4 The Acquisition of Sign Language by Deaf Children with Autism Spectrum Disorder

Aaron Shield and Richard P. Meier

Introduction

Autism spectrum disorder (ASD) consists of a set of neurobiological developmental disorders characterized by communicative and social deficits as well as repetitive, stereotyped behaviors.[1] In this chapter, we use the terms 'ASD' and 'autism' interchangeably; although 'autism' is not a clinical term, it is the term popularly used to refer to the range of disorders found in ASD.

The language deficits of hearing children with autism are well documented, and can range from the very mild in highly fluent speakers to the very severe in children with a total absence of productive spoken language. For those children who do acquire speech, the most common characteristics of autistic language include echolalia (echoing the utterances of others), pronoun reversal, idiosyncratic language use and neologisms (the creation of new words), difficulty with pragmatics (problems interpreting the use of language in context and the non-literal use of language), and abnormal intonation and vocal quality. Although relatively little research to date has focused on the sign language deficits of deaf children with autism, in this chapter we will review what is currently known about the sign language of such children. It is worth noting from the outset that virtually all work on this population has occurred since 2010, and findings are still preliminary.

Apparent dramatic increases in the rates of autism in the general population (1 in 88 children in the United States; Centers for Disease Control, 2012)

have been widely publicized. Since autism is a brain disorder and occurs whether or not hearing is intact, it is likely that autism affects at least as high a percentage of the deaf population as the general population. Indeed, Szymanski *et al.* (2012) recently reported that 1 in 59 deaf or hard of hearing children in the 2009–2010 Annual Survey of Deaf and Hard of Hearing Children and Youth (Gallaudet Research Institute, 2011) carried an ASD diagnosis. Chess *et al.* (1978) reported that 7% of 243 students deafened by rubella had autistic symptoms, while Jure *et al.* (1991) found that 46 (4%) of a sample of 1150 children with hearing impairment also carried a diagnosis of autism. Conversely, there is evidence that severe hearing loss occurs at a higher rate in the autistic population (3.5%; Rosenhall *et al.*, 1999) than in the general population (0.3%; White, 2004).

In this chapter, we seek to introduce the community of sign language researchers to the theoretical and practical issues involved in autism research. Our aim is to describe what is known about the interaction of autism with sign acquisition, discuss how the social, cognitive and linguistic deficits of autism are likely to impact sign language acquisition, and suggest areas that may be particularly fruitful for future research.

Methodological problems

Sign language researchers interested in autism will immediately encounter a methodological hurdle in their research: no diagnostic instruments have yet been designed specifically for deaf children, although several instruments are – at the time of this writing – in the process of being adapted for use with deaf children. Still, current gold standard instruments such as the Autism Diagnostic Observation Schedule, Second Edition (ADOS-2; Lord *et al.*, 2012) or the Autism Diagnostic Interview – Revised (ADI-R; Lord *et al.*, 1994) have yet to be adapted for deaf children, and the ADOS explicitly warns against use with deaf children. Moreover, recent research has demonstrated that behavioral checklists widely used as ASD screening instruments lack sensitivity when used with deaf children: Szymanski (2010) found that only 50% of 52 deaf children with a reported diagnosis of an ASD scored in the clinically significant range on three common screeners for ASD, the Gilliam Autism Rating Scale – Second Edition (GARS-2; Gilliam, 2006), the Social Communication Questionnaire (SCQ; Rutter *et al.*, 2003), or the Social Responsiveness Scale (SRS; Constantino, 2002). It is thus possible that ASD could be under-identified in deaf children, given the lack of appropriate diagnostic and screening instruments. Accurately diagnosing a deaf child with ASD remains a formidable obstacle, and often requires the judgment of clinicians who are both expert in ASD and familiar with deaf children.

The translation and adaptation of such instruments for use with deaf children is likely to be complex, as some of the items are inappropriate for

deaf children. For example, one item on the ADOS concerns the child's response to his/her name being called by the examiner. The purpose of this task is 'to observe the consistency of the child's response to a hierarchy of auditory stimuli' (ADOS module 1, p. 2) and to see what the examiner needs to do in order to get the child's attention. It is unclear how this item would be adapted for use with a deaf child. There is no sign language equivalent of calling a child's name, although there are conventional attention-getting behaviors in the Deaf community (hand-waving, foot-stomping, or touching a person on the shoulder). How would these various behaviors be scored, and are they all equivalent to calling the child's name? Other parts of the ADOS are problematic as well, including items scoring pointing, gesture, facial expressions and intonation of vocalizations, all of which would require significant adaptation for deaf children acquiring sign. Until appropriate test instruments are published, it will remain difficult to be certain that an autism diagnosis for a deaf child is correct. Several studies have documented that diagnosis of ASD in deaf children is often delayed, if it occurs at all: Roper *et al.* (2003) found that the mean age of diagnosis in their sample of nine deaf ASD British children was 15;0 (range 5;0–16;0), compared with 7;5 (4;0–11;0) in a group of hearing autistic children. Jure *et al.* (1991) similarly reported that autism diagnosis was delayed in their sample of 46 hearing-impaired autistic children, with some children not being diagnosed until age 17. Mandell *et al.* (2005) found that diagnosis of ASD in deaf children lagged behind hearing children by approximately one year.

Although we believe that it is advantageous to expose deaf children to a visual language that is more fully accessible to them than is speech, the acquisition of sign is nonetheless likely to be challenging for deaf children with ASD. This is because some of the social skills impaired in autism are particularly crucial for the acquisition of signed language, and could lead to sign-specific linguistic deficits.

Indeed, the visual-gestural modality of sign relies crucially on a set of social, perceptual and articulatory skills that are known to be impaired in autism. We will mention three obstacles that may confront children with autism. First, hearing children with autism differ both from typically developing (TD) children and from children with other kinds of developmental delay in their limited use of gesture; children with autism produce significantly fewer gestures (Buitelaar *et al.*, 1991) and are developmentally less advanced in their use of gesture (Mundy *et al.*, 1986). Although non-linguistic gesture should not be confused with sign, sign and gesture are both articulated with the hands, and signers gesture while they sign. Could a deficit in gesture impact how deaf children with ASD acquire sign? Secondly, the perception and comprehension of visual linguistic stimuli by autistic children could be disrupted by a variety of known deficits in the areas of eye gaze, face-scanning behavior and comprehension of facial expression. Thirdly, hearing children with autism often show impairments in the ability to

imitate the body movements of others (Williams *et al.*, 2004) and exhibit a variety of motor deficits (Ming *et al.*, 2007) that could lead to articulatory problems in sign. Thus, the acquisition of sign by autistic children is likely to be affected by these social, perceptual and motoric deficits.

In the next sections, we will describe what is known about the interaction of autism with sign acquisition in both hearing and deaf children.

What is Known About the Interaction of Autism with Sign Acquisition?

Few studies have examined the signing of deaf children or adults on the autism spectrum, although there have been several case studies of deaf children with autism who do not sign. For example, Brimer and Murphy (1988) reported the case of a deaf autistic boy, but focused exclusively on his acquisition of English, and Malandraki and Okalidou (2007) described a 10-year-old deaf Greek child with autism who was trained to use the Picture Exchange Communication System (PECS; Bondy & Frost, 1994), but was not taught a sign language.

Poizner *et al.* (1990) reported a single 21-year-old deaf autistic signer who exhibited sign echolalia. Morgan and colleagues have reported extensively on the British Sign Language (BSL) acquisition of Christopher, a hearing language savant with autistic characteristics (Morgan *et al.*, 2002a, 2002b, 2007; Smith *et al.*, 2011).[2] These reports contain some of the most detailed sign language data available about a person with autism. We will discuss the findings on Christopher in a later section.

More recently, two studies in particular have investigated specific sign language structures in the signing of deaf children with autism. Denmark (Denmark, 2011; Denmark *et al.*, 2009) studied how deaf British children and adolescents on the autism spectrum produce and perceive facial grammar in BSL, while Shield (2010) and Shield and Meier (2012) analyzed formational errors in the signing of deaf American children with autism. These studies will also be described in detail in later sections.

In contrast to the few studies on the signing of deaf children with autism, there is a rich literature on the therapeutic use of signs as an alternative to speech for hearing children with severe autism. Despite the limitations of these studies, it is worth reviewing the major findings of these works, which are reported below.

Sign language and hearing children with autism

In the late 1960s, an interest developed in the ability of autistic children to learn signs – particularly children who had failed to acquire speech following intensive speech therapy. It was suggested that some non-verbal

autistic children 'complied readily if gesture or demonstration were used to convey the request' (Webster *et al.*, 1973: 338). Another paper reported, 'We have found it impossible to teach some children to speak. Yet some of these same children have learned to express themselves quite rapidly once they have been shown how to use their hands' (Stull *et al.*, 1979: 144). As a result of these early studies, sign was seen as a possible alternative communication mode for autistic children who had failed to acquire speech. Numerous studies in the late 1970s and early 1980s performed interventions with non-verbal autistic hearing children (for reviews, see Bonvillian *et al.*, 1981; Carr, 1979). These children were taught manual signs either alone or in addition to speech.

Although these papers are not sufficiently detailed to enable a proper analysis of the signs that the children produced, the results showed that some autistic children were successful at learning signs, even when previous attempts to teach spoken words had failed. Bonvillian *et al.* (1981: 128), in their review of over 20 studies involving the teaching of signs to more than 100 children with autism, note that:

> results of these studies indicate that even fairly brief simultaneous communication or sign language training can be an effective means of improving communication skills in low-functioning autistic children. Despite an extensive range of individual outcomes, almost every subject acquired the ability to comprehend trained signs.

Bonvillian *et al.* reported that the children acquired vocabularies ranging from five signs to over 350 signs, although Bonvillian and Blackburn (1991: 276) suggested in a later paper that 'statements in the literature about the sign vocabulary sizes of autistic children . . . may considerably over-represent their real working vocabularies' because most of the signs trained to criterion in such studies were not observed in spontaneous usage outside of training sessions. Still, researchers argued that signs could be advantageous over speech because children's hands can be guided and molded, and signs can be exaggerated, enlarged or frozen to allow for additional processing time (Jordan, 1990). As various researchers have noted (recently, Pizer *et al.*, 2011), deaf mothers of TD deaf children also sometimes enlarge their signs or mold their children's hands in the acquisition process.

Importantly, most of the signs acquired by these hearing children with autism were nouns, while there are contradictory claims in the literature about the ability of these children to master what Carr (1979: 353) called 'abstract sign language . . . prepositions, pronouns, and other abstractions'. A few researchers reported success: Creedon (1973) claimed that her 21 formerly non-verbal autistic subjects between the ages of four and nine achieved great success in many areas of language acquisition after an intervention employing simultaneous communication (that is, the simultaneous use of

spoken and signed English). Similarly, Bonvillian *et al.* (1981: 128) reported that 'in many cases children moved to daily production of many complex sign utterances', although it is not clear what kinds of 'complex sign utterances' were produced by these children. Indeed, any claim about the acquisition of complex structures must be looked at skeptically. As Bonvillian *et al.* (1981: 130) note:

> [the] absence of detailed records of most of the children's sign language combinations makes it impossible to determine for fairly fluent children whether there is sufficient regularity of syntax or comprehension of complex semantic aspects in the children's sign utterances to credit them with these fundamentals of language.

Thus, despite the large number of studies on the subject, the available data are insufficient to determine if sign intervention with hearing ASD children (whether using American Sign Language [ASL] or Signed English) facilitates the mastery of complex grammatical structures. For most children, the data indicate that sign learning is limited to a small number of simple signs, after which they 'make only limited progress in terms of the average length and complexity of their sign utterances' (Bonvillian *et al.*, 1981: 130).

In general, these studies provide little information about the form or use of signs produced by children with autism. Only one study (Seal & Bonvillian, 1997) looked at the form of signs produced by a sample of children with autism, all of them hearing. They analyzed the sign production of 14 low-functioning hearing autistic students (12 male, 2 female) who were enrolled at a residential school for children with developmental disorders and who ranged in age from 9;2 to 20;4 (mean age 13;8). The goal of the study was 'to determine the sign formational elements that autistic children successfully and unsuccessfully produced in making their signs' (Seal & Bonvillian, 1997: 440), with an eye towards 'uncovering associations between autistic children's signing and any underlying motor deficits' (Seal & Bonvillian, 1997: 439). Focusing on the sign parameters of handshape, location, and movement[3] (see Editor's Introduction, this volume), they analyzed 348 signs produced by the children with autism. Although there was wide variability in error rates across the participants, locations were produced more successfully (16% error rate) than either handshapes or movements (36% error rate for both). Three locations – neutral space, the chin and the torso (trunk) – accounted for nearly three-quarters of subjects' signs. The movement parameter was difficult for subjects and the source of many formational errors. Signs that exhibited a contacting action with the body were produced most accurately, while several frequently occurring movements (twisting, toward-the-body, circling and away-from-the-body) had high error rates, ranging from 43% to 53%. Also, subjects tended to add epenthetic movements – extra movements not included in the citation form

– and to reduce signs consisting of two or three sequential movements to a single movement.

The size of the students' vocabularies and their accuracy in articulating signs were highly correlated with scores on tests for fine motor age and apraxia, a neuromotor disorder that impairs the ability to perform pre-planned or voluntary motor movements. Seal and Bonvillian (1997) inter-preted this result as an indication that sign formation errors could result in part from underlying motor deficits. However, they explicitly rejected the idea that such deficits could be the sole explanation for the communicative difficulties of autistic children, allowing for the possibility that there could be cognitive and perceptual reasons for such errors as well.

A later study (Soorya, 2003) further explored the relationship between motor skills, apraxia (a motor planning disorder that results in an inability to carry out planned movements), and the acquisition of signs by hearing children with autism. In two experiments, Soorya compared 12 children with autism to TD children who were matched for either mental or chrono-logical age. She found that the children with autism performed significantly more poorly than mental-age-matched TD children on apraxia tests, but not on motor tests. However, she did not find differences between children with autism and mental-age-matched TD children on sign language production or comprehension.

Collectively, these studies on hearing children accounted for the prepon-derance of work on sign and autism until very recently. The paucity of stud-ies of deaf children – particularly studies of deaf children of deaf parents exposed to a sign language from birth – limits our ability to understand how autism affects sign language development. Two earlier studies (Bonvillian & Blackburn, 1991; Ornitz & Ritvo, 1976) reported the presence of deaf or hearing-impaired subjects within their study populations, but data from those subjects were analyzed together with the hearing subjects. Poizner *et al.* (1990) and Denmark (2011) both observed a single native deaf signer in their studies. To our knowledge, only our own study (Shield & Meier, 2012) has reported on multiple native-signing children on the autism spectrum. In studies of theoretical significance, in which the goal is to understand how autism affects cognition, it is preferable to include children exposed to sign language since birth (deaf-of-deaf children), inasmuch as deaf children of hearing parents have documented developmental and language delays (Schick *et al.*, 2007) that could obscure the effects of autism on language and cogni-tive development. Since 90–95% of deaf children are born to hearing parents (Mitchell & Karchmer, 2004), identifying and recruiting native-signing autis-tic children represents a formidable methodological challenge.

Therefore, most previous studies on the acquisition of sign by children on the autism spectrum, although useful in describing a possible alternative communication strategy for hearing children when speech training has failed, do not help us understand how the core deficits of autism interact

with language acquisition in the visual-spatial modality. A question of fundamental importance is whether the linguistic characteristics of autistic signing are the same as those of autistic speech. Identifying the characteristics of autistic signing may clarify the role of modality in language acquisition, insofar as sign and speech draw upon somewhat different sets of perceptual, cognitive and social skills. Differences in the linguistic profiles of deaf and hearing autistic children would provide strong evidence for the effects of these modality differences. In the next two sections, we will examine two of the most well documented characteristics of autistic speech – echolalia and pronoun reversals – as a way to analyze the interaction of modality with the deficits of autism.

Echolalia

Echolalia[4] is the repetition of other people's vocal productions, which can occur either immediately or with a delay. It was first reported in autistic children by Kanner (1943) and is 'the most frequently cited characteristic of verbal autistic children' (Prizant & Duchan, 1981), affecting up to 85% of the autistic children in some studies (Schuler & Prizant, 1985). All children repeat other people's utterances, and indeed imitation is a necessary building block for language acquisition. It is the extreme and exact nature of autistic children's repetitions that make them noteworthy; they may reflect a 'gestalt' approach to language acquisition (Prizant, 1983) rather than the analytic mode typical of normal language acquisition (Bloom & Lahey, 1978; Peters, 1983).

Is echolalia a modality-independent function of the autistic child's approach to language, or a specific effect of the vocal-auditory modality? Several reports of echolalia in signing children with autism suggest that it is the former. Poizner *et al.* (1990) described the signing of a 21-year-old native-signing deaf woman with autism whom they call Judith M. Despite the rich signing environment in which she was raised – her deaf parents and two elder brothers communicated exclusively in sign – Judith M. produced her first sign at age five. Poizner *et al.* (1990: 68) report a simple exchange between Judith M. and her father, in which the majority of her utterances are echolalic:

Father: Do you want to see a train?[5]
Judith M.: SEE TRAIN. [An imitation of sign just produced by her father.]
Father: First, we will…?
Judith M.: FIRST. [Imitation.]
Father: Second, we will…?
Judith M.: SECOND… STORE.
Father: Yes, we will go to the store. Third, we will…?
Judith M.: THIRD. [Imitation.]

Father: Yes, we will be home soon.
Judith M.:   HOME, SOON. [Imitation.]
Father: What will we do on Wednesday?
Judith M.:   STORE… TRAIN.
Father: That again?
Judith M.:   AGAIN. [Imitation.]
Father: Father and Judith M. will go to a store.
Judith M.:   STORE… FIRST… SECOND.
Father: In the morning, we first go to the store.
Judith M.:   FIRST. [Imitation.]

The authors indicate that Judith M. exhibited no evidence of grammatical knowledge, morphology or syntax. Her signing consisted largely of imitations of signs produced immediately before by her interlocutor. She rarely initiated communication or signed spontaneously. It is worth noting that this case study demonstrates that children raised in signing households can also have severe language problems, just as some hearing children with autism do: sign is not a panacea for children with language disorders.

There are several other mentions of sign echolalia in the literature. Smith *et al.* (2011) have reported that Christopher, upon first exposure to BSL, would often repeat signs without understanding them.[6] Of 27 deaf children with autism exposed to sign language in Jure *et al.*'s (1991) study, 21 could sign words or phrases, and five of these produced echolalic utterances. Finally, follow-up analyses of the data reported in Shield (2010) revealed that one participant, a deaf girl of deaf parents age 11;9, showed markedly echolalic signing, repeating the instructions to tasks as the experimenter signed them. For example, in introducing a task in which a novel object was labeled with a nonsense sign, the experimenter signed I INVENT SIGN, YOU-COPY-ME, YOUR-TURN. The child echoed each sign produced by the experimenter, signing back I INVENT SIGN, YOU-COPY-ME, YOUR-TURN. The fact that she did not maintain pronominal or verb agreement reference strongly implies echolalic signing without comprehension. We thus feel confident, even at this early stage, in concluding that echolalia is a modality-independent phenomenon characteristic of both autistic speech and autistic signing.

In the next section, we turn to another hallmark of autistic speech, pronoun reversal. Although pronoun reversal may be related to echolalia in some instances, there is reason to suspect that the cognitive deficit underlying pronoun reversal in autistic speech may lead to quite different effects in sign.

Pronoun reversal

Pronoun reversal – especially the reversal of the first- and second-person pronouns *I/me* and *you* – is more common in children with autism than in

any other group (Lee *et al.*, 1994). It was originally noted by Kanner (1943), who believed that the pronoun reversals found in his case studies were related to echolalia:

> [Don] always seemed to be parroting what he had heard said to him at one time or another. He used the personal pronouns for the persons he was quoting, even imitating the intonation. When he wanted his mother to pull his shoe off, he said: 'Pull off your shoe.' When he wanted a bath, he said: 'Do you want a bath?'

Since Kanner's seminal paper, pronoun reversals in the speech of hearing children with autism have been reported in many other studies (e.g. Bartak & Rutter, 1974; Charney, 1980). TD children also sometimes reverse pronouns early in development, between the ages of 1;7 and 2;4 (Chiat, 1982; Clark, 1978; Oshima-Takane, 1992; Schiff-Myers, 1983), but this is a transitory phase, and does not persist (Bartak & Rutter, 1974; Dale & Crain-Thoreson, 1993).

Several hypotheses have been advanced to explain the difficulty that many autistic children have in mastering first- and second-person pronouns. One theory has emphasized pragmatic factors, particularly 'in conceptualizing the notion of self and other as it is embedded in shifting discourse roles between speaker and listener' (Lee *et al.*, 1994; Tager-Flusberg, 1993, 1994, 2000). Thus, a child acquiring language must come to understand that the meaning of pronouns depends on who the speaker is: *I* is not a name for any particular person, but rather refers to the speaker of a given utterance. According to this hypothesis, not just pronouns but all deictic terms should cause problems for people with autism. Indeed, Hobson *et al.* (2010) found that a majority of children with autism in their sample (but not a single one of the children without autism) incorrectly referred to a location that was distal to themselves with the more proximal terms *this* or *here*, and scored significantly lower on a task in which they were asked to place toy animals either close to or distant from themselves after receiving instructions containing contrasting terms such as *this* and *that*, *here* and *there*, *bring* and *take*, and *come* and *go*.

A second hypothesis that is particularly interesting for the study of sign language is that the proper use of person pronouns could require a more general understanding of people's differing spatial perspectives. In one study, Loveland (1984) tested a group of 27 TD children between the ages of 2;0 and 3;3 on the comprehension and production of first- and second-person subject and possessive pronouns as well as the understanding of differing visual perspectives. She found that only children who demonstrated comprehension of other people's different spatial points of view made no errors on pronouns, suggesting that an appreciation of the spatial perspectives of others is a cognitive prerequisite for the proper acquisition of pronominal forms. In another

study, Ricard *et al.* (1999) tested French- and English-speaking toddlers on visual perspective-taking skills and pronoun usage. They found that performance on perspective-taking tasks was correlated with pronoun acquisition, and that the ability to coordinate two perspectives preceded mastery of first- and second-person pronouns. Thus, there is some evidence that visual perspective-taking skills underlie the pragmatic understanding necessary for the proper use of pronouns in speech. Although results have been mixed, several studies (Hamilton *et al.,* 2009; Reed, 2002; Warreyn *et al.,* 2005) have shown that children with ASD are impaired in their ability to understand the differing visual perspectives of others.

Unlike pronouns in spoken languages, which are arbitrary combinations of sounds unrelated to their meaning, pronouns in signed languages tend to be indexical points to the intended referent. Despite this transparency, there is evidence that some TD deaf children produce pronoun reversals at a stage early in development. Petitto (1987) found reversals in first- and second-person pronominal points produced by two TD native-signing deaf children between the ages of 21 and 23 months. However, she argued that these reversals were not due to a perspective-taking failure, but rather to an over-lexicalization of indexical points, effectively turning a deictic point into a frozen lexical item. In other words, the signing child interpreted the points directed at her (the ASL pronoun YOU) as her name, and would thus produce a point outwards from herself in reference to herself. This is indeed how lexical items (but not pronouns) in signed languages typically work, as Petitto (1987: 42) observed in the same paper:

> Learning signs requires that the child be able to perform a spatial transformation, such that what she produces is the mirror image of what she sees, rather than its literal form. Failure to perform this transformation would result in perceptually-based errors. . . . Essentially, the child should sign backwards.

We will return to this important observation about the nature of sign later, in our discussion of reversal errors in autistic signing.

To date, Petitto's study is the only report of pronoun reversals in sign, although Casey (2003) has reported a similar instance of a reversed verb (GIVE-YOU to mean 'give me', produced by a two-year-old TD deaf child).[7] Hatzopoulou (2010) studied the acquisition of pronouns in Greek Sign Language by one native-signing deaf Greek child between 12 and 36 months of age, but did not find pronoun errors. While it is clear that pronoun reversals in sign are possible, it is not yet clear how pervasive this phenomenon is, and whether reversals occur in sign for the same reasons they occur in speech.

There are no documented reports of pronoun reversals in the signing of deaf children with autism, though some authors have presumed (prematurely, it would seem) that pronoun reversals will occur in autistic signing, just as

in autistic speech (e.g. Collins & Carney, 2007). Some of this confusion may have stemmed from studies which have documented pronoun reversals in the *speech* of deaf children (Oshima-Takane *et al.*, 1993).

Shield (2012) analyzed the spontaneous production of pointing signs, including pronouns, by four native ASL users with autism between the ages of 4;6 and 7;5. In 20-minute samples taken from naturalistic data in his dissertation, he found that all four children produced points, and that these points included points to self (i.e. first-person pronouns), points to others (second/third person pronouns) and points to objects. Two children produced five points each, one child produced 11 points, and one child produced 25 points. He analyzed the points to self and others in discourse for intended reference but did not find evidence of reversals.

Despite the lack of documented pronoun reversals in the signing of deaf children with ASD, there may still be abnormalities in pointing behavior. In interviews reported by Shield (2010), four Deaf mothers of deaf children with autism reported abnormalities in how their children referred to themselves and to others. One mother indicated that her son would sometimes refer to himself with his name sign rather than an indexical point (pronoun), although note that she also reports correct pronominal usage:

> [My son] can point to himself as in I WANT FOOD. Before he used to sign [his sign name]. I corrected him, instructing him to not say his name and instead to point to himself. He learned that about three or four years ago [when he was between the ages of four and five]. Now he points to himself. Sometimes he alternates between pointing to himself and signing his name sign[8] . . . When he refers to us, he points a little bit, but he tends to fingerspell our names. He will sign MOMMY, fingerspell his brother's name, and sign his own name sign. He seldom points to refer to us. Occasionally, if he fights with his brother, he will point to [his brother] emphatically and yell YOU WRONG (*'you're wrong!'*). He points at his brother and doesn't sign his name. But if he comes up to me, he will use his brother's name sign instead of a point.[9]

Another mother stated that her son did not use points to refer to people, but did use points to make requests:

> I don't see pointing from [my son] at all. But long ago, when he was younger, he used to point to things to express what he wanted. For example, if he wanted something like food, he would point at the refrigerator incessantly. He used to point at things to make requests, but he stopped. Since then, I don't see him pointing.

These maternal reports are consistent with studies reporting abnormal pointing behavior in the communicative gestures of hearing children with autism

(Ricks & Wing, 1975). Baron-Cohen (1989) found that protodeclarative pointing (as in sharing or commenting on an object) is impaired in autism, though protoimperative pointing (as in requesting) is not. Other studies have confirmed that gestures used for requesting objects, actions or social routines may be present in autism (Attwood *et al.*, 1988; Loveland & Landry, 1986), while gestures sharing an awareness of an object's existence or properties are absent (Curcio, 1978; Mundy *et al.*, 1986, 1987; Wetherby, 1986).

We cannot yet say with confidence whether pronoun reversals are characteristic of the signing of deaf children with autism, or indeed if they occur at all. However, converging findings in the areas of gesture imitation and sign language acquisition suggest that the same cognitive deficits that underlie pronoun reversal in hearing children with autism will affect various levels of structure in sign, from the sub-lexical to the morphological. In the next section, we will provide evidence for this hypothesis from studies on gesture imitation in autism, and then proceed to more recent work on acquisition of sign by deaf children with autism.

Imitation of gestures in autism

Children with autism are impaired in their ability to imitate others, although the exact nature of this impairment, as well its underlying cause, has occasioned much debate. Most studies on the subject have found an imitation deficit in autistic subjects (although a few studies have not; e.g. see Morgan *et al.*, 1989). DeMyer *et al.* (1972) found that children with autism were impaired in their ability to imitate the bodily actions of others as well as motor-object actions, such as stringing beads. Curcio (1978) found that non-verbal children with autism between the ages of four and 12 performed poorly on gestural imitation, a finding that has been replicated in other studies (e.g. Dawson & Adams, 1984).

These deficits have led to different accounts of what underlies the imitation impairment in autism. Smith and Bryson (1994: 262), in their review of 15 studies of the imitation skills of autistic children, commented that these studies 'provide some support for the existence of a specific imitative deficit in autism but are uninformative as to its nature.' In another review of 21 studies of imitation by autistic subjects, Williams *et al.* (2004) concluded that of the six major theories advanced in the literature about the nature of the imitation deficit in autism, a specific deficit in self-other mapping ability (Rogers & Pennington, 1991) was most consistent with the evidence presented. Self-other mapping refers to the process(es) by which children or adults are able to observe the movements of others and map those observed movements onto their own bodies, thus reproducing the movements accurately.[10]

The most compelling evidence for this theory is the striking finding of a number of studies (Brown, 1996; Hobson & Lee, 1999; Ohta, 1987; Smith &

Bryson, 1998; Whiten & Brown, 1998) that when autistic children attempt to imitate the arm and hand movements produced by others, they sometimes reverse palm orientation and the direction of these arm movements. Ohta (1987) was the first to report such errors (which he called 'partial imitations') in imitations of gestures. Children with autism showed a tendency to imitate a wave-like gesture in which the experimenter's open palm was oriented toward the child with a gesture in which the palm was oriented inward toward the child him/herself. Later, Smith and Bryson (1998) found that children with autism made significantly more 180° reversal errors in palm orientation than age-matched language-impaired and TD children in the imitation of eight ASL handshapes and eight bimanual gestures.

These errors appear to be unique to autism. They have been observed in a variety of contexts, including the imitation of object-related actions, pantomimes, and meaningful and meaningless gestures. Like the spoken language pronominal reversals discussed earlier, these errors may reflect a general ability to imitate words and gestures but a specific difficulty with the shifts in perspective needed to use spoken language pronouns correctly or to imitate manual gestures accurately. Instead, children with autism tend to replicate bodily movements as observed from their own point of view, not as they are produced by the person they are attempting to imitate. This finding has clear implications for the acquisition of sign by deaf children with autism, since palm orientation and direction of arm movements have linguistic value in sign. For example, the ASL signs PAPER and CLEAN vary only in the direction of movement of the dominant hand. If the sign-learning child reproduces a sign's direction of movement as observed from his own perspective, such an error could lead to an unintended meaning. This outcome could also arise with pairs of signs that differ primarily or solely in their palm orientation, such as the ASL signs TUESDAY (palm inward) and TOILET (palm outward); see Figure 4.1.

There is evidence that indeed, the same reversal errors found in the imitation of gesture by hearing children with autism also appear in the production of signs by deaf children with autism. These errors will be described in the next section.

Reversal errors in autistic signing

In the first linguistic studies of native-signing children with autism, Shield (2010) and Shield and Meier (2012) found palm orientation and movement reversals in the signing of such children. In a series of experiments, they observed 10 native-signing children (nine deaf children and one hearing child of deaf parents, or CODA; ages 4;7–16;3) who had been diagnosed with an ASD. Naturalistic observation revealed that three of the younger children produced numerous articulatory errors in interaction with their teachers or parents, particularly reversals in palm orientation from inward to outward,

Figure 4.1 The ASL signs TUESDAY (left) and TOILET (right)

and vice versa. Shield also performed a series of experiments designed to elicit lexical signs and ASL-like nonsense signs that could lead to perspective-taking reversal errors. Although the small sample size did not yield results of great statistical power, Shield found that four of the younger children (all under the age of 10) produced inward-outward palm reversals in elicited fingerspelling, spontaneous and elicited lexical signs, and imitated nonsense signs. These types of palm orientation reversals do not appear to occur frequently in the typical acquisition of signed languages by deaf children.

Of the experimental tasks, the fingerspelling task (reported in Shield & Meier, 2012) yielded the most robust results. This task consisted of showing children a series of 10 English words (*bed*, *table*, *watch*, *telephone*, *cap*, *chair*, *door*, *shoes*, *book* and *scissors*) on cards and asking them to fingerspell those words. Three out of four young ASD subjects showed a robust tendency to fingerspell with an inward palm orientation, despite the fact that fingerspelling in ASL is in general articulated with an outward orientation. One child (age 5;8) reversed 20 of 28 fingerspelled letters (71%), another child (age 6;6) reversed 26 of 43 fingerspelled letters (61%), and the third child (age 7;5) reversed 27 of 57 fingerspelled letters (47%). A search of the literature on the acquisition of the fingerspelling system of ASL (Padden, 1991, 2006; Padden & Lemaster, 1985) found no reports of such errors. None of the 13 TD deaf children in the control group produced any fingerspellings with reversed palm orientation.

Shield and Meier considered whether the source of the palm orientation errors observed could be purely articulatory (i.e. whether the errors could be attributed to a physiological rather than a perceptual deficit). However, the subjects produced fewer errors on the handshape parameter, which is typically mastered latest in development (Cheek *et al.*, 2001; Clibbens & Harris, 1993; Karnopp, 1997; Marentette & Mayberry, 2000; Meier, 2006; Siedlecki & Bonvillian, 1993; Takkinen, 2003; von Tetzchner, 1984), than on the palm orientation and movement parameters. Moreover, in naturalistic observation and in lexical elicitation these same children also produced outward palm

orientation reversals on signs specified for inward palm orientation (e.g. ASL BUTTERFLY), demonstrating that the children were capable of producing outward palm orientations. Finally, these errors are unlike those found in disorders of neuromotor control: the only palm orientation errors observed in, for example, Parkinsonian signers involved the substitution of a neutral palm orientation toward the midline for an upward/downward palm orientation (Brentari *et al.*, 1995). Nor have inward-outward palm substitutions been found in reports of sign language paraphasias: Chiarello *et al.* (1982) reported two orientation errors in a signer with a left-hemisphere lesion, both involving substitution of an orientation toward the midline for an inward-facing orientation. It thus appears unlikely that motor difficulties could be the sole source of these errors.

The palm orientation errors produced by deaf signing children with autism are striking for a number of reasons: they are virtually unattested in the literature on the typical acquisition of signed languages past 18 months of age, they do not appear to be the result of articulatory difficulty, and they are suggestive of a self-other mapping error. These errors, therefore, have the potential to shed light on the cognitive processes of the autistic child in learning to represent signs mentally, although more work needs to be done in order to identify the individual cognitive processes involved. On a clinical note, these errors may serve as a marker of autism in signing children.

While the role of perspective-taking is most obvious in deictic constructions in spoken languages, it impacts the structure and acquisition of signed languages at many levels. Shield and Meier found reversal errors at the sub-lexical level, as described above, but Morgan *et al.* also found reversal errors in verb agreement and spatial classifier constructions in the signing of Christopher. Despite his abilities in learning other morphosyntactic constructions, Christopher had persistent problems in producing the correct direction of movement on inflecting verbs (such as HELP in British Sign Language) that change direction depending on their argument structure: in trying to copy his teacher's signing of 'you help me', Christopher produced the equivalent of 'I help you', reversing the direction of movement (Morgan *et al.*, 2002a). It is not clear, however, whether Christopher reversed the direction of movement so as to preserve the semantics of the phrase or because of a perceptually based error (a failure to shift perspectives). Shield and Meier did not test verbs in their study, so it remains to be seen whether native-signing deaf children with autism have difficulty with verbs in which the direction of movement changes depending on their argument structure.

Returning to the earlier discussion of pronoun reversals, we now have reason to hypothesize that pronoun reversals may not occur frequently in the signing of autistic children, or at least not for the same reasons they occur in speech. Why would children who have a deficit in self-other mapping not reverse sign pronouns? Reversing pronouns in speech entails repeating pronouns exactly as they are spoken to the child: the child repeats 'you'

as spoken by their conversation partner, failing to change the pronoun to 'I' or 'me'. Yet the studies on gesture imitation and lexical phonology discussed above suggest that children with autism sometimes do not reproduce signs exactly as produced by their conversational partners, but instead reproduce signs as observed from their own perspective. This could lead the signing autistic child to reproduce the pronoun YOU addressed to him as ME – in other words, the correct pronoun. Although more research is needed to test this hypothesis, the available evidence suggests that the deficit underlying pronoun reversals in autistic speech may manifest in sign language as palm orientation and movement reversals, rather than pronominal reversals per se. This may be a possible difference in the linguistic manifestations of autism in sign and speech.

We have thus demonstrated how two of the hallmarks of autistic speech – echolalia and pronoun reversal – manifest in autistic signing. Echolalia appears to be modality independent, insofar as there is already evidence from several different studies that signing children with autism produce echolalic signed utterances, much like hearing children with autism do in speech. However, at the time of this writing there is no evidence of pronoun reversals in the signing of children with autism. There is ample evidence in the literature for palm and movement reversals in gesture imitation by hearing and deaf children with autism, and for palm reversals in the spontaneous and elicited signing and fingerspelling of native-signing children with autism. These errors are suggestive of a deficit in understanding the relationship between self and other as it is embodied and reflected in language.

Joint attention, eye gaze and facial grammar

One of the most interesting aspects of sign language acquisition that is likely to be affected by ASD is facial grammar. In this section, we will discuss the linguistic consequences for signed languages of autistic deficits in eye gaze, attention and face processing. We will then proceed to a discussion of facial grammar – the encoding of linguistic information on the face in signed languages – and discuss recent work testing the abilities of autistic signers in this area.

Children with autism are impaired in the ability to engage in dyadic interactions (Leekam & Ramsden, 2006), resulting in fewer episodes of joint attention (Curcio, 1978; Loveland & Landry, 1986; Mundy et al., 1986; Sigman et al., 1999). Joint attention is positively associated with language development (Charman et al., 2003) and is thought to be a fundamental building block in the acquisition of word meanings (Tomasello & Farrar, 1986). Such an impairment could reflect a general deficit in the ability to orient to social as opposed to non-social stimuli (Dawson et al., 1998; Leekam & Ramsden, 2006; Leekam et al., 2000). Here we encounter an interesting

difference between sign and speech: in sign the linguistic stimulus cannot be isolated and separated from the person producing it, while in speech the linguistic stimulus can in fact be perceived without attending to the person producing it. In other words, hearing children with autism can perceive speech without looking at the person speaking, whereas deaf children with autism cannot perceive sign without looking (at least peripherally) at the person signing.

The implications of communicating in the visual modality are broad. Deaf children with autism may face challenges in learning the meanings of signs. Bloom (e.g. Bloom, 2002) has shown that hearing children's ability to learn words is related to an ability to follow other people's gaze, and thus understand the referential intent of their interlocutor. For example, if a child is looking at an object and an adult simultaneously utters a label, a TD child will consult the adult's gaze to confirm that the adult intended to label the object in the child's gaze, and not a different object. In other words, children are more likely to make mappings between words and objects when they are able to infer that the people uttering these words intend to refer to such objects (Baldwin *et al.*, 1996; Bloom, 2002). Yet children with autism do not appear to learn words like TD children. In one study (Baron-Cohen *et al.*, 1997a), children with autism were tested to see if they consulted a speaker's direction of gaze in word-object mappings. They found that TD children only learned to associate a word with an object if the speaker looked at the object in question while labeling it. Children with autism, on the other hand, made significantly more mapping errors when the speaker's gaze was discrepant with the label, showing that unlike normal children, they were relatively insensitive to a speaker's gaze direction as an index of the intention to refer.

We expect that deaf children with autism will make similar mapping errors in the learning of sign labels for objects. However, to date there have been no studies testing this hypothesis. Furthermore, there could be interesting differences between deaf and hearing children with autism since sign labels are unimodal (a visual linguistic stimulus is mapped to a visual object) while spoken labels are intermodal (an acoustic linguistic stimulus is mapped to a visual object). This represents a fruitful area for future research.

The autistic impairment in joint attention and in the gauging of referential intent has implications for the learning of symbols in both sign and speech. However, a deficit in face processing has unique linguistic consequences in sign (although it may also disrupt the comprehension of pragmatic aspects of speech). Signed languages encode a variety of grammatical structures on the face, including questions (Baker, 1983), relative clauses (Liddell, 1980), conditionals (Liddell, 1986), topics (Coulter, 1979), and adverbial and lexical information (Anderson & Reilly, 1999; Liddell, 1980). A number of studies have shown that skilled deaf signers fixate on the face rather than the hands while perceiving sign language (e.g. Agrafiotis *et al.*, 2006).

Yet children with autism have documented deficits in attending to and recognizing information from the face (Dawson *et al.*, 2005; Klin *et al.*, 1999; Schultz *et al.*, 2003), as well as deficits in the comprehension (Baron-Cohen *et al.*, 1993; Capps *et al.*, 1992; Grossman & Tager-Flusberg, 2008; Lacroix *et al.*, 2009; Rump *et al.*, 2009) and imitation (e.g. Hertzig *et al.*, 1989; Loveland *et al.*, 1994) of affective facial expressions. Several research studies have shown that the face scanning behavior of autistic individuals differs from that of non-autistic individuals (Dalton *et al.*, 2005; Klin *et al.*, 2002; Pelphrey *et al.*, 2002). Pelphrey *et al.* (2002) compared the visual scan paths of autistic adults and non-autistic controls, finding that the scan paths of the autistic group were undirected whereas the scan paths of control subjects focused on a triangle between the eyes, nose and mouth.

Several other studies of face gaze by hearing autistic subjects are suggestive of how deaf children with autism may process facial grammar. Joseph and Tanaka (2003) tested autistic and TD subjects' ability to recognize facial features that were presented in isolation or in an image of the whole face. Only the TD group showed a whole-face advantage, whereas the autism group demonstrated a mouth advantage and was impaired in recognizing the eyes. Other studies have reported similar findings: Spezio *et al.* (2007) compared nine high-functioning adults with autism to IQ-matched controls on face gaze behavior and found that the autistic adults relied on information from the mouth region while neglecting the eye region. Finally, Baron-Cohen *et al.* (1997b) analyzed autistic recognition of basic emotions and complex mental states based on whether subjects were shown pictures of whole faces, the eyes alone or the mouth alone. When compared to normal subjects, adults with Asperger's syndrome showed a significant impairment in recognizing complex mental states (such as *scheme* or *distrust*), particularly in the eyes-alone condition, indicating a difficulty in interpreting facial expressions signaled by the eyes.

These impairments pose a unique problem for the deaf child with autism acquiring sign, since the eyes and mouth sometimes encode different linguistic information (Sandler, 2009; Wilbur, 2000). For example, in ASL the mouth can encode lexical information (as in the sign NOT-YET, which is differentiated from the sign LATE by a mouth movement alone), adverbial information (e.g. a protruding tongue accompanied by exhalation 'THH' indicates carelessness when produced with a verb; Liddell, 1978), and adjectival information (e.g. puffed cheeks to indicate large size). The eye region is key for the signaling of questions (with raised or furrowed eyebrows), topicalized noun phrases, and conditionals. If deaf children with autism are impaired in their ability to gain/process information from the eye region but not the mouth, then this could differentially impact linguistic structures encoded in the eye region.

There is still relatively little work examining the eye gaze or facial processing ability of deaf people with autism. The study by Poizner *et al.* (1987) reported that Judith M. stopped making eye contact at the age of 11 months,

did not vary her facial expressions and did not respond to the facial expressions of others. Smith *et al.* (2011) reported that Christopher initially avoided eye contact with his conversational partner while learning BSL, although he soon overcame his reluctance. He also did not produce appropriate question facial markers during the repetition or spontaneous production of question sentences. Based on these few reports, and given the wide variability found in the severity and symptoms of autism, it appears likely that there will be wide variability among deaf children with autism in terms of their ability to make eye contact, to infer referential intent through the following of gaze, and to comprehend and produce grammatical and affective facial expressions. It is also possible that sign language exposure could help mitigate some of the face processing deficit in autism, as deaf signing children and hearing signing adults have both been found to have a face processing advantage compared to non-signers on the Benton Facial Recognition Test (Bellugi *et al.*, 1990; Bettger, 1992).

In Shield's (2010) interviews with Deaf mothers of deaf children with autism, the mothers reported that their children were able to comprehend non-manual markers but were limited in their ability to produce grammatical facial markings. One mother remarked:

> I don't see a lot of facial expressions in [my autistic son], compared with [my non-autistic son] … [My autistic son] is more expressionless when he signs. He points to what he wants, just communication for basic needs. He doesn't elaborate his point with facial expressions … I think he can understand facial expressions, but he can't express them. Does he realize that facial expressions are an important part of communication? I don't know. [My non-autistic son] knows that, but for [my autistic son], I don't know. I'm not sure.

The mothers also reported a deficit in their children's ability to produce facial morphemes, such as the question-marking facial expression used for Wh-questions:

> On the WHY question, [my son] doesn't produce the lowering eyebrows and squinting eyes. No. Like the WHERE question, he doesn't produce the raising eyebrows and widening eyes.[11] No.

These reports, although anecdotal, are interesting because they indicate that facial grammar may be difficult for deaf children with autism, even those with native exposure from birth.

Recent studies by Denmark and colleagues (Denmark, 2011; Denmark *et al.*, 2009) provide the only systematic data available on the use of the face by deaf signers with autism. Denmark (2011) investigated deaf autistic signers' face and emotion recognition abilities as well as their comprehension

and production of grammatical and affective facial markers in BSL. She compared a group of 13 deaf children and adolescents with autism (age range 8;5–18;0, $M = 12;6$) to a group of 12 TD deaf children ($M = 11;8$). The groups were matched for chronological age, BSL proficiency and non-verbal ability. Only one of the deaf subjects was a native signer with deaf parents. She found that the deaf ASD signers showed a mixed profile of abilities; however, overall they did not show characteristic impairment in their comprehension and production of linguistic and affective facial expression, as might have been expected.

The deaf ASD group showed strengths in several areas. First, deaf ASD subjects did not differ significantly from controls on the Benton Facial Recognition Test (BFRT; Benton, 1983), unlike hearing autistic subjects who demonstrate impaired performance on the BFRT. Second, on a task designed to elicit emotional facial expressions, ASD subjects were only slightly worse than controls at reproducing observed facial expressions, and there was no statistical difference in the number of expressions produced by the two groups, despite the fact that prior studies have shown that hearing children with autism produce fewer facial expressions than TD hearing children (Bieberich & Morgan, 1998; Muller & Schuler, 2006; Yirmiya et al., 1989) and their facial expressions have also been judged as more unusual or odd than those of controls (Macdonald et al., 1989; Volker et al., 2009). Third, on a task designed to elicit linguistic and affective facial expressions, ASD signers were not significantly impaired in the frequency with which they produced facial expressions, although they were impaired in terms of quality, producing fewer expressions that were judged by raters as identical to stimuli than the control group. Fourth, on tasks designed to test comprehension and production of negation and question facial expressions in BSL, the ASD group was not impaired relative to controls on the comprehension or production of either type of linguistic facial marker. As an explanation for these surprising findings, Denmark suggested that the attention to faces needed to perceive sign language forces attention to faces during development, leading to improved facial recognition ability. On a related note, other studies have found that native exposure to a sign language leads to enhanced visuospatial abilities (cf. Bosworth & Dobkins, 2002).

The ASD group did show several weaknesses, however. On an emotion recognition task, the deaf ASD group performed significantly worse than the deaf control group. Denmark concluded that this finding suggests that deaf ASD subjects glean less affective information from the face than deaf controls. Furthermore, she hypothesized a connection to an autistic deficit in prosody (Baltaxe & Guthrie, 1987; McCann & Peppé, 2003; Peppé et al., 2006; Tager-Flusberg, 1981), since affective facial expressions produced during signing could be akin to prosodic elements of speech (Dachkovsky & Sandler, 2009).

The second weakness Denmark found was on tasks designed to test the comprehension and production of adverbial facial expressions. TD deaf

children were more accurate than the ASD group in comprehending adverbial facial expressions. Furthermore, the ASD group was less accurate at comprehending adverbial facial expressions when unaccompanied by a manual sign. On the production task, moreover, the ASD group produced fewer adverbial facial actions than controls. Thus, Denmark concluded that deaf people with autism may be specifically impaired in their ability to comprehend and produce adverbial facial markers. We would like to see more research that investigates this important topic.

Taken as a whole, Denmark's study represents the first attempt to understand how a known social deficit in autism – a deficit in face processing and in the comprehension and production of facial expression – impacts specific grammatical structures encoded on the face in a signed language. Surprisingly, her studies did not find evidence of a primary impairment in face processing that has linguistic effects on the use of facial expressions in BSL. Rather, she argued that the pattern of spared and impaired abilities in deaf autistic signers can be explained by deficits in emotional understanding. However, we must be cautious in generalizing from her findings. Only one of her subjects was a native BSL signer. More importantly, her participants were far beyond the typical age of acquisition for the various facial structures that were tested (4:0 for negation, 5:0 for adverbials and 6:0 for questions in ASL; Mayberry & Squires, 2006). More studies of younger subjects with autism will be needed in order to understand how grammatical facial expressions develop. Finally, her study only included children with high-functioning autism; five deaf children with severe autism who had insufficient signing skills were excluded from the study. Nevertheless, her surprising findings suggest that repeated exposure to a sign language may counteract underlying social deficits in autism and that at least some deaf children with autism are capable of acquiring facial grammar.

Conclusions and Future Directions

Research into the sign language development of children with autism is still in its infancy. We have described initial investigations into this area which, despite being suggestive of interesting interactions between autism and communication using the visual-gestural modality, need to be confirmed by future studies.

Although it is still too early to be able to make recommendations for clinicians and school psychologists with much confidence, the studies currently available do suggest a few implications for clinical practice. First, the finding of palm reversals in the signing of deaf children with ASD is a rare occurrence of a 'positive' symptom of ASD – that is, the presence of a phenomenon rather than the absence of a skill. As such, it may be particularly useful for parents and clinicians alike in signaling a possible ASD. Secondly,

since perspective-taking appears to be problematic for children with ASD, parents, teachers and clinicians may find it helpful to sit beside the child, rather than opposite him or her, while signing or providing therapy to a deaf child with ASD.

As for a future research agenda, we envision several major areas where future research could be fruitful:

(1) Further research on facial grammar and eye gaze behavior, including eye-tracking studies. Studies of younger subjects in particular are needed. Such studies may depend on earlier identification of ASD in deaf children.
(2) Further research on structures in sign language grammar that require self-other mapping, including pronouns, verb agreement, classifier constructions and role shift. In particular, we currently cannot say whether the pronoun reversals that are so typical of autistic speech are also found in autistic signing.
(3) Research into the relation between non-linguistic cognitive skills, such as theory of mind, inter-subjective identification and motor imitation, and the acquisition and development of sign language structures.
(4) Longitudinal studies that document sign language development over time. Such studies could help clarify the developmental trajectory of language development in autism and the nature of developmental delay in autism.
(5) Bilingual studies of hearing children exposed to sign language and speech from birth (CODAs), which may be able to reveal important modality differences between sign and speech development. In particular, we believe that a study of pronoun use in a bilingual CODA with autism may be of special interest, since pronoun reversals are so characteristic of autistic speech but have yet to be documented in autistic signing.

The first goal of such a research agenda must be the **documentation** of the comprehension and production skills of native and non-native signing children. As we have argued in this chapter, the characteristics of autistic signing will likely differ in certain key ways from the characteristics of autistic speech. We cannot yet say with certainty whether all the hallmarks of autistic speech will also be found in the signing of deaf children with autism. Cross-linguistic studies into different signed languages will be helpful for confirming phenomena that are general to the modality, or identifying language-specific phenomena.

In the documentation process, several methodological considerations must be carefully attended to. First, utmost care must be taken in the **selection** of subjects. The diagnosis of autism must be confirmed carefully using appropriate instruments. However, as we have already pointed out, the lack of sign language translations of the current gold standard instruments poses

a significant challenge to both clinicians and researchers. We thus suggest a multifaceted approach, using the available screening and diagnostic instruments with appropriate adaptations made for deaf children. It is crucial that children be evaluated by clinicians who are familiar with deaf children and are aware of the modality differences that exist between sign and speech, as well as the different social norms of Deaf culture.

A related issue is the careful **matching** of ASD subjects to subjects without ASD (both TD and with other developmental disorders). In particular, subjects should be matched for chronological age, language age, and/or nonverbal intelligence, depending on the research question.

Measures of motor skills should be taken in studies of autistic signing, so as to properly identify whether errors observed have a perceptual or motor origin. Ming *et al.* (2007) found various motor problems in a sample of 154 ASD children, including hypotonia (51%), motor apraxia (34%), toe-walking (19%) and gross motor delay (9%). Since sign language entails both gross and fine motor movements, such impairments are likely to impact how deaf children on the spectrum acquire sign.

Once there is sufficient documentation of autistic signing, these studies should be used in the **adaptation** of existing gold-standard diagnostic instruments for use with deaf children (e.g. the ADOS and ADI-R), and the **development** of appropriate sign language educational strategies and interventions. The translation of diagnostic instruments into various signed languages will in itself be a large undertaking, and will require careful consideration of differences between the visual-gestural and vocal-auditory modalities, as well as the heterogeneity of the deaf population (i.e. age of exposure to language, sign versus oral speech training, amplification and cochlear implantation, comorbidities, etc.).

Research into sign language development of deaf children on the autism spectrum has the potential to shed light on issues of interest well beyond the community of scientists who work on signed languages. In particular, in observing language acquisition in the visual-gestural modality, there is an opportunity to test hypotheses about the nature of the autistic phenotype and the core cognitive mechanisms underlying autistic impairments. Signed languages rely crucially on a set of social skills known to be impaired in autism, and careful study of deaf children on the spectrum could clarify the nature of cognitive deficits in autism, as well as the relationship between social skills and language development. Thus, despite the considerable methodological difficulties that we have highlighted, we hope that researchers will feel encouraged to pursue studies in this area. We believe that such research is feasible (albeit methodologically complex), and could benefit deaf and hearing children on the autism spectrum, as well as the Deaf community, the scientific community and society at large, by contributing insights about the nature of autism, and its complicated effects on cognition and language.

Notes

(1)   Until DSM-5, subcategories of ASD included autistic disorder, Asperger's disorder, and pervasive developmental disorder-not otherwise specified (PDD-NOS).

(2)   Although he lacks an official diagnosis, the authors cite Christopher's aversion to eye contact and social interaction as well as his consistent failure on false-belief tasks as evidence of his autism.

(3)   Seal and Bonvillian did not examine palm orientation as a separate parameter.

(4)   We use the term 'echolalia' (the automatic imitation of the vocalizations of others) here rather than 'echopraxia' (the involuntary imitation of the body movements of others) because of the linguistic nature of the signs being imitated. Both echolalia and echopraxia have been documented in hearing autistic children.

(5)   Note that Poizner *et al.* translated the father's ASL signing into English. Thus, despite the translation, there would have been no indefinite article in this first sentence. Consequently Judith appears to have echoed the last two signs of her father's utterance verbatim.

(6)   To our knowledge, there is no report of whether or not Christopher was echolalic in his production of spoken languages.

(7)   It is unclear whether this example is truly an instance of verb reversal or merely an uninflected citation form of the verb give. Indeed, homonymy or near-homonymy of citation forms and 1st-to-2nd person inflected forms presents a serious methodological problem in detecting verb agreement reversals in sign.

(8)   A name sign is a sign that is used to uniquely identify a person, like a name.

(9)   Translated from ASL to English by Lynn Hou.

(10)   Some authors have argued that the mirror neuron system of the brain, through which children match their movements to those observed in others, is impaired in ASD (cf. Dapretto *et al.*, 2005; Iacoboni & Dapretto, 2006).

(11)   Note that this mother's description of the facial marking for the ASL question word where conflicts with the standard facial marking reported in the literature (Baker, 1983; Baker-Shenk & Cokely, 1991).

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