests existed at the time of publication.*

Downloaded From: http://jslhr.pubs.asha.org/ by a University of Hong Kong Library User on 03/19/2015
Terms of Use: http://pubs.asha.org/ss/Rights_and_Permissions.aspx

order to indicate the continuity of discourse (McNeill, 1992). As a result, establishing a cohesive use of gesture space for referential identification helps speakers engage in a discourse and helps the listener comprehend the speaker's message effectively.

Previous research has shown that typically developing (TD) children start locating referents in abstract space as early as 7 to 8 years of age (McNeill, 1992) and use referents frequently when they are 10 or 11 years of age (Cassell & McNeill, 1991; Sekine & Furuyama, 2010). Sekine and Kita (in press) recently found that, as early as age 6 years, children integrate information from speech and its co-occurring gestures that are produced in abstract locations by a speaker. In their study (Experiment 1), they showed each participant in four age groups (adults and 5-, 6-, and 10-year-old children) video clips of an actor narrating short passages. Each of the passages consisted of three sentences about two protagonists. The actor indicated both protagonists in overt-subject noun phrases and pointing gestures (e.g., pointed to the right when referring to the first protagonist and to the left when referring to the second protagonist) in the first two sentences. The actor did not produce an overt noun phrase in the third sentence, thus leaving the protagonist lexically unspecified. He did, however, produce a pointing gesture, which represented one of the protagonists (e.g., pointed to the right for the first protagonist), in the third sentence. This pointing was a referent-identifying gesture. Participants were then asked which protagonist the actor was referring to in the third sentence. The findings showed that all participants except 5-year-olds performed above chance level, although 6-year-olds performed poorer than 10-year-olds and adults. This study provided evidence that TD children are able to integrate information from speech and referent-identifying gestures as early as 6 years of age.

The question of interest is whether children with autism spectrum disorder (ASD) can integrate information from speech and referent-identifying gestures. Previous studies have reported that children with ASD have difficulty following what was previously said, and thus their responses to others are less contingent on the context of discourses compared with the responses of TD children (Tager-Flusberg & Anderson, 1991). In addition, although children with ASD have relatively intact grammatical skills, they display discourse deficits in language use (see Tager-Flusberg, 2000, for a review). For example, they often focus too much on the details of discourse, thereby hindering the global organization of their narratives (Ochs & Solomon, 2005) and the integration of speech and gestures. On the basis of these findings, we hypothesized that children with ASD are less able to integrate information from speech and referent-identifying gestures than TD children. The present study aimed to test this hypothesis. We examined whether children with ASD, in comparison with TD children, could form associations between referents and their corresponding spatial locations and then gesture at the specified locations when referring to the referents.

In addition, we explored the potential underlying language and cognitive skills that might contribute to the use of referent-identifying gestures among children with ASD and whether those skills were also important for TD children. A few correlational studies have examined the relationships between various general cognitive and language skills and gesture production in typical adults (e.g., Hostetter & Alibali, 2007). Previous research has shown that verbal and spatial memories are associated with gesture frequency among typical individuals (Chu, Meyer, Foulkes, & Kita, 2014; Hostetter & Alibali, 2007; Sassenberg, Foth, Wartenburger, & van der Meer, 2011). For example, individuals with low verbal skills but high spatial skills gesture more often than others (Hostetter & Alibali, 2007). Another study reported that individuals with poorer visual and spatial working memory gesture more often than those who have stronger visual and spatial working memory (Chu et al., 2014). However, we know of no evidence suggesting the relationship between language and cognitive ability and the ability to produce gestures in school-aged children with ASD. Previous studies have shown that cognitive and language abilities are strong predictors of language and communication skills in young children with ASD (e.g., Charman, Drew, Baird, & Baird, 2003; Luyster, Kadlec, Carter, & Tager-Flusberg, 2008). Three recent studies have examined whether and how cognitive and language abilities are correlated to gesture use in preschool children with ASD. One study found that higher numbers of gesture types were positively associated with better language comprehension, language expression, and nonverbal thinking skills among 20- to 51-month-old children with ASD (Braddock et al., 2013). Another study found that cognition and age explained only one fourth of the variance in production of actions and gestures among 24- to 63-month-old children (Kjellmer, Hedvall, Fernell, Gillberg, & Norrelgen, 2012). In contrast, the severity of autism symptoms explained an additional 11% of variance in production of actions and gestures. Mastrogiuseppe, Capirci, Cuva, and Venuti (2014) found that the number of ideative gestures, which include iconic gestures and markers, was positively correlated with reasoning skills but negatively correlated with language skills among 30- to 66-month-old preschool children. On the basis of previous findings on young children with ASD and normal adults, our study included assessments of language abilities and cognitive skills (including visual–spatial skills and spatial memory) of children with ASD and examined the correlation of these language abilities and cognitive skills to the ability to perceive and produce referent-identifying gestures among elementary school children.

Most research on gesture use in individuals with autism has been conducted among children in early childhood (e.g., Attwood, Frith, & Hermelin, 1988; Bono, Daley, & Sigman, 2004; Camaioni, Paola, Filippo, & Annarita, 1997; Capps, Kehres, & Sigman, 1998; Medeiros & Winsler, 2014; Werner & Dawson, 2005; but see Wetherby & Prizant, 2002). Previous findings showed that young children with ASD gesture less often than TD children and other children who are developmentally delayed (e.g., Bono et al., 2004; Camaioni et al., 1997; Medeiros & Winsler, 2014; but see Attwood et al., 1988; Capps, Kehres, & Sigman, 1998). It is

Downloaded From: http://jslhr.pubs.asha.org/ by a University of Hong Kong Library User on 03/19/2015
Terms of Use: http://pubs.asha.org/ss/Rights_and_Permissions.aspx

important to note that some studies have shown that young children with ASD are particularly impaired in protodeclarative pointing gestures (a type of gesture used to draw others' attention to an object and share interest in it) but have relatively spared ability to generate protoimperative pointing (a type of gesture used in making requests; Baron-Cohen, 1989; Wetherby & Prizant, 2002). The deficits of gesture use for communication among young children with ASD also include the use of intransitive gestures, which communicate symbolic meaning, such as the raised thumb for hitch-hiking. However, such children have relatively intact use of transitive or pantomime gestures, which are used to describe actual objects or object uses, such as using a finger to represent a toothbrush (Ham, Bartolo, Corley, Swanson, & Rajendran, 2010). Previous findings have also shown that in young children with ASD the production of other types of gesture, such as iconic gestures (e.g., both hands flapping as a reference to a bird or the action of flying) and speech beats (e.g., the right hand flipping outward to beat the rhythm of speech), might be delayed (Charman & Baird, 2002; Luyster, Lopez, & Lord, 2007). Young children with ASD also have trouble imitating gestures (e.g., Mostofsky et al., 2006) and synchronizing gestures with speech (De Marchena & Eigsti, 2010).

Data on gesture use by school-age children are relatively sparse. One study has shown that in comparison with TD adolescents, adolescents with ASD have difficulty recognizing and imitating transitive, intransitive, and pantomime gestures (Ham et al., 2011). Still, very little is known about gesture use among individuals in late childhood and adolescence. The present research therefore could fill this knowledge gap by examining the ability to produce referent-identifying gestures among children with ASD aged 6 to 12 years in comparison with TD children. Our findings would improve our theoretical understanding of the development of school-age children's communication using referent-identifying gestures, which would contribute to the refinement of therapeutic strategies pinpointed to the specific needs of children and adolescents with ASD.

Method

Participants

Thirty Cantonese-speaking children aged 6 to 12 years participated in this pilot study. Seventeen had been diagnosed with ASD or autistic disorder and 13 were age- and intelligence quotient (IQ)-matched TD children. There was no significant difference in mean age between ASD and TD children, $t(28) = 0.68$, $p = ns$. Table 1 displays the chronological ages of both groups of children. All children were right handed.

According to parents' verbal reports, neither TD children nor children with ASD had any history of traumatic brain injury, birth-related injury, or seizure disorder, and no TD children had a family history of ASD or other diagnosed developmental disorders or impairments. All procedures were approved by the Chinese University of Hong Kong's institutional review board in compliance with the Declaration of Helsinki.

Participant IQ was assessed with the Wechsler Intelligence Scale for Children–Fourth Edition (Hong Kong) (WISC-IV HK; The Psychological Corporation, 1981) by a qualified clinical psychologist. The participants with ASD had IQs ranging from 72 to 124 ($M = 94.52$), and the TD children had IQs ranging from 79 to 112 ($M = 95$), $t(28) = 0.095$, $p = ns$.

Autism or autism spectrum diagnoses were confirmed by a licensed clinical psychologist with the Autism Diagnostic Observation Schedule–Second Edition (ADOS-2; Lord, Rutter, Risi, Gotham, & Bishop, 2012). A total score ≥ 7 confirmed the presence of an ASD ($n = 11$), and a total score ≥ 9 confirmed the presence of an autistic disorder ($n = 6$). Table 1 shows the mean score (*SD*) in ADOS-2.

Procedure

Children with ASD were recruited through two primary schools and three family organizations. TD children were recruited through three primary schools in the same region as the children with ASD. The intelligence, language abilities, and cognitive abilities of each child were assessed. We administered Raven's Coloured Progressive Matrices (RCPM; Raven, 1936), the Rey Complex Figure Test and Recognition Trial (RCFT; Meyers & Meyers, 1995), and the Hong Kong Cantonese Oral Language Assessment Scale (HKCOLAS; T'sou et al., 2006) to capture the individual variations in language and cognitive skills. The RCPM measures participants' ability to extract and understand information in a complex situation. The RCFT measures participants' visual–spatial ability and visual–spatial memory in four trials: one copy, two recall, and one recognition. The HKCOLAS measures children's expressive and receptive language abilities.

In order to avoid the stress of overloading the children and parents with research tasks, we separated the assessments into three sessions in different venues. Children were first administered the ADOS-2 (exclusively for children with ASD) and the WISC-IV HK in a clinical psychologist's clinic. Then they were administered the HKCOLAS, either in a speech therapist's clinic or in their primary schools. In the last session, they completed the referent-identifying gesture comprehension task, followed by RCPM and RCFT, in a university laboratory with instructions from research assistants. The order of the assessment tools was identical for all participants.

Before the assessments began, researchers explained the content of the tasks to each parent and child. We obtained the parents' informed consent prior to the implementation of the study.

Tasks

HKCOLAS. The HKCOLAS was designed to provide a holistic picture of a child's strengths and weaknesses in his or her language production and comprehension. It consists of seven subtests (textual comprehension, word definition,

Downloaded From: http://jslhr.pubs.asha.org/ by a University of Hong Kong Library User on 03/19/2015
Terms of Use: http://pubs.asha.org/ss/Rights_and_Permissions.aspx

Table 1. Descriptive statistics for chronological age and ADOS-2, RCPM, HKCOLAS, and RCFT scores in children with ASD and TD children.

	ASD (*N* = 17; two girls, 15 boys)				TD (*N* = 13; six girls, seven boys)			
Age and task scores	***M***	***SD***	**Minimum**	**Maximum**	***M***	***SD***	**Minimum**	**Maximum**
Chronological age (years)	8.82	1.19	7.42	12.15	9.18	1.75	6.63	11.58
ADOS-2	8.12	1.25	7	10				
RCPM	31.29	3.44	25	36	28	4.81	21	35
HKCOLAS (story content)	49.58	9.41	35	72	47.15	13.77	23	66
RCFT (recognition)	18.24	3.85	12	26	19.69	2.1	16	23

Note. ASD = autism spectrum disorder; TD = typically developing; ADOS-2 = Autism Diagnostic Observation Schedule–Second Edition (Lord et al., 2012); RCPM = Raven's Coloured Progressive Matrices (Raven, 1936); HKCOLAS = Hong Kong Cantonese Oral Language Assessment Scale (T'sou et al., 2006); RCFT = Rey Complex Figure Test and Recognition Trial (Meyers & Meyers, 1995).

lexical–semantic relations, Hong Kong Cantonese grammar, expressive nominal vocabulary, nonword repetition, and narrative) that assess children's expressive and receptive language abilities in Cantonese. It was administered by a registered speech therapist.

We focused on participants' scores in the narrative test. In this task, a participant viewed a series of 24 pictures depicting a story with four interconnected episodes while listening to a story played on a disc. The story was narrated by a male individual. The narration and the sounds that signaled the participant to turn the page were recorded on a mini disk. The experimenter ensured that the participant was looking at the correct picture while listening to the narratives. Then each participant was asked to retell the story.

The narrative test measured children's ability to retell the content of the story, construct sentences, introduce and switch references, and use connectives to join sentences in Cantonese. We coded these four aspects based on the HKCOLAS manual but report only the standardized score for story content in the present study. In terms of story content, we examined whether participants could express the content relevant to the story and whether they used appropriate vocabularies to express the meaning. The score of story content was particularly relevant in the present study because it allowed us to capture children's receptive and expressive language abilities and verbal memory. Participants could get a maximum of 92 points in the story content measure.

RCPM. The RCPM is one of the forms of Raven's Progressive Matrices and is designed for children aged 5 to 11 years. Other forms are Raven's Standardized Progressive Matrices (RSPM) and Raven's Advanced Progressive Matrices (RAPM), which are designed for older children and adults. The RCPM consists of 36 items in which participants identify the missing elements in order to complete the patterns, without a time limit. Each item is printed on a colored background to attract children's attention. Children can earn a maximum of 36 points in the RCPM. There are no established norms for RCPM in Hong Kong. We thus reported and applied the raw test scores in the analyses.

The RCPM is known to measure participants' eductive ability, which is the ability to extract and understand information from a complex situation. Previous research has also shown that it measures Spearman's *g*, which is often referred to as general intelligence (Raven, Raven, & Court, 2003).

RCFT. This test was designed to measure children's ability to learn, construct, and memorize visual–spatial information. In this task, children were asked to reproduce a complicated line drawing, first by copying it and then by recalling it 3 min later (immediate recall) and 30 min later (delayed recall). In the recognition trial, which took place after the delayed recall, children selected 12 out of 24 patterns presented in the line drawing. We report here the participants' performance in the recognition trial, which was scored based on the manual (Meyers & Meyers, 1995). The recognition total correct raw score was the sum of the recognition true positives (i.e., the 12 items that showed the patterns in the complex figure) and recognition true negatives (i.e., subtracting the recognition false positives from 12, where recognition false positives are the items that were not part of the complex figure). Children could get a maximum of 24 points in the recognition trial.

Referent-identifying gesture task. This task was modified from the demonstration task in the ADOS-2.[1] In this task, the experimenter sat beside the participant in front of a table and invited the participant to play a game. The participant was told to demonstrate how he or she performed four activities in four separate trials. In each trial, the experimenter asked the participant to imagine that the table was the setting for a particular daily activity, including making a sandwich, washing the face, taking lunch, or packing a schoolbag. The experimenter then introduced verbally and by gesture four objects that were usually involved in the activities. All the objects were indicated by the experimenter to be hypothetically present at four spatial

[1]In the demonstration task in the ADOS-2, children were asked to demonstrate how to brush their teeth and take a shower. In our referent-identifying gesture task, we asked children to demonstrate different daily routines (see the description of the task in the Method section). In addition, the demonstration task in the ADOS-2 examined whether children could verbally demonstrate the activity and represent familiar actions with gestures, regardless of the spatial locations of the gestures. In the present study, we focused on the spatial locations children gestured to, because these locations could represent the references involved in the daily routines.

Downloaded From: http://jslhr.pubs.asha.org/ by a University of Hong Kong Library User on 03/19/2015
Terms of Use: http://pubs.asha.org/ss/Rights_and_Permissions.aspx

locations on the table, although they were not present in reality. For example, in the task "taking lunch" an experimenter said, "Pretend that this is a dining table and now you are going to have your lunch. Pretend that you put your chopsticks here" (index finger drawing a rectangle on the right side of the table), "your bowl of food here" (index finger drawing a rectangle in the center of the table), "your spoon here" (index finger drawing a rectangle on the left side of the table), "and your napkin here" (index finger drawing a rectangle at the lower center of the table). "Now you show and tell me how you eat." The order of the four daily activities was randomized across the participants. If a participant did not respond with both verbal expression and action, the experimenter would repeat the instructions to prompt him or her. If the child still did not respond to the task requirement after the second prompt, the experimenter would proceed to the next trial.

We transcribed the participants' speech and coded their gestures. For the purpose of the present study, we looked only at relevant speech while the children enacted the gestures. In terms of speech, we counted the number of words spoken by each participant in each trial and the number of referents mentioned in their speech. In terms of gestures, we coded the shapes and the placements of their hands and the trajectory of the motions. Changes in any one of these parameters marked the end of one gesture and the beginning of another. Each gesture was then assigned a meaning indicating the referent represented in the gesture (see So et al., 2009).

Our data showed that participants produced two types of gesture: abstract deictic and iconic. *Abstract deictic gestures* are pointing gestures in an abstract space—for example, the right hand pointing to the left side of the table. *Iconic gestures* were used to resemble the objects being represented or their associated actions through hand movement directions or hand shapes—for example, lifting up the right hand on the left side of the table in a gesture that resembles the action of picking up an object. We calculated the average number of abstract deictic and iconic gestures per word.

Among the abstract deictic and iconic gestures produced, we assessed the spatial locations of gestures that were accompanied by referents mentioned in speech (e.g., the right hand pointed to the left corner of the table while saying, "I pick up a spoon"). A gesture was considered to be referent identifying if it was produced at the location assigned by the experimenter in the instruction. The proportion of referent-identifying gestures for each participant was calculated as the number of referent-identifying gestures the participant produced divided by the total number of gestures the participant produced for the referents.

In addition, we examined the participants' performance in the referent-identifying gesture task. In each trial, we looked at how many referents (out of four) participants gestured at the same locations. A participant could be awarded a maximum of 4 points (each point assigned to one referent) in each trial. Then we summed the number of points each participant received in all four trials. A participant could get a maximum of 16 points. A participant was considered to produce the referent-identifying gesture for a particular referent if he or she gestured at its specified location while mentioning the referent in the accompanying speech. For example, a participant pretends to pick up a spoon by lifting his hand on the left side of the table while saying, "I pick up my spoon." In this example, 1 point would be given to the child for his or her production of the referent-identifying gesture representing a spoon. If a participant pretended to put the spoon into the bowl of food by moving his hand from the left to the center while saying, "I use my spoon to take the food," 2 points would be given for the production of the referent-identifying gestures of both the spoon and the food. However, no point would be given if the participant only gestured at the specified location without giving a verbal description because we were not able to derive the meaning of the gesture if it was produced without speech. A participant was considered to have not produced a referent-identifying gesture if he or she gestured at the other locations (e.g., a participant lifts his hand on the right side of the table rather than the left side while saying, "I take my spoon") or if he or she did not gesture at the specified locations (e.g., a participant moves his hand to his mouth and says, "I eat my food"). No point would be counted in these two examples.

Results

The present study sought to examine the ability of children with ASD to produce referent-identifying gestures, how this ability compared with that of TD children, and whether the language and cognitive abilities of children with ASD were associated with their production of referent-identifying gestures. In this section we report the children's performance in the referent-identifying gesture task, their language and cognitive abilities, and the association among these variables.

Both children with ASD and TD children understood the instructions given in the referent-identifying gesture task and demonstrated the four daily routine tasks verbally and nonverbally in their first or second attempt. We found that TD children produced more words than children with ASD in each trial, TD: $M = 24.17$, $SD = 8.13$; ASD: $M = 18.54$, $SD = 6.70$; $t(28) = 2.08$, $p < .05$. However, the groups did not differ in the number of referents mentioned in speech, TD: $M = 3.59$, $SD = 1.13$; ASD: $M = 3.42$, $SD = 1.07$; $t(28) = 57.08$, $p = ns$.

Both groups produced comparable numbers of abstract deictic and iconic gestures before and after controlling for the amount of speech. Before controlling for the amount of speech, in each trial there were 0.36 ($SD = 0.78$) abstract deictic gestures in children with ASD and 0.44 ($SD = 0.62$) in TD children, $t(28) = 0.32$, $p = ns$. In each trial there were 4.39 ($SD = 2.13$) iconic gestures in children with ASD and 3.56 ($SD = 0.69$) in TD children, $t(28) = 0.19$, $p = ns$. We found no differences in the number of abstract deictic and iconic gestures produced after controlling for the amount of speech in both groups. In each trial, children with ASD produced 0.05 ($SD = 0.08$) abstract deictic gestures per word, whereas TD children produced 0.02 ($SD = 0.04$),

Downloaded From: http://jslhr.pubs.asha.org/ by a University of Hong Kong Library User on 03/19/2015
Terms of Use: http://pubs.asha.org/ss/Rights_and_Permissions.aspx

$t(28) = 0.98$, $p = ns$. Also in each trial, children with ASD produced 0.23 ($SD = 0.32$) iconic gestures per word, whereas TD children produced 0.15 ($SD = 0.09$), $t(28) = 1.29$, $p = ns$.

Because there were very few abstract deictic gestures, we collapsed abstract deictic and iconic gestures in both groups in the following analyses. We examined the proportion of referent-identifying gestures: 52.13% ($SD = 0.23$) of the gestures produced by children with ASD and 75.36% ($SD = 0.29$) of the gestures produced by TD children identified referents, $t(28) = 3.02$, $p < .001$. These findings suggest that children with ASD are less likely to gesture at the specified locations compared with TD children. Regarding the children's overall performance in the referent-identifying gesture task, we found that children with ASD scored lower than their TD peers, ASD: $M = 8.71$, $SD = 3.77$; TD: $M = 11.85$, $SD = 2.54$; $t(28) = 2.58$, $p < .02$.

Our findings showed that approximately only half of the gestures were produced at the specified locations (i.e., referent-identifying gestures) among the children with ASD. We therefore looked at where else they produced the gestures when verbally demonstrating the activities. Errors were made when they did not gesture at the specified locations. We observed two kinds of errors made by children with ASD and TD children: gesturing away from the table and gesturing at the wrong locations on the table. Among children with ASD, 79.83% ($SD = 0.23$) of erroneous gestures were produced off the table, which was the setting of the pretend daily activities. Six children with ASD gestured off the table during the demonstration, and their gestures were not produced at the relative spatial locations (e.g., gesturing to the right as the location of the spoon and to the left as the location of the chopsticks). For example, one child with ASD turned away from the table and gestured in his frontal space in all four trials when doing the demonstration. More important, in each trial he gestured all the referents at the center in his frontal space (i.e., his gestures did not keep the relative locations). The remaining erroneous gestures (20.17%) were produced at the wrong locations on the table (e.g., lifting up the hands on the right side of the table instead of the left side to represent picking up the spoon). As opposed to children with ASD, TD children did not gesture away from the table. Rather, they made errors because they gestured at the wrong locations.

Next, we summarized the participants' scores in the language and cognitive tasks (see Table 1). Children with ASD scored higher than TD children in the RCPM, $t(28) = 2.19$, $p < .04$. There was no difference in the story content measure, $t(28) = 0.23$, $p = ns$, or RCFT recognition, $t(28) = 1.23$, $p = ns$.

Figure 1 shows the scatter plot depicting the relationship between the performance in the RCPM and the referent-identifying gesture task. We ran two correlation analyses in order to examine the correlation between performance in the referent-identifying gesture task and language and cognitive abilities for the two groups of children. Table 2 shows the correlation coefficients for data of children with ASD and TD children.

Our findings show that story content and spatial memory recognition were positively correlated to performance on the referent-identifying gesture task in both children with ASD and TD children. The RCPM score was positively correlated to performance on the referent-identifying gesture task among children with ASD but not among TD children.

Discussion

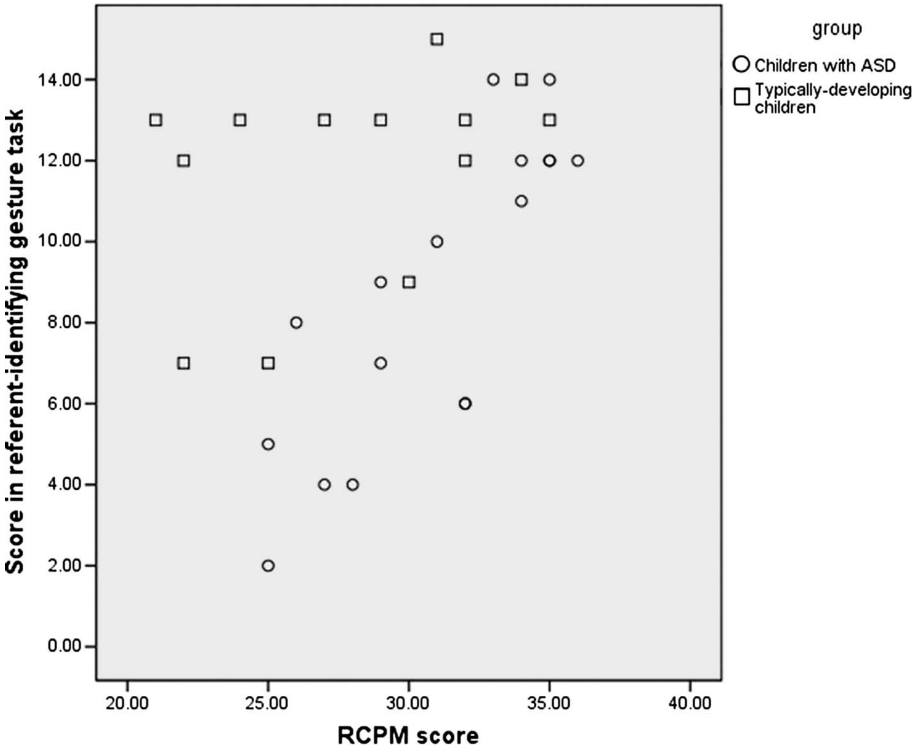
This pilot study investigated whether children with ASD, in comparison with TD children, were able to produce referent-identifying gestures and examined which variables were correlated to such gesturing ability. Children with ASD produced referent-identifying gestures less often than TD children and scored lower than TD children in the referent-identifying gesture task. The ability to produce referent-identifying gestures was positively correlated to performance on the verbal and spatial memory task for both groups of children. However, of note, RCPM scores were positively correlated with referent-identifying gesture performance only in children with ASD—not in TD children. This implies that children with ASD may rely more heavily on visual–spatial skills in performing referent-identifying gestures compared with TD children. There is limited research into the ability of children with ASD to produce gestures in the late childhood stage. The present research examined whether children with ASD aged 6 to 12 years were able to produce abstract deictic and iconic gestures that identified referents and how they compared with their TD peers. We found that children with ASD showed a delay in referent-identifying gestures. Such a deficit may hinder their communication with others in natural conversations where speakers use spatial locations to represent nonpresent referents.

There are a few possibilities to explain the deficit in producing referent-identifying gestures in children with ASD. One possibility is that children with ASD have general difficulty producing gestures and that this difficulty is not confined to producing referent-identifying gestures. Previous research has suggested that children with ASD may have difficulty with sensorimotor coordination between the hands and the mouth (Iverson, 2010). Speech and gesture, which are two independent systems in early language development, are later naturally integrated in TD children but not in children with ASD (Sowden, Perkins, & Clegg, 2008). However, we found that the children with ASD in our study did not demonstrate delay in producing gestures while talking. Instead, the numbers of iconic and abstract deictic gestures per word produced by children with ASD were comparable to those produced by TD children.

Another possibility is that children with ASD have poorer spatial and verbal memory (as measured by the RCPM and story content tasks, respectively) compared with TD children and therefore have difficulty remembering the nonpresent objects involved and their spatial locations. However, our findings show that verbal and spatial memory performances of children with ASD were comparable to

Downloaded From: http://jslhr.pubs.asha.org/ by a University of Hong Kong Library User on 03/19/2015
Terms of Use: http://pubs.asha.org/ss/Rights_and_Permissions.aspx

Figure 1. Scatter plot showing the relationship between performance in the Raven's Coloured Progressive Matrices (RCPM; Raven, 1936; *x*-axis) and the referent-identifying gesture task (*y*-axis) in children with autism spectrum disorder (ASD; represented by o) and typically developing children (represented by □).



those of TD children (also see Minshew, Luna, & Sweeney, 1999; Pennington et al., 1997; Steele, Minshew, Luna, & Sweeney, 2007; but see Griffith, Pennington, Wehner, & Rogers, 1999; Ozonoff & Strayer, 2001; Williams, Goldstein, Carpenter, & Minshew, 2005). In addition, both groups of children recalled a comparable number of referents in speech.

Children with ASD did not gesture at the specified locations; rather, they gestured away from the table and assigned new locations to different referents. One possible

Table 2. Pearson correlation coefficients of the relationships among referent-identifying gesture task score, RCPM, HKCOLAS, and RCFT for the data of children with ASD and TD children.

Variable	Referent-identifying gesture task	RCPM	HKCOLAS (story content)	RCFT (recognition)
Children with ASD				
Referent-identifying gesture task	—			
RCPM	.71**	—		
HKCOLAS (story content)	.51*	.29	—	
RCFT (recognition)	.59*	.59	.26	—
TD children				
Referent-identifying gesture task	—			
RCPM	.41	—		
HKCOLAS (story content)	.57*	.57*	—	
RCFT (recognition)	.60*	.15	.19	—

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

Downloaded From: http://jslhr.pubs.asha.org/ by a University of Hong Kong Library User on 03/19/2015
Terms of Use: http://pubs.asha.org/ss/Rights_and_Permissions.aspx

explanation for why children with ASD did not gesture toward the table is their deficit in theory of mind understanding (Baron-Cohen, 1995), which is one of the crucial skills in maintaining a coherent discourse (Capps et al., 1998). In the referent-identifying gesture task, theory of mind understanding enables a child to take the perspectives of others and maintain a conversation by keeping the spatial locations of gestures consistent in the discourse. Assignment of referents to new spatial locations would result in ambiguity, thereby hindering the comprehension of listeners. It is possible that the inability to think from the experimenter's perspective caused the children in our study to neglect the spatial locations specified by the experimenter.

Another possibility is the deficit in integrating gestures and speech in comprehension among children with ASD. To successfully perform the referent-identifying task, children needed to integrate the spatial information expressed in gestures with the referents conveyed in speech. By doing so, they could derive the meaning of referent-identifying gestures from the accompanying speech produced by the experimenter. If children with ASD were not able to integrate the experimenter's speech and gestures, they would not be able to form an association between the spatial locations of referent-identifying gestures and their corresponding referents. As a result, children with ASD were less likely to use the locations specified by the experimenter to represent different referents. This interpretation is consistent with previous research, which has shown that adolescents with high-functioning autism are less able to integrate iconic gestures and speech than TD individuals, thereby hindering their comprehension (Silverman, Bennetto, Campana, & Tanenhaus, 2010). Difficulty integrating speech and co-occurring gestures may result in learning problems in the classroom, where teachers use spatial gestures to elaborate concepts such as mathematical ideas (Singer & Goldin-Meadow, 2005), transformation (Ping & Goldin-Meadow, 2008), and symmetry (Valenzeno, Alibali, & Klatzky, 2003). Although abundant research has shown that gesturing while teaching helps TD children learn and remember various concepts (e.g., Church, Ayman-Nolley, & Mahootian, 2004; Singer & Goldin-Meadow, 2005; Valenzeno et al., 2003), children with ASD may not benefit from such multimodal instruction.

Our findings also show that children with ASD outperformed TD children in the RCPM test performance. This finding was consistent with previous research, which showed that children with ASD performed better than children without ASD in the RCPM task when these two groups were matched by WISC-IV HK test scores, suggesting that children with ASD have strong abstract spatial reasoning skills (Dawson, Soulières, Gernsbacher, & Mottron, 2007; Hayashi, Kato, Igarashi, & Kashima, 2008; but see Pennington & Ozonoff, 1996). Recent findings have reported that individuals with ASD might solve the RCPM problems differently than individuals without ASD. Kunda and Goel (2008a, 2008b) suggested that individuals with ASD tend to solve problems with visual reasoning mechanisms, whereas individuals without ASD tend to solve problems with analytic and perceptual processes. This hypothesis was supported by findings from a neuroimaging study (Soulières et al., 2009). The neuroimaging data revealed that, compared with control group participants, individuals with ASD had lower brain activation in the prefrontal and parietal areas commonly found to be involved in the processing of verbal information and higher activation in the visual occipital areas when solving the RCPM tasks.

Our findings have shown that the ability of children with ASD to produce referent-identifying gestures was positively correlated with their scores in the RCPM task ($r = .71$). The strong and positive correlation between these two tasks was not found in TD children. This suggests that, in addition to verbal and spatial memory, children with ASD may rely on visual strategies to perform referent-identifying gesture tasks. It is possible that children with ASD formed visual representations of referent-identifying gestures. Therefore, those with better visual processing skills (i.e., those who performed better in the RCPM task) scored higher in the referent-identifying gesture task. However, the way in which visual strategy bias facilitates comprehension and production of referent-identifying gestures in children with ASD needs to be examined further.

Conclusions

The present pilot study examined whether children with ASD aged 6 to 12 years can produce gestures that identify referents and how they compare with TD children. We found that children with ASD may have difficulty producing referent-identifying gestures. Such difficulty may be attributable to deficits in theory of mind understanding and the integration of gestures and speech in comprehension. It is interesting to note that children with ASD may rely on visual processing to interpret and produce referent-identifying gestures. Our results further our understanding of the ability of children with ASD to perceive and produce gestures, specifically referent-identifying gestures, which has not been investigated in previous research. The study of referent-identifying gesture has significant practical implications because this kind of gesture use is important for maintaining a coherent discourse in social interactions and for learning various concepts in a classroom setting. Future studies could examine how training programs can be designed specifically to enhance the ability of children with ASD to perceive and use referent-identifying gestures to communicate ideas about nonpresent objects in mind.

Acknowledgments

This research was fully supported by Research Grants Council of the Hong Kong Special Administrative Region, China, Project 449813, awarded to Wing-Chee So, and Chinese University of Hong Kong Projects CUHK4930017, awarded to Wing-Chee So, and CUHK4058005, awarded to Wing-Chee So and Virginia Yip. We acknowledge the help of our research assistants Ben Ka-Ho Choi, Wing-Lam Amy Chong, Sheera Chan, and Hiu-Man Lavender Chiu. Special thanks to all of the children and their parents for their help and their dedication to education.

Downloaded From: http://jslhr.pubs.asha.org/ by a University of Hong Kong Library User on 03/19/2015
Terms of Use: http://pubs.asha.org/ss/Rights_and_Permissions.aspx

References

Alibali, M. W. (2005). Gesture in spatial cognition: Expressing, communicating and thinking about spatial information. *Spatial Cognition & Computation, 5,* 307–331.

Attwood, A. H., Frith, U., & Hermelin, B. (1988). The understanding and use of interpersonal gestures by autistic and Down's syndrome children. *Journal of Autism and Developmental Disorders, 18,* 241–257.

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

Baron-Cohen, S. (1995). *Mindblindness: An essay on autism and theory of mind*. Boston, MA: MIT Press/Bradford Books.

Bono, M. A., Daley, T., & Sigman, M. (2004). Relations among joint attention, amount of intervention and language gain in autism. *Journal of Autism and Developmental Disabilities, 34,* 495–505.

Braddock, B. A., Pickett, C., Ezzelgot, J., Sheth, S., Korte-Stroff, E., Loncke, F., & Bock, L. (2013). Potential communicative acts in children with autism spectrum disorders. *Developmental Neurorehabilitation*. doi:10.3109/17518423.2013.799243

Camaioni, L., Paola, P., Filippo, M., & Annarita, M. (1997). Brief report: A longitudinal examination of the communicative gestures deficit in young children with autism. *Journal of Autism and Developmental Disorders, 27,* 715–725.

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

Cassell, J., & McNeill, D. (1991). Non-verbal imagery and the poetics of prose. *Poetics Today, 12,* 375–404.

Charman, T., & Baird, G. (2002). Practitioner review: Diagnosis of autism spectrum disorders in 2- and 3-year-old children. *Journal of Child Psychology and Psychiatry, 43,* 289–305.

Charman, T., Drew, A., Baird, C., & Baird, G. (2003). Measuring early language development in preschool children with autism spectrum disorder using the MacArthur Communicative Development Inventory (Infant Form). *Journal of Child Language, 30,* 213–236.

Chu, M., Meyer, A. S., Foulkes, L., & Kita, S. (2014). Individual differences in frequency and saliency of speech-accompanying gestures: The role of cognitive abilities and empathy. *Journal of Experimental Psychology: General, 143,* 694–709.

Church, R. B., Ayman-Nolley, S., & Mahootian, S. (2004). The role of gesture in bilingual education: Does gesture enhance learning? *International Journal of Bilingual Education & Bilingualism, 7*(4), 303–320.

Dawson, M., Soulières, I., Gernsbacher, M. A., & Mottron, L. (2007). The level and nature of autistic intelligence. *Psychological Science, 18,* 657–662.

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

Griffith, E. M., Pennington, B. F., Wehner, E. A., & Rogers, S. J. (1999). Executive functions in young children with autism. *Child Development, 70,* 817–832.

Gullberg, M. (1998). *Gesture as a communication strategy in second language discourse: A study of learners of French and Swedish*. Lund, Sweden: Lund University Press.

Gullberg, M. (2003). Gestures, referents, and anaphoric linkage in learner varieties. In C. Dimroth & M. Starren (Eds.), *Information structure, linguistic structure and dynamics of language acquisition* (pp. 311–328). Amsterdam, the Netherlands: John Benjamins.

Gullberg, M. (2006). Handling discourse: Gestures, reference tracking, and communication strategies in early L2. *Language Learning, 56,* 156–196.

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.

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, 46,* 407–409.

Hayashi, M., Kato, M., Igarashi, K., & Kashima, H. (2008). Superior fluid intelligence in children with Asperger's disorder. *Brain and Cognition, 66,* 306–310.

Hostetter, A. B., & Alibali, M. W. (2007). Raise your hand if you're spatial: Relations between verbal and spatial skills and representational gesture production. *Gesture, 7,* 73–95.

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

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.

Kunda, M., & Goel, A. K. (2008a). Thinking in pictures: A fresh look at cognition in autism. In B. C. Love, K. McRae, & V. M. Sloutsky (Eds.), *Proceedings of the 30th Annual Conference of the Cognitive Science Society* (pp. 321–326). Austin, TX: Cognitive Science Society.

Kunda, M., & Goel, A. K. (2008b). What can pictorial representations reveal about the cognitive characteristics of autism? In G. Stapleton, J. Howse, & J. Lee (Eds.), *Diagrams 2008* (LNAI 5223, pp. 103–117). Heidelberg, Germany: Springer.

Lord, C., Rutter, M., Risi, S., Gotham, K., & Bishop, S. L. (2012). *Autism Diagnostic Observation Schedule–Second Edition*. Los Angeles, CA: Western Psychological Services.

Luyster, R., Lopez, K., & Lord, C. (2007). Characterizing communicative development in children referred for autism spectrum disorder using the MacArthur-Bates Communicative Development Inventory (CDI). *Journal of Child Language, 34,* 623–654.

Luyster, R. J., Kadlec, M. B., Carter, A., & Tager-Flusberg, H. (2008). Language assessment and development in toddlers with autism spectrum disorders. *Journal of Autism and Development Disorders, 38,* 1426–1438.

Mastrogiuseppe, M., Capirci, O., Cuva, S., & Venuti, P. (2014). Gestural communication in children with autism spectrum disorders during mother-child interaction. *Autism*. doi:10.1177/1362361314528390

McNeill, D. (1992). *Hand and mind: What gestures reveal about thought*. Chicago, IL: University of Chicago Press.

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

McNeill, D., Cassell, J., & Levy, E. T. (1993). Abstract deixis. *Semiotica, 95,* 5–19.

McNeill, D., & Levy, E. T. (1993). Cohesion and gesture. *Discourse Processes, 16,* 363–386.

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

Downloaded From: http://jslhr.pubs.asha.org/ by a University of Hong Kong Library User on 03/19/2015
Terms of Use: http://pubs.asha.org/ss/Rights_and_Permissions.aspx

Meyers, J. E., & Meyers, K. R. (1995). *Rey Complex Figure Test and Recognition Trial: Professional manual*. Lutz, FL: Psychological Assessment Resources.

Minshew, N. J., Luna, B., & Sweeney, J. A. (1999). Oculomotor evidence for neocortical systems but not cerebellar dysfunction in autism. *Neurology, 52,* 917–922.

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,* 314–326.

Ochs, E., & Solomon, O. (2005). Practical logic and autism. In C. Casey & R. B. Edgerton (Eds.), *A companion to psychological anthropology: Modernity and psychocultural change* (pp. 140–167). Malden, MA: Wiley-Blackwell.

Ozonoff, S., & Strayer, D. L. (2001). Further evidence of intact working memory in autism. *Journal of Autism and Developmental Disorders, 31,* 257–263.

Pennington, B. F., & Ozonoff, S. (1996). Executive functions and developmental psychopathology. *Journal of Child Psychology and Psychiatry, 37,* 51–87.

Pennington, B. F., Rogers, S. J., Bennetto, L., Griffith, E. M., Reed, D. T., & Shyu, V. (1997). Validity tests of the executive dysfunction hypothesis of autism. In J. Russell (Ed.), *Autism as an executive disorder* (pp. 143–178). Oxford, England: Oxford University Press.

Ping, R., & Goldin-Meadow, S. (2008). Hands in the air: Using ungrounded iconic gestures to teach children conservation of quantity. *Developmental Psychology, 44,* 1277–1287.

The Psychological Corporation. (1981). Hong Kong Wechsler Intelligence Scale for Children manual. New York, NY: Author.

Raven, J., Raven, J. C., & Court, J. H. (2003). *Manual for Raven's Progressive Matrices and Vocabulary Scales. Section 1: General overview*. San Antonio, TX: Harcourt Assessment.

Raven, J. C. (1936). *Mental tests used in genetic studies: The performances of related individuals in tests mainly educative and mainly reproductive* (Unpublished master's thesis). University of London, England.

Sassenberg, U., Foth, M., Wartenburger, I., & van der Meer, E. (2011). Show your hands—Are you really clever? Reasoning, gesture production, and intelligence. *Linguistics, 49,* 105–134.

Sekine, K., & Furuyama, N. (2010). Developmental change of discourse cohesion in speech and gestures among Japanese elementary school children. *Rivista di Psicolinguistica Applicata, 10*(3), 97–116.

Sekine, K., & Kita, S. (in press). Development of multimodal discourse comprehension: Cohesive use of space by deictic gestures. *Language and Cognitive Processes*.

Silverman, L. B., Bennetto, L., Campana, E., & Tanenhaus, M. K. (2010). Speech-and-gesture integration in high functioning autism. *Cognition, 115,* 380–393.

Singer, M. A., & Goldin-Meadow, S. (2005). Children learn when their teacher's gestures and speech differ. *Psychological Science, 16,* 85–89.

So, W. C., Coppola, M., Liccidarello, V., & Goldin-Meadow, S. (2005). The seeds of spatial grammar in the manual modality. *Cognitive Science, 29,* 1029–1043.

So, W. C., Kita, S., & Goldin-Meadow, S. (2009). Using the hands to identify who does what to whom: Gesture and speech go hand-in-hand. *Cognitive Science, 33,* 115–125.

Soulières, I., Dawson, M., Samson, F., Barbeau, E. B., Sahyoun, C. P., Strangman, G. E., . . . Mottron, L. (2009). Enhanced visual processing contributes to matrix reasoning in autism. *Human Brain Mapping, 30,* 4082–4107.

Sowden, H., Perkins, M., & Clegg, J. (2008). The co-development of speech and gesture in children with autism. *Clinical Linguistics and Phonetics, 22*(10–11), 804–813.

Steele, S. D., Minshew, N. J., Luna, B., & Sweeney, J. A. (2007). Spatial working memory deficits in autism. *Journal of Autism and Developmental Disorders, 37,* 605–612.

Tager-Flusberg, H. (2000). The challenge of studying language development in autism. In L. Menn & N. Bernstein Ratner (Eds.), *Methods for studying language production* (pp. 313–332). Mahwah, NJ: Erlbaum.

Tager-Flusberg, H., & Anderson, M. (1991). The development of contingent discourse ability in autistic children. *Journal of Child Psychology and Psychiatry, 32,* 1123–1134.

T'sou, B., Lee, T., Tung, P., Chan, A., Man, Y., & To, C. (2006). *Hong Kong Cantonese Oral Language Assessment Scale*. Hong Kong, China: City University of Hong Kong Press.

Valenzeno, L., Alibali, M. A., & Klatzky, R. (2003). Teachers' gestures facilitate students' learning: A lesson in symmetry. *Contemporary Educational Psychology, 28,* 187–204.

Werner, E., & Dawson, G. (2005). Regression in autism: Validation of the phenomenon using home videotapes. *Archives of General Psychiatry, 62,* 889–895.

Wetherby, A. M., & Prizant, B. M. (2002). *Communication and Symbolic Behavior Scales Developmental Profile–First Normed Edition*. Baltimore, MD: Brookes.

Williams, D. L., Goldstein, G., Carpenter, P. A., & Minshew, N. J. (2005). Verbal and spatial working memory in autism. *Journal of Autism and Developmental Disorders, 35,* 747–756.

Yoshioka, K. (2008). Gesture and information structure in first and second language. *Gesture, 8,* 236–255.

Downloaded From: http://jslhr.pubs.asha.org/ by a University of Hong Kong Library User on 03/19/2015
Terms of Use: http://pubs.asha.org/ss/Rights_and_Permissions.aspx