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The Signing of Deaf Children with Autism: Lexical Phonology and Perspective-Taking in the Visual-Spatial Modality

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The Signing of Deaf Children with Autism: Lexical Phonology and Perspective-Taking in the Visual-Spatial Modality

by

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Dedication

For

Rosangela, Mei, and Christine – Supermoms of the first degree

and

because of Jarvis – *sine qua non*

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The Signing of Deaf Children with Autism:

Lexical Phonology and Perspective-Taking in the Visual-Spatial Modality

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This dissertation represents the first systematic study of the sign language of deaf children with autism. The signing of such children is of particular interest because of the unique ways that some of the known impairments of autism are likely to interact with sign language. In particular, the visual-spatial modality of sign requires signers to understand the visual perspectives of others, a skill which may require theory of mind, which is thought to be delayed in autism (Baron-Cohen et al., 1985). It is hypothesized that an impairment in visual perspective-taking could lead to phonological errors in American Sign Language (ASL), specifically in the parameters of palm orientation, movement, and location.

Twenty-five deaf children and adolescents with autism (10 deaf-of-deaf and 15 deaf-of-hearing) between the ages of 4;7 and 20;3 as well as a control group of 13 typically-developing deaf-of-deaf children between the ages of 2;7 and 6;9 were observed in a series of studies, including naturalistic observation, lexical elicitation, fingerspelling, imitation of nonsense gestures, two visual perspective-taking tasks, and a novel sign learning task. The imitation task was also performed on a control group of 24 hearing, non-signing college students. Finally, four deaf mothers of deaf autistic children were interviewed about their children's signing. Results showed that young deaf-of-deaf autistic children under the age of 10 are prone to making phonological errors involving the palm orientation parameter, substituting an inward palm for an outward palm and vice versa. There is very little evidence that such errors occur in the typical acquisition of ASL or any other sign language. These results indicate that deaf children with autism are impaired from an early age in a cognitive mechanism involved in the acquisition of sign language phonology, though it remains unclear which mechanism(s) might be responsible. This research demonstrates the importance of sign language research for a more complete understanding of autism, as well as the need for research into atypical populations for a better understanding of sign language linguistics.

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Chapter 1: Introduction

This dissertation is concerned with the intersection of sign language and autism. These two phenomena are similar in that they have only recently become the object of real scientific interest and inquiry; the intersection of the two has received very little scrutiny at all. In all other aspects they are dissimilar: autism is a cognitive disorder, while signed languages are natural languages of a cognitively normal subpopulation of the human species, the deaf. I mention this at the outset lest anyone mistakenly think that sign language is itself a form of disordered communication, or that deaf people are cognitively disabled by virtue of their inability to hear; such an assumption, though long believed to be true by most – as we shall see – has been belied by decades of linguistic research. This dissertation is an attempt to start to bridge the gap between the formal study of signed languages by linguists on the one hand, and the study of autism spectrum disorders (ASDs) by developmental psychologists and psychiatrists on the other hand.

1.1 A Brief History of Sign Linguistics

Until William Stokoe's seminal work, *A Dictionary of American Sign Language on Linguistic Principles* (Stokoe, 1960), the signed languages of the deaf were not considered languages at all, and thus were deemed unworthy of the attention of linguists. Prior to Stokoe, some of the most pre-eminent linguists in the world had characterized sign as little more than collections of pantomimic expressions lacking the structure of spoken languages. Leonard Bloomfield, one of the founders of the Linguistic Society of America, remarked in 1933 that

> Some communities have a gesture language which upon occasion they use instead of speech… It seems certain that these gesture languages are merely developments of ordinary gestures and that any and all complicated or not immediately intelligible gestures are based on the conventions of ordinary speech. (39)

Many others, too, believed that the vocal-auditory modality of speech was an essential characteristic of language. Nearly all definitions of language prior to Stokoe included the vocal-auditory modality as a prerequisite for language. In his paper "The Field of Linguistics", Trager (1949) wrote: "A language is a system of arbitrary *vocal* symbols by means of which the members of a society interact in terms of their total culture." The *Introductory Linguistics* textbook by Hall (1964) declared that "language is the institution whereby humans communicate and interact with each other by means of habitually used *oral-auditory* arbitrary symbols" [italics mine]. Perhaps most famously, Hockett (1960) described 13 essential "design features" thought to characterize every human language; the first feature was the vocal-auditory modality, which he described as "the most obvious" of the design features (6).

It is remarkable in itself that all of these great thinkers were wrong. Stokoe showed that American Sign Language (ASL) is indeed a language, endowed with many of the characteristics and structures that characterize spoken languages. Perhaps most importantly, he demonstrated that manual signs are not holistic symbols, but are rather made up of smaller meaningless sub-components, just as words in spoken languages are made up of individual sounds, which on their own are devoid of meaning. This *duality of patterning* is an essential characteristic of all human languages; once ASL was shown to exhibit this duality, it was no longer possible to believe that signed languages were nothing more than elaborate mimetic systems having little in common with speech.

In the years that followed, linguists began to systematically study signed languages in an attempt to discover their properties. There have been studies in all subfields of linguistics, including syntax (e.g., Liddell, 1980; Neidle, Kegl, MacLaughlin, Bahan, & Lee, 2000), morphology (e.g., Klima & Bellugi, 1979), phonology (e.g., Brentari, 1998; Sandler, 1989), and psycholinguistics (e.g., Emmorey, 2002; Marentette & Mayberry, 2000; Marschark, 1998; Mayberry, 1993; Newport, 1990). Although ASL and the signed languages of Western Europe have received the lion's share of attention, in recent years there has been a concerted effort to describe and analyze signed languages from around the world, with notable work being conducted in Asia, South America, and the Middle East.

Because sign was thought to be inferior to speech for so long, early studies often sought to the similarities between the two, in line with a more general search within the field of linguistics for universals of human language. However, the role that modality plays in language can no longer simply be viewed as incidental. Although both sign and speech have a common linguistic origin in the brain, their manifestations in the physical world are different. The visual-spatial modality of sign facilitates certain kinds of expression just as the vocal-auditory modality of speech facilitates others. The physical facts of these two modalities are likely to affect the linguistic structure of sign and speech, and in recent years attention has turned to these modality-specific differences. For example, much has been made of the tendency for "simultaneous" rather than "sequential" morphology in signed languages (e.g., Aronoff, Meir, & Sandler, 2005; Sandler & Lillo-Martin, 2006; Stokoe, 1980). The articulators in sign (the arms) are larger and slower than the speech articulators (the vocal tract); this fact may account for a general compacting of information and the simultaneous articulation of morphemes on the face and hands (Klima & Bellugi, 1979). Today, much remains to be learnt about how modality interacts with language. Indeed, any serious inquiry into linguistic universals must now take modality into account, since some presumed universals could turn out to be modality-specific. It is precisely in this shadowy area that my interest lies. This dissertation aims to engage questions about how signed languages are acquired by children with autism, and how the specific cognitive impairments in autism may affect the acquisition of sign in ways that are different from the acquisition of speech. In other words, what does the deaf child with autism need to do in order to learn a signed language? What skills does he or she need, and are these skills the same as the hearing child learning speech? The short answer is that the skills needed are clearly different. How different, and how exactly autism affects these skills, is a more difficult question.

1.2 Motivation for this research

This dissertation is motivated by both theoretical and practical factors. First, and perhaps most obviously, the population of deaf children with autism has never before been studied. Just as the early years of sign language inquiry were largely devoted to finding commonalities between sign and speech, so too has most research primarily focused on typical development. Furthermore, although a great deal is now known about how typically-developing deaf children acquire signed languages, the linguistic development of multi-handicapped deaf children remains largely unexplored, with few exceptions, such as Woll and Grove (2004), who looked at the sign language acquisition of hearing twins with Down syndrome who had deaf parents. There are exceedingly few references to deaf people with autism in the sign language literature: Bonvillian and Blackburn (1991) included two deaf subjects in their study of 22 autistic signers, and Poizner, Klima, and Bellugi (1990) made note of a deaf autistic signer in reference to their account of a signer with Broca's aphasia, as I will describe in greater detail in Chapter 2.

There is much that can be learnt from the study of sign language acquisition by atypical populations. First, research in this area can shed light on language disorders themselves, thereby facilitating interventions and educational strategies. Although it is not currently known how many deaf autistic children or adults there are in the United States, estimates of the incidence of autism in the general population (1 in 91 children or 1.1%; Kogan et al., 2009) as well as the very high incidence of pronounced to profound bilateral hearing loss or deafness in the autistic population (3.5%; Rosenhall, Nordin, Sandström, Ahlsén, & Gillberg, 1999) yield an estimated 115,000 autistic people with profound hearing loss or deafness in the United States, of which 25,000–30,000 are children. Such a number is likely to be high; a more conservative estimate of the size of this population may be calculated using the incidences of autism (1%) and prelingual deafness in the general population (1 in 1000; Schein & Delk, 1974), which yields a smaller estimate of approximately 3,300 individuals. In any case, this dissertation represents the first time that this population is being studied systematically, and it can safely be said that there is a significant subpopulation of deaf children about whom little to nothing is known, and whose educational needs cannot possibly be addressed.

In addition to this practical motivation for this research, the examination of sign language acquisition by atypical populations is important for theoretical reasons. For example, the study of how deaf children with autism acquire sign language may shed light on aspects of cognition that would not come to light through the study of typical development. What can be learned about the nature of sign language itself by examining how it is acquired and used by deaf people with autism? Are there aspects of sign that may have been overlooked in the study of typical development? Conversely, just as the study of the sign language of deaf children with autism could be important for the field of sign linguistics, it could also yield significant information for the study of autism, since signed languages require a somewhat different set of cognitive skills than spoken languages.

Finally, there is reason to believe that the specific impairments of autism will interact with the structures of signed languages in interesting ways, since several essential skills underpinning sign learning are likely to be impaired in autism. First, unlike hearing children acquiring speech, deaf children acquiring sign must rely on visual attention and eye gaze – widely known to be impaired in autism (Baron-Cohen, Baldwin, & Crowson, 1997; Mundy, Sigman, & Kasari, 1990) – in order to perceive language. Second, signed languages use facial expressions for grammatical as well as affective functions; children with autism tend to avoid eye contact and have difficulty interpreting facial expressions (Celani, Battacchi, & Arcidiacono, 1999). Third, signer and addressee do not typically share the same visual perspective on the signs that the signer produces; signing children must therefore learn to understand the visual perspectives of others in order to properly comprehend and reproduce sign language structures. This process may require theory of mind (ToM), which is delayed in children with autism (Baron-Cohen, Leslie, & Frith, 1985). Fourth, pragmatic skills are known to be impaired in autism (Baron-Cohen, 1988), but signing children must understand how to make their articulators visible to others under varying physical conditions, a skill that may require pragmatic knowledge. Finally, children learning sign must be able to replicate the body movements and stances of others in order to learn signs (a complicated process which I will refer to as "self-other mapping"), but autistic children have well-documented impairments in motor imitation (Williams, Whiten, & Singh, 2004). These factors suggest that autistic children learning sign may face particular obstacles unlike those faced by hearing autistic children exposed to speech.

As a result, I hypothesize that a linguistic analysis of the signing of deaf children with autism will yield certain kinds of errors that are unlike the errors found in typically-developing deaf children. If this hypothesis is correct, then something will have been discovered about the nature of sign and the nature of autism. Perhaps more importantly, there will be a better understanding of the cognitive and linguistic needs of a small but important sub-group of deaf children. Understanding these needs is a first step towards devising better educational and communicative strategies with these children.

1.3 Organization of this Dissertation

This dissertation is divided into the following sections. Chapter 2 gives a brief background on autism spectrum disorders and the linguistic and social impairments characteristic of people with autism. Chapter 3 reviews past research on autism and sign language. Chapter 4 introduces a theory about how autism affects cognition, and uses this theory to create a hypothesis about how autism will affect aspects of language in the visual-spatial modality – lexical phonology in particular. Chapter 5 describes pilot data collected from hearing and deaf autistic children that led to the formulation of an experimental hypothesis about the sign language of deaf children with autism. Chapter 6 describes a series of sign language experiments that were designed to test this hypothesis and that were conducted on a sample of deaf autistic children and deaf typically-developing children. Chapter 7 discusses evidence from other sources that supports the conclusions of these experiments. Chapter 8 states the conclusions of these experiments, discusses their limitations, and outlines an agenda for future research.

Chapter 2: Autism Spectrum Disorders

2.1 Autism Spectrum Disorders

Autism spectrum disorders (ASDs) have garnered much attention in recent times. Thousands of newspaper and magazine articles in the popular press have focused on the much-publicized autism "epidemic" – the huge rise in diagnosis over the last few decades. It is now estimated that autism affects up to 1 in 91 children in the United States, according to the Centers for Disease Control's latest figures (Kogan et al., 2009). Though popular attention has helped familiarize the public with autism, much still remains unknown. In this section, I will briefly summarize the history of research on autism and describe the essential characteristics of the disorder as we currently understand it.

Kanner (1943) was the first to describe and name "autistic disturbances of affective contact". He described 11 children "characterized by a failure to develop the kinds of emotionally-charged interpersonal relations that usually become part of a child's behavioural repertoire" (Bowler, 2007: 2). In addition to the marked affective impairment exhibited by these children, Kanner also noted that his subjects were linguistically delayed, if they developed speech at all. Their linguistic peculiarities included a tendency towards echolalia, the repetition of vocalizations made by others, and pronoun reversal – reference to oneself as "you" and to others as "I" or "me". He noted that "the peculiarities of language present an important and promising basis for investigation" (Kanner, 1946: 245). At around the same time, Hans Asperger (1944) published an account of children in his pediatric practice who exhibited social impairments similar to Kanner's children, yet had relatively intact speech. (The condition of these children later came to bear the eponym "Asperger Syndrome".) Both of these pioneering works would lay the groundwork for decades of autism research thereafter.

Our current understanding is that autism encompasses a spectrum of social and cognitive disorders ranging from the very mild to the very severe. People with ASDs, therefore, are a very heterogeneous population, and no two subjects present the same cognitive and behavioral profile. Diagnosis is based on behavioral criteria from each of three areas: social impairments, communicative impairments, and repetitive or stereotyped behaviors, according to the most current edition of the Diagnostic and Statistical Manual (*DSM-IV-TR*, 2000):

Diagnostic Criteria for 299.00 Autistic Disorder

A. A total of six (or more) items from (1), (2), and (3), with at least two from (1), and one each from (2) and (3):

1. qualitative impairment in social interaction, as manifested by at least two of the following:
    - **a.** marked impairment in the use of multiple nonverbal behaviors such as eye-to-eye gaze, facial expression, body postures, and gestures to regulate social interaction
    - **b.** failure to develop peer relationships appropriate to developmental level
    - **c.** a lack of spontaneous seeking to share enjoyment, interests, or achievements with other people (e.g., by a lack of showing, bringing, or pointing out objects of interest)
    - **d.** lack of social or emotional reciprocity
2. qualitative impairments in communication as manifested by at least one of the following:
    - **a.** delay in, or total lack of, the development of spoken language (not accompanied by an attempt to compensate through alternative modes of communication such as gesture or mime)
    - **b.** in individuals with adequate speech, marked impairment in the ability to initiate or sustain a conversation with others
    - **c.** stereotyped and repetitive use of language or idiosyncratic language

d. lack of varied, spontaneous make-believe play or social imitative play appropriate to developmental level

3. restricted repetitive and stereotyped patterns of behavior, interests, and activities, as manifested by at least one of the following:

a. encompassing preoccupation with one or more stereotyped and restricted patterns of interest that is abnormal either in intensity or focus

b. apparently inflexible adherence to specific, nonfunctional routines or rituals

c. stereotyped and repetitive motor manners (e.g., hand or finger flapping or twisting, or complex whole-body movements)

d. persistent preoccupation with parts of objects

B. Delays or abnormal functioning in at least one of the following areas, with onset prior to age 3 years: (1) social interaction, (2) language as used in social communication, or (3) symbolic or imaginative play.

C. The disturbance is not better accounted for by Rett's Disorder or Childhood Disintegrative Disorder.

Figure 1. DSM-IV-TR criteria for Autistic Disorder**.**

Diagnostic criteria for Asperger Syndrome are extremely similar, consisting in both impaired social behavior and repetitive and stereotyped patterns of behavior; however, unlike the autism diagnosis, there is no clinically significant delay in language, as evidenced by single word use by age 2 and communicative phrases by age 3 (See Figure 2).[1]

Diagnostic Criteria For 299.80 Asperger's Disorder

1. Qualitative impairment in social interaction, as manifested by at least two of the following:
    a. marked impairments in the use of multiple nonverbal behaviors such as eye-to-eye gaze, facial expression, body postures, and gestures to regulate social interaction

[1] It appears that the diagnosis of Asperger Syndrome will be subsumed under Autistic Disorder in the forthcoming fifth edition of the DSM, to be published in 2013; see http://www.dsm5.org/ProposedRevisions/Pages/proposedrevision.aspx?rid=97

b. failure to develop peer relationships appropriate to developmental level
c. a lack of spontaneous seeking to share enjoyment, interests, or achievements with other people (e.g. by a lack of showing, bringing, or pointing out objects of interest to other people)
d. lack of social or emotional reciprocity

2. Restricted repetitive and stereotyped patterns of behavior, interests, and activities, as manifested by at least one of the following:
(1) encompassing preoccupation with one or more stereotyped and restricted patterns of interest that is abnormal either in intensity or focus
(2) apparently inflexible adherence to specific, nonfunctional routines or rituals
(3) stereotyped and repetitive motor mannerisms (e.g., hand or finger flapping or twisting, or complex whole-body movements)
(4) persistent preoccupation with parts of objects

C. The disturbance causes clinically significant impairment in social, occupational, or other important areas of functioning

D. There is no clinically significant general delay in language (e.g., single words used by age 2 years, communicative phrases used by age 3 years)

E. There is no clinically significant delay in cognitive development or in the development of age-appropriate self-help skills, adaptive behavior (other than social interaction), and curiosity about the environment in childhood

F. Criteria are not met for another specific Pervasive Developmental Disorder or Schizophrenia.

Figure 2. DSM-IV-TR criteria for Asperger Syndrome.

Although the DSM-IV-TR refers explicitly to “speech” and “spoken language” as well as to the more generic “language”, the DSM-IV criteria for diagnosis of an ASD can apply to deaf individuals acquiring a sign language without significant modification, insofar as deafness does not imply or entail developmental delay *per se*, especially in the case of the deaf children of deaf parents. In other words, the inability to hear does not cause developmental delay in and of itself: deaf children who are exposed to sign language from birth and are raised in a language-rich environment acquire sign language in much the same way their hearing peers acquire speech, reaching similar milestones at similar times: manual babbling at around 10 months or earlier (Petitto & Marentette, 1991); first signs at about one year of age; and two-sign combinations during the second year (Meier & Newport, 1990; Newport & Meier, 1986). As with speech, however, the ability to learn signed languages declines over time (Johnson & Newport, 1989; Newport, 1990), so early exposure is therefore necessary for normal development to occur. For this reason (and others which will be explained in greater detail later on), the deaf children of deaf parents hold a privileged place in the literature on sign language acquisition.

This is a linguistics dissertation, so the focus will naturally be on language. Thus, my primary concern will henceforth be the communicative/linguistic aspects of autism, where these can be separated from the social component. Where the two cannot be separated, both will be dealt with in tandem. In the next section, I will briefly describe what is known about the linguistic characteristics of people with autism. The bulk of previous research has focused on spoken language, and what I report here will reflect that fact. Where research has been done on sign language, those findings will be reported in Chapter 3.

2.2 LANGUAGE IN AUTISM

Consistent with the heterogeneity of symptoms across the autism spectrum, the language of people with autism ranges from fluency to a total lack of expressive language. Nonetheless, a range of linguistic phenomena has consistently appeared across subjects who have developed spoken language. Linguistic areas that appear to be relative strengths of autistic individuals include phonology, syntax, and semantics, which may be intact or only mildly impaired (Volden & Lord, 1991), although speech articulation may be more impaired than has previously been thought (Shriberg et al., 2001). What follows is a brief synopsis of some of the major deficits that have been described in hearing autistic subjects that may be relevant to a study of deaf children with autism: echolalia, pronoun reversal, abnormal prosody and vocal quality, abnormal eye gaze behavior and processing of affective facial expressions, and impaired pragmatics and use of the communicative functions of language.

2.2.1 Echolalia

Echolalia 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). A distinction is often made between utterances that are repeated immediately, and those that are repeated at a later time ("delayed echolalia"). Delayed echolalia may in part be responsible for the highly idiosyncratic uses of words or phrases by autistic individuals. For example, Kanner (1943) reported that an autistic boy would always say "Peter eater" in reference to a saucepan. It was determined that this seemingly nonsensical usage began following an incident at age two in which his mother dropped a saucepan while reciting the nursery rhyme "Peter, Peter, pumpkin eater" to him.

Prizant and colleagues (Prizant, 1978; Prizant & Rydell, 1984; Prizant & Duchan, 1981) have analyzed how echolalic utterances are used functionally in context by individuals with autism. They found that both immediate and delayed echoes are used in a variety of contexts to serve various functions. Some of the echoes they reported evidenced comprehension of the utterances being echoed, and were used to rehearse utterances, self-direct, take turns, label, provide information, call attention to oneself, affirm a previous utterance, make a request, protest, and direct others' actions (Schuler & Prizant, 1985). However, other echoes did not show evidence of comprehension, and were instead deemed either to be meaningless or self-stimulatory.

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. Autistic children may approach language acquisition in a "gestalt" mode (Prizant, 1983) rather than the analytic mode typical of normal language acquisition (Bloom & Lahey, 1978). Schuler and Prizant (1985) explain that

> in an analytic mode, a child progresses in language through movement from single to two- to three-word utterances and beyond, by the acquisition and application of productive linguistic rules. An analytic approach in early language development allows for greater creativity and flexibility than is apparent in the early language of "gestalt" children (174).

Typically-developing children learn to break language down in sub-phrasal units, such as words, and recombine them to form novel sentences (Prizant & Rydell, 1993). This creativity is a hallmark of the non-behavioristic nature of normal language acquisition: children produce utterances that they have never heard before. For autistic people, however, echolalia is more than a passing phase, and can persist past childhood.

Since echolalia is such a defining hallmark of autistic speech, we would expect it to appear in the signing of children with autism. However, it is also possible that echolalia is a function of the vocal-auditory modality, and not a more general linguistic effect. If this is so, then the signing of deaf children with autism might not be echoic. This is but one example of how an investigation into the signing of deaf autistic children could help clarify how the symptoms and deficits of autism can be attributed to language- or modality-specific cognitive mechanisms.

2.2.2 Pronoun reversal

Another striking characteristic of the language of children with autism is their tendency to reverse pronouns, particularly those of the first and second person. Children with autism tend to treat pronouns much like names, such that they often refer to themselves as "you" and to others as "me" or "I". Typically-developing children also sometimes reverse pronouns early in development (Clark, 1976), but this is a transitory phase, and does not persist (Bartak & Rutter, 1974; Dale & Crain-Thoreson, 1993); furthermore, pronoun reversal is more common in children with autism than in any other group (Lee, Hobson, & Chiat, 1994). Tager-Flusberg (1994) found that young autistic children between one and two years of age made frequent pronoun reversal errors, but improved with age. However, even some older autistic children who were able to use pronouns properly in structured tasks sometimes had difficulty using them in spontaneous utterances.

Several hypotheses have been advanced to explain the clear difficulty that many autistic children have with mastering 1^{st}- and 2^{nd}-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 pronouns are relative to the person using them: 'I' does not refer absolutely to any particular person, but rather to the particular speaker in any given situation.

A second hypothesis that is particularly interesting from the perspective 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 children between the ages of 2;0-3;3 on the comprehension and production of 1st- and 2nd-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, Girouard, and Décarie (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 1st- and 2nd-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.

Visual perspective-taking plays a far more direct role in sign than in speech, as will be explained in greater detail in Chapter 4. The consistent finding of reversed pronouns in many hearing children with autism bears particular relevance for a study of the signing of deaf children with autism, as it may suggest a general impairment in autism in the understanding of visual perspectives.

2.2.3 Abnormal prosody and vocal quality

Abnormal prosody (that is, abnormal speech rhythm, stress, and intonation) in children with autism was first described by Kanner (1946), and has been repeatedly reported over the years. Prosody has linguistic, pragmatic, and affective components (Shriberg et al., 2001). The linguistic aspects of prosody include, for example, higher pitch at the end of an English sentence signaling a question, and stress indicating the difference between a noun (`con – test) and a verb (con – `test). Pragmatically, stress can be used to emphasize or focus the listener's attention on information the speaker deems important (e.g., the difference between "I'm asking YOU where you want to go" versus "I'm asking you WHERE you want to go"). Lastly, prosody can signal how a speaker feels about a given topic. Shriberg et al. (2001) hypothesized that the results of a number of studies suggest that the pragmatic or affective functions of prosody are impaired in autism, while the grammatical functions are relatively spared. The prosody of autistic children has characteristically been described as "improperly modulated, dull, and wooden" (Baltaxe & Simmons, 1985: 104) or "atonal, arrhythmic, and hollow" (Ornitz & Ritvo, 1976). Provonost et al. (1966) found the vocal quality of autistic children to be judged as hoarse, harsh, and hypernasal. Problems have been reported with control of amplitude (volume) as well as with pitch and rhythm (Goldfarb, Goldfarb, Braunstein, & Scholl, 1972; Pronovost, Wakstein, & Wakstein, 1966). These problems appear to persist through adolescence even when overall speech has improved (Baltaxe & Simmons, 1977, 1983; Kanner, 1971; Ornitz & Ritvo, 1976); this is true for high-functioning autistic individuals and individuals with Asperger Syndrome as well as lower-functioning autistic individuals (Shriberg et al., 2001).

The concept of prosody must be translated in order to be understood as it applies to signed languages. Vocal quality is obviously irrelevant to a discussion of signing, though we might seek to analyze the rhythm of autistic signing to see whether it exhibits some of the qualities manifest in autistic speech. The linguistic instantiations of prosody, such as question-marking, appear to be analogous to the different grammatical facial expressions employed by signed languages to signal questions (Liddell, 1980 and others). Similarly, pragmatic and affective aspects of prosody may have counterparts in facial expression and eye gaze. The affective information conveyed by changes in pitch and volume in speech is typically conveyed by facial expressions in sign; thus, it might be expected that deaf autistic signers would show abnormal "prosody" in their ability to convey information through the use of facial expressions, as will be described in more detail in the next section.

2.2.4 Eye gaze and facial expression

A finding related to pragmatic impairment is that people with autism have difficulty interpreting affective facial expressions (Hobson, 1986; Ozonoff, Pennington, & Rogers, 1991). Affective facial expressions are means for conveying mental and emotional states, such as anger, fear, disgust, surprise, happiness, and sadness; many of these basic expressions are universal and appear to be biological in nature, though their interpretation can be culturally influenced (Mandal & Ambady, 2004). Several recent studies have focused on autistic eye gaze behavior, with interesting results. Spezio, Adolphs, Hurley, and Piven (2007) compared 9 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. In another study, Baron-Cohen, Wheelwright, and Jolliffe (1997) analyzed autistic comprehension of basic emotions and complex mental states based on whether subjects viewed pictures of whole faces, the eyes alone, or the mouth alone. Adults with Asperger's Syndrome showed a significant impairment relative to normal adults on complex mental states (such as *scheme* or *distrust*), most markedly in the eyes-alone condition, indicating an inability to use information transmitted through the eyes. Finally, several studies (e.g., Hertzig, Snow, & Sherman, 1989; Loveland et al., 1994) have found that autistic children are impaired in their ability to imitate affective facial expressions.

Such findings have major implications for the study of sign language, since facial expression is used in sign not only to signal affect but also for grammatical functions. There is as yet no study of how deaf people with autism use or comprehend the parts of sign language grammar related to facial expression, though at the time of this writing, Tanya Denmark and colleagues are investigating whether autistic signers of British Sign Language comprehend grammatical facial markers for negation and interrogation (Denmark, Swettenham, Atkinson, & Campbell, 2009).

2.2.5 Impaired pragmatics/language functions

It has been widely reported (e.g., Baron-Cohen, 1988; Frith, 1989; Happé, 1994) that people with autism are impaired in their ability to interpret language pragmatically. Pragmatics refers to the ability of people to make and interpret utterances appropriately in context, and can involve prosody, indirectness, and metaphor. People with autism tend to be overly literal and have difficulty understanding the unspoken implications in people's utterances, as well as sarcasm, humor, and irony (Bogdashina, 2005). People with autism may also show impairment in those parts of the grammar that refer to social roles; for example, Baltaxe (1977) showed that German adolescents with autism improperly used the two second-person singular pronouns, *Sie* and *du*, reflecting a lack of understanding of social hierarchies. The difficulties that autistic individuals exhibit with pragmatic communication may reflect an impairment in theory of mind, and will be discussed further in the next chapter.

A related finding has to do with the different functions of language. Language is used to achieve a great number of goals: to make statements, to make requests, or to ask questions. In relation to typically-developing children, children with autism make more requests, comment less often, and are less likely to point, show objects, or use eye gaze to communicate (Stone, Ousley, Yoder, Hogan, & Hepburn, 1997). In general, autistic people show a more restricted range of the communicative functions of language than non-autistic people.

It is likely that the pragmatic impairments found in autistic speech will also be present in autistic signing, since the ability to understand context-dependent meanings is independent of language modality. However, there is at least one particular aspect of sign language that may be impaired due to a pragmatic deficit in autism. Unlike hearing speakers, signers must make sure that their articulators are visible to interlocutors in order to be understood. It is unclear how and when deaf children come to be aware of this fact. Moreover, signers must adapt to ever-changing physical situations in the real world, in which interlocutors may be situated in various configurations that require modifications to one's signing. I hypothesize that the ability to adapt to these situations requires pragmatic understanding. Thus, deaf children with autism might be expected to make fewer modifications to their signing in order to make it visible to others.

2.3 THE CONNECTION BETWEEN THE SOCIAL AND THE LINGUISTIC

By definition, autistic children are characterized by both communicative and behavioral impairments. Notwithstanding whatever innate linguistic predisposition we might have (Chomsky, 1957, 1959), language must be acquired in a social context. Children learn language from the people around them, and in order to do so, it is necessary to possess certain (non-linguistic) cognitive skills. As evidence of this, language has been found to be positively associated with performance on joint attention and imitation (Charman et al., 2003). The ability to engage in episodes of joint attention, long thought to be a fundamental building block for the acquisition of word meanings (Tomasello & Farrar, 1986), is often impaired in autistic children (Curcio, 1978; Loveland & Landry, 1986; Mundy, Sigman, Ungerer, & Sherman, 1986; Sigman et al., 1999). Leekam & Ramsden (2006) found impairment in autistic children's ability to orient to dyadic interactions (i.e., interactions between the child and another person), with fewer episodes of joint attention as a result. Children with autism also have specific problems orienting to social as opposed to non-social stimuli (Dawson, Meltzoff, Osterling, Rinaldi, & Brown, 1998; Leekam, Lopez, & Moore, 2000; Leekam & Ramsden, 2006). This lack of social orienting is directly related to the ability to follow another person's eye gaze, and it appears that such children rely instead on larger movements such as head turns or pointing:

> For individuals with autism, human stimuli may simply not be important early in development and this lack of salience may lead to a failure to learn the reward value of dyadic interaction (Dawson et al., 1998; Mundy, 1995). Children with autism may therefore fail to pick up on some of the expressive vocal or tactile information provided in social attention bids and may rely on other information such as gross visual movements when responding to human cues such as head turns and pointing (Leekam & Ramsden, 2006: 195).

Another basic language process that may be impaired by social deficits in autism involves how children are able to learn words. A seemingly banal but fundamental question for psycholinguistic researchers is how children are able to learn to associate a linguistic stimulus, be it a word or a sign, with an object in the most concrete case, or an abstraction later on. Researchers in this area such as Paul Bloom (2002) have shown that 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 interlocutors. For example, if a child is looking at an object and an adult simultaneously utters a label, a typically-developing child will consult the adult's gaze to confirm that the adult intended to label the object in the child's gaze, and not some other 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). As trivial as this may seem, this process entails a bit of basic mind-reading, or "theory of mind". Much more will be said about theory of mind in Chapter 4, but for now a simple working definition will suffice: theory of mind is the ability to infer what other people are thinking or feeling; this ability is thought to be impaired in autistic children (Baron-Cohen et al., 1985). Not coincidentally, the age at which children start to understand referential intent – 18 months – matches up neatly with the age at which the vocabulary explosion takes place.

Children with autism do not learn words like typically-developing children. In one study (Baron-Cohen, Baldwin, & Crowson, 1997), autistic children were tested to see if they consulted a speaker's direction of gaze in word-object mappings. They found that typically-developing children only learned to associate a word with an object when the speaker was looking 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.

In sum, the language of people with autism shows distinct characteristics which highlight the connection between linguistic and social skills. The ability to imitate others is another skill that is fundamental to both social and linguistic understandings. Imitation is necessary for both sign- and word-learning; however, imitation in sign language entails the copying of the bodily movements of others, while imitation in speech involves the reproduction of the sounds of the vocal tract. There is a large literature on the gestural imitation skills of hearing people with autism that is germane to a discussion of the signing of deaf children with autism. The next section will describe the major findings of such studies.

2.4 Imitation in Autism

Imitation is one of the cornerstones of language learning. Hearing children learning speech must be able to accurately perceive and subsequently reproduce the vocalizations of others when learning to speak. Similarly, deaf children acquiring sign must be able to perceive and reproduce the bodily movements and facial expressions that make up the substance of a sign language. The nature of these imitations is different in the two modalities of speech and sign; however, normal hearing infants imitate gestures and facial expressions at a very early age and there is evidence of an innate predisposition in humans for such imitation skills. In this section, I will briefly summarize the research findings on imitation in typical development, proceed to a discussion of the impairments and abilities of people with autism in imitating others, and raise questions about what such findings might mean for deaf children acquiring a sign language.

It is by now well accepted that infants demonstrate imitative abilities from the earliest stages of life. Imitation of facial expressions (such as mouth opening and tongue protrusion) has been demonstrated in newborn infants under 3 days old (Meltzoff & Moore, 1983, 1989), a finding that suggests that the ability to imitate facial expressions is innate. Inasmuch as infants in the first month of life also show the ability to imitate basic finger movements (Meltzoff & Moore, 1977), Meltzoff and Decety (2003: 497) have suggested that "imitation indicates that newborns, at some level of processing no matter how primitive, can map actions of other people onto actions of their own body" and that this skill underpins social cognition. Infants take advantage of their innate imitation skills to relate the actions of others to their own bodies and, with time and experience, come to construct inferences about the intentions and mental states of others.

Children with autism are impaired in their ability to imitate others, though the exact nature of this impairment, as well its underlying cause, have been the subject of much debate. It appears that people with autism are impaired in some kinds of imitation, while other imitative abilities are relatively intact. For one thing, echolalia -- a hallmark of autism – entails the imitation of others' vocalizations (albeit in contexts that may be inappropriate). Despite the evidence for a vocal imitation ability that is shown by echolalia, other researchers such as Dawson and Adams (1984) have found abnormalities in the vocal imitations of children with autism when compared with controls.

Many studies have focused on gestural or object-oriented imitation, which is highly relevant to a discussion of autistic sign language. These studies, however, have yielded conflicting results. Though most studies on the subject have found an imitation deficit in autistic subjects, a few studies have not. For example, Morgan, Cutrer, Coplin, and Rodrigue (1989) reported that autistic children did not perform significantly differently from language-matched controls on gesture and action tasks. Others (e.g., Beadle-Brown & Whiten, 2004; Charman & Baron-Cohen, 1994; Hobson & Lee, 1999) found that children with autism are able "to copy others' goal-directed actions on objects and gestures when they are motivated or encouraged to do so" (Hobson & Hobson, 2007: 413).

Still, the majority of researchers who have looked into this area have found impairments in the imitation abilities of autistic children. For example, DeMyer et al. (1972) found that autistic children 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 autistic children between the ages of 4 and 12 performed poorly on gestural imitation; this finding has been replicated in other studies (e.g., Dawson & Adams, 1984). Finally, autistic children have been found to exhibit difficulty with pantomimed actions with imaginary objects (Bartak, Rutter, & Cox, 1975; Curcio & Piserchia, 1978). These various deficits have led to different accounts as to what the underlying impairment in autism may be. One meta-analysis was inconclusive: Smith and Bryson (1994), 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” (262). In another meta-analysis of 21 studies of imitation by autistic subjects, Williams et al. (2004) list the following six major theories advanced in the literature about the nature of the imitation deficit in autism:

> (1) A deficit in representational or symbolic functioning (Curcio, 1978).
> (2) Poor engagement in the experimental tasks by the autism group (Trevarthen & Aitken, 2001).
> (3) A long-term deficit in social interaction that leads to less practiced motor skills (Tantam, 1991).
> (4) A dyspraxic problem (Jones & Prior, 1985).
> (5) A disorder of action representation (Smith & Bryson, 1994).
> (6) A specific deficit in self-other mapping ability (Rogers & Pennington, 1991). (295)

Williams et al. conclude that of these theories, a “specific deficit in self–other mapping ability” was most consistent with the evidence presented. By “self-other mapping”, Rogers and Pennington (1991) were referring to the ability to “form and co-ordinate social representations of self and other at increasingly complex levels via amodal or cross-modal representational processes” (157). The most compelling evidence for this theory is the striking finding of a number of studies (Brown, 1996; Hobson & Lee, 1999; Ohta, 1987; Whiten & Brown, 1998) that when autistic children attempt to imitate, they tend to reverse movements and palm orientations. Such errors have occurred in the context of various tasks: object-related actions, pantomimes, and meaningful and meaningless gestures, and appear to be unique to autism. Reversal errors may reflect a general ability to imitate but an inability to alter perspectives according to the model being imitated. In other words, children with autism tend to replicate bodily movements as observed from their own point of view, not as they were produced by the model. This observation has obvious implications for the acquisition of sign by deaf children with autism, since palm orientation and direction of arm movements have linguistic value in sign.

To sum up, in this chapter I have reviewed some of the most robust characteristics of the linguistic, social, and imitation skills of autistic children. I have attempted to show two things: first, how autism manifests itself on a linguistic level in the speech of hearing autistic children, and second, how an impairment in social skills could be related to language problems in both deaf and hearing children. Finally, I have summarized the literature on imitation deficits in autism, which has clear implications for the signing of deaf autistic children. In considering the signing of deaf children with autism, it will be useful to keep these findings in mind, and use them to formulate hypotheses about the kinds of errors that might surface in the domain of sign language.

I will now proceed to a review of previous work on deafness, autism, and sign language.

Chapter 3: Previous Research on 'Sign Language' and Autism

3.1 Deafness and autism

Deafness and hearing loss appear to be much more common in the autistic population than the general population. In one study of 199 children and adolescents with autism (Rosenhall et al., 1999), about 3.5% of subjects had pronounced or profound bilateral hearing loss or deafness, an incidence that is about 30 times that found in the general population. Despite this fact, very little research has examined the population of individuals who are both deaf and autistic. In one of the few studies of this population, Roper, Arnold, and Monteiro (2003) found that deaf people with autism exhibited the same autistic (non-linguistic) behaviors as their hearing counterparts, suggesting that the underlying cognitive disorder is the same in deaf and hearing people. However, it is often more difficult to diagnose autism in deaf individuals than in hearing people (due to inadequate instruments and/or assessment), and consequently diagnosis is often delayed, if it occurs at all (Garreau, Barthelemy, Sauvage, Leddet, & LeLord, 1984; Jure, Rapin, & Tuchman, 1991; Roper et al., 2003).

A primary motivation for this dissertation is that there exists almost no work describing how deaf people with autism use sign language. The scant literature on the subject includes a brief report by Poizner et al. (1990: 67-70) of a single deaf autistic signer with deaf parents, a 21-year-old named Judith M.; this subject was described primarily as a counterpoint to a signer with Broca's aphasia. Judith M. began to exhibit symptoms of autism at the age of 11 months, failing to make eye contact with people or respond to facial expressions. She produced her first sign, ICE-CREAM[2], at the age of five. The brief example of Judith M.'s signing consists of one exchange with her father, in which she produced some 14 signs, most of which were echoes of her father's utterances. She rarely initiated communication with others on her own, except to make requests to serve her basic needs. Most strikingly, she exhibited no knowledge of complex ASL grammar and had difficulty making eye contact or understanding grammatical facial expression. While these findings are suggestive, they are inadequate as the most in-depth description of the signing of a deaf autistic person to date: much more research is needed.

Other than Judith M., there are but two brief mentions of deaf people with autism in the literature: Bonvillian and Blackburn (1991) mention that two of their 22 autistic subjects were "profoundly hearing impaired" (260). However, their hearing impairment was not used to distinguish them in any way from the rest of the subjects, and thus the quality of these particular subjects' signing cannot be commented upon. Finally, Malandraki and Okalidou (2007) detail a case study of how a 10-year-old deaf Greek child with autism was trained to use a Picture Exchange Communication System (PECS), but the child was not taught sign language. This paucity of data on deaf autistic signers clearly highlights the need for more in-depth study.

3.2 Previous research: Sign as an alternative/augmentative strategy for hearing people with autism

In contrast to the virtual absence of information about the use of sign by deaf people with autism, a considerable amount of research was conducted in the sixties,

[2] As is conventional, signs are glossed by their English equivalent in all capital letters.

seventies, and early eighties on the use of 'sign language' with hearing children with autism who either could not speak or had extreme difficulty learning speech. It should be noted from the outset that the term 'sign language' cannot properly be used to refer to what these people were exposed to. For linguists, the term 'sign language' refers to a full-fledged visual-spatial linguistic system such as American Sign Language (ASL), that possesses its own syntax, morphology, and phonology (Klima & Bellugi, 1979; Stokoe, 1960); none of the hearing subjects in these studies were exposed to such a system. Rather, most studies attempted to introduce manual signs concurrently with speech, a method known as "simultaneous communication". Utterances thus tended to follow English word order and lacked the morphological and syntactic markers of true signed languages.

The limited understanding of sign language possessed by many of the researchers writing these articles is evidenced by their reporting of the earlier success in teaching "sign language" to chimpanzees as a motivation for its use with autistic children, particularly in the case of Washoe (Gardner & Gardner, 1969). To be sure, it is true that Washoe (and various other apes over the years) have shown some limited success in using manual gestures as a means for communication. However, this cannot be likened to the sign language acquisition of a human child in any meaningful way. Non-human primates have shown little or no evidence of acquiring syntax or other complex linguistic structures (see, for example, Terrace, Pettito, Sanders, & Bever, 1979), and there is very limited evidence of any creativity or productivity in their use of language, one of the basic hallmarks of human language (Chomsky, 1957; Hockett, 1960).

In the late sixties, an interest developed in the ability of autistic children to learn signs – particularly children who had failed to acquire speech following intensive speech therapy. This failure of language to emerge in autistic children had led psychologists to apply the principles of behaviorism (i.e., imitation and reinforcement) to language therapy for such children. Since autistic children do not seem to be motivated by the rewards inherent in social interaction as typically-developing children are, they must be motivated in other ways if they are to learn to communicate and interact socially. Thus, speech interventions using operant conditioning methods were developed for autistic children during the sixties (Ferster & DeMyer, 1962; Lovaas, Berberich, Perloff, & Schaeffer, 1966; Lovaas, 1966; Wolf, Risley, & Mees, 1964).

Despite the relative success of these methods, some autistic children still did not acquire functional speech after undergoing interventions. It was suggested that some non-verbal autistic children "complied readily if gesture or demonstration were used to convey the request" (Webster, McPherson, Sloman, Evans, & Kuchar, 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). 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. Thus, numerous studies in the late seventies and early eighties performed interventions with non-verbal autistic hearing children in which the children were taught manual signs either by themselves or in addition to speech.[3] The main findings of these studies will be summarized in the next section.

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[3] See, among others: Barrera, Lobato-Barrera, & Sulzer-Azaroff, 1980; Benaroya, Wesley, Ogilvie, Klein, & Meaney, 1977; Bonvillian & Nelson, 1976; Brady & Smouse, 1978; Carr, 1979; Carr, Binkoff, Kologinsky, & Eddy, 1978; Carr, Kologinsky, & Leff-Simon, 1987; Carr & Kologinsky, 1983; Carr, Pridal, & Dores, 1984; Casey, 1978; Cohen, 1981; Creedon, 1973; Fulwiler & Fouts, 1976; Layton, 1988; Konstantareas, Oxman, & Webster, 1977; Leibovitz, 1976; Miller & Miller, 1973; Remington & Clarke, 1983; Salvin, Routh, Foster, & Lovejoy, 1977; Schaeffer, 1980; Schaeffer, Kollinzas, Musil, & McDowell, 1977; Watters, Wheeler, & Watters, 1981; Wherry & Edwards, 1983; Yoder & Layton, 1988.

3.2.1 Main findings on the use of signs by hearing autistic children

Though many of these papers are not sufficiently detailed to enable a proper analysis of the signs produced by these children, results of these studies showed that some autistic children were successful at learning signs, even when previous attempts to teach spoken words had failed. Bonvillian, Nelson, and Rhyne (1981), in their review of over 20 studies involving the teaching of signs to more than 100 autistic children, 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. (128)

Bonvillian and colleagues reported that sign learning ranged from 5 signs to over 350 signs per subject, though Bonvillian and Blackburn (1991) 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" (276). Carr (1979), in reviewing 7 studies involving 52 non-verbal autistic children who received sign/speech interventions, claimed that these studies "provide overwhelming evidence that these children can profit from this method in that they acquire the ability to use sign language." (351).

Of course, by 'sign language', he was referring to only a small subset of possible sign language phenomena. Indeed, "the greatest gains in sign language acquisition were typically made in the area of noun usage" (352). There are contradictory claims in the literature about the ability of these children to master what Carr called "abstract sign language… prepositions, pronouns, and other abstractions" (353). A few researchers reported success: Webster and colleagues' (1973) 6-year-old autistic subject reportedly used signs spontaneously after acquiring them, and Creedon (1973) reported that her 21 formerly non-verbal autistic subjects between the ages of 4 and 9 achieved great success in many areas of language acquisition: they “used signs for their immediate needs and affective states” (2), “spontaneously combined two words” (3), “spontaneously added or changed their learned sentences” (3), used sentences that included “articles, numbers, demonstrators [sic] with nouns, transformations [sic] including possessive, negative, interrogative, “wh” question, imperative, auxiliary “be”, adjectives, adverb, pronoun, conjunction, infinitival complement (“to”), forms and prepositions” (5), and could even use language creatively and metaphorically -- e.g., “‘Jacket is sick’ was signed to report a broken zipper” (3). This last example also seems to reflect idiosyncratic use of language, which has been observed in the spoken language of autistic subjects (Volden & Lord, 1991). Similarly, Bonvillian et al. (1981) reported that “in many cases children moved to daily production of many complex sign utterances” (128), though it is not clear what kinds of “complex sign utterances” were produced by these children. Indeed, any claims about the acquisition of complex structures must be looked at skeptically, since an

> 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 (130).

Thus, despite a large number of studies on the subject, the available data are insufficient to determine whether autistic children were able to master more complex sign language structures such as syntax. Nor do these reports enable an analysis of the form of such children’s signs. 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” (130). Bonvillian and Nelson

(1976) reported a case study of a 12-year-old boy, Ted, who had been learning ‘sign language’ for about three years. Despite learning nearly 400 signs, and producing many two- and three-sign combinations, Ted did not acquire grammatical structures such as verb inflection (192-193).

3.2.2 Sign as a bridge to speech

Sign training in these studies was almost never seen as an end to itself, but rather as a means to increase spoken language and adaptive functioning (Layton & Baker, 1981; Salvin et al., 1977; Schaeffer, 1980). However, it appears that this occurred for only a small percentage of autistic children: only 12 of the 52 children in Carr’s (1979) review developed some speech following the sign/speech intervention. In general, children who were non-verbal before a sign/speech intervention did not acquire speech, while children who had some functional speech before the intervention were more successful, as measured by improved vocal repertoire. One notable exception is Fulwiler and Fouts' (1976) study of a 5-year-old nonverbal autistic boy, who after only 20 hours of intervention, reportedly showed advances in both signed and spoken communication: “signed words were emitted during the first hour, signed phrases were first emitted in the second hour, single vocal words were first used appropriately in the fourth hour, and vocal phrases were first emitted in the eleventh hour” (46-47). This subject was reported to have learned signs for nouns, verbs, adverbs (‘more’) and the pronouns ‘you’ and ‘me’. However, subsequent research has not replicated Fulwiler and Fouts’ results, casting doubt on the generalizability of their conclusions.

3.2.3 Theories about a possible sign advantage

Though these studies are problematic in various ways, it is worth reflecting on why some hearing autistic children have shown the ability to learn signs, and to use them in a limited fashion, when speech training has failed. There have been various proposals over the years, a few of which will be outlined here. In some cases, research has disproved the hypothesis in question, while other claims may have some validity.

The relative success of early studies was initially taken by some researchers as an indication that sign training might be something of a silver bullet. Webster et al. (1973) declared that "Hermelin & O'Connor (1970) are on the right track in suggesting that… the deficit [of autism] is to some extent modality dependent, and affects the auditory-vocal channels more than visual and particularly motor activity" (344). Fulwiler and Fouts (1976) asserted that "the autistic child is capable of using language when given the appropriate tools… one of the main factors in autism may not be a cognitive malfunction, but a perceptual nonfunctioning in the crossmodal array." (50) Subsequent research has disproved these theories, as it is now well-known that autism does indeed entail a cognitive impairment (Baron-Cohen et al., 1985; Baron-Cohen, 1989) and that the symptoms of autism are much the same in deaf people as in hearing people (Roper et al., 2003). Of course, this is not to say that the visual modality of sign language imposes the same cognitive requirements on its users as does the auditory modality for speech; indeed, this dissertation will demonstrate that sign-specific modality effects do exist, and that these effects impact autistic signers in ways that are characteristically different from hearing autistic speakers. Unlike previous research, however, I will seek to illustrate how sign language may be *more* difficult than speech for autistic learners, at least with regard to certain kinds of linguistic structures.

Another hypothesis advanced in the literature was that the iconic, or pictorial, nature of some signs functioned as a natural scaffolding upon which sign language acquisition could rest, claiming that autistic children may be more apt to learn iconic symbols than arbitrary ones and thus the increased iconicity of sign in relation to speech may facilitate vocabulary development (Konstantareas, Oxman, & Webster, 1982). This may indeed be a factor, though it is worth noting that typically-developing deaf children appear to take relatively little advantage of iconicity in their acquisition of lexical items (Orlansky & Bonvillian, 1984), verb agreement (Meier, 1982, 1987) or early sign phonology (Meier, Mauk, Cheek, & Moreland, 2008).

Other researchers also clearly believed that sign language was simply not as complex as speech. Stull et al. (1979), in motivating their advocacy for sign language interventions with non-verbal, hearing autistic children, stated that "since most autistic children lag far behind the norm in terms of verbal ability, it makes intuitive sense to revert to a more "primitive" system in the expectation that it will be somewhat more within the child's reach" (144). While it is quite likely that the sign systems being taught to these children were indeed simplified, it is wrong to think of sign as an inherently more "primitive" linguistic system than speech.

A more likely hypothesis is that autistic people may have a preference for visual over auditory stimuli (Salvin et al., 1977) or are more "visual thinkers" (Grandin, 1995). Indeed, the TEACCH (Treatment and Education of Autistic and Communication Handicapped Children) educational model (Mesibov, Shea, & Schopler, 2005), now widely used internationally in the education of children with autism, is based on this assumption. Various studies have found that autistic children ignore auditory stimuli in favor of visual stimuli when the two are presented simultaneously (Lovaas & Schreibman, 1971; Lovaas, Schreibman, Koegel, & Rehm, 1971; Pronovost et al., 1966;

Rincover & Koegel, 1975). A related theory is that sensory integration is impaired in autistic individuals (Rogers & Ozonoff (2005) for a review), leading some researchers to suggest that the cross-modal nature of word learning in spoken languages may be especially difficult for people with autism (Fulwiler & Fouts, 1976; Webster et al., 1973). In other words, the learning of object labels in spoken language requires the ability to make mappings between sequences of sounds (the word label) and visual stimuli (the object), while sign language mappings occur between visual labels and visually-perceived objects.

Another possibility is that the gestures involved in signing are more teachable than the sounds of speech. For example, Stull et al. (1979) attributed the relative success of sign to the increased ability to prompt and reinforce the child's sign productions, compared to speech: "It is simple to reach out and mold a child's arm and hands into an appropriate position. And once the hands are in place it is easy to provide reinforcement if needed." (144). Therefore, for these researchers, the ability to mold the sign articulators is an advantage over speech, since the speech articulators cannot be directly molded. Similarly, the relative slowness of sign compared to speech could also be advantageous for autistic learners. Klima and Bellugi (1979) showed that signs tend to be produced at a slower rate than vocalizations, although the rate of propositions remains the same in sign and speech. Moreover, signs have the potential to be slowed down even further to allow for more additional processing time. Signs can be held in a static position in space, while speech sounds cannot be paused or held static for any significant time without degradation of the speech signal: "slowing down speech to any significant extent can make it unintelligible" (Jordan, 1990: 10).

3.2.4 Summary and limitations of previous research

The main findings of several decades of research on sign language interventions with hearing autistic children have been reported, and the limitations of these studies should be quite clear. Most significantly, it must be emphasized that these hearing autistic children were not exposed to a true sign language, nor was their exposure early enough or consistent enough to be comparable to normal language acquisition. Bonvillian et al. (1981) acknowledge, in fact, that "the optimal effectiveness levels of sign language programs are not likely to be reached until some teachers and parents become fluent signers with each other and with the autistic children" (135). Furthermore, it should be noted that the primary focus of these interventions was not sign language *per se* but sign language as a bridge to speech. Therefore, these studies cannot make claims about sign language acquisition in the way that linguists understand that term.

A second, related issue is that the autistic subjects in these studies were all hearing. There is nothing inherently wrong with this, as hearing children are just as capable of learning sign language as a deaf child – under the right circumstances. However, it is striking that in all the research about sign language and autism, no one has ever attempted to report on a deaf autistic child learning sign language. Certainly these children are limited in number, but a visit to any school for the deaf (particularly in more recent times) will yield a number of deaf autistic children. The lack of information about these children is probably a result of the fact that researchers in autism have traditionally known little about the deaf community. Conversely, researchers in sign language have known little about autism. This dissertation is an attempt to start to bridge this gap in the literature.

3.3 Linguistic analyses of autistic signing

As reported in the last section, one limitation of most previous studies is that they only sought to analyze the usefulness of sign as it related to the speech and did not analyze the linguistic properties of the children's signing. Many of the researchers lacked the technical knowledge of sign language to be able to pursue such analyses. Indeed, trained linguists have focused almost exclusively on the typical acquisition of sign language, while atypical development has primarily been the purview of psychologists. There are very few studies analyzing the sign productions of individuals with autism from a linguistic point of view. Two exceptions, Seal and Bonvillian's (1997) study and Gary Morgan and colleagues' work on Christopher (Morgan, Smith, Tsimpli, & Woll, 2002, 2007; Morgan, Woll, Tsimpli, & Smith, 2002) will be briefly discussed here.

3.3.1 Sign Language and Motor Functioning in Students with Autistic Disorder

Seal and Bonvillian (1997) analyzed the sign language 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" (440), with an eye towards "uncovering associations between autistic children's signing and any underlying motor deficits" (439). Therefore, Seal and Bonvillian were interested in examining whether there was a relationship between motor deficits in autism and sign language productions, and if the former could be used to explain errors in the latter. Focusing on the sign parameters of handshape, location, and movement (Stokoe, 1960), they analyzed 348 signs produced by the autistic children. It should be noted that

Seal and Bonvillian did not consider a fourth commonly-accepted sign articulation parameter: palm orientation (Sandler, 1989; Brentari, 1998), the importance of which will be explained in greater detail in Chapter 4. They found a wide variability in error rates across the subjects, but were able to make several generalizations about the children's signing. 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 (448).

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. Interestingly, several of the movements that occurred relatively frequently – "twisting, toward-the-body, circling, and away-from-the-body… had high error rates, ranging from 43-53%" (452). Movements towards and away from the body are of particular interest because they could be indicative of a perspective-taking deficit, more about which will be said in the next chapter. 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 into a single movement.

Students' vocabulary size and sign formation accuracy were highly correlated with scores on tests for fine motor age and apraxia, a neuromotor disorder that impairs the ability to perform preplanned or voluntary motor movements. Seal and Bonvillian interpret this result as an indication that sign formation errors could partially be a result of underlying motor deficits. However, they explicitly reject the idea that such deficits could be the sole explanation for the communicative difficulties of autistic children, and admit that more research into the various mechanisms that could be responsible for autistic children's abilities and impairments in learning signs is needed.

Though this paper provides some relevant information about how autistic subjects learn signs, as well as what effects motor deficits may have on autistic signing, there are several problems that limit the usefulness of the data presented. First, the study only examined students with severe autism who were low-functioning. Thus, resulting errors in signing could be the result of low intelligence rather than autism per se.

Secondly, none of the subjects had been exposed to sign language since birth, as a deaf child with deaf parents would be. Most of the subjects first started receiving instruction in sign between the ages of 6 and 10, although one subject (Subject 14, a male age 17;4) had been receiving sign instruction for 15 years and 8 months, indicating that instruction had started before the age of 2. Still, this subject had a mental age of 27 months, so his progress was likely hindered by intellectual disability (his observed and reported sign vocabulary included some 123 signs). With the exception of this one subject, the late age of exposure to sign of the subjects in this study raises concerns about possible critical period effects, making it difficult to draw conclusions about how autism and sign language might interact under more favorable conditions. A study of subjects exposed to sign since birth could shed light on linguistic impairments that are truly due to autism and not just an artifact of delayed linguistic exposure.

3.3.2 The case of Christopher

The other case reported on in the literature is Morgan and colleagues' (Morgan, Smith, et al., 2002, 2007; Morgan, Woll, et al., 2002) analyses of the signing of Christopher, a mildly autistic, hearing, adult linguistic savant. Christopher's linguistic abilities are extraordinary despite his cognitive deficits in other areas: he is proficient in some 20-25 languages, while lacking certain basic skills needed for independent adult living. Morgan, Smith, et al. (2002) report that, although he has not received an official diagnosis, Christopher shows some characteristics typical of autism. Specifically, he fails some false-belief tasks and avoids eye contact, among other typical autistic characteristics. Morgan and colleagues sought to teach Christopher British Sign Language (BSL), in order to observe how his acquisition of this visual language might differ from his extraordinary abilities in learning spoken languages.

The most interesting findings involve Christopher's deficits in learning particular areas of the grammar of BSL. Despite his abilities in learning other morpho-syntactic constructions, Christopher showed a striking deficit in those areas of the grammar that relied on spatial constructions, such as verb agreement:

> …he had persistent problems in using the correct directional affix on the verb stem. For example, in trying to copy a verb sign such as HELP, produced by his tutor, which moved from C's location towards the tutor's location to express 'you help me', C instead moved the sign from himself towards his tutor's location, signifying 'I help you'. This difficulty in retaining meaning by adapting the visual dynamics of the sign persisted across several months of exposure to BSL (Morgan, Smith, et al., 2002: 25).

This was not just the case for verb agreement, as Christopher failed to articulate pronominal points correctly:

> There was a similar problem in his first uses of pronominal points, where he also produced the mirror image of what he was seeing, rather than adapting the directional affix to reflect the point of view of the signer…This reversal was systematic rather than random (25).

While Christopher eventually was able to correctly incorporate agreement into some verbs, his reversal of first- and second-person pronouns persisted.

Morgan, Smith, et al.'s (2007) follow-up study on Christopher focused on classifier constructions, which, like verb agreement and pronominal reference, rely on space for their interpretation. Though their designation as "classifiers" is controversial (since it is unclear that they are the same as classifiers in spoken languages), classifiers represent an important part of sign language grammar, "describ[ing] spatial relations in terms of a correspondence between real-world entities and an array represented in sign space as a spatial map" (1343). Christopher performed significantly worse than control subjects in his learning in this area, despite being able to master other parts of the grammar. Morgan et al. hypothesize that Christopher's difficulty with regard to spatial constructions in BSL

> reflects a dissociation between the various cognitive components – linguistic and spatial – involved in the representation of classifiers; in particular, we suspect that C has problems with features that draw on spatial cognition, an area in which it is independently known that he has a severe deficit (1347).

Hence, Morgan, Smith et al. (2007) make an interesting case for the cognitive division between linguistic and spatial abilities seemingly evidenced by Christopher's specific impairment. However, I would like to make the case that it is not spatial cognition *per se* that is implicated in Christopher's difficulties with classifier constructions, verb agreement, and pronouns. Rather, in the chapters that follow I will argue for an alternative interpretation of the data, one that is supported by my own data as well as by theoretical models of autism. Namely, I hypothesize that a deficit in the ability to understand the visual perspectives and replicate the bodily stances of others is impaired in autism, and that such an impairment will lead to predictable linguistic deficits in signed languages at every level – phonological, morphological, and syntactic. The rationale for this hypothesis will be discussed at length in the next chapter.

Therefore, there exist at least two fairly detailed linguistic analyses in the literature of the sign language of hearing people with autism. Each is instructive in its own right, but the generalizability of their conclusions is limited. This and other reasons serve as motivating factors for the present research, which will be described in the next section.

3.4 MOTIVATION FOR RESEARCH ON DEAF PEOPLE WITH AUTISM

The vast literature on how hearing people with severe autism learn to use signs communicatively is not without merit. However, as previously suggested, a study of autistic children who have been exposed to sign since birth – such as the deaf and hearing children of deaf parents – is likely to be more informative about how autism affects sign language acquisition. Almost nothing is known about such children.

Also lacking is information about signers who are on the milder end of the autism spectrum. Since previous research with hearing autistic children typically focused on children who were completely non-verbal or had significant difficulties with speech, these children were likely to have severe impairments. But what of high-functioning autistic deaf children and deaf children with Asperger Syndrome? These children could be particularly interesting to study, since they would be more likely to exhibit complex language.

Finally, previous research has not considered the visual modality of sign as a possible *obstacle* to autistic learners rather than an advantage. Much has been made of sign's purported advantages for autistic learners: its relative slowness, the fact that signs and their referents are perceived through a single sense (vision), and the possibility of molding the sign articulators. However, the converse must also be seriously considered: might there be reasons why the visual-spatial modality could create cognitive challenges for autistic learners that are simply not present in speech? In Chapter 2, I described how the social skills of joint attention and coordinated eye gaze underlie word learning in typically-developing young children. If these skills are important to hearing children learning speech, they are even more crucial to deaf children learning sign, since all linguistic stimuli in sign must be perceived through vision alone. As outlined in Chapter 1, the known impairments in autism are likely to interact with sign language structures in interesting ways that may not be evident in speech. In particular, the visual-spatial modality of sign is infused at every level – phonological, morphological, and syntactic – with structures that require learners to map the movements of other people occupying different points in space onto their own bodies, a complicated process that likely requires skills that are impaired in autism. In the chapters that follow, I will explore the nature of this process, illustrate how it is implicated in sign language structure, and form a hypothesis about how sign language is likely to be affected by the cognitive deficits of autism.

Thus, we are faced with a contradiction: previous research has highlighted the relative merits of sign in comparison to speech for autistic learners, yet the impairments of autism are likely to specifically affect the acquisition of sign language structures. A careful study of the signing of deaf children with autism – particularly those with deaf parents who have been exposed to sign since birth and are being educated in a deaf environment – is therefore warranted in order to clarify how autism affects sign language acquisition.

Chapter 4: Perspective-Taking in a Visual-Spatial Language

The previous chapter reviewed past research on the use of manual signs as a communicative strategy for hearing children with severe autism. Despite the success that many of these studies reported in teaching individual signs to these hearing children, there is still much to be learned about how people with autism – particularly deaf children with autism – acquire sign language. In particular, a linguistic analysis of the signing of such individuals could be valuable and instructive.

A study of deaf children with autism is also of interest for theoretical reasons. Current theories about the nature of autism make the deaf population an especially intriguing subject group because of the hypothesis that theory of mind (ToM), the ability to impute mental states to oneself and to others (Premack & Woodruff, 1978), is impaired in autism spectrum disorders (Baron-Cohen et al., 1985). In the by-now classic study, Baron-Cohen et al. compared the performance of 20 autistic children ranging in chronological age from 6;1-16;6 (*M* = 11;11, *SD* = 3;0) on standard ToM tasks ("false belief") to age-matched children with Down's syndrome and a control group of significantly younger typically-developing children (age range = 3;5-5;9, *M* = 4;5; *SD* = 0;7). Despite the fact that the Down's syndrome group had considerably lower non-verbal and verbal mental ages (*M* = 5;11 and 2;11, respectively) than the autism group (*M* = 9;3 and 5;5), a large percentage (80%) of the autistic children failed the false-belief task, whereas only a small percentage (14%) of the Down's syndrome children failed. This dramatic result has been replicated in numerous studies (Happé, 1995), and strongly supports the view that autistic children have a specific cognitive impairment in ToM, which appears to be independent of intellectual ability. This claim is supported by other

ToM tasks, such as appearance-reality, in which autistic children have also been found to lag well behind their mental age-matched peers. It should be noted, however, that this generalization does not apply to all people with autism, nor does it appear to imply a permanent deficit. Even though the great majority of autistic subjects fail false-belief tasks, there is a minority who pass them. It has therefore been suggested (Baron-Cohen, 1989) that ToM is not completely absent in autistic people, but rather grossly delayed. Indeed, Steele, Joseph, and Tager-Flusberg (2003) found that children with autism made significant gains in various ToM domains over the course of one year, suggesting that ToM skills are neither static nor absent in autism.

An impairment in ToM is likely to have different linguistic implications for a visual-spatial language such as ASL than for speech, due to its likely role in understanding the visual perspectives and bodily stances of others and translating those stances into one's own, a process that is fundamental for sign-learning. I begin this chapter with two questions: how does a deaf child acquiring sign come to understand what others see from their different physical perspectives? Secondly, how does the child produce body movements that match the signs that he or she observes? I will propose that the process of understanding the visual perspectives of others is related to ToM development, and underpins the acquisition of phonological representations of signs. As a consequence, I hypothesize that an impairment in ToM will have specific consequences for the acquisition of sign language, given that signers must acquire the "ability to correctly imagine another person's viewpoint" (Reed & Peterson, 1990: 555).

4.1 Theory of Mind and Visual Perspective-taking

Put simply, theory of mind refers to the ability that normal people have to understand the contents of other people's minds. Humans are unique in their ability to constantly observe other people's behavior in an effort to uncover their (unstated) motivations, intentions, and feelings. Normally children develop such mindreading skills over time, acquiring them naturally and effortlessly. The idea that mindreading skills emerge over the course of childhood was first proposed by Piaget (1926, 1928), who termed the young child's lack of ToM *egocentrism*, meaning that "they initially do not know that there are such mental entities in the world as conceptual, perceptual, and affective perspectives or points of view" (Flavell, 1992: 107). Piaget and his colleagues used this concept in their analysis of an assortment of developmental phenomena, including perspective-taking, communication, and the understanding of intentions and thoughts.

Piaget's groundbreaking research on spatial-perceptual perspective-taking (Piaget & Inhelder, 1956) is particularly notable for the purposes of this dissertation. Piaget and Inhelder found that young children performed poorly on a task in which they were asked to predict a doll's perspective on a model of three mountains (the "three mountains" task); instead they described their own perspective even when they had just been shown what the doll could see. Piaget and Inhelder remarked that the young egocentric child thus "appears to be rooted to his own viewpoint in the narrowest and most restricted fashion so that he cannot imagine any perspective but his own" (242). Children improved in this skill with age, they thought, because with experience they would learn more about others' points of view through interaction and dispute.

Decades later, Flavell and colleagues produced numerous studies on how children come to have knowledge about what others see (Flavell, 1992 for a review). They have provided evidence for a two-stage development in children's knowledge about the visual experience of others. Level 1 visual perspective-taking refers to the ability of a child to know that an object visible to the child may not be visible to another person if that person's view of that object is obstructed. This ability is typically mastered before the child knows that "an object simultaneously visible to both the self and [an]other person may nonetheless give rise to different visual impressions or experiences in the two if their viewing circumstances differ" (Flavell et al., 1981: 99). This skill was dubbed by Flavell and colleagues as level 2 visual perspective-taking. Masangkay and colleagues (1974) conducted a series of experiments that tested children's ability to understand another person's visual perspective and found evidence that hearing children could accurately report another person's visual perspective by age 4- to 4-1/2.[4] In one experiment, the experimenter put a picture of a turtle on the table in between the experimenter and the child. The experimenter would then ask the child "Do you (I) see the turtle rightside-up [i.e., on his feet, though those words were not used], or do you (I) see the turtle upside-down [i.e., on his back]?" (361). Children were thus asked to distinguish between what they saw and what the experimenter saw. This and other experiments have been useful in testing children's perspective-taking abilities.

Thus, the ability to correctly imagine the visual perspectives of others emerges over the first few years of life. Importantly, it typically emerges in relation to other ToM skills; Melot, Houdé, Courtel, and Soenen (1995) showed that success on level 2 visual perspective-taking tasks always precedes success on appearance-reality and false-belief tasks, indicating that the skills are related and emerge in a specific sequence. Moreover, it has been argued that the experience with visual perspective-taking involved in the

[4] Children may well come into this ability earlier, but our ability to test for mastery of this skill has so far been limited to tasks in which children can report what they perceive.

acquisition of a signed language can facilitate the development of higher-order ToM: in a study of 155 deaf French children, Courtin (2000) found that deaf children of deaf parents performed significantly better on a series of false-belief tasks than a group of age-matched hearing children. Courtin argued that the visual modality of sign underpinned the deaf children's success:

> The perspective-taking process inherent in sign language can help children grasp the idea that other individuals do not have the same visual perspectives of objects as their own. This visual-perspective effect is the basis for success on false belief tasks: the child now knows that others have to see a critical fact in order to be aware of it." (273)

Courtin thus views visual perspective-taking as a component of ToM similar to false belief, though it is more basic in nature and emerges earlier in development. If ToM is impaired in autism, then deaf children with autism would be expected to have trouble with those parts of sign language structure that crucially rely on perspective-taking skills. However, there has been some controversy in the literature about whether or not visual perspective-taking is indeed impaired in autism, the evidence for which will be discussed in the next section.

4.2 PERSPECTIVE-TAKING IN AUTISM: INTACT OR IMPAIRED?

Though visual perspective-taking entails understanding the visual percepts of others, it is unclear whether it is actually impaired in autism. A distinction has been made in the literature between two kinds of perspective-taking: visual (or perceptual) and cognitive (or conceptual) perspective-taking. The former refers to "the ability to imagine what another person can see when looking at a scene from a contrasting vantage point," while the latter refers to "the ability to assess such aspects of another person's mental state as knowledge, ignorance, or belief" (Reed & Peterson, 1990: 556). Baron-Cohen

(1988) asserted that only cognitive perspective-taking involves theory of mind, because "perceptual role taking can be performed using a strategy of mental rotation on primary representations" (394). In other words, although both visual and cognitive perspective-taking involve taking another person's perspective, only cognitive perspective-taking involves meta-representations, which are thought to be impaired in autism, according to one theory (Leslie 1987, 1988). Inferences about another person's visual percepts can be made at a primary level (invoking spatial reasoning), while inferences about another person's mental states involve second-order representations.

If the ability to form abstract meta-representations is impaired in autism, then autistic subjects should only show deficits on cognitive perspective-taking tasks, but not on visual perspective-taking tasks. And indeed, both Hobson (1984) and Reed and Peterson (1990) have demonstrated that autistic children are capable of passing certain kinds of visual perspective-taking tasks, indicating that they are not selectively impaired in this domain. Reed and Peterson (1990) tested autistic subjects' ability to perform both visual and cognitive perspective-taking tasks at two levels. The visual perspective-taking tasks were the following: in the Level 1 task, two dolls were introduced on a table that had a divider on it. The child was asked to hide one doll so that the other doll could not see it. Twelve out of 13 autistic subjects (mean chronological age 12;0) passed this task successfully. For the Level 2 task, one of four different objects possessing a front/back or head/tail (a tiger, a teddy bear, a toy car, and a tow truck) was placed on a turntable on the table in front of the child. The child was asked to turn the turntable so the experimenter could see the front/back, nose/tail, depending on the object presented. Again, all autistic subjects but one completed this task successfully.

A stark difference was found on the cognitive perspective-taking tasks, however. These, too, were divided into levels 1 and 2; both were based on a classic false-belief task. Only three of the 12 autistic subjects passed the Level 1 false-belief task, and just two passed the Level 2 task. Thus, both Hobson's and Reed and Peterson's studies offered evidence in support of Baron-Cohen et al.'s (1985) hypothesis that visual perspective-taking skills are intact in autistic subjects while cognitive perspective-taking skills are impaired.

However, there is a problem with generalizing on the basis of both of these studies that must be considered: the mean age of Reed and Peterson's autistic subjects was 12;0 (range = 4;3 – 29;11) and the mean age of the 12 autistic subjects in Hobson's (1984) study was 13;8 (range = 9;9 – 16;1). Since typically-developing children master level 2 visual perspective-taking by age 4-1/2 (if not earlier), then the subjects in these two studies may have simply been too old to have problems with visual perspective-taking. I therefore do not take it as a foregone conclusion that visual perspective-taking is intact in autism, and believe testing deaf autistic children's perspective-taking skills along with their signing skills to be a worthwhile endeavor.

Whatever the place of visual perspective-taking within the ToM landscape, any discussion of ToM in the context of research on deaf children must include a discussion of the significant differences in ToM development that have been documented between deaf children who are exposed to sign language since birth, and those who are either exposed to sign later in childhood or not exposed to sign at all. These findings, which have important methodological considerations for the research in this dissertation, will be presented in the next section.

4.3 THEORY OF MIND IN DEAF CHILDREN

When discussing theory of mind in deaf children, a distinction must be made between the small portion of deaf children (4-8%; Mitchell & Karchmer, 2004) who are born to one or two deaf parents (deaf-of-deaf, or DoD) and the vast majority of deaf children who are born to two hearing parents (deaf-of-hearing, DoH). The linguistic circumstances that these two groups of children grow up in are very different indeed: DoD children are exposed to sign language from birth and are raised in a language-rich environment comparable to that of hearing children. DoH children, on the other hand, often have late access to language, particularly if they are raised orally without exposure to sign language. Even if their parents do learn sign language, the linguistic content is often relatively poor, primarily concerning the here-and-now (Marschark, 1993). These different environments have been found to have a significant effect on the ToM development of deaf children. Various studies (Courtin & Melot, 1998; Courtin, 2000; Peterson & Siegal, 1999, 1995; Remmel, Bettger, & Weinberg, 2001) have found that DoD children do better than DoH children on a range of ToM tasks. Schick, de Villiers, de Villiers, and Hoffmeister (2007) found that DoD children show ToM development on par with their hearing peers, while DoH children are delayed. This held true both for low-verbal ToM tasks in which minimal language was used, as well as higher-order, language-dependent false-belief tasks.

The finding that DoH children are delayed in their development of ToM has led to different interpretations by researchers. For example, Peterson and Siegal (1995, 2000) attributed the delay in ToM primarily to a lack of access to conversations, particularly about abstract things like thoughts and feelings. Others (de Villiers & de Villiers, 2000, 2003; de Villiers, 2005) have argued that mastery of grammar itself – specifically, the acquisition of the embedded complement structure required by certain verbs referring to mental states (such as "think" and "believe") – leads to the development of ToM, because these syntactic structures enable the representation of false beliefs. In any case, this situation points to an obvious methodological confound of research on deaf children with autism: the ToM of autistic DoH children could be delayed either because of autism or because of an impoverished home language environment, or more likely, both. Thus, in an examination of the signing of deaf children with autism, it will be necessary to take the hearing status of parents into account.

In stark contrast to deaf children with hearing parents, deaf children with deaf parents may be even more advantaged than their hearing peers. Indeed, some research has suggested that sign language may facilitate aspects of ToM development. Multiple studies (e.g., Bellugi et al., 1990; Lillo-Martin, Bellugi, Struxness, & O'Grady, 1985; Petitto & Bellugi, 1988) have shown that DoD children demonstrate comprehension of linguistic structures that depend on complex cognitive skills related to vision by the age of 3. These structures include the comprehension of inflected verbs by age 2 (Marschark, 1993) and descriptions of non-present spatial arrays by age 3 (Lillo-Martin et al., 1985). The comprehension of these structures implies that DoD children show the ability to mentally rotate objects in space and shift perspectives by the age of 3 (Bellugi et al., 1990; Lillo-Martin et al., 1985; Petitto & Bellugi, 1988). Courtin and Melot (1998: 86) thus suggest that the "signing deaf children of deaf parents may differ from hearing children, as well as from oral deaf ones, in their visual perspective-taking abilities." Thus, it appears that DoD autistic children may be a particularly interesting group to study, since their early exposure to sign language seems to privilege the development of visual perspective-taking and other ToM skills, yet ToM is delayed in autism. If this is indeed the case, and ToM is implicated in the acquisition of sign language in ways unlike speech (i.e., through visual perspective-taking), then it is possible that deaf children with autism learning sign will face significant obstacles that are unlike the obstacles facing hearing autistic children learning speech. Specifically, such an impairment may lead to errors in those parts of the language that depend on visual perspective-taking. In the next section, I will illustrate how perspective-taking is necessary for learning the phonology, morphology, and syntax of a visual-spatial language such as ASL. I will then focus on lexical phonology in ASL to form a testable hypothesis about the signing of deaf children with autism.

4.4 Language in Space

Hearing children do not need to possess a fully-developed ToM in order to acquire spoken language, since most children's language acquisition is already quite advanced by the time that higher-order ToM skills develop. By the time false-belief abilities form around the age of four, typically-developing children have long been producing fluent and grammatical utterances. This is not to say that ToM is not helpful in language acquisition: clearly, having knowledge about the contents of other people's minds will help in structuring expressions about intentions and mental states. Even more basically, the ability to follow other people's gaze is a building block of word learning (Bloom, 2002). But the fact is that speech emerges well before we have evidence of the development of ToM.

The role that modality plays in the acquisition of language in relation to the development of non-linguistic cognitive skills (e.g., visual perspective-taking) is a central question of this dissertation. That is, how is the task of the deaf child acquiring sign language different from that of the hearing child learning speech? There is strong evidence that the human language capacity is implicated equally in the acquisition of both sign and speech. For example, Newport and Meier (1986) showed that the overall time course of acquisition is similar across the two modalities, with linguistic milestones being reached at approximately the same ages. Various studies (Boudreault & Mayberry, 2006; Mayberry, 1993; Mayberry & Eichen, 1991) have found critical period effects in the acquisition of signed languages, just as the ability of hearing children to acquire spoken languages declines as childhood progresses (Johnson & Newport, 1989; Lenneberg, 1967). Also, the early acquisition of a signed language has been shown to promote the subsequent acquisition of English (Mayberry, Lock, & Kazmi, 2002).

Despite these basic similarities, the different physical modalities of speech and sign must not be overlooked or deemed irrelevant to the learning process. Indeed, "at all structural levels, the form of an utterance in a signed language is deeply influenced by the modality in which the language is cast" (Bellugi, 1980). It is therefore necessary to examine how modality impacts the actual circumstances in which learners are exposed to language.

Imagine being a deaf child faced with the task of learning sign language. The world is experienced through vision, smell, and touch. Language is perceived through vision alone, the parameters of which limit how language exposure can occur: the deaf child must be looking at a person in order to perceive sign language. This is clearly different from the hearing child who does not need to be looking at or otherwise attending to his caregiver in order to perceive language. Indeed, from the outset, the task of the deaf child appears to be more difficult than that of the hearing child – or at least difficult in a different way.

The articulators in sign and speech are also different. The organs of the vocal tract – the oral and nasal cavities, pharynx, and larynx – are the articulators of speech and it is through their action that speech sounds are produced. Listeners do not directly perceive the movements of the vocal tract, but the sounds produced by the tract. While it is possible to match certain mouth movements to sounds (lipreading), speech sounds cannot be identified with a high degree of accuracy through vision alone due to the fact that certain classes of sounds appear the same (e.g., bilabials [b], [p], and [m]), and many sounds are invisible (e.g., velars [k] and [g]). Just as importantly, though lipreading may aid comprehension, it is not required for speech to be correctly perceived, as anyone who has used a telephone can tell you.

By contrast, in sign the articulators themselves – the upper limbs and face – are themselves the object of perception. This basic modality difference has important implications for sign-learning children. Due to the fact that signer and addressee occupy different points in space and often face each other, conversational partners do not typically share the same perspective on signs produced in a discourse. Learners must therefore learn to normalize signs observed from different vantage points through a spatial transformation in order to correctly form phonological representations of lexical signs or correctly perceive the grammatical use of space. Although visual information about the movement of the speech articulators (e.g., lipreading) can contribute to speech perception, there are no contrastive mouth movements in speech – in other words, mouth movements do not in and of themselves determine differences in meaning. Perhaps the closest analog to this sort of phenomenon in speech is pronominal reference. Children must learn that the word "you", when uttered by an adult to the child, refers to the child, but when the child refers to himself he must instead use the word "I/me". This also entails a shifting of perspectives, and can be problematic for young hearing children, who sometimes reverse first- and second-person pronouns (Clark, 1976). The fundamental difference is that visual perspective-taking and mental rotation are not necessary to determine the phonological representations of words in spoken languages. In sign, as I will illustrate in the sections that follow, these processes are necessary both for the comprehension of grammatical structures and for the proper phonological acquisition of lexical forms.

Space is used in sign languages to perform a variety of linguistic functions. Most obviously, space is the medium in which signs are articulated. One of the phenomena that characterizes signed languages most distinctively is that space can be used to establish grammatical or spatial relationships between referents: “the most striking and distinctive use of space in ASL is in its role in syntax and discourse, especially in nominal assignment, pronominal reference, verb agreement, anaphoric reference and the referential spatial framework for discourse” (Bellugi et al., 1990: 280). I will first detail how differing visual perspectives must be normalized with regard to the grammatical use of space, a point that has been discussed in detail by others (e.g., Emmorey, Klima, & Hickok, 1998; Emmorey, Tversky, & Taylor, 2000). I will then proceed to a discussion of how the same kinds of spatial transformations are also necessary for the acquisition of lexical phonology in signed languages.

Signed languages use space to talk about space. Unlike spoken languages, which are constrained to describing space lexically (e.g., in English through the use of prepositional phrases such as “on top of”, “below”), signed languages are capable of expressing real-world spatial relationships directly by locating referents in spatial arrays that are analogous to real-world spatial configurations. In order for these spatial relationships to be unambiguous, however, a certain referential perspective on the spatial array being described must be taken; this perspective is typically that of the signer. Courtin and Melot (1998: 85) point out that this situation requires “a visual perspective change; the addressee has to reorient the linguistic space according to the angle existing between himself and the signer.”

For purposes of illustration, let's suppose that a signer wishes to communicate to an addressee that a certain book is located to the left of a glass on the kitchen counter. In order to convey this information, the signer does not need to use lexical items such as "right" or "left". Rather, he can produce the sign BOOK and the sign GLASS, and point to locations in space in front of him that represent their actual physical configuration in space. Such a situation could be schematized as follows, with solid lines representing signs being produced and dotted lines representing how such signs are visually perceived by an addressee:

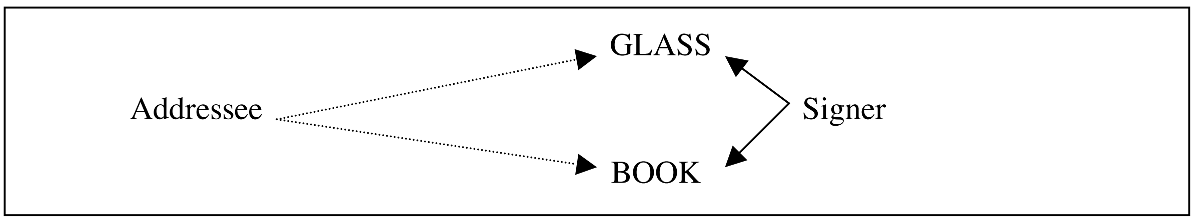

Figure 3. An example of a spatial array in a signed language.

In order for the addressee to correctly comprehend the location of the book to the left of the glass, he must then mentally rotate the spatial array that the signer has produced; a failure to do so would lead to an incorrect understanding. Figure 4 illustrates the kind of mental transformation that is necessary for understanding this type of spatial array. The array must be mentally rotated such that the book, which was first perceived on the right, is rotated to appear on the left, while the glass, which was first visually perceived on the left, must be rotated such that it is understood to be located on the right.

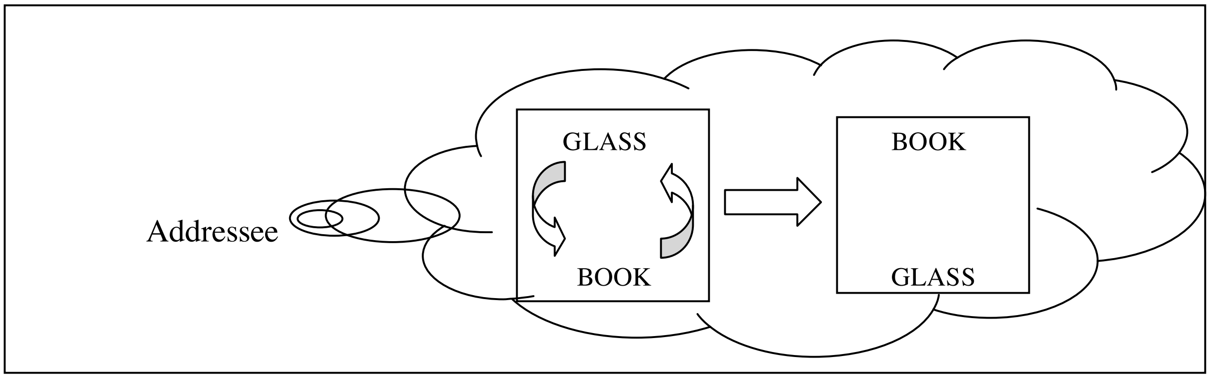

Figure 4. An example of the kind of mental transformation necessary for understanding a simple spatial array in a signed language.

This situation also holds for much more complex descriptions of spatial relationships between objects, or for movements by actors in space. For example, a signer can indicate the direction of a movement through space using the sign space in front of him. The path movement must then be mentally rotated by the addressee in order to be correctly perceived. Emmorey (2002) provides a useful schematic for how such constructions are produced and understood. In Figure 5 below, the arrow represents the direction of movement of a referent, which is represented by the X and is first located in the sign space in front of the signer. The signer wishes to communicate that X moved through space, first to the left, then forward, and finally back to the right. The direction of movement is only properly understood if reversed by the addressee (as in A below); mirroring the movement (as in B below) yields an incorrect interpretation (right, forward, left):

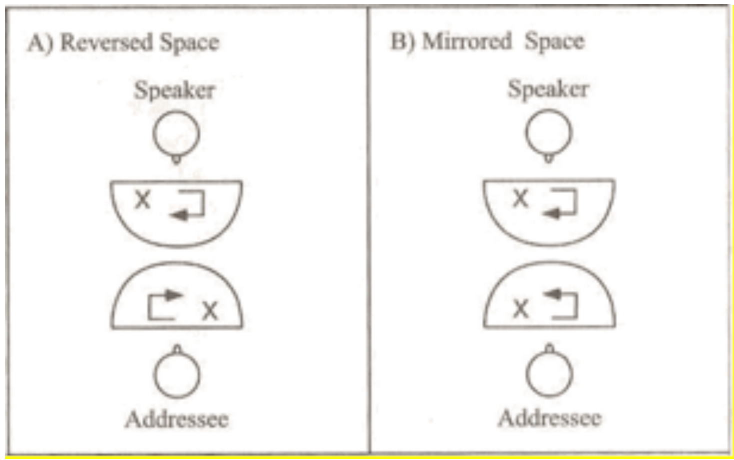

Figure 5. A signed spatial mapping correctly reversed (A) and incorrectly mirrored (B) (reproduced from Emmorey, 2002: 102)

Thus, descriptions of spatial arrays in sign language often require addressees to perform mental transformations of the signs observed. Bellugi et al. (1990) note the challenges that such structures pose to learners: "The young deaf child is faced with the dual task in sign language of spatial perception, memory, and spatial transformations on the one hand, and processing grammatical structure on the other, all in one and the same visual event" (287). Unsurprisingly, linguistic structures in sign that crucially depend on such mental transformations appear later in development than might otherwise be expected (Bellugi, 1988; Bellugi & Klima, 1982; Lillo-Martin et al., 1985), since "the young deaf child, unlike his or her hearing counterpart, must acquire nonlanguage spatial capacities that serve as prerequisites to the linguistic use of space." (Bellugi et al., 1990: 287). Though the development of spatial reasoning vis-à-vis the acquisition of sign language can delay the acquisition of linguistic structures that rely on such skills, the use of spatial reasoning in sign language has also been shown to have positive effects on spatial cognition in the non-linguistic domain. Bellugi et al. (1990) tested the abilities of young deaf and hearing children on processes of spatial construction, spatial orientation, and mental rotation, finding that young deaf children between the ages of 3 and 5 scored above their age expectancies compared to age-matched hearing children's norms. They concluded "that there may be an enhancement of spatial capacities in deaf signing children, particularly at younger ages" (297).

In the sections that follow, I will argue that spatial transformations are not just necessary for descriptions of space in sign language, but also for learning the phonological representations of some – though not all – lexical signs.

4.5 Visual perspective-taking and Sign Language Lexical Phonology

As I explained above, under typical learning conditions signers must take the physical perspective of their interlocutor in order to understand descriptions of spatial arrays. In this section, I will make a series of predictions about how children might perceive and reproduce the forms of lexical signs if they fail to make a mental transformation of signs observed from their perspective. I will outline a typology of phonological sign forms that could lead children to commit specific kinds of phonological errors, and compare them with other phonological sign forms that would not be expected to be susceptible to such errors. I will proceed one-by-one through the phonological parameters that make up lexical signs: palm orientation, movement, location, and handshape (Klima & Bellugi, 1979; Stokoe, 1960; Battison, 1978).

For each parameter, I will also attempt to show what kinds of errors have been found in typical development through an examination of the literature as well as an analysis of a database of early childhood signing. I examined a database of 659 sign tokens that had been collected from four deaf children of deaf parents between 9 and 17 months old. This database had been compiled several years earlier and was available to me through the Meier Lab; the data contained therein were reported on extensively in Cheek, Cormier, Repp, & Meier (2001) and Meier et al. (2008). These sign tokens had been collected in naturalistic observation at the children's homes while they were engaged in play with their mothers. Each sign was coded for the articulatory parameters of handshape, location, movement, and palm orientation. I searched in this database for signs specified for inward or outward palm orientations and asymmetrical movements or locations, as these signs were hypothesized to also be subject to perspective-taking and might be more error-prone than symmetrical signs. A summary of the signs searched for in the database and the number of tokens found can be found in Table 1 below.

Sign	**Number of Tokens**	**Relevant Articulatory Parameter**
APPLE	1	location
BED	4	location
BLACK	12	movement
FLOWER	4	movement
FARM(ER)	3	movement
MOUSE	2	movement
RED	5	palm orientation
ME	12	palm orientation
BIRD/DUCK	23	palm orientation
DOG	36	palm orientation
MINE	3	palm orientation

Table 1. Tokens of relevant signs found in Early Sign Database.

Each of these tokens was examined in the database to see if errors predicted by the perspective-taking model had been made. If the original videotape was available, the token was reviewed visually. However, not all of the original videotapes could be accessed and reviewed.

4.5.1 Palm Orientation

Stokoe (1960) identified 11 palm orientations in his original treatise, though palm orientation was conflated with handshape under the category '*dez*'. For the purposes of the present research, only six palm orientations need be distinguished: facing away from the signer ("outward"), facing the signer ("inward"), upwards, downwards, towards the midline, or away from the midline. Palm orientations facing downwards or upwards are not predicted to lead to perspective-taking errors, as these orientations appear the same to both signer and addressee. Orientations towards or away from the midline are not expected to lead to phonological errors due to the articulatory difficulty of reversing these orientations; for many signs (such as ASL MOTHER and FATHER, which face the midline; see Figure 5 below) a mirroring error would be physically awkward to produce.

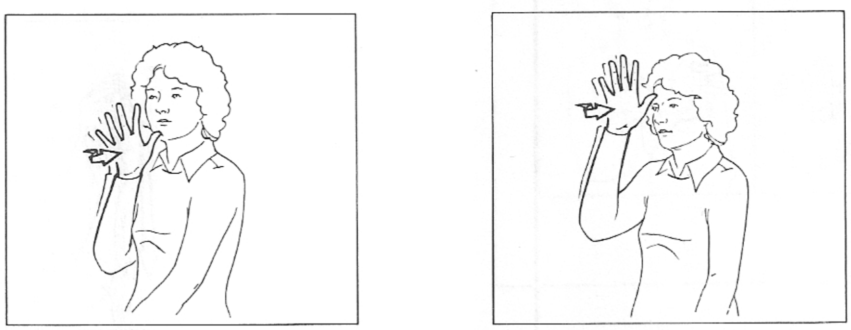

Figure 6. The ASL signs MOTHER (left) and FATHER (right; line drawings reproduced from Humphries et al., 1980; © T.J. Publishers).

In contrast, palm orientations facing away from and towards the signer could be prone to perspective-taking errors. This category of signs is exemplified by the ASL sign SUNDAY, which is produced with both hands facing outwards from the signer in a 5-handshape, moving downwards in an arc or in a circle:

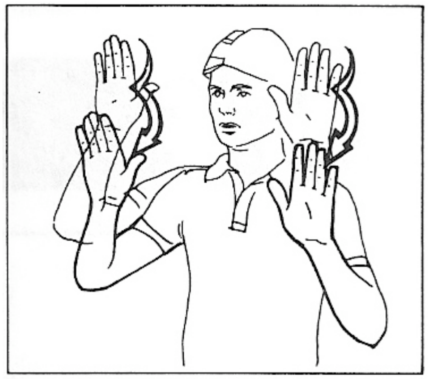

Figure 7. The ASL sign SUNDAY (reproduced from Humphries et al., 1980).

A child learning this sign, and others like it, will see the signer's palms. In producing the sign, he might then reproduce exactly what he has observed and face his own palms inward towards himself. Such an error would entail a failure to replicate the observed movement as it was originally produced from the signer's point of view. It is precisely this type of error that has been found in the gestural imitations of hearing people with autism (e.g., Ohta, 1987). I hypothesize that such perspective-taking errors could crystallize into erroneous phonological representations for autistic children acquiring sign, leading to phonological errors on lexical signs specified for inward and outward-facing palm orientations. Other ASL signs that fall into this category are DOG, TOILET, the possessive pronouns MY and YOUR, most letters of the fingerspelling alphabet (described in more detail in Chapter 5), numbers, and the days of the week.

It does not appear that such errors occur with much frequency in typical sign language acquisition. To my knowledge, there are no documented examples of this kind of palm orientation error in the literature[5]. However, palm orientation is the parameter that is least reported on in the acquisition literature and is often conflated with the

[5] I have heard from colleagues of only one such example reported in the literature (by Ursula Bellugi on the sign DUCK), but was unable to locate the reference.

movement parameter, making a separate analysis difficult. Cheek et al. (2001) found that palm orientations were produced relatively successfully in a study of four typically-developing deaf children (compared to handshapes and movements), and that those errors found tended to involve the substitution of downward for upward orientation. However, they did not code for “inward” and “outward” palm orientations, instead coding for the pronation and supination of the forearm. Therefore, palm orientations were classified as “down” (pronated), “up” (supinated), or “mid” (neither pronated nor supinated). In this schema, a “down” orientation could correspond to either an outward palm orientation or a downward palm orientation. Likewise, an “up” orientation could correspond to either an inward palm orientation or an upward palm orientation.

An examination of the early sign database (on which Cheek et al. based their report) revealed 15 instances in which children produced signs with an upward palm orientation where the adult citation form called for downward palm orientation, on the signs CLOTHES (2 tokens), BLACK (5 tokens), BARNEY (1 token), CROCODILE (1 token) and BIRD (6 tokens). Of these signs, only BIRD is specified for an outward palm orientation; the others are specified for a downward palm orientation. The six errors on BIRD in the database were all produced by one fourteen-month-old child. In addition, there were 19 tokens in the database in which children produced a downward palm orientation where the adult citation form called for upward palm orientation. Several of these signs are specified for upward palm orientation rather than inward (BABY, FAN, and SHOUT) and are therefore not relevant to this discussion. The remaining signs were MONKEY (1 token), EAT (3 tokens), RED (2 tokens), DOG (2 tokens). Of these, DOG is perhaps the clearest example, as it is produced in neutral space and does not have contact with the body. There were 36 tokens of DOG in the database, and only 2 errors, an error rate of about 5%. Overall we can count some 14 tokens (6 inward substitutions and 8 outward substitutions) of reversed inward-outward palm orientation in a database of 659 signs produced by very young typically-developing children.

Thus, a review of the literature as well as an analysis of a database of early signs yielded few clear examples of inward/outward palm orientation reversals. It therefore appears reasonable to conclude that such errors do not appear with much frequency in typical development, especially compared to the high error rates found on handshape and movement (Cheek et al., 2001; Karnopp, 1994, 2002; Juncos et al., 1997). The few examples of their occurrence were in very young typically-developing deaf children between 10 and 16 months of age. By contrast, I predict that such palm orientation errors will persist over time in deaf children with autism.

4.5.2 Inward-Outward Movements

Lexical signs incorporate a large number of movements and no uniform approach (or terminology) has been adopted in the literature. Stokoe (1960) identified some 24 component movements used in ASL. I hypothesize that a certain category of movements – asymmetric movements across a horizontal plane (e.g., from right to left, from left to right, away from or towards the body) – will be most likely to require learners to engage in visual perspective-taking in order to master them. In this section, I will discuss only inward-outward movements, due to their similarity to signs specified for an inward or outward palm orientation. An example of a minimal pair of signs specified for such movements are the ASL signs CLEAN and PAPER, shown below in Figure 7.

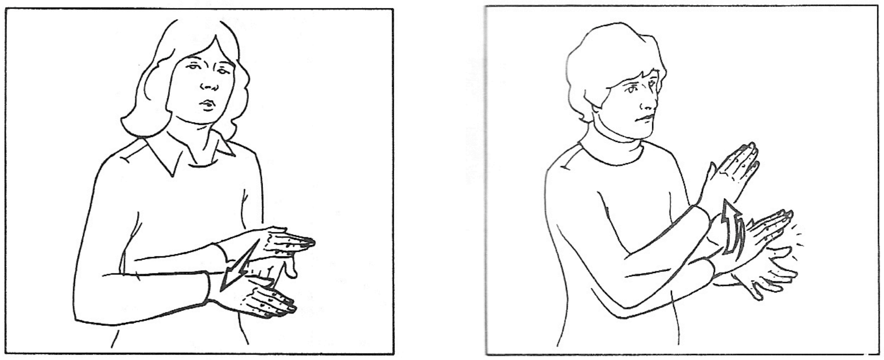

Figure 8. The ASL signs CLEAN (left) and PAPER (right), which differ only in the direction of movement. Line drawings from Humphries et al. (1980).

I hypothesize that such movements could be subject to errors by deaf autistic signers due to a self-other mapping deficit, and indeed, such movements were reversed by autistic subjects in studies of hearing autistic gesture imitation (e.g., Hobson & Lee, 1999). Additionally, Seal and Bonvillian (1997: 452) found that autistic signers had high error rates (43-53%) on movements towards and away from the body.

In the next section, I will proceed to a discussion of the parameters of location and cross-body movements. These two parameters are a bit more complicated than palm orientation and inward-outward movements because of their interaction with handedness. I will first sketch some background on handedness in sign language, and then go on to explain the cross-body movement and location parameters and how they are likely to affect the acquisition of phonological representations of lexical signs.

4.5.3 The Implications of Hand Dominance on Phonological Acquisition

The prototypical signing situation is one in which two right-handed signers face each other. In this type of situation, certain lexical signs – particularly those specified for asymmetrical movements across the body or asymmetrical one-handed locations – require learners to mentally transform signs observed in order to correctly form phonological representations of such signs. Conversely, situations involving heterogeneous dominance would not require rotation of the sign. It is possible to estimate how often such situations occur based on handedness data. It is commonly accepted that about 90% of the general population is right-handed (Corballis, 1980, 1992), and the signing population has been estimated to show similar, though slightly lower, percentages of right-dominance (83%; Conrad, 1979; 87%; Bonvillian, Orlansky, & Garland, 1982), which emerge strongly early in development (Bonvillian & Richards, 1993; Bonvillian, Richards, & Dooley, 1997). Thus, taking the average of these two studies, it can be assumed that about 85% of signers are right-dominant. Keeping in mind that over 90% of deaf children are born to hearing parents (Schein, 1987, 1989; Schein & Delk, 1974), we obtain the following likely distribution of situations involving signing parents and deaf children[6]:

	Right-dominant hearing parents	**Left-dominant hearing parents**	**Right-dominant deaf parents**	**Left-dominant parents**
Right-dominant deaf children	0.9 x 0.9 x 0.85 = .69	0.1 x 0.9 x 0.85 = .08	0.85 x 0.1 x .85 = .07	0.15 x 0.1 x 0.85 = .01
Left-dominant deaf children	0.9 x 0.9 x 0.15 = .12	0.1 x 0.9 x 0.15 = .01	0.85 x 0.1 x 0.15 = .01	0.15 x 0.1 x 0.15 = .002

Table 2. Break-down of statistical probability of sign-learning situations between parents and deaf children.

Hence, around three-quarters of sign-learning situations should involve both a right-dominant language model and a right-dominant learner (i.e., 69% + 7% = 76%). Likewise, between one and two percent of sign-learning situations should involve left-

[6] I do not take into account hearing parents who do not sign to their deaf children.

dominant language models and left-dominant learners (1.4% + 0.2% = 1.6%). Sign-learning situations involving heterogeneous dominance – specifically, situations involving a left-dominant language model and a right-dominant learner or a right-dominant language model and a left-dominant learner – should account for the remaining one-fifth of situations. These situations are likely to require less mental rotation than situations of homogeneous dominance, since signs can simply be reflected rather than rotated when handedness is not shared. Therefore, it can be seen that nearly four-fifths of sign-learning situations are likely to involve language models and learners who have the same hand dominance. Such situations present the difficulty of taking the perspective of another person in order to properly learn certain kinds of asymmetrical locations and horizontal movements, assuming that parents and children do not share the same perspective on the signs produced. Although Holzrichter and Meier (1999) found that deaf mothers of deaf children sometimes share the perspective of their child by sitting behind or beside the child and signing on the child's body, it is reasonable to assume that a good deal of sign language learning takes place in the prototypical situation.

I will now proceed to an illustration of the movement and location parameters, keeping in mind that these parameters have a complex interaction with hand dominance, and are only subject to mental rotation and transformation when signers are both right- or left-dominant.

4.5.4 Cross-body and Lateral Movement

Having discussed inward-outward movements in Section 4.5.2, I will now describe a different class of signs that exhibit asymmetric movement across the body or to the side of the body. Such movements could require learners to engage in perspective-taking, but only if handedness is shared.

Figure 9 shows the ASL sign CHILDREN, which is produced with the dominant hand (in this case the right hand), palm down, moving up and down as the arm travels rightward away from the body, as if patting the heads of three children:

Figure 9. The ASL sign CHILDREN (reproduced from Humphries et al., 1980).

In order for a right-handed child to imitate this sign correctly, he/she must produce the sign with his right hand and move his hand to his right.[7] Under typical conditions, this requires perspective-taking and mental rotation. Failing to do so, the child might attempt to mirror the sign by using his left hand and moving the sign to his left. This form is not ungrammatical (indeed, it would be normal for a left-dominant signer), but it would be unusual for a right-dominant signer. A third possibility is that the child might not switch hands, but mirror the movement of the observed sign, such that his hand would move leftward across his body rather than rightward away from his body. This is also a form of mirroring, but such a pronunciation is never considered phonologically well-formed,

[7] Signs are never listed in the lexicon in terms of right and left, but rather dominant and non-dominant.

regardless of hand dominance. Yet a fourth (though perhaps unlikely) possibility is that signs could be interpreted cardinally, indicating an absolute location, which remains stable regardless of the changing locations and perspectives of signers. In this case, the sign CHILDREN would be produced with movement in the cardinal direction of the first signer's hand movement, wherever that might be. As there exist no data suggesting that children do in fact adopt this strategy, either in the literature or in my research, the cardinal strategy will not be addressed further.

In sum, a failure to take the perspective of one's interlocutor for the ASL sign CHILDREN and other signs similar in form could lead to errors in direction of movement or in the use of the non-dominant hand. Signs falling into this category would be one-handed and exhibit asymmetric horizontal movement. Other ASL signs of this type include BLACK (Figure 10), FARM, UGLY, SUMMER, DRY, and THING:

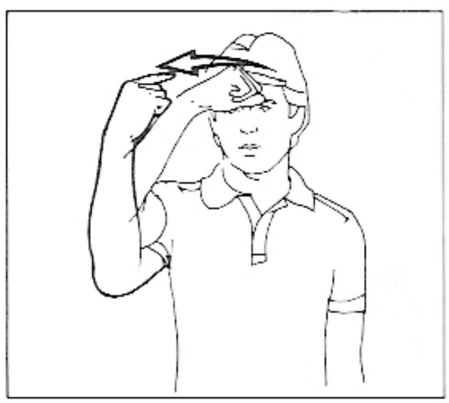

Figure 10. The ASL sign BLACK (reproduced from Humphries et al., 1980).

4.5.4.1 Acquisition of the movement parameter

In formulating a hypothesis about the signing of deaf autistic children, it is important to examine the literature on the typical acquisition of sign language phonology by deaf children, in order to determine what kinds of errors are normally made during the course of acquisition and what kinds of errors might be unique to autism.

Bonvillian, Orlansky, Novack, Folven, and Holley-Wilcox (1985) found that the most common movement primes produced by children were contact, inward and outward movements, downward movements, and pronating and supinating movements. Movement that includes contact with the body is produced most accurately and frequently by both typically-developing and autistic children (Marentette & Mayberry, 2000; Seal & Bonvillian, 1997; Siedlecki & Bonvillian, 1993), perhaps due to its connection with the location parameter.

Morgan, Barrett-Jones, and Stoneham (2007) studied the phonological acquisition of Gemma, a typically-developing DoD British child, between the ages of 19 and 24 months. They found that Gemma altered the movement parameter in three ways:

> (a) by using a different path of movement (e.g., linear instead of circular), (b) by changing the sign's hand-internal movement (e.g., a target finger flick changed to an open–close), and (c) by changing the combination of path and secondary hand-internal movements (e.g., producing one but not the other or producing both but not simultaneously) (9-10).

Furthermore, Morgan et al. reported that movement segments were commonly deleted in Gemma's signing, especially when hand-internal movements were combined with a path (external) movement. Finally, Gemma showed a tendency to reduplicate signs and make them bigger than their citation forms. Therefore, such errors might be expected in the typical acquisition of sign language phonology. Notably, these are not the types of errors that are predicted by perspective-taking failures.

Previous research on hearing autistic signing can also shed light in this regard, though it is difficult to discern from such studies if my predictions will hold true for deaf autistic signers. Seal and Bonvillian (1997: 451) found that autistic signers produced few errors on upward and downward movements, while "leftward" and "rightward" movements were rarely produced at all (1.2% and 0.9% of all movements, respectively). It is therefore unclear from their results whether asymmetric movements along a horizontal plane will be more susceptible to errors than other kinds of movements, such as those along a vertical plane (e.g., upward and downward movements). Finally, unlike Gemma, autistic students tended to add epenthetic movements – extra movements not included in the citation form – and to reduce signs consisting of two or three sequential movements into a single movement.

The study of Christopher (Morgan, Woll, et al., 2002) provides more suggestive evidence that the kinds of movements described above are difficult for autistic learners. Christopher showed evidence of errors in the movement parameter, though not in lexical signs but rather on movements related to verb agreement. I will briefly describe how verb agreement works in many signed languages, including BSL, in order to illustrate Christopher's difficulties with the movement parameter.

All mature, natural signed languages use space to express grammatical relations between arguments; one of the ways that BSL does this is through spatial movement of the verb between locations associated with arguments. So-called "agreement verbs" (Padden, 1983) change their direction of movement depending on the indexed location of subject and object in the signing space. Therefore, such verbs may include inward/outward path movements to indicate agreement between 1st and 2nd person. These types of movements are precisely the kinds of movements hypothesized to be difficult for deaf children with autism. An example of how one agreement verb (GIVE) changes direction of movement in order to reflect agreement with its arguments is shown in the figure below.

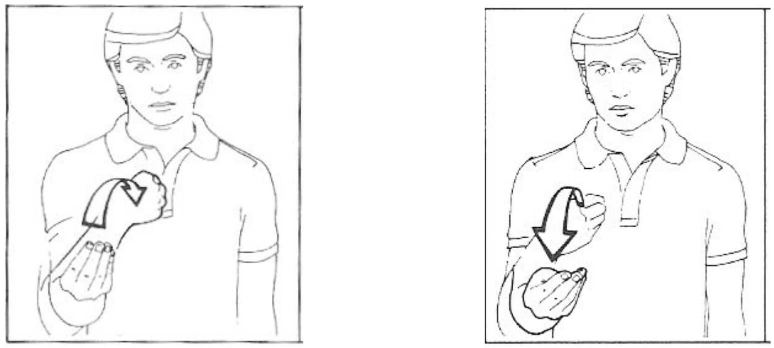

Figure 11. YOU-GIVE-ME (left) and I-GIVE-YOU (right), examples of inflected verb agreement in ASL (pictures reproduced from Humphries et al., 1980).

Christopher showed persistent problems in copying the direction of movement in agreeing verbs, especially in the early phases of acquisition; such problems contrasted with a control group of talented, non-autistic language learners. Morgan et al. reported that "overall Christopher's errors in using verb agreement arise either from omitting agreement (using a citation form of the verb plus pointing to the subject and object), *or by articulating the verb inflection in the wrong direction*" (435-436; emphasis mine). Verb agreement path movements tend to be asymmetrical movements on a horizontal plane; in other words, they fall into the category of movements identified as being most dependent on perspective-taking skills.

Therefore, the case of Christopher provides some evidence for the hypothesis that certain kinds of movements – in this case, verb agreement – will be problematic for autistic learners due to a deficit in the ability to shift perspectives and properly imitate the body movements of others. However, it remains to be seen whether this holds true for the phonological parameter of movement in lexical signs.

An examination of the early sign database revealed several movement errors. There were 5 examples of a substitution of an upward movement for a downward movement: these tokens included two tokens of CLOTHES and three of the name-sign for one of the children's brothers. Children substituted an inward movement for an outward movement on 4 sign tokens: two of CAT and two of OUT. However, there were no tokens found of the opposite substitution (an outward movement for an inward movement). It should be noted that the kind of movement error that is of particular interest was not coded for (asymmetrical movements across the body in either direction). Finally, one token of the sign BLACK showed bidirectional movement rather than contralateral to ipsilateral movement.

4.5.5 Location

Stokoe (1960) identified 12 locations that contrast phonemically in ASL: neutral space, the face/whole head, the forehead/brow/upper face, eyes/nose/midface, lips/chin/lower face, cheek/temple/ear/side face, neck, shoulders/chest/trunk, upper arm, elbow/forearm, inside of the wrist, and back of the wrist. For the purposes of the present typology, it is useful to distinguish between those locations that are produced symmetrically (i.e., along the midline, such as the ASL sign MOTHER; Figure 12, or with both hands on symmetrical places on the body) and asymmetric locations (i.e., signs on one side of the face or body such as the ASL sign GIRL; Figure 12). I hypothesize that signs with asymmetric locations require perspective-taking if signer and addressee share handedness, while signs locations on the midline never do. (It should be recalled that the perspective-taking problem is obviated if signer and addressee do not share hand dominance.) In ASL, the sign GIRL is produced with the thumb of the dominant hand brushing the cheek on the ipsilateral side of the face. This sign – and others like it such as CANDY, APPLE, ONION, and the one-handed variants of HORSE and COW – may be susceptible to articulation errors of the location parameter (i.e., an erroneous location on the contralateral side of the face) if handedness is shared and signers fail to engage in perspective-taking.

Figure 12. The ASL signs MOTHER (left) and GIRL (right; reproduced from Humphries et al., 1980).

4.5.5.1 Acquisition of the location parameter

Location appears to be acquired earlier and with greater success than other articulatory parameters: numerous studies have found location to be the articulatory parameter produced most accurately by children acquiring sign language (Cheek et al., 2001; Conlin, Mirus, Mauk, & Meier, 1999; Marentette & Mayberry, 2000; Morgan et al., 2007; Siedlecki & Bonvillian, 1993). However, some studies (Juncos et al., 1997; Marentette & Mayberry, 2000; Siedlecki & Bonvillian, 1993) have found that signs located on the face and head can cause problems after two years of age. Morgan et al. (2007) note that

> Despite the difficulty in getting target locations on the face correct, signs located on the face and head are very prevalent in first signs (the other location being in

> front of the body), so much so that the head and face are sometimes used as replacements for other locations (Conlin et al., 2000). The head and face may give the child more salient information through tactile feedback as to where the hands are (7).

With regard to locations located on the body (as opposed to the head and face), Conlin et al. (1999) found errors in which an ipsilateral location was substituted for a contralateral or medial location; these errors confirmed a pattern reported by Bonvillian and Seidlecki (1996), who attributed the errors to a general motor difficulty with reaching across the midline.

As for autistic learners, Seal and Bonvillian (1997) reported that their 14 autistic subjects produced locations more accurately than either handshapes or movements, though it does not appear that a distinction was made between contralateral and ipsilateral locations. However, Morgan, Woll, et al.'s (2002) study of Christopher provides a very interesting example of a location error: they report that "[Christopher's] sign for WOMAN was produced by moving the index finger down his contralateral cheek, rather than on the ipsilateral side" (429). The BSL sign for WOMAN is shown in Figure 13 below. It is precisely this kind of error that is predicted by the model I have sketched regarding asymmetrical locations, and thus could be interpreted as a perspective-taking/self-other mapping failure. It is also worth noting that such a contralateral facial location is phonologically constrained in ASL. In other words, there are no naturally-occurring ASL signs that are specified for a location on the contralateral side of the face that do not also involve an ipsilateral touch or location. Furthermore, such a contralateral location error does not appear to be part of the typical acquisition of sign language phonology, and indeed conflicts with the assertion of Bonvillian and Seidlecki (1996) that children prefer to avoid crossing the midline early in development; this tendency toward ipsilateralization has also been demonstrated for adult pronominal usage in American and British Sign Language by Cormier (2007).

Figure 13. The BSL sign for WOMAN (reproduced from Woll & Lawson, 1987).

An examination of the early sign database confirmed the pattern of ipsilateralization. There were no tokens of the opposite mistake (contralateralization of ipsilateral signs). There were four instances in which contralateral locations were articulated as ipsilateral locations by the children: 3 tokens of BARNEY and 1 of BEAR. There were 42 tokens of signs in which children substituted an ipsilateral location for a medial location, an error which can again be explained by motoric factors. These errors included tokens of the signs for ME, MINE, FATHER, MOTHER, GRANDFATHER, EAT, SLEEPY, BITE, DIRTY, SHOUT and RED. The opposite error (substitution of a medial location for an ipsilateral one) was found in just 3 tokens: two tokens of WASH and one token of HURT. There were six instances in which children substituted a contralateral location for a medial location: PIANO (1 token), SLEEPY (1 token), and DIRTY (4 tokens).

4.5.6 Handshape

Handshape (or hand configuration) is one of the major parameters specified for every sign. It has been shown numerous times that handshape is the least accurate of all sign parameters in young children (Cheek et al., 2001; Clibbens & Harris, 1993; Karnopp, 1997; Marentette & Mayberry, 2000; Meier, 2006; Siedlecki & Bonvillian, 1993; Takkinen, 2003; von Tetzchner, 1984), probably due to the late development of fine motor control needed to produce handshapes accurately. Seal and Bonvillian (1997) also found very high error rates on handshape in their hearing autistic subjects: 36.1% of handshapes produced on the dominant hand were errors and 36.5% of handshapes on the non-dominant hand were errors. Handshape will not be examined further in this dissertation because there are no handshapes that contrast due to differing visual perspectives. In other words, even though handshapes do appear differently from different visual perspectives, there are no handshape errors that could be attributed specifically to a failure in perspective-taking.

4.5.7 Hand selection

The choice of either the right or left hand in the execution of a one-handed sign has implications for this research as well. Bonvillian and Richards (1993) found that hand preference was stronger for sign production than non-sign production (such as playing with toys), suggesting that hand preference is at least in part due to the lateralization of language in the brain. However, the hand preference of autistic individuals does not appear to resemble that of the normal population. Numerous studies (e.g., Bishop, 1990; Colby & Parkison, 1977) have reported that children with autism exhibit a much higher rate of left- or mixed-dominance, or even "ambiguous" dominance (Soper et al., 1986). In a more recent study, Bonvillian, Gershoff, Seal, & Richards (2001) examined hand preference in the signing of 14 non-speaking autistic subjects. In contrast to typically-developing deaf signers, four of the autistic signers showed a strong right-hand preference, four showed a left-hand preference, and six did not show a preference for either hand. Bonvillian et al. made some interesting observations that are germane to the present study in their discussion of these children. They speculated that the relatively large number of subjects showing a left-hand preference may be attributable to a mirroring effect in the students' signing: "Because teachers signed more with the right hand, the students facing them would imitate by signing with the left" (2001: 276). In the context of the present study, this finding can again be interpreted as an attempt to obviate the perspective-taking problem. It could thus be predicted that autistic signers may use their non-dominant hand to execute one-handed signs more often than typically-developing signers. However, should this be found to be true, caution must be exercised in seeking an explanation. Students' hand preferences must be carefully documented, and students with ambiguous dominance may have to be excluded from analysis. A failure to develop dominant handedness may be indicative of a failure of the brain to lateralize normally, including for language. Therefore, hand selection in sign production will be considered along with the articulatory parameters of the sign listed above, but any observations made about atypicalities found can only be speculative at this point.

4.6 Summary and Predictions

Thus, it can be seen that unlike speech, learning the phonological form of lexical signs could require signers to understand the visual perspectives of others and perform mental transformations on the signs they observe. I have outlined a typology of phonological forms that are likely to be particularly challenging for autistic learners, given a deficit in self-other mapping, visual perspective-taking, or ToM:

(1a) Signs specified for inward/outward palm orientations.

(2a) Signs specified for inward/outward movements.

In addition, the following types of signs may also be difficult for learners if both signer and addressee are right- or left-handed:

(3a) One-handed signs specified for asymmetric cross-body or lateral movements.

(4a) One-handed signs with locations not on the midline.

For these four types of signs, it is logical to conclude that the child has to make inferences about his interlocutor's visual perspective on the sign and perform a mental rotation operation in order to be able to reproduce the sign. A failure to do so could lead to the following types of errors, respectively:

(1b) Inward/outward palm orientation reversals.

(2b) Inward/outward movement reversals.

(3b) Direction of movement reversals.

(4b) Contralateral location substitutions for ipsilateral locations and vice versa.

If deaf children with autism are found to make these kinds of errors, and typically-developing deaf children do not, then such a finding could shed light on the nature of the cognitive deficit in autism. It could also provide evidence that the acquisition of phonological representations in sign language requires certain skills that are not necessary for the acquisition of spoken language phonology (such as visual perspective-taking).

In the next chapter, I will describe pilot studies conducted with deaf and hearing autistic children in 2007-2008. I will illustrate how results of these pilot studies led to the development of experimental methods used to test hypotheses about how autism affects sign language acquisition.

Chapter 5: Pilot Data and Initial Studies

This dissertation began with an open question: what does the signing of deaf children with autism look like? Though partially motivated by questions about theory of mind, I did not start with a specific hypothesis about how autism would affect the phonology, syntax, or morphology of ASL.

This chapter will describe how pilot data were collected and how those data contributed to the development of a testable hypothesis about autistic sign language.

5.1 Initial pilot data

In the Spring of 2007, I sought to observe for myself what autistic children's signing looked like and whether it differed characteristically from other signing children. I was interested in observing two different groups of children. First, I was obviously interested in observing deaf children with autism. However, it seemed to me that there might be other autistic children being exposed to sign language, since so many studies of hearing autistic children seemed to show the efficacy of teaching signs in addition to or in lieu of speech. I therefore sought to find hearing autistic children who were being exposed to sign language, or perhaps just signs, in addition to speech.

5.1.1 Hearing children with autism

Four hearing autistic children were identified at the Capitol School of Austin, a private school specializing in language disorders. These four children, all males (Adam[8],

[8] All names are pseudonyms.

age 4; Mario, age 5; Calvin, age 5; and Corey, age 7), were all being exposed to signs as an augmentative strategy to speech. They were observed interacting with teachers and with each other in a classroom setting on three different occasions between February and May of 2007. I sought permission to videotape at times when a maximum amount of signing could be observed; thus, data were collected during activities in which children were being prompted to sign or otherwise encouraged to practice communication skills. A total of 2 ¼ hours of video was collected; the average observation of an individual child lasted 15 minutes.

Subject	**Age**	**Observation Date(s)**	**Length of observation (in minutes and seconds)**
Adam	4	2/7/07 3/5/07 4/30/07	5:28 26:05 9:11
Mario	5	2/28/07 4/30/07	21:19 11:19
Calvin	5	2/28/07	23:12
Corey	7	2/7/07 3/5/07	21:02 12:35
		TOTAL	2:10:11

Table 3. Observations of Hearing Autistic Children Exposed to Signs in Addition to Speech.

It quickly became obvious that the data collected from this group would not be of much use for the purposes of this study. This is because the signs that the children were exposed to were highly variable. The teachers (all of whom were hearing) modeling the signs for the children were not consistent in their sign production. In other words, a single sign produced for the children varied in its phonological parameters (handshape, location, palm orientation, and movement) over multiple productions of the same sign. This lack of a consistent stimulus made it impossible to draw conclusions about how the children were perceiving and subsequently reproducing signs. This finding also strengthens my assertion that a weakness of prior studies of autistic "sign language" is that the signed input of hearing teachers tends to be highly variable and inconsistent.

Still, there were clues in the signs produced by these children about their perception of signs. During one session, I asked two different teachers to produce a set of signs and ask children to imitate the signs. Each teacher was working one-on-one with one child. One of the teachers happened to be left-handed, and the right-handed child she was working with (Mario, age 5) successfully imitated all of the signs. The other teacher was right-handed, as was the child she was working with (Calvin, age 5). This child made a number of interesting imitation errors.

On the sign MOUSE, Calvin reversed the direction of movement, such that the sign traveled from the contralateral side of the face to the ipsilateral side of the face. This error was notable insofar as it was suggestive of a failure to shift perspectives and produce the sign as it was produced by the teacher. Rather, the child imitated the direction of movement as it appeared from his perspective.

A similar error was observed in the location parameter of the sign APPLE. The teacher produced this sign with her right hand on her right cheek. Calvin used his right hand but crossed his face to produce the sign on his left cheek, thus matching the location of the sign in absolute, rather than relative, terms.

Figure 14. APPLE as imitated by Calvin (5;4), with contralateral location.

Finally, Calvin switched hands and produced three one-handed signs (MOUSE, ICE-CREAM, and CANDY) with his left hand, all of which he copied correctly.

The three phenomena observed (reversed direction of movement on MOUSE, contralateral location on APPLE, and hand-switching on one-handed signs) are all predicted by the hypotheses laid out in Chapter 4. It is particularly notable that such errors were produced by a right-handed child when imitating a right-handed teacher, but not by a right-handed child imitating a left-handed teacher. These errors could be indicative of a perspective-taking failure (in the case of the movement and location errors) or an attempt to obviate the perspective-taking problem (in the case of hand-switching).

Thus, though the hearing autistic children I observed were not exposed to consistent sign language, the imitation skills exhibited by these children helped in the formation of hypotheses about how handedness might interact with the location and movement parameter of signs. Still, it was clear that if I wanted to observe the effects of autism on sign language, I would have to observe deaf children acquiring ASL as a primary means of communication. I thus stopped observing hearing autistic children at this point in the research.

5.1.2 Deaf children with autism: Naturalistic observation

My first observations of deaf children with autism occurred at the Texas School for the Deaf. I conducted videotaped observation of five children and adolescents: Ricky, age 5; Christine, age 12; Manuel, age 14; TJ, age 15; and Ronnie, age 15. Some of these students were in special needs classrooms while others were in traditional classrooms with typically-developing deaf children. All of them had at least some productive and receptive signing skills; several other autistic students at TSD were excluded from the study on the basis of the fact that they produced few or no signs, although they may have had some receptive abilities. Obviously, there was a discrepancy between the average age of the deaf autistic children and the hearing autistic children observed at the Capitol School: the deaf autistic children were, on average, much older.

It should be noted that at this point in the research, the diagnosis or suspicion of autism for each subject was not verified. For this initial pilot phase, I did not have permission to access subjects' educational or medical records, which might include a record of such diagnoses. "Autistic" subjects were indicated to us by school administrators and these labels were accepted on faith. It should be clear that these initial observations, therefore, are only suggestive.

All of these children were videotaped in naturalistic interaction with teachers and other students. Observation sessions lasted between 10 and 60 minutes each time. A total of six hours of preliminary data was collected. The data were examined for sign tokens produced by the subjects, and these tokens were used to develop the hypotheses described below. Table 4 below lists the sessions with each subject, dates of observation, and length of observation.

Subject	Age	Dates of observation	Total length of observation (in hours:minutes:seconds)
Ricky	5;3 – 6;1	2/26/07; 3/7/07; 4/2/07; 4/4/07; 5/2/07; 10/26/07; 12/17/07	3:18:49
Christine	12	4/18/07	30:14
Manuel	14	4/2/07; 5/7/07	1:30:13
Ronnie	15	4/18/07	26:48
TJ	15	4/18/07	30:17
		TOTAL	6:16:21

Table 4. Naturalistic observations at Texas School for the Deaf of deaf students with autism.

One subject, Ricky, was found to be of particular interest and was observed on multiple occasions throughout 2007. (Three of the other four subjects were videotaped just once; the remaining subject, Manuel, was observed twice.) Ricky's age made him an especially interesting subject to observe: he was 5 years and 3 months old when first observed in February 2007, while all of the other subjects were teenagers.

A TSD administrator pointed Ricky out to me when I came to the school for an initial meeting. She mentioned that although an official diagnosis had not yet been made, she suspected that he might have Asperger Syndrome or high-functioning autism[9]. Though he exhibited typical autistic behavior in his abnormal social skills and repetitive and stereotyped behaviors, he exhibited a large productive and receptive sign vocabulary, as well as reading and math skills that were indicative of normal or above-average intelligence. The sign language development of such a young deaf child with mild autism

[9] Though Asperger Syndrome is still a separate diagnosis from autism at the time of this writing, a proposal has been made to include Asperger Syndrome under the diagnosis of Autistic Disorder in the forthcoming edition of the Diagnostic and Statistical Manual (DSM-V, to appear in 2013).

has never been studied and could be greatly informative about the effects of autism on sign language development.

It was with Ricky that I first observed the kinds of palm orientation errors that I would come to see in other deaf autistic subjects, and which lie at the heart of my hypothesis about how autism affects sign language. Ricky was observed turning his palm inwards while fingerspelling with a teacher, whereas normal adult fingerspelling has an outward palm orientation. This kind of error was striking, both because errors of this type have not been reported in the acquisition literature, but also because it suggests that the child was reproducing signs as they appeared from his perspective, rather than engaging in the kind of perspective-taking that is necessary for the proper acquisition of signs.

Before describing the observed errors, a word should be said about the nature of fingerspelling. Fingerspelling is a manual system through which signed languages represent the written words and letters of the ambient spoken language of a country. Thus, the ASL fingerspelling alphabet represents the letters of the Roman alphabet and is used by American Deaf signers to represent English words. Similarly, fingerspelling in Israeli Sign Language represents the letters of the Hebrew alphabet (Meir & Sandler, 2007), and so on for other signed languages and their respective orthographic systems. In ASL, fingerspelling is used quite often, not just to refer to proper names but also to English words that have not yet been lexicalized in ASL (Battison, 1978).

Fingerspelled words are produced in neutral space and the palm is oriented outwards on nearly all letters, with the exceptions of G and H, for which the palm normally faces inward toward the signer, and P and Q, for which the palm faces down. Most of the fingerspelled letters have no movement, with the exception of “J” and “Z”, which trace the shape of their written analogs in the air. In a paper on the acquisition of fingerspelling by deaf children, Padden and Lemaster (1985) have this to say about palm orientation while fingerspelling: “while the orientation of the palm relative to the body in a sign can vary from facing upward, downward, to the sides, fingerspelling orientation is limited: *the palm must face outward from the speller’s body*” (163, italics mine).

Although the citation forms of most fingerspelled letters are specified for an outward palm orientation, the picture is made more complicated in real conversation since signers typically orient their signing to their interlocutor. Thus, if a signer is addressing someone sitting on their left, the signer might turn his hand so that his palm is facing his interlocutor, rather than the empty space in front of him. In this case, the palm orientation as articulated in real life could differ from the citation form (e.g. facing left rather than outward). However, in both cases, the sign “faces” the interlocutor; it does not “face” the signer.

Returning to my initial observations, Ricky was observed fingerspelling with his palm facing inward toward himself, the reverse of the typical palm orientation. Figure 12 below shows an especially interesting instance of such an error.

Figure 15. The fingerpelled letter ‘D’, produced by Ricky with palm facing inwards rather than outwards.

The example above is particularly instructive insofar as it shows Ricky following the lead of his teacher’s signing. The teacher’s hand is oriented towards the child, whereas the child’s hand is clearly turned inward. This orientation is interesting; while he successfully imitates the handshape of the sign being produced, he errs by copying the teacher’s palm orientation in relation to himself, rather than turning his own palm outward. It is as if he does not realize that fingerspelled letters are supposed to face his interlocutor, not himself.

An initial hypothesis might be that this child prefers to sign with an inward palm orientation, perhaps due to an immature motor control. Could signing with a supinated forearm be easier than with a pronated forearm, for example? However, the data quickly disproved such a theory, as Ricky was also observed producing an outward palm orientation on signs that would normally have an inward palm orientation (the days of the week MONDAY, TUESDAY, WEDNESDAY, and FRIDAY).

Figure 16. The ASL sign WEDNESDAY produced by Ricky on two different occasions with reversed palm orientation (left and middle) and the citation form (right; reproduced from Humphries et al., 1980).

The same palm reversal was also observed while he was doing a math problem; he signed ELEVEN, TWELVE, THIRTEEN, and FOURTEEN with outward rather than inward palm orientation. Thus, it is clear that he did not have a predisposition towards one particular palm orientation, but rather seemed to be systematically reversing the two.

These palm orientation errors occurred at various times and in different contexts. I coded 98 minutes of naturalistic observation of Ricky over four different taping sessions. During these 98 minutes, Ricky produced 182 sign tokens, 29 of which contained an inward/outward palm orientation reversal. He consistently reversed palm orientation on fingerspelling, numbers, and days of the week.

The two kinds of errors described above (i.e., inward orientation substituted for outward and outward substituted for inward) accounted for all but one of the palm orientation errors observed. The other error consisted of the substitution of a downward-facing palm orientation for an upward-facing palm orientation for the sign BOWL.

Significantly, however, this type of substitution has been observed before in typically-developing deaf children (Cheek et al., 2001).

The other four subjects videotaped at TSD were not observed making any errors in their lexical phonology. However, they were all over the age of 12. At this point, I decided to continue my research on Ricky and to focus on the issue of lexical phonology and leave aside some of the other issues I began my research with, such as questions about eye gaze behavior and facial expression. Thus, throughout the rest of 2007 I continued observing Ricky and formulated a hypothesis about what the palm orientation errors I observed could mean.

At the same time, I contacted other schools for the deaf around the country in an effort to recruit more deaf autistic subjects. I also started developing an experimental protocol aimed at eliciting targeted structures from these subjects. In the next section, I will describe these additional pilot studies conducted in 2008.

5.2 PILOT EXPERIMENTS

5.2.1 Subjects

Subjects were recruited at the Iowa (Council Bluffs) and Ohio (Columbus) Schools for the Deaf and The Learning Center for Deaf Children in Framingham, Massachusetts, during the Spring of 2008. A faculty liaison at each school identified potential subjects and sent a letter written by the researcher to each child's parents. This letter (included in Appendix D) explained the research project and asked parents to sign a consent form giving me permission to videotape their child in naturalistic and experimental observation. Because of the very small population of deaf children with autism, an effort was made to be as inclusive as possible: the faculty liaison was asked to identify all children with autism of any age who had at least some productive sign vocabulary. Thus, only children who were completely non-signing were initially excluded from recruitment.

Once it had been determined that a sufficient number of children from each school could participate, arrangements were made for a site visit. Each visit typically lasted 2-3 days and consisted of approximately 30 minutes of naturalistic observation in the classroom, a lexical elicitation task and fingerspelling task, and documentation of the child's autism through verification of educational and medical records. Parents were asked to sign a separate consent form granting me access to protected health information in the child's records. Permission to be videotaped was also obtained from parents of other (non-subject) children in the same classroom as autistic children, in the event that these children were incidentally videotaped during naturalistic classroom observation.

In addition, a home visit was made to a family in Austin, Texas, in which both parents were deaf and there were two hearing children, one of them autistic. These hearing children of deaf parents (CODAs) were included in the research because ASL was their first language. The non-autistic CODA was the only typically-developing subject who participated in the research at this point.

Independent verification of each child's autism status could not be made by the researcher. It should be noted that there exist no instruments for diagnosing or screening for autism that have been normed on deaf children. An initial attempt was made to adapt the Social Communication Questionnaire or SCQ (Rutter, Bailey, & Lord, 2003), a questionnaire of 40 questions about children's language, non-verbal communication, and socialization, for deaf children. However, the data obtained proved unreliable, as several of the deaf-of-deaf children with confirmed diagnoses of autism failed to score above the threshold for risk of autism. Thus, it was decided that a confirmed diagnosis of autism, pervasive developmental disorder (PDD), or Asperger Syndrome from the child's records made by a qualified clinician would have to suffice as a criterion for inclusion in this research.

A total of 13 deaf subjects and two hearing children of deaf parents (one of whom was typically-developing) ranging in age from 2;7-12;8 participated. However, seven children were later excluded from the analysis because their school records failed to confirm that an official diagnosis of autism had been made.

Six of the eight remaining children had at least one deaf parent, guaranteeing that they had been exposed to sign language at home since birth. Because of the very small subject pool of deaf children with autism, it was decided not to exclude deaf autistic children with hearing parents from the data. However, these data must be judged with the caveat that deaf children of hearing parents are known to lag in theory of mind development by comparison to their hearing peers as well as to deaf children of deaf parents (Courtin, 2000; Remmel et al., 2001; Schick et al., 2007). Thus, the deaf-of-deaf and deaf-of-hearing subjects must be considered separately.

Information about each child was gathered from school records including autism diagnosis, disability profile, hand dominance, educational test results, hearing status of parents and length of exposure to ASL. Children were excluded if they had other co-morbid conditions in addition to deafness and autism that could affect their language development, such as fine motor difficulties or very significant mental retardation. Information about the subjects tested can be found in Table 5 below.

Subject	Sex	Age	Hand Dominance	Hearing status	Parental hearing status	Autistic
RK*	M	2;7	Right	Hearing	Deaf	No
Ruben	M	4;6	Right	Deaf	Deaf	Yes
Brock	M	5;1	Left	Hearing	Deaf	Yes
Cameron	M	7;5	Right	Deaf	Deaf	Yes
Dana	F	9;3	Right	Deaf	Deaf	Yes
Peter	M	10;6	Right	Deaf	Hearing	Yes
Sam	M	11;10	Right	Deaf	Hearing	Yes
Mark	M	12;8	Left	Deaf	Deaf	Yes

*Non-autistic (typically-developing) subjects are referred to by their initials.

Table 5. Subjects tested in pilot tasks (naturalistic observation, lexical elicitation and fingerspelling).

5.2.2 Naturalistic Observation

All the subjects were videotaped in naturalistic observation for 30 minutes. This consisted of videotaping the children while they were engaged in normal classroom activities. Teachers were asked to choose an activity or school period during which the maximum amount of sign language might be observed. The researcher videotaped the child interacting with teachers and other students, but did not directly interact with subjects during this part of the experiment.

Segments of the naturalistic data were then examined for instances of the signs produced by each child. The three youngest autistic children, Ruben, Brock, and Cameron, were observed producing unusual errors in their signing which will be discussed in detail in the next section.

5.2.2.1 Ruben (age 4;6)

Ruben, the youngest signer in the sample at age 4;6, exhibited several unusual characteristics in his signing. First, and perhaps most significantly (in light of the initial pilot data collected in Texas), he spontaneously reversed palm orientation on several signs, signing the numbers 6-10 with palm orientation turned towards himself rather than turned outward.

Figure 17. Ruben (at right) signing the number SEVEN with inward palm orientation instead of outward.

This error is particularly interesting because of the physical arrangement of Ruben and his teacher: they are standing side by side, not face to face as is typical of most signing situations. As such, they share the same perspective on the calendar, the object of their visual attention. In this situation, imitation of the teacher's sign would be relatively straightforward, since the self-other mapping necessary to imitate would not entail a shift in perspectives. However, it does not appear that Ruben is imitating his teacher; rather, he appears to have learned the sign SEVEN and has recalled it from memory. This would explain why Ruben would produce a reversed palm orientation, even when he is sharing the same visual perspective as his teacher and his teacher is correctly modeling the sign for him. This indicates that self-other mapping failures that occur during the initial imitation and learning of signs can crystallize into the phonological representation of the sign in the child's mental lexicon. Hence, a prior error in learning could show up even in situations in which perspectives are shared.

Ruben also reversed palm orientation on several fingerspelled letters, which he produced while pointing at letters of the alphabet posted on the wall; these errors will be described in more detail in Section 5.4.4.

In addition to the palm orientation errors described above, Ruben also produced the sign FISH with a reversed movement: rather than an outward path movement from the signer, Ruben produced FISH with a path movement that started with his arm extended; he then retracted his arm and pulled it to the right, executing a near-reversal of the target path movement. Such a reversed movement fits the hypothesis of predicted errors described in the last chapter.

Ruben also produced several signs with modifications that could be viewed as in line with more typical development: he deleted path movements from the signs GIRAFFE and ELEPHANT, and deleted hand-internal movement on the sign SLEEP. He also simplified the sign STORY from its disyllabic citation form to a monosyllabic pronunciation. Finally, he proximalized movement on the signs AARON (the name-sign of the researcher) and TEN from a forearm twist to a shoulder twist, also a modification typical of young signers early in development (Meier et al., 2008).

5.2.2.2 Brock (age 5;1)

Brock is the hearing child of deaf adults, a so-called CODA (Child Of Deaf Adults). His first language is ASL and he communicates with both parents through sign. However, he was also exposed to spoken English and his signing was often accompanied by vocalization. He was videotaped interacting with his father and mother during a home visit.

Brock was observed making several different palm orientation errors. The first occurred near the beginning of the taping session, when his father asked him to wave to the researcher (who was behind the videocamera). Brock waved with his palm turned inward rather than outward. The reversal of this common gesture, used throughout American hearing and Deaf culture, was particularly striking, and suggests that whatever cognitive mechanism is responsible for these palm reversals is not specific to language, but also extends to communicative gesture.

Figure 18. Brock waving hello with palm turned inwards.

Brock also reversed palm orientation on the letters ‘H’ (producing it was an outward orientation rather than inward) and ‘R’ (producing it with an inward orientation rather than outward). The production of the letter ‘H’ was particularly interesting in its articulatory awkwardness:

Figure 19. Brock producing the letter ‘H’ with reversed palm orientation.

It should be noted that it is also possible to produce the ‘H’ with a reversed palm orientation by extending the arm out straight to the side; this configuration would be less marked in terms of articulation and would maintain the supinated character of the forearm during normal articulation. However, he twisted his forearm such that it is pronated, resulting in reversed palm orientation.

Brock produced the letters ‘Y’ and ‘L’ with palm facing the floor; these errors could be due to the absence of wrist flexion to bring the palm up to face outward, but are not considered reversals insofar as the arm retains the pronated character of the citation form, unlike the ‘H’ and ‘R’ errors described above.

Brock also produced errors in location and movement. With regard to movement, he reversed the direction of movement on the sign MONKEY, executing a downward movement rather than the citation form’s upward movement. He also reversed the direction of the movement of the dominant hand on the signs COMPUTER and LION, executing a movement with a forward/outward direction rather than the backward/inward direction that both of these signs are specified for. These reversals in inward/outward movement are predicted by the model. However, I cannot account for the downward/upward movement reversal found on the sign MONKEY.

In addition, Brock exhibited a tendency to simplify or delete movement segments. He reduced numerous signs that are commonly reduplicated (HORSE, DUCK, CHICKEN, RABBIT, PIG, BLUE, PURPLE, AIRPLANE, APPLE) to a single movement. This differs from what has been reported for much younger typically-developing deaf children; Meier et al. (2008) and Morgan (2006) have both reported that very young typically-developing deaf children tend to add repetition to single-cycle signs, but don't tend to simplify signs with repeated movements. Brock also deleted the movement segment entirely on the sign HAPPY. Other simplifications included the loss of the non-dominant hand on the sign DANCE as well as the substitution of one hand for a two-handed sign (BEAR).

As for location, Brock produced a one-handed variant of the sign MONKEY, substituting a contralateral location for the ipsilateral location. Alternatively, this could be interpreted as the sign for BEAR. He moved the location of HORSE from the temple to his cheek. However, this sort of location substitution is quite common in the adult language (Liddell & Johnson, 1989) and could be due to the articulatory markedness of the temple/forehead location.

Brock produced a proximalized version of the sign YES, using his elbow joint rather than his wrist joint; this kind of proximalization is common in young children's signing.

Finally, he produced the sign STAR without contact between the hands, at chest level rather than chin/head level.

5.2.2.3 Cameron (age 7;5)

Cameron was observed fingerspelling during naturalistic observation with his palm turned in towards himself. During one classroom activity, the teacher asked him to fingerspell the alphabet. Cameron signed each letter with reversed palm orientation, except for the letters O, P, and Q. Later, he fingerspelled “kite” twice, both times with reversed (inward-facing) palm orientation. Cameron was also administered the fingerspelling test, the results of which will be discussed in section 5.2.4. It was clear from both the naturalistic observation as well as the experimental data that Cameron had a strong tendency to reverse palm orientation, particularly while fingerspelling.

5.2.2.4 General Conclusions from Naturalistic Observation

The naturalistic data collected were suggestive insofar as they provided evidence of several different kinds of errors in the form of the signs that the children produced. Some of these errors are typical of normal sign language development, such as deletion of path and hand-internal movements, syllabic reduction, the substitution of the cheek location for the temple location, and the substitution of downward palm orientation for upward palm orientation and vice versa. However, several of the errors found appear to be atypical: chief among these is the substitution of outward palm orientation for inward palm orientation and vice versa, especially while fingerspelling, and the reversal of the direction of path movements. These kinds of errors support the hypothesis that lexical phonology in signed languages is underpinned by cognitive skills that could be impaired in autism. However, a weakness of naturalistic data collection is that every data collection session will be different, and there is no way to systematically compare across subjects. Therefore, two experimental test protocols were developed in order to elicit the same signs from all subjects. These tests will be described in the following sections.

5.2.3 Lexical Elicitation

5.2.3.1 Introduction

Based on the theoretical predictions that arose out of observations from the naturalistic pilot data collected, a lexical test was designed to test children's production of two kinds of lexical signs: signs whose phonological forms require shifts of perspective, and signs that do not. The goal was to elicit these signs from the children using pictures and then analyze the form of those signs. It was predicted that children with autism and young typically-developing deaf children would make more errors on signs that require perspective shifts than on signs that do not. Twenty-four signs were chosen from the ASL version of the MacArthur Communicative Development Inventory (Anderson & Reilly, 2002); half of these signs were test items (entailing perspective shifts) and half were control items. These signs are among the most common signs learned early in acquisition (Acredolo & Goodwyn, 2002). Stimuli consisted of pictures produced using Boardmaker® software and printed on a 5" x 7" laminated card. There were four test items for each of the parameters of location, movement, and palm orientation.[10] The signs elicited by test condition are listed below; see Appendix A for images of the actual pictures used.

[10] Some signs have multiple test parameters; e.g. AIRPLANE could be analyzed with respect to movement or orientation. Furthermore, hand selection is a variable for all one-handed signs.

Condition	Test Parameter	Signs	Target Parameter Value
TEST (Entailing perspective shifts)	Location	GIRL, BED, APPLE, CANDY	ipsilateral
	Palm orientation	BATHROOM, BIRD DOG, BUTTERFLY	outward inward
	Movement	FLOWER, MOUSE BLACK AIRPLANE	ipsilateral → contralateral contralateral → ipsilateral proximal → distal (outward)
CONTROL (Not entailing perspective shifts)	Location	ICE CREAM, BUG, BOY BEAR	midline both sides
	Palm orientation	BOWL TRAIN, SHOES, TABLE	upward downward
	Movement	ALLIGATOR EGG, TOMATO, HOUSE	up-down downward

Table 6. Signs elicited in Lexical Test, separated by test condition and test parameter.

5.2.3.2 Methods

The researcher showed the stimulus cards to the child one by one, asking “What’s this?” or “What is this called?” in ASL. The order of presentation of the stimuli was randomized. If subjects did not respond after prompting, the researcher produced the sign and asked the child to imitate him. The task therefore included an imitation component; imitated signs may be more likely to exhibit perspective-taking errors than elicited signs, since signs that have been learned well could cease to show such errors after repeated correction.

Items were coded in relation for the parameter being tested, and items were coded as either an error or no error. A deaf signer of ASL re-coded 4 of the 7 subjects (57%). Since the number of tokens was relatively low and the coding of phonological parameters fairly straightforward, any resulting disagreements in judgment were resolved through a discussion between coders.

5.2.3.3 Results

Contrary to expectation, none of the subjects had difficulty complying with the demands of the task, which took 5-10 minutes to administer. Neither did subjects make many errors on the lexical test: of 160 sign tokens elicited, 12 (7.5%) contained an error in location, movement, or palm orientation. It should not be surprising that the overall error late was low: these signs are among the earliest signs learned and most of the subjects were beyond the age when a high error rate might be expected. Indeed, to observe any phonological errors at all on these signs should be considered abnormal. Still, all but one subject (Brock) produced at least one error. There were 8 non-responses to stimuli. Importantly, 8 of the 12 errors observed were of the types predicted. Each error observed will be illustrated and discussed below. The errors that fit the prediction model will be discussed first, followed by a discussion of the errors that did not fit the model.

5.2.3.3.1 Errors that Fit the Model: Location Errors

The sign GIRL was produced with a location error (contralateral cheek rather than ipsilateral) by Cameron, age 7;5. This error was rather suggestive in that it was not the first sign that Cameron produced for the picture. Indeed, this sign was produced not in response to the stimulus picture for 'girl' but rather for 'boy.' At first Cameron produced the sign for 'girl' on the correct cheek (his right). However, his teacher (who was eliciting the signs from him) shook her head, at which point he produced the sign on his left cheek. Finally, the teacher produced the sign BOY, which Cameron correctly imitated.

Figure 20. Cameron's location error on GIRL, and citation form (reproduced from Humphries et al., 1980).

This error is suggestive for several reasons. One, this is the kind of location error predicted for perspective-taking failures. Indeed, a contralateral location produced by a right-handed signer could be an attempt to mirror the location of a sign produced by another right-handed signer. Secondly, this error is interesting because Cameron produced the error after being prodded by the teacher. This would seem to suggest that he is used to making certain kinds of errors and being corrected. Indeed, it would seem that he knows that he sometimes makes errors involving sign location, and thus his best guess as to what was wrong when the teacher shook her head was to switch locations. Finally, this error is remarkable in that it violates a phonological constraint of ASL. There are no signs in ASL which are specified for a location on the contralateral cheek. Crossing the face is quite restricted in ASL, although it does occur; in those instances when it does occur, it is in relation to a second location with movement from one side of the face to the other (such as in BLACK, FLOWER, UGLY, or FARM).

Another location error was produced by Sam (11;10) on the sign BED. Just as with the previous example with GIRL, the target ipsilateral location was produced on the contralateral side, with a consequent phonological location error:

Figure 21. Sam's location error on BED, and citation form (reproduced from Humphries et al., 1980).

This error, too, fits the model's prediction for location errors on signs requiring perspective-taking.

5.2.3.3.2 Palm Orientation Errors

Two subjects produced palm orientation errors on the sign DOG. The citation form of DOG is produced with the palm facing inwards toward the signer, while both subjects produced the sign with the palm either facing outward or towards the side:

Figure 22. Citation form for DOG (top; reproduced from Humphries et al., 1980), and two tokens with erroneous palm orientation (bottom), produced by Dana (9;3) and Mark (12;8).

Though these tokens fit the model's predicted errors, there is an alternate interpretation of Dana's error: it appears that she was resting her elbow on her knee, which could have caused her palm to face to the side rather than inward. Dana also produced TOILET with her palm facing to the left rather than outward:

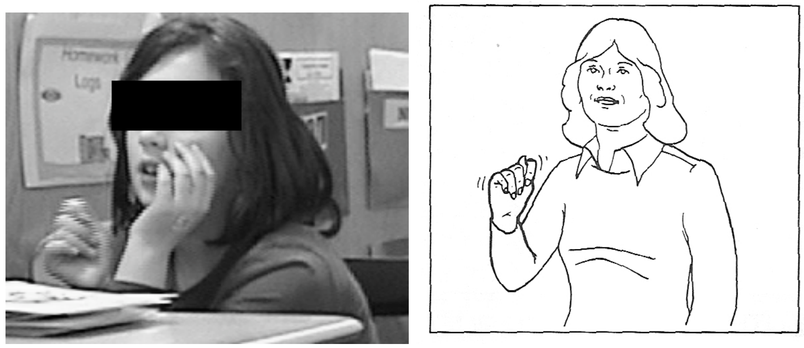

Figure 23. TOILET as produced by Dana, age 9;3 (left) and citation form (right; reproduced from Humphries et al., 1980).

Dana exhibited low muscle tone overall and appeared to be exerting minimal energy as she produced the signs elicited. Although this error (as well as the occurrence of DOG described above) could be interpreted as supporting our model, I will err on the side of caution and attribute these two errors to the physical circumstances of the articulation produced.

5.2.3.3.3 Movement Errors

The hypothesis predicted that signs specified for asymmetrical movements could be subject to self-other mapping errors. The sign FLOWER elicited three movement errors. The citation form of FLOWER calls for an O-handshape to touch the ipsilateral cheek and then move just under the nose to the contralateral side where it makes contact on the contralateral cheek. This cross-facial movement could cause perspective-taking errors. Two of the three errors observed showed reversed movement (contralateral $\rightarrow$ ipsilateral):

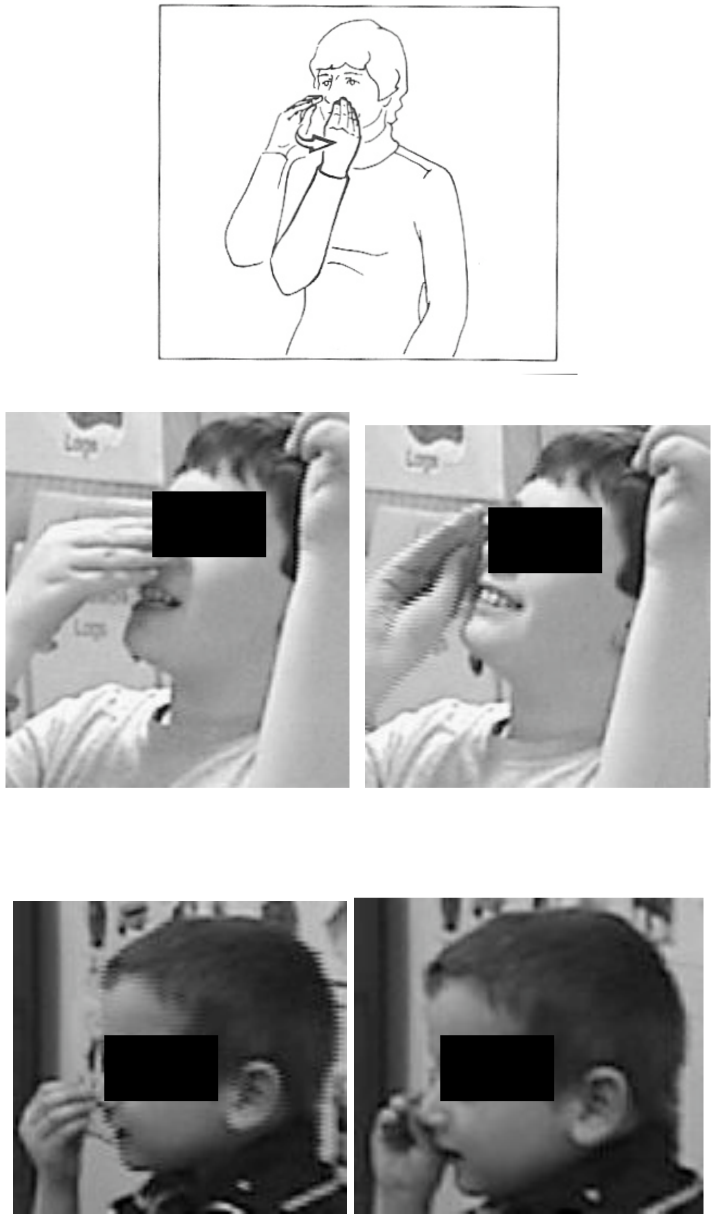

Figure 24. Citation form of FLOWER (top; reproduced from Humphries et al., 1980); as produced by Peter, age 10;6 (middle) and by Ruben, age 4;7 (bottom), with reversed direction of movement from the contralateral side to the ipsilateral side of the face.

The third error on FLOWER was produced without directional movement at all: Cameron produced it by bouncing his hand on his nose:

Figure 25. FLOWER as produced by Cameron (7;5) with repeated movement to contact on the nose.

One possible reason for the reduction of movement for this sign is the difficulty involved in perceiving asymmetric movement across the face and subsequently reproducing such movement. Another possibility is that movement across the face is physically difficult. Morgan, Barrett-Jones, et al. (2007) noted that movement deletion was a characteristic of their young typically-developing subject, though Marentette and Mayberry (2000) found that movements that include contact with the body are among the earliest movements acquired. Thus, it is not clear whether a reduction of this asymmetric movement to a more static movement reflects a perceptual or articulatory difficulty. At this point, these questions could not definitively be answered. Rather, the characteristics of the errors produced have been described in the hope that such errors could be used to guide the development of research hypotheses and designs.

All of the errors that have been described up to this point were produced by signing autistic children and fit the hypothesis about what kind of errors might occur if the ability to shift perspectives in the formation of phonological representations is impaired. The next section will report on errors that were observed in the one typically-developing child tested at this stage in the research.

5.2.3.3.4 Errors from a young typically-developing signing child

One very young (2;7) non-autistic subject was tested during a home data collection visit. This boy, RK, is the brother of the autistic subject Brock and is a hearing child of deaf parents (CODA) whose first language is ASL. At the time, he was tested simply because he was in the room while his brother was being tested, and he felt left out and wanted to participate. Since part of my hypothesis concerns the signing of very young typically-developing children and RK was under the age of 3, I decided that it would be useful to observe his signing.

Indeed, he produced two very interesting errors: a movement error on BLACK and a palm orientation error on BUTTERFLY. Let us first consider the sign BLACK. The target form moves across the forehead, from the contralateral side towards the ipsilateral side; RK reversed the direction of movement, producing the sign starting on the ipsilateral side and moving towards the contralateral side.

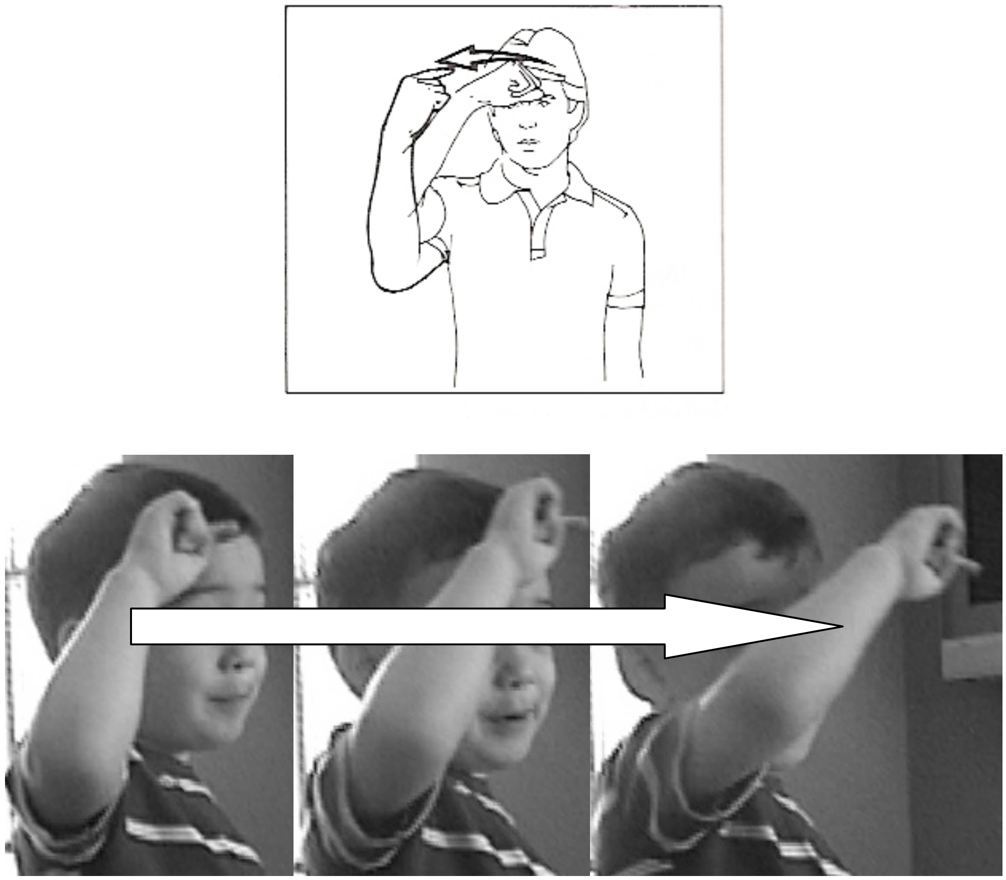

Figure 26. Citation form of BLACK (top; reproduced from Humphries et al., 1980) and as produced by RK (2;7), a typically-developing CODA and younger brother of an autistic CODA.

Such a movement reversal is predicted by the model, provided that the sign-learning child and the person from whom he learns the sign have the same hand dominance. In this case, both parents as well as the child were right-handed.

RK also produced an interesting error on BUTTERFLY, reversing the palm orientation:

Figure 27. The sign BUTTERFLY as produced by RK (2;7) with reversed palm orientation, and the citation form (from www. ASLPro.com).

This error is also predicted by the model of palm orientation reversals.

How are these errors to be interpreted? There are two distinct possibilities. The first is that such errors reflect a perspective-shifting failure, just as I have hypothesized for deaf autistic children. Such an interpretation would imply that young typically-developing deaf children may also have problems learning the phonological representations of lexical signs that require shifts in visual perspective. If this were the case, then young TD children and autistic children would both make the same kinds of phonological errors, though it could be expected that TD children would stop making these errors earlier than autistic children. Furthermore, such an interpretation implies that the cognitive processes entailed in perspective-shifting and self-other mapping emerge relatively late with regard to phonological development.

An alternate interpretation is that RK learned these signs at least in part from his older autistic brother, Brock. Although the older brother was not observed making these same errors, the mother informed me that Brock had produced these signs with the same phonological errors at an earlier stage. She speculated that RK could have learned to produce the signs BLACK and BUTTERFLY with reversed movement and palm orientation, respectively, through watching his older brother. Thus, it is unclear at this point what the significance of these mistakes are: do typically-developing signing children make such errors at an early age, implying that perspective shifts are difficult for all young signing children? Or is it in this case evidence only of the older brother's autism, insofar as he had been a model for his younger brother's signing? Clearly, this hypothesis warranted further investigation, the results of which will be described in the next chapter.

5.2.3.3.5 Errors that did not fit the predicted model

All of the errors described up until now – in palm orientation, location, and movement – followed the predictions made at the end of Chapter 5. However, several of the errors observed did not fit the model and will be described in this section. One was an odd production of BUTTERFLY, produced by Peter (10;6):

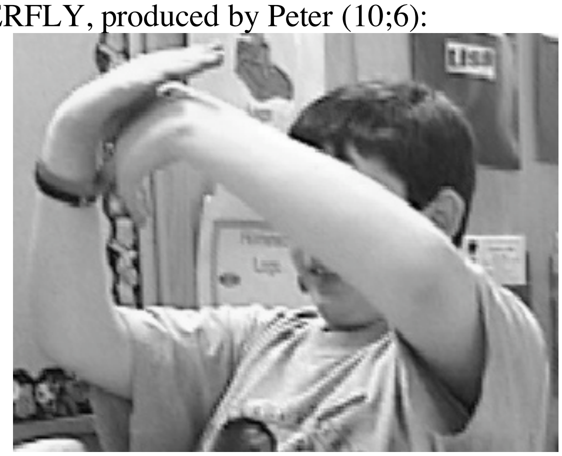

Figure 28. BUTTERFLY as produced by Peter (10;6).

Peter’s forearms are pronated, not supinated as in the citation form. However, he manages to produce the sign in such a way that the palm orientation still faces inward.

In addition to the palm orientation errors that fit the model of hypothesized errors due to failures to shift perspectives, subjects produced several downward/upward palm orientation substitutions, which have also been found in the typical acquisition of ASL. One example of this was Ruben’s production of the sign BOWL, in which he substituted a downward-facing palm orientation for an upward palm orientation:

Figure 29. BOWL as produced by Ruben (4;6), with palm orientation facing down rather than up.

A similar error was produced on the sign AIRPLANE by Cameron, who substituted a downward palm orientation for an upward one:

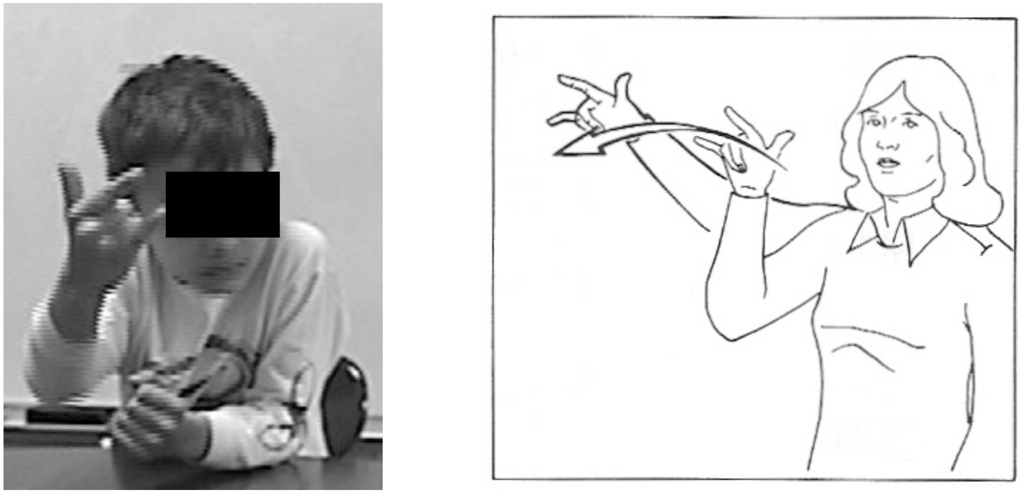

Figure 30. AIRPLANE as produced by Cameron (7;5) with palm orientation facing up (left); and the citation form (right; reproduced from Humphries et al., 1980).

These types of substitution errors were reported for typically-developing deaf children by Cheek et al. (2001). Therefore, it seems likely that these errors fit a pattern of typical language acquisition.

Thus, the sign elicitation test produced a number of errors, two-thirds of which were of the predicted type. Of those that did not fit the predicted model, most fit with reports of errors in typical acquisition, while one error remains unaccounted for. It was clear at this point that more data needed to be collected from both autistic and typically-developing subjects before conclusions could be made.

5.2.4 Fingerspelling test

5.2.4.1 Introduction

Ricky's intriguing palm orientation errors while fingerspelling in naturalistic observation led to the speculation that other deaf children with autism might make similar errors in fingerspelling. Fingerspelling might provide a particularly interesting way to test hypotheses about the effects of autism on the development of phonological representation in sign language, since it is mastered later in development than elementary lexical signs and could be particularly challenging to learners.

5.2.4.2. Methods

A fingerspelling test was designed in which children were shown English words printed on 8” x 3.5” laminated cards and asked to fingerspell the words. The words were *bed*, *table*, *watch*, *telephone*, *cap*, *chair*, *door*, *shoes*, *book*, and *scissors*. The fingerspelling test was conducted immediately after the Sign Elicitation task and the order of presentation of stimuli was randomized. The subjects were the same as in the previous task.

5.2.4.3. Results and Discussion

Two of the seven subjects showed a tendency to produce fingerspelled letters with reversed palm orientation: Cameron (7;5) and Brock (5;1). The words elicited are listed below. Reversed palm orientation on fingerspelled letters is indicated by bolded and underlined letters.

STIMULUS	Brock (5;1)	Cameron (7;5)
bed	D-E-D	**D-B**-E-**D**
table	T-D-B-I-L-E	**T-A-D-B-I-L-E**
watch	W-D-**C-H**	**W-A-T-**C-N-H
book	**D**-O-O-K	**B**-O-O-**K**
cap	**C-P**	C-**A-R**-P
chair	L-D-**C-H**-D-H-I-I-R	C-H-**A-I-T-R**
shoes	S-H-**E-O-E-S**	**E-S**-H-O-**E-S**
door	D-O-O	**B-X-E**-O-R
telephone	(no response)	**D-T-I-E-L-E**-P-Q-H-O-**R-N-**E
scissors	(no response)	**S**-C-X-**I-**C-**S-S**-O-R-E-S
% of letters reversed	**29.7% (11/37)**	**60.6% (40/66)**

Table 7. Performance of Cameron and Brock on the fingerspelling task, with letters with reversed palm orientation bolded and underlined.

Cameron exhibited a strong tendency to reverse palm orientation, reversing 40 of 66 letters produced (60.6%), while Brock's tendency was more moderate, reversing 11 of 37 letters produced (29.7%). Still, reversals were not completely consistent for either subject.

Figure 31. The word “table” (T-A-D-B-I-L-E) fingerspelled by Cameron with palm orientation facing inward rather than outward.

One other subject, Peter, produced just one fingerspelled letter with reversed palm orientation on the word “book”, which he produced B-O-**K**. Another subject, Mark (age 12;8), did not actually produce any letters with reversed palm orientation, but he did pause while fingerspelling the word “watch”, turned his hand inward, looked at his hand, turned his palm outward again, and then spelled the word. Finally, Ruben (4;7) did not respond to the word stimuli, but spontaneously produced the fingerspelled alphabet when he saw it posted on the wall in his testing room. He reversed palm orientation on the letters N and S:

Figure 32. Inward palm orientation on the letter N (left) and S (right), produced by Ruben (4;7).

In all, reversed palm orientation on fingerspelled letters was observed across five different subjects in three different states. Such errors have not been previously reported in the literature on the acquisition of the fingerspelling system of ASL (Padden & Lemaster, 1985; Padden, 1991, 2006), and indeed, the author of several papers on the acquisition of fingerspelling indicated that she had never seen a deaf child fingerspell with inward palm orientation (C. Padden, personal communication, December 3, 2009). Combined with the data collected from the sign elicitation task and the naturalistic observations conducted, there appeared to be evidence for a persistent class of phonological palm orientation errors in the signing of autistic children. This novel class of errors, furthermore, seemed largely to fit a theory-based model of how a cognitive deficit in autism could affect phonological acquisition in sign language. I therefore proceeded to the development of a larger experimental protocol to be conducted on a sample of typically-developing and autistic deaf children. This protocol will be described in the next chapter.

Chapter 6: Experiments

The previous chapter described how pilot data were collected and how these data were used to form hypotheses about how autism might affect the acquisition of sign language. This chapter will describe how additional subjects were recruited and a battery of tests was designed and run on these subjects. This battery included two visual-perspective-taking tasks, the sign elicitation and fingerspelling tasks described in the previous chapter, a nonsense sign imitation task, and a novel sign learning task. The visual perspective-taking tasks were designed to examine whether subjects had attained visual perspective-taking abilities that may be relevant for sign learning. The sign elicitation and fingerspelling tasks tested production of previously learned signs, while the nonsense sign learning task tested on-line learning of new signs that had never been seen before. The imitation task tested subjects' abilities to imitate ASL-like nonsense gestures. This battery of tasks represents an attempt to tease apart the various cognitive and linguistic skills needed for the acquisition of the correct phonological representations of lexical signs.

6.1 SUBJECTS

6.1.1 Recruitment

Deaf children on the autism spectrum, as well as a control group of typically-developing deaf subjects between the ages of 3 and 6, were recruited at the Indiana School for the Deaf and the Minnesota State Academy for the Deaf during the Spring of

2009. In addition, 4 subjects (2 typically-developing and 2 autistic) were tested during a home visit in Austin, Texas.

A faculty liaison at each school identified potential subjects and sent a letter written by the researcher to each child's parents. This letter (included in Appendix D) explained the research project and asked parents to sign a consent form giving the researcher permission to videotape their child in an experimental setting. Just as with the pilot experiment, an effort was made to be as inclusive as possible: the faculty liaison was asked to identify all children of any age with autism who had at least some productive signing vocabulary. Thus, only children who were completely non-signing were initially excluded from recruitment. However, the control group had more stringent inclusion criteria: only deaf children of deaf parents were recruited.

Parents were also asked to fill out a screening form (included in the Appendix) in which they were asked to identify their child's handedness (based on an abridged version of the Edinburgh Handedness Questionnaire; Oldfield, 1971), the handedness of the parents or caregivers, the hearing status of the parents or caregivers, the language or languages used at home, and whether or not the child had ever been suspected of or diagnosed with an autism spectrum disorder or Asperger Syndrome. Finally, parents were asked to state if children had any known vision problems that could not be corrected with lenses.

In addition, the Language Proficiency Profile-2 (LPP-2: Bebko & McKinnon, 1993) was collected for each subject as a measure of expressive pragmatic/semantic language use. This was done so that subjects could be matched for language ability. The LPP-2 is an appropriate instrument for assessing language ability in deaf or hearing children, since it "was developed specifically for use with deaf children with consideration of the complexity and heterogeneity of their expressive communication styles" (Bebko, Calderon, & Treder, 2003: 450) and the questions are structured in such a way as to be independent of modality. In addition, it "repeatedly has demonstrated good concurrent validity with other language measures used with hearing and deaf children (i.e., Vineland Adaptive Behavior Scales, Bankson Language Screening Test)" (*Ibid*., 450). The LPP-2 consists of 56 questions about the child's language ability that are to be answered by a person familiar with the child's language skills (e.g., a parent or teacher). For each question, the rater selects whether the child is past the skill or currently has the skill (2 points), if the skill is currently emerging (1 point), or if the child does not possess the skill or the rater does not know if the child possesses the skill (0 points). The instrument's five sub-sections focus on five areas of expressive language and communication skills: content, form, use, cohesion, and reference. The maximum score on the LPP-2 is 112, with hearing children reaching ceiling levels around age 7 and deaf children reaching ceiling levels significantly later, between the ages of 10 and 14 (*Ibid*., 442). The authors note that this lag could be expected since the deaf sample on which the instrument was normed included both deaf-of-deaf and deaf-of-hearing children; the language abilities of the latter group are likely to be delayed with regard to both hearing and deaf-of-deaf children for reasons already discussed.

Once it had been determined that a sufficient number of children from each school could participate, arrangements were made for a site visit. Each visit typically lasted 2-3 days and consisted of a videotaped session with each subject in which a battery of tasks was performed by the researcher. These tasks took between 10 and 20 minutes to perform, on average.

6.1.2 Inclusion and Exclusion Criteria

A thorough examination of educational and medical records was performed for each child in the autism test group. A separate consent form had to be signed by the parents that granted the researcher access to this protected health information in the child's records. This verification served to identify who had made each child's diagnosis and which instruments had been used in making the diagnosis. Since I am not qualified to make such a clinical determination, it was extremely important to verify that the diagnosis had been made by a qualified clinician and that the instruments used were reliable. A diagnosis of autism, pervasive developmental disorder - not otherwise specified (PDD-NOS), or Asperger Syndrome from the child's records were all considered criteria for inclusion in this research.

Instruments that were considered acceptable for diagnosing autism included the Autism Diagnostic Interview-Revised (ADI-R; Lord et al., 1994), the Autism Diagnostic Observation Schedule (ADOS; Lord et al., 1989), the Gilliam Autism Rating Scale (GARS; Gilliam, 1995), the Childhood Autism Rating Scale (CARS; Schopler, Reichler, DeVellis, & Daly, 1980), the Autism Spectrum Screening Questionnaire (ASSQ; Ehlers, Gillberg, & Wing, 1999), the Gilliam Asperger's Disorder Scale (GADS; Gilliam, 2001), the Devereux Scales of Mental Disorders (Naglieri, LeBuffe, & Pfeiffer, 1994), and the Asperger Syndrome Diagnostic Scale (ASDS; Myles, Bock, & Simpson, 2001). An important caveat should be made at this point: to date, no instrument for diagnosing autism has been validated for use with deaf children. This fact should be kept in mind when considering the validity of the data presented.

Subjects whose records revealed evidence of co-morbid conditions which could affect their language development or production, such as fine motor difficulties or very significant mental retardation, were excluded from the analysis after data were collected.

Two subjects were excluded in this manner: the first, a 16-year-old deaf boy diagnosed with autism, had also been diagnosed with Tetralogy of Fallot (a congenital heart defect), Golderhar Syndrome (a congenital defect to the ear, nose, palate, lips, and jaw), bilateral atresia (absence of ear canals), spina bifida (incompletely developed vertebral column), microcephaly, Obsessive-Compulsive Disorder (OCD) and Attention Deficit Disorder (ADD). The second excluded subject was an 11-year-old deaf boy who had been diagnosed with PDD-NOS, presented significant mental retardation, a cleft palate, Pierre Robin Sequence (a congenital condition causing facial abnormalities), Stickler Syndrome (a genetic disorder affecting connective tissue) as well as Attention Deficit and Hyperactivity Disorder (ADHD) and Oppositional Defiant Disorder. It was decided that both of these subjects had too many co-morbid conditions to be considered appropriate test subjects.

6.1.3 Control Group

The control group consisted of 12 typically-developing deaf children of deaf parents and 1 typically-developing hearing child of deaf adults (CODA). These children ranged in age from 3 years 7 months to 6 years 9 months. The age range is significantly younger than the autistic (test) groups; this is because the phonological representations of lexical forms, as well as the cognitive skills being investigated (visual perspective-taking) typically develop quite early on, and therefore only very young typically-developing signing children were sought out for the control group. Table 8 below shows the characteristics of the control subjects:

Initials	Age	Sex	Hearing Status	Hand Dominance	LPP-2 score*
OW	3;7	F	Deaf	Right	97
SW	3;7	F	Deaf	Right	99
LW	3;8	M	Deaf	Right	102
RK†	3;11	M	Hearing (CODA)	Right	88
AV	4;0	F	Deaf	Right	72
JM	4;4	F	Deaf	Right	88
TW	4;9	M	Deaf	Right	63
JB	4;10	F	Deaf	Left	112
LS	4;11	F	Deaf	Right	86
AG	5;6	F	Deaf	Right	103
BR	5;7	M	Deaf	Left	59
WG	6;2	M	Deaf	Right	100
MS	6;9	M	Deaf	Right	102

**maximum possible score = 112.*
† also participated in Pilot Studies.

Table 8. Control group of typically-developing signing children.

One additional male child (age 4;6) was excluded from the analysis after a teacher indicated that he was suspected of having autism, and was to be tested later that year. Despite the fact that no diagnosis had been made, it was important that these subjects not be suspected of having autism.

6.1.4 Test Group 1: Autistic Deaf Children of Deaf Parents (ASD-DoD)

The autistic (test) subjects fell into two categories: deaf children of deaf parents (Deaf-of-Deaf, or DoD) and deaf children of hearing parents (Deaf-of-Hearing, or DoH).

As explained in Chapter 4, this distinction was made because a lack of exposure to sign language since birth – as in the case of deaf children of hearing parents – could have detrimental effects on the development of both language and associated cognitive skills such as theory of mind (Schick et al., 2007).

Six deaf-of-deaf children with autism and one hearing CODA with autism (Brock, who was also a subject in the pilot study) ranging in age from 5;8 to 16;3 participated in the research. In the paragraphs below, I will briefly describe each subject, in the interest of giving as complete a picture as possible of their diagnostic profile. Each subject will be identified by their initials, and their age, sex, hand dominance, hearing status, diagnostic information, co-morbid conditions, and intelligence scores will be included (where available).

Raymond: A right-handed deaf-of-deaf male age 5;8. Diagnostic information: evaluated at age 2;4 by AWS Infant and Toddler Services First Steps. Childhood Autism Rating Scale (CARS) – score 35, indicating mild-moderate autism. Gilliam Autism Rating Scale-2 (GARS-2) autism index 106, indicating a very likely probability of autism. Intelligence information: Leiter-R Full Scale IQ composite score 143, percentile rank 99+, indicating very high intelligence, gifted child. LPP-2 score 32.

Brock: A left-handed hearing male child of deaf adults (CODA) age 6;6. Diagnostic information: evaluated by licensed psychologist, CARS score 32 ½ (cut-off for autism 30), diagnosed with Pervasive Developmental Delay (PDD). LPP-2 score 26.

Logan: A right-handed deaf-of-deaf male age 7;2. Diagnostic information: evaluated at age 3;4 by Pediatric Neuropsychology Associates, receiving a primary diagnosis of autism and ADHD. GARS-2 by parents and teacher at age 6: Autism Quotient 111, indicating a very likely probability of autism. Co-morbid conditions: limb kinetic dyspraxia and static encephalopathy. LPP-2 score 90.

Cameron: A right-handed deaf-of-deaf male age 8;11. Diagnostic information: diagnosed with Pervasive Developmental Disorder – Not Otherwise Specified (PDD-NOS) at the Mayo Clinic; second evaluation at the University of Nebraska Medical Center. Intelligence information: Leiter IQ of 97. LPP-2 score 52.

Olga: A right-handed deaf-of-deaf female age 11;9. Diagnostic information: GARS autism quotient 96, indicating an average/probable likelihood of autism, filled out by mother and teacher. LPP-2 score 36.

Jonathan: A right-handed deaf-of-deaf male age 14;1. Diagnostic information: records indicate autism was caused by brain damage from meningitis. Diagnosis made by a neuropsychologist fluent in ASL at Greater Minnesota Assessment Program. Child Behavior Checklist: scored well above T-score of 70, indicating significance at a clinical level. LPP-2 score 52.

Justin: A left-handed deaf-of-deaf male age 16;3. Diagnostic information: originally diagnosed PDD-NOS but currently diagnosed with Asperger Syndrome. Diagnosed at Learning and Behavior Clinic at Minneapolis Children's Hospitals and Clinics. ADOS: "scored like a child with an ASD on the ADOS" (no score given), and "meets DSM-IV criteria for PDD-NOS", according to that report. Autism Spectrum Screening Questionnaire (ASSQ) score = 19. LPP-2 score 106.

6.1.5 Test Group 2: Autistic Deaf Children of Hearing Parents (ASD-DoH)

Eleven deaf-of-hearing children with autism ranging in age from 11;10 to 20;3 participated in the research.

Kyle: a right-handed deaf-of-hearing male age 11;10. Diagnostic information: diagnosed PDD-NOS by Behaviorcorp psychiatrist. Results of GADS suggest a borderline range for having probable Asperger's disorder. LPP-2 score 103.

Cale: a right-handed deaf-of-hearing male age 12;6. Diagnostic information: GARS-2 autism quotient 104, indicating a very likely probability of autism. LPP-2 score 47.

Jaden: a right-handed deaf-of-hearing male age 12;8. Diagnostic information: autism diagnosis made by a neuropsychologist at age 9. CARS completed by teacher and guardian indicated an overall impression of mild autism. GARS completed by teacher and guardian resulted in an autism quotient 95, indicating an average probability of autism. Co-morbid conditions: microcephaly, hypotonia (low muscle tone), cytomegalovirus, ADHD. LPP-2 score 47.

Braden: a right-handed deaf-of-hearing male age 14;0. Diagnostic information: Devereux Scales of Mental Disorders resulted in 'very elevated' autism t-scores of 75 and 85; GARS filled out by teacher resulted in an autism quotient of 98, indicating an average probability of autism. Intelligence information: WISC: 58 composite score (very low). LPP-2 score 101.

Max: a right-handed deaf-of-hearing male age 14;7. Diagnostic information: diagnosed with PDD by a consulting psychiatrist; GARS autism quotient of 95, indicating an average probability of autism. LPP-2 score 103.

Joseph: a right-handed deaf-of-hearing male age 14;9. Diagnostic information: GARS filled out by teacher indicated an "above-average probability of having autism, consistent with all our other assessment information and observations, all of which indicate that [he] is on the autism spectrum." Co-morbid condition: Tourette's Syndrome.

Anna: A deaf-of-hearing female age 17;1 with mixed handedness. Diagnostic information: GARS resulted in an autism quotient of 75, indicating a less-than-average probability of being autistic, down from 86 in 2006. Originally diagnosed with PDD at age 4. Co-morbid conditions: OCD and ADHD.

Graham: a right-handed deaf-of-hearing male age 17;11. Diagnostic information: CARS score of 26 (cut-off for autism for adolescents is 27).

Chad: A right-handed deaf-of-hearing male age 18;1. Diagnostic information: CARS performed by school psychologist yielded a score of 32.5, indicating "mild to moderate autism." An additional outside evaluation was performed by a neuropsychologist in 2006; PDD inventory yielded a composite score of 51, indicating autism.

Ella: a right-handed deaf-of-hearing female age 18;5. Diagnostic information: Licensed Pyschologist used CARS to diagnose autism; diagnosed PDD-NOS, possibly high-functioning autism or Asperger's Disorder. Co-morbid conditions: Tourette's Syndrome, Anxiety Disorder NOS, Adjustment Disorder.

Noah: a right-handed deaf-of-hearing male age 20;3. Diagnostic information: GADS score of 95, indicating a high probability of Asperger Syndrome, and ASDS score of 80, indicating a possible probability of Asperger Syndrome.

6.1.6 Subject Matching

LPP-2 scores were used to determine if there were significant differences in the language skills of the subject groups. All 7 DoD subjects and the 5 youngest DoH subjects were combined into one ASD group. (The LPP-2 scores of the older DoH subjects were not collected.) A t-test found that the group means of the ASD group (M =

66.25, *SD* = 31.49) and the TD group (*M* = 90.08, *SD* = 16.35) were significantly different, t(23) = -2.34, $p < .05$. The mean chronological age of the ASD group (*M* = 11.33, *SD* = 3.46) was also significantly higher than the TD group (*M* = 4.74, *SD* = 1.03), t(23) = 6.35, $p < .001$. Thus, the two groups could not be matched on the basis of either chronological or language age.

The methodological challenges of matching groups of autistic and TD subjects have been discussed in the literature. Charman (2004) noted that samples of autistic preschoolers are likely to have lower language skills than samples of preschoolers with developmental delay/mental retardation or developmental language delay. Eliminating the lowest scoring autistic subjects from the analysis, Charman observed, could result in "the 'autism' that is the subject of study [being] removed" (62). He suggested a helpful approach to group matching and statistical analysis:

> One pragmatic approach is to adopt both a "language generous" and a "language cautious" approach to the analysis. The groups, even if unmatched on absolute language level, can be compared to one another on the dependent variables of interest. The analysis can then be repeated either with the subgroup of ASD children with the lowest language level removed or … logistic regression with language ability entered into the equation at step one in advance of the independent variable (for nonparametric data) (62).

The lowest-scoring autistic subjects are of great interest to this research, and removing them from the analysis by virtue of their low scores would be counterproductive. Thus, I followed Charman's strategy for conducting statistical analysis with unmatched groups wherever possible.

6.2 EXPERIMENTS

6.2.1 Visual Perspective-taking Tasks

Given the hypothesized role of visual perspective-taking in sign language development, the visual perspective-taking skills of each child were tested. However, the tasks described in the literature pertained to hearing children and tasks were not readily available in ASL. Translation of the tasks into ASL was a significant challenge. I developed two tasks: one to test Level 1 visual perspective-taking and another to test Level 2 visual perspective-taking. These two tasks will be described in detail below.

6.2.1.1 Level 1 Task

6.2.1.1.1 Introduction

As explained in Chapter 4, Level 1 visual perspective-taking refers to the ability of a child to know that an object visible to the child may not be visible to another person if that person's view of that object is obstructed. In Reed and Peterson's (1990) study, Level 1 visual perspective-taking was tested in the following way: two dolls were introduced on a table that had a divider on it. The child was asked to hide one doll so that the other doll could not see it. Twelve out of 13 autistic subjects (mean age 12;0) passed this task successfully.

An ASL version of Reed and Peterson's task would also require that subjects have a command of complex linguistic structures in ASL. The goal of this task is to test visual perspective-taking skills with minimal dependence on language. Therefore, I adapted one of the level 1 tasks from Masangkay et al. (1974), referred to in that article and subsequent papers (e.g., Flavell et al., 1981) as 'cat/dog_1'.

6.2.1.1.2 Methods

Each subject was seated at a table across from the researcher. The researcher showed the subject an 8.5" x 11" laminated, double-sided card with a picture of a cow on one side and a picture of a cat on the other side (this was an adaptation of the stimuli from the original task, which used an image of a cat and a dog). These pictures were made with Boardmaker® software and are included in Appendix B. The researcher prompted the child to label each animal, in order to ensure that he/she possessed the proper vocabulary to answer the test questions. After each side had been labeled, the researcher picked up the card, lifted it in the air, and twirled it around several times, so as to emphasize the double-sided nature of the card. He then placed the card, standing-up, on the table between himself and the subject so that one side would be visible to the child and the other side would be visible to the researcher. The researcher then asked the child "What do you see?" This was the control trial, aimed to make sure that the child could report his own perspective. The researcher then asked the child the essential question getting at whether or not the child had mastered Level 1 visual perspective-taking: "What about me – do I see the cow/cat, too?" This question was designed to elicit a simple yes/no answer, and to see if the child would report that the researcher could or could not see the side of the card visible to the child.

The control trial was coded as a "pass" if the child accurately reported whether he/she saw the cat or the cow, and was coded as a "fail" if he/she reported what he/she saw inaccurately. The test trial was coded as a "pass" if the child correctly reported that the researcher could not see the picture visible to the child, and was coded as a "fail" if he/she reported that the researcher was also able to see the stimulus visible to the child. A deaf signer of ASL re-coded 25% of the data for reliability, and inter-coder disagreements were discussed until agreement was reached.

6.2.1.1.3 Results and Discussion

Twenty-five subjects completed the task. Of the control group, no subjects failed the control trial, five subjects passed the control trial but failed the test trial, and eight subjects passed both the control and the test trial. DoD and DoH subjects were combined into one autism group; one subject failed the control trial, four subjects passed the control trial but failed the test trial, and seven subjects passed both the control and test trial.

A logistic regression was performed in order to determine if success on the level 1 test trial was related to autism status, age, language level or sex. Of these, only language level as indicated by LPP-2 score was a significant predictor of success on the level 1 task, $\chi^2(1, N = 25) = 4.68$, $p < .05$. Autism status was not found to be a significant predictor of whether or not a child passed the level 1 test trial, $\chi^2(1, N = 25) = .20$, *NS*. Sex was not a significant factor, $\chi^2(1, N = 25) = .09$, *NS*; nor was age, $\chi^2(1, N = 25) = 2.26$, *NS*. Figure 33 shows the differences in mean LPP-2 scores between those failing the level 1 task and those passing the level 1 task in both the ASD and TD groups:

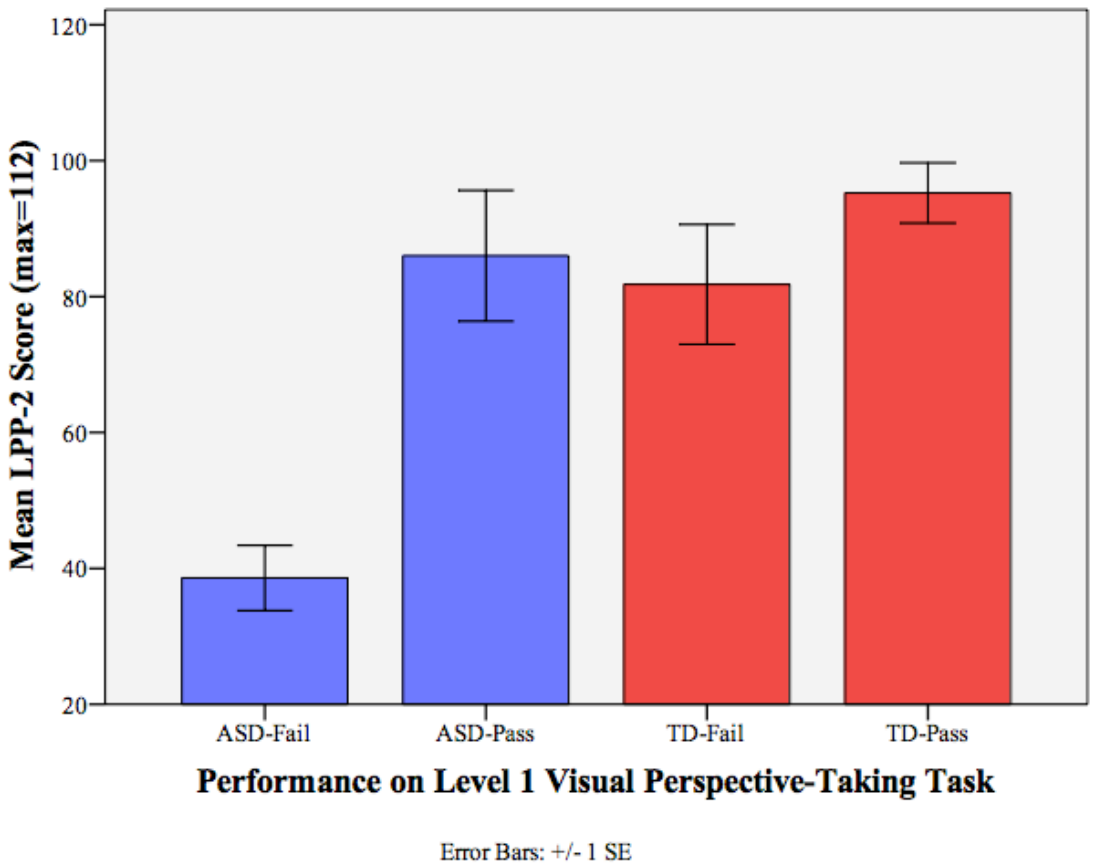

Figure 33. Mean LPP-2 scores of autistic and control subjects in relation to performance on the level 1 visual perspective-taking task.

Although the mean LPP-2 score of the TD subjects who passed the level 1 task was higher than those who failed, it fell within the margin of error. By contrast, there was a clear difference in mean LPP-2 score in the autistic group, with those passing the level 1 task achieving a significantly higher LPP-2 score than those who failed the level 1 task. Therefore, it appears that language level, as indicated by LPP-2 score, was a predictor for success on the level 1 visual perspective-taking task for the autism group. Although efforts were made to use minimal language in the instructions for the task, the instructions were given in ASL and thus depended on subjects' ability to comprehend the test questions ("Do I also see the cow/cat?").

An important result of this task is that seven autistic children passed the test trial, demonstrating an ability to understand that the visual perspective of another person differs from their own. This result lends some support to the findings of Hobson (1984) and Reed and Peterson (1990), all of whom found that visual perspective-taking was not impaired in autism per se. In the sections that follow, I will revisit the performance of the autistic children on the visual perspective-taking tasks in relation to their performance on the sign language tasks, to see if such a comparison can shed light on the possible impact of visual perspective-taking on sign language acquisition.

6.2.1.2 Level 2 Task

6.2.1.2.1 Introduction

The level 2 task was administered immediately after the level 1 task. Level 2 visual perspective-taking refers to the knowledge that "an object simultaneously visible to both the self and [an]other person may nonetheless give rise to different visual impressions or experiences in the two if their viewing circumstances differ" (Flavell et al., 1981). It has generally been found that this skill occurs only after Level 1 visual perspective-taking has been mastered, by age 4-4½.

6.2.1.2.2 Methods

The classic task reported by Masangkay et al. (1974) was the turtle task, which children were able to complete far earlier than the original Piagetian "Three Mountains" task, which children did not demonstrate mastery of until around age 7. An attempt was made to translate the turtle task into ASL. However, this proved to be extremely difficult due to the nature of the task itself and the linguistic structure of ASL.

The turtle task as reported by Masangkay et al. (1974) was performed in this manner: the experimenter put a picture of a turtle on the table in between the experimenter and the child. The experimenter then asked the child "Do you (I) see the turtle rightside-up [i.e., on his feet, though those words were not used], or do you (I) see the turtle upside-down [i.e., on his back]?" (361).

It became apparent that the locutions "rightside-up" and "upside-down" do not have the same meanings in ASL as they do in English. Indeed, after consulting with ASL instructors and interpreters about how best to translate this task, I became convinced that the task was not directly translatable. Inevitably, asking whether a turtle is "rightside-up" or "upside-down" in ASL is rendered as something like "on its feet" or "on its back." This is expressed through the use of classifier predicates which symbolize the legs of the turtle either sticking into the air or standing on the ground. The subtle difference in meaning between "rightside-up" and "on its feet" is crucial to the success of this task in spoken English; the question is not whether or not the animal itself is standing up or lying on its back, but whether or not the animal *appears to the other person* to be upside-down or rightside-up. Asking the question in a more abstract way, without resorting to a classifier construction that makes explicit reference to the animal's legs, was deemed unnatural and difficult to understand by the ASL experts consulted. Thus, it was decided to pursue a different direction and design a different Level 2 task.

A level 2 task performed by Reed and Peterson (1990) was the inspiration for the task I eventually developed. In their task, one of four different objects possessing a front/back or head/tail (a tiger, a teddy bear, a toy car, and a tow truck) was placed on a turntable on the table in front of the child. The child was asked to turn the turntable so the experimenter could see the front/back, nose/tail, depending on the object presented.

After debating whether to attempt to translate this task in ASL, it was decided that there were problems confounding translation – it was not clear how the head/tail or front/back of each of these objects would be translated into ASL. Instead, a small plastic toy turtle was placed on a turntable in front of the child. The researcher was again seated across the table from the child. The researcher spun the turntable and encouraged the child to give the turntable a spin as well. The researcher then introduced a 8 ½" x 14" laminated card containing four images of the turtle on the turntable, from four different angles (below):

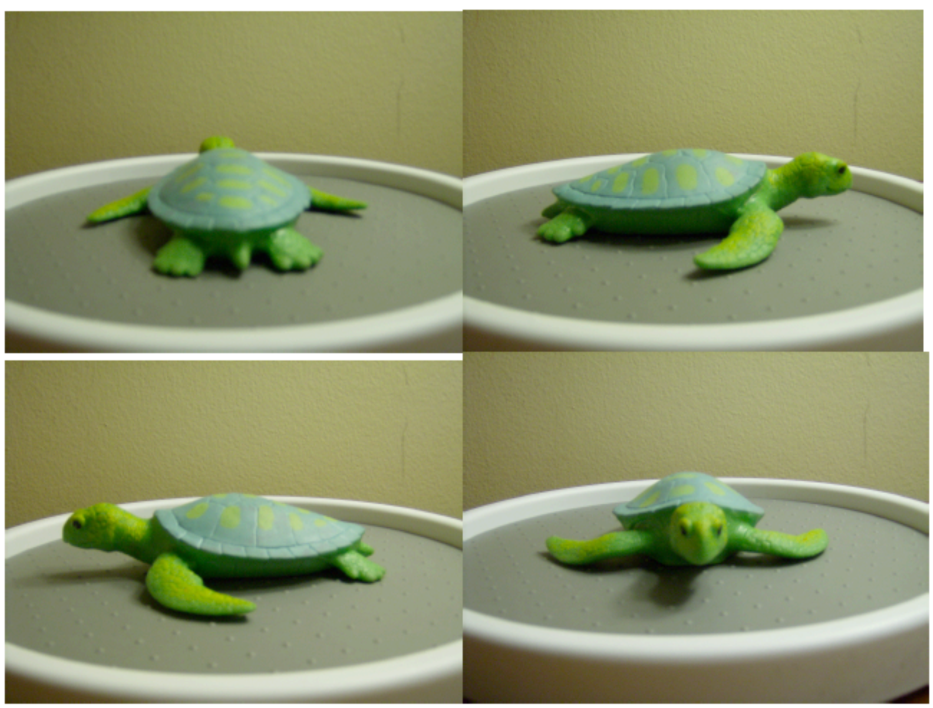

Figure 34. The stimuli used in the Level 2 turtle task.

The researcher placed this card on the table in between the child and the turtle. He then spun the turntable so that either the tail or head of the turtle was facing the child and asked the child the following: "See the turtle? Look at each of these pictures. Now look at the turtle, and tell me which picture matches what you see."[11] This was the control trial, in which the child only had to report what he/she saw from his/her perspective. Following the control trial, the researcher spun the turntable again, so that either the head or tail was facing the child. This time, the researcher asked the child, "Now, I'm looking at the turtle from my place over here. Can you tell me which picture matches what I see?"[12] This was the test trial, in which the child was asked to report how the researcher saw the turtle from across the table.

The control trial was coded as a "pass" if the child successfully indicated the picture matching his/her view of the turtle, and was coded as a "fail" if he/she indicated any of the three other pictures. The test trial was coded as a "pass" if the child successfully indicated the picture matching the point of view of the researcher, and was coded as a "fail" if he/she indicated any of the three other pictures. A deaf signer of ASL re-coded 25% of the data for reliability, and inter-coder disagreements were discussed until agreement was reached.

6.2.1.2.3 Results and Discussion

Twenty-five subjects completed the level 2 visual perspective-taking task. Of the control group, three subjects failed the control trial, five subjects passed the control trial but failed the test trial, and five subjects passed both the control and the test trial. Of the

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[11] In ASL: SEE TURTLE? SEE PICTURES? YOU LOOK-AT TURTLE, TELL-ME MATCH PICTURE WHICH-ONE

[12] In ASL: I LOOK-AT TURTLE, TELL-ME MATCH PICTURE WHICH-ONE I SEE

combined DoD and DoH autism group, three subjects failed the control trial, five subjects passed the control trial but failed the test trial, and four subjects passed both the control and test trial.

A logistic regression was performed in order to determine if performance on the level 2 test trial could be predicted by autism, age, language level, or sex. The regression analysis revealed that none of these factors were significant predictors of success on the level 2 test trial, though language level as indicated by LPP-2 score approached significance, $\chi^2(1, N = 25) = 3.30$, $p = .07$. For autism, $\chi^2(1, N = 25) = .85$, *NS*; for age, $\chi^2(1, N = 25) = .39$, *NS*; and for sex, $\chi^2(1, N = 25) = .00$, *NS*.

Subjects were then sorted into three groups: those who failed both the control and test trials, those who passed the control trial but failed the test trial, and those who passed both trials. Using language level as the dependent measure, the estimated marginal means of each of these groups were calculated. Pairwise comparisons between these groups indicated significant differences in language level between all three groups, $p < .05$. Figure 35 shows the mean LPP-2 scores of each group based on performance on the level 2 task:

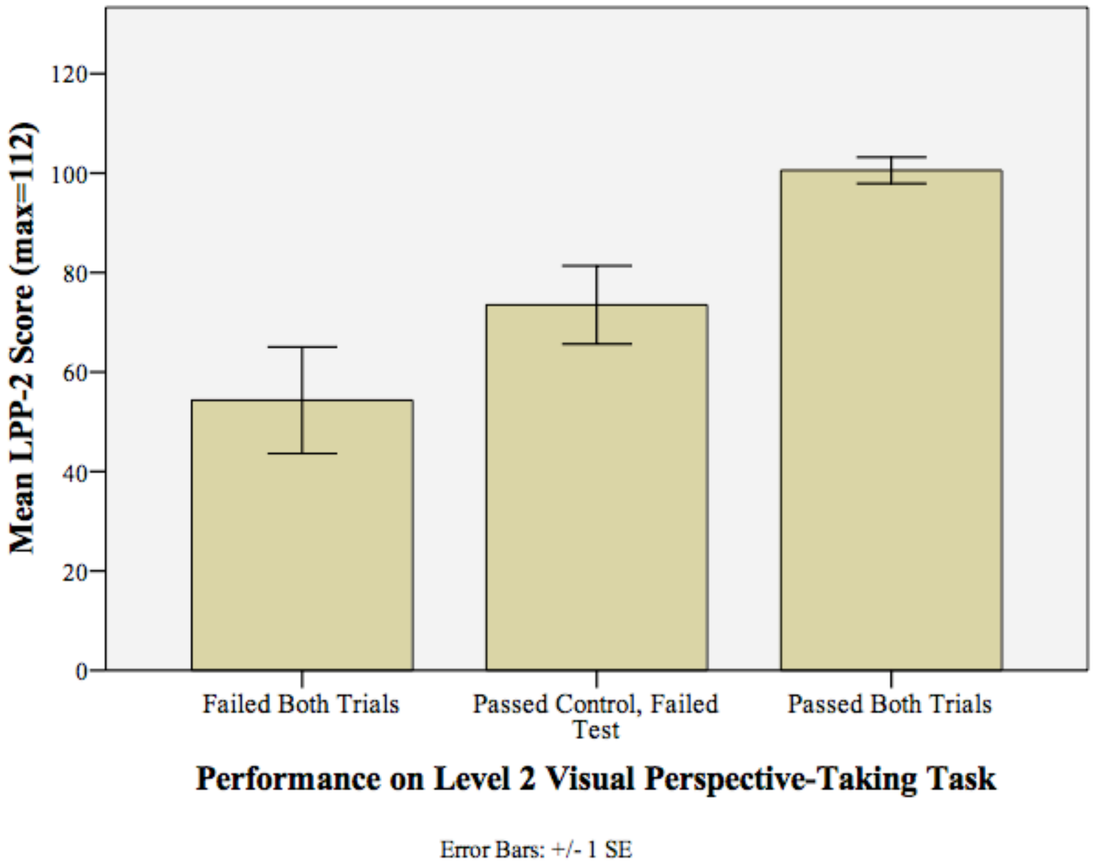

Figure 35. Mean LPP-2 score based on performance on Level 2 Task.

Breaking down these results further by autism status shows that language scores increased in both groups as success on task performance increased. In Figure 36, "Fail" indicates that subjects failed both the control and the test trials, "Mix" indicates that subjects passed the control trial but failed the test trial, and "Pass" indicates that subjects passed both the control and the test trial. It is interesting to note that there is virtually no difference in language scores of the TD and autistic children who passed the test trial.

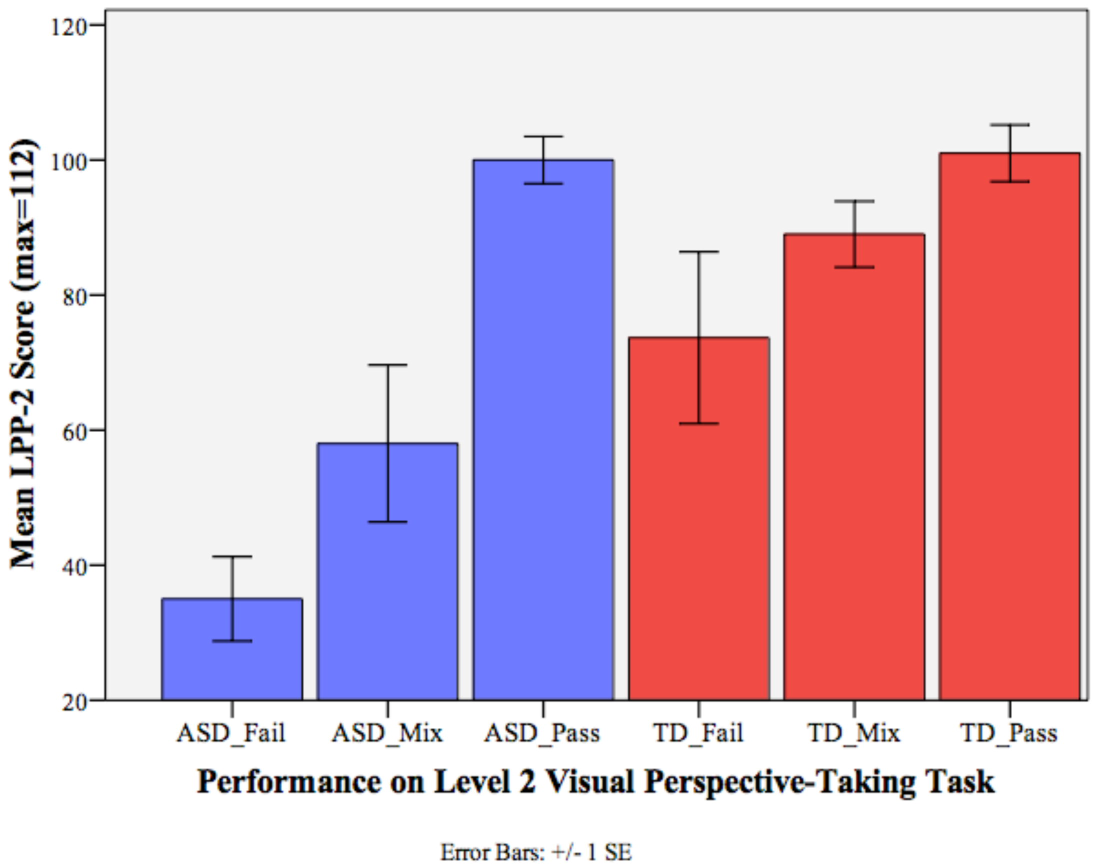

Figure 36. Mean LPP-2 scores based on performance on Level 2 Task, broken down by autism status.

Thus, language level, but not autism status, predicted performance on the level 2 task. This task relied even more heavily on language comprehension than did the level 1 task. Again, it is noteworthy that four of the autistic subjects passed the test trial, indicating that they were able to demonstrate comprehension of another person's visual perspective. However, these four subjects (Logan, Braden, Kyle, and Justin) also had particularly high LPP-2 scores (90, 101, 103, and 106, respectively). In analyzing performance on the sign language and imitation tasks that follow, it will be important to revisit the performance of these subjects, in order to see if mastery of visual perspective-taking skills is related to language and imitation skills.

6.2.2 Elicitation Task

6.2.2.1 Introduction

Once the visual perspective-taking tasks had been conducted, the researcher went on to perform the same sign elicitation task as in the Pilot Study described in Chapter 4. The signs and stimulus cards used were the same. Again, there were four test items for each of the parameters of location, movement, and palm orientation. The signs elicited by test condition are listed in Table 9; to see the actual pictures used, see Appendix A.

Condition	**Test Parameter**	**Signs**	**Target Parameter Value**
TEST (Perspective-taking required)	Location	GIRL, BED, APPLE, CANDY	ipsilateral
	Palm orientation	BATHROOM, BIRD DOG, BUTTERFLY	outward inward
	Movement	FLOWER, MOUSE BLACK AIRPLANE	ipsilateral → contralateral contralateral → ipsilateral outward
CONTROL (No perspective-taking required)	Location	ICE CREAM, BUG, BOY BEAR	midline both sides
	Palm orientation	BOWL TRAIN, SHOES, TABLE	upward downward
	Movement	ALLIGATOR EGG, TOMATO, HOUSE	up-down downward

Table 9. Signs elicited in Elicitation Task, separated by item type and test parameter.

6.2.2.2 Methods

The researcher showed the stimulus cards to the child one by one, asking "What's this?" or "What is this called?" in ASL. The order of presentation of stimuli was randomized. If subjects did not respond after prompting, the researcher produced the sign and asked the child to imitate him.

Items were coded in relation to the parameter being tested, and items were coded as either an error or no error. A deaf signer of ASL re-coded 25% of the data for reliability, and inter-coder disagreements were resolved through discussion.

6.2.2.3 Results and Discussion

Data from the Pilot Study were combined with the new data gathered, since the task was the same. Ten DoD subjects, 12 DoH subjects, and 13 TD subjects completed the task.

The overall error rate on this task was very low: just 30 errors were found out of 840 tokens (3.6%); see Table 10.

	TEST			**CONTROL**		
Group	Location	Palm	Movement	Location	Palm	Movement
ASD-DoD	2 (4.5%)	6 (13.6%)	8 (18.2%)	1 (2.3%)	1 (2.3%)	4 (9.1%)
ASD-DoH	0	0	0	0	0	0
TD	0	1 (1.8%)	4 (7.1%)	1 (1.8%)	2 (3.6%)	0

Table 10. Number of errors (error rates in parentheses) on the elicitation task, by parameter, sign type, and subject group.

Error rates on the elicitation task were analyzed using generalized estimating equations for repeated measures multinomial logistic regression. *P*-values reported are for the Wald chi-square. Of the 30 errors made, 20 were made on test items (66.7%). A statistical analysis showed that subjects made significantly more errors on test items than control items, $\chi^2(1, N = 24) = 3.87$, $p < .05$, indicating that the test signs involving perspective shifts were more difficult than control signs. Typically-developing children accounted for 8 of the errors (26.7%) while the DoD children with autism accounted for the other 22 errors (73.3%). The difference in error rate between the DoD autistic group and TD group approached significance, $\chi^2(1, N = 24) = 3.09$, $p = .079$. The effect of parameter (location, palm orientation, movement) also approached significance, $\chi^2(2, N = 24) = 5.25$, $p = .073$. Subjects made only 4 errors on signs where location was the test parameter, 10 errors on signs where palm orientation was the test parameter, and 16 errors on signs where movement was the test parameter.

DoH children with autism did not make a single phonological error on these lexical items. However, a one-way ANOVA with age as the dependent variable and group as the independent variable found that the mean age of the DoH group was significantly higher ($M = 15.2$, $SD = 3.08$) than either the DoD autistic group ($M = 9.53$, $SD = 3.94$) or the TD group ($M = 4.74$, $SD = 1.03$), $F(2,34) = 42.8$, $p < .001$.

An important question to ask is whether there was a relationship between performance on this task and performance on the visual perspective-taking tasks. Of the 12 DoH subjects who completed the elicitation task, one participated in the pilot study only and thus did not perform the visual perspective-taking tasks. Of the remaining 11 subjects, 10 passed the level 1 visual perspective-taking task (only Jaden failed it). Results on the visual perspective-taking task were mixed: four of the DoH subjects passed the test trial, five passed the control trial but failed the test trial, and one subject failed both trials (Jaden).

As for the DoD subjects, three of them only participated in the pilot study, and thus did not also perform the perspective-taking tasks. Of the remaining seven, five subjects made errors on the elicitation task. The two subjects who made no errors (Jonathan and Justin) both passed the level 1 perspective-taking task, while on the level 2 perspective-taking task, Justin passed and Jonathan passed the control trial but failed the test trial. By contrast, four of the five DoD subjects who made errors on the sign elicitation task (Raymond, Brock, Cameron, and Olga) *also failed the level 1 visual perspective-taking task*. However, the two TD subjects (RK and AG) who made errors on test items in the elicitation task both passed the level 1 visual perspective-taking task, though it must be kept in mind that RK is the younger brother of a child with autism and could therefore have modeled his signing after his brother, who made five errors on the elicitation task.

The results of the elicitation task lend some quantitative support (albeit somewhat weak) for the hypotheses that (a) deaf children would make more phonological errors on signs with phonological forms involving shifts in perspective, and (b) deaf children with autism would make more phonological errors on such signs than TD deaf children. There is some indication, moreover, that visual perspective-taking skills underpin the acquisition of phonological forms in sign. Still, it must be remembered that the small sample sizes make the statistical power of the tests conducted relatively low. While a statistically significant result would lend robust evidence to the hypotheses advanced, credence must also be given to qualitative observations about the data collected.

Finally, the test itself may have had certain design flaws that limited its ability to elicit the desired results. For example, certain stimuli did not consistently elicit the target sign. These stimuli and the problems encountered are described below.

The picture of a dog presented problems because the sign DOG in ASL has several variants. The target sign consists of an inward-facing palm and the brushing together of thumb and forefinger; this was a test item for the palm orientation parameter.

Figure 37. The citation form for the ASL sign DOG (reproduced from Humphries et al., 1980).

One variant of the sign DOG consists of a thigh-slap plus the manual sign above, while a second variant consists of the thigh-slap alone. This last variant, which lacked the manual component that was the target of elicitation, was produced by five deaf children with autism and seven typically-developing deaf children. When this occurred, the researcher would produce the target variant shown in Figure 33 above and ask the subject to imitate him.

The stimulus card designed to elicit the sign BUG (a control item for the location parameter) often elicited the sign SPIDER instead; see Figure 38.

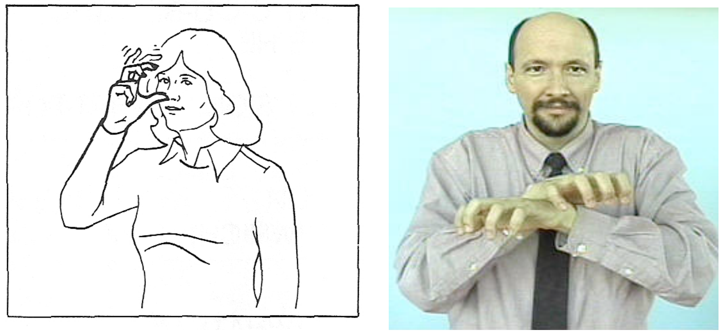

Figure 38. The citation form for the ASL sign BUG (left; reproduced from Humphries et al., 1980) and SPIDER (right; reproduced from http://www.lifeprint.com/index.htm).

This occurred for 9 deaf children with autism and 6 typically-developing subjects. Whenever this occurred, the researcher prompted the child to produce another sign. Failing this, the researcher produced the target sign BUG and asked the child to imitate him. Still, neither BUG nor SPIDER require perspective shifts for the target parameter (location), since the former is produced on the midline and the latter is a two-handed symmetrical sign. Thus, either sign would be an acceptable control sign for the location parameter.

The stimulus card meant to elicit the sign CANDY (a test item for the location parameter) instead often elicited the sign SWEETS, which is produced on the midline (chin) and thus would not be an appropriate test sign for the location parameter.

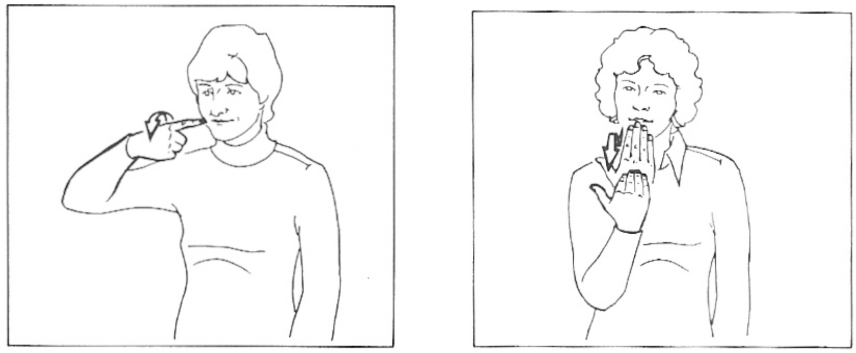

Figure 39. The citation forms for the ASL signs CANDY (left) and SWEET (right; reproduced from Humphries et al., 1980).

Eight children in the autistic group and 5 in the typically-developing group produced the sign SWEETS instead of CANDY. Whenever this occurred, the researcher prompted the child to produce another sign. Failing this, the researcher produced the target sign CANDY and asked the child to imitate him.

The stimulus card meant to elicit the sign BLACK (a test item for the movement parameter) consisted of a picture of a solid black circle. Children often produced the sign BALL at first, to which the researcher would ask "What color is it?"

The stimulus card meant to elicit the sign TABLE (a control item for the palm orientation parameter) consisted of a picture of a table with a bowl and a cup on it. Children often produced the sign BOWL, EAT, or CUP at first. In this case, the researcher would then point to the table at which the child and researcher were seated, to emphasize that the target sign was TABLE.

Despite these methodological difficulties, the elicitation task yielded a small number of phonological errors, which – when considered qualitatively as well as quantitatively – support the hypotheses advanced in this dissertation.

6.2.3 Fingerspelling Task

6.2.3.1 Introduction

This task was a continuation of the fingerspelling task described in the pilot study (see Section 5.2.4).

6.2.3.2 Methods

Subjects were shown English words printed on 8" x 3.5" laminated cards and asked to fingerspell the words. The words were *bed*, *table*, *watch*, *telephone*, *cap*, *chair*, *door*, *shoes*, *book*, and *scissors*.

Each fingerspelled letter was transcribed in the order it was produced. Palm orientation was noted for each letter, and letters were marked as being either properly-formed or ill-formed with regard to palm orientation. A deaf signer of ASL re-coded 25% of the data for reliability, and inter-coder disagreements were discussed until agreement was reached.

6.2.3.3 Results and Discussion

None of the TD subjects or ASD-DoH subjects reversed palm orientation while fingerspelling. However, 3 of the 4 youngest native-signing autistic children – Raymond (5;8), Brock (6;6), and Cameron (8;11) – showed a tendency to reverse their palm orientation or turn their hand to the side while fingerspelling. The results are reported in the table below, with letters with reversed palm orientation bolded and underlined, and letters turned to the side (neither clearly inward or outward) in italics:

STIMULUS	Raymond (5;8)	Brock (6;6)	Cameron (8;11)
bed	**B-E-B-D**	**B-E-D**	*L-B-A-E-L-D*
table	**T-A-U-B-I-L-3-E**	**T-A-D-I-E**	**I-T-A-L-D-E**
watch	(no response)	*W-A-T-C-H*	**W-A-T-**C-H
book	**B**-O-O-**K**	**B-O-O-K**	**D**-O-O-K
cap	C-**A-P**	**C-A-K**	C-**A-**P
chair	(no response)	C-H-**A-I-R**	C-H-**E-**A-**I-T-U**
shoes	**S**-H-O-E-**S**	**A-S**-H-**O-E-S**	*S-H-O-E-S*
door	**D**-O-O-**R**	**D-O-O**-R	**D-B-**O-**D**
telephone	(no response)	*T-E-I-?-H-O-N-E*	**T-**E-**L-E-**P-H-O**-N-E**
scissors	(no response)	(obscured)	**S**-C-**I**-S-S-O-**R-S**
% of letters ill-formed (reversed + sideways)	**71.4% (20/28)**	**90.7% (39/43)**	**66.7% (38/57)**
% of letters reversed	**71.4% (20/28)**	**60.5% (26/43)**	**47.4% (27/57)**

Table 11. Performance of Raymond, Brock, and Cameron on the fingerspelling task, with letters with reversed palm orientation bolded and underlined, and letters turned to the side in italics.

Thus, 3 young deaf-of-deaf autistic subjects showed a robust tendency to fingerspell with an inverted palm orientation, a rare phenomenon that has never before been described. Just as noteworthy is the fact that none of the older autistic subjects or typically-developing deaf children produced any fingerspellings with reversed palm orientation.

Two of the subjects who reversed palm orientation while fingerspelling, Brock and Cameron, had also been tested during the pilot phase of the research. It is therefore possible to compare their performance from the pilot phase to their performance during this stage of the research.

STIMULUS	Brock (5;1)	Brock (6;6)
bed	D-E-D	<u>**B-E-D**</u>
table	T-D-B-I-L-E	<u>**T-A-D-I-E**</u>
watch	W-D-<u>**C-H**</u>	*W-A-T-C-H*
book	<u>**D**</u>-O-O-K	<u>**B-O-O-K**</u>
cap	<u>**C-P**</u>	<u>**C-A-K**</u>
chair	L-D-<u>**C-H**</u>-D-H-I-I-R	C-H-<u>**A-I-R**</u>
shoes	S-H-<u>**E-O-E-S**</u>	<u>**A-S**</u>-H-<u>**O-E-S**</u>
door	D-O-O	<u>**D-O-O**</u>-R
telephone	(no response)	*T-E-I-?-H-O-N-E*
scissors	(no response)	(obscured)
% of letters reversed	**29.7% (11.37)**	**60.5% (26/43)**

Table 12. Performance of Brock on the fingerspelling task at two ages (5;1 and 6;6), with letters with reversed palm orientation bolded and underlined, and letters turned to the side in italics.

The percentage of inverted fingerspelled letters actually increased from less than one-third to about three-fifths of fingerspelled letters between the ages of 5;1 and 6;6. However, at the same time, fingerspelling accuracy increased in terms of the letters produced matching the target words, indicating that a decrease in overall intellectual functioning was unlikely.

A small decrease in the percentage of fingerspelled letters produced by Cameron with reversed palm orientation can be seen between the two data collection sessions:

STIMULUS	Cameron (7;5)	Cameron (8;11)
bed	**<u>D-B</u>**-E-**<u>D</u>**	*L-B-A-E-L-D*
table	**<u>T-A-D-B-I-L-E</u>**	**<u>I-T-A-L-D-E</u>**
watch	**<u>W-A-T</u>-**C-N-H	**<u>W-A-T-</u>**C-H
book	**<u>B</u>**-O-O-**<u>K</u>**	**<u>D</u>**-O-O-K
cap	C-**<u>A-R</u>**-P	C-**<u>A-</u>**P
chair	C-H-**<u>A-I-T-R</u>**	C-H-**<u>E-</u>**A-**<u>I-T-U</u>**
shoes	**<u>E-S</u>**-H-O-**<u>E-S</u>**	*S-H-O-E-S*
door	**<u>B-X-E</u>**-O-R	**<u>D-B-</u>**O-**<u>D</u>**
telephone	**<u>D-T-I-E-L-E</u>**-P-Q-H-O-**<u>R-</u>** **<u>N</u>-**E	**<u>T-</u>**E-**<u>L-E-</u>**P-H-O**<u>-N-E</u>**
scissors	**<u>S</u>**-C-X-**<u>I</u>**-C-**<u>S-S</u>**-O-R-E-S	**<u>S</u>**-C-**<u>I</u>**-S-S-O-**<u>R-S</u>**
% of letters reversed	**60.6% (40/66)**	**47.4% (27/57)**

Table 13. Performance of Cameron on the fingerspelling task at two ages (7;5 and 8;11), with letters with reversed palm orientation bolded and underlined, and letters turned to the side in italics.

The percentage of fingerspelled letters with inverted palm orientation produced by Cameron decreased from about three-fifths to just under one-half of all letters between the ages of 7;5 to 8;11. However, the tendency to fingerspell with an inward-facing palm remained strong. Given that none of the other autistic subjects tested (who ranged in age from 11;9 to 20;3) demonstrated an inward palm orientation while fingerspelling, one would expect that Cameron would eventually stop fingerspelling with an inverted palm orientation. A longitudinal study of Cameron, Brock, and Raymond would be useful in understanding whether and how these signers learn to correct their palm orientation errors.

It is important to note that all three subjects failed both level 1 and level 2 visual perspective-taking tasks.

Thus, the fingerspelling task revealed that three of the youngest autistic deaf-of-deaf signers tended to fingerspell with an inward palm orientation. This kind of fingerspelling error has not previously been reported in the literature on the typical acquisition of fingerspelling phonology, and lends additional support to the hypothesis that deaf children with autism have difficulty with signs requiring perspective shifts.

6.2.4 Imitation Task of Nonsense Signs

6.2.4.1 Introduction

The elicitation task described in section 6.2.2 was originally designed to see if children with autism would produce specific kinds of phonological errors on signs that had previously been learned. However, this task is only capable of detecting the most persistent of errors; it cannot show us which signs were initially difficult to learn but have since been mastered. Because of this problem, as well as the fact that children produced a low rate of errors on the elicitation task in general, a task was created that would test children's performance on one aspect of sign learning: imitation. When children are first exposed to a new sign, they must imitate it. How they imitate it initially can then be molded, reinforced, or changed depending on input. However, the initial imitation could be more indicative of how children perceive signs than a previously-learned sign.

The ASL signs in the elicitation task were thus altered by one or more parameters such that the resulting gesture would not correspond to an existing sign in ASL. In this way, each of the test parameters (location, palm orientation, and movement) could still be tested, but with signs that the child had presumably never seen before. A list of the signs used appears in Table 14 below, with the real ASL sign each gesture was derived from, and the modification(s) made:

Condition	**Test Parameter**	**Signs**	**Target Parameter Value**
TEST (Perspective-taking required)	Location	GIRL with outward movement and S-handshape at forehead*	ipsilateral
		BED with S-handshape	ipsilateral
		APPLE with S-handshape on ear	ipsilateral
		CANDY with outward movement from cheek*	ipsilateral
	Palm orientation	~~BATHROOM~~	
		BIRD facing inward produced on forehead	inward
		DOG w/palm outward	outward
		BUTTERFLY with palms out	outward
	Movement	FLOWER with reversed direction produced on forehead	contralateral → ipsilateral
		MOUSE with reversed direction	contralateral → ipsilateral
		AIRPLANE with reversed movement across body	contralateral → ipsilateral
		BLACK with reversed direction	ipsilateral → contralateral
CONTROL (No perspective-taking required)	Location	ICE CREAM with outward movement*	midline
		BUG on chin	midline
		BOY on chin	midline
		BEAR with hands on ipsilateral sides	both sides
	Palm orientation	BOWL with palms reversed	downward
		TRAIN with palms up	upward
		SHOES with palms up	upward
		TABLE with arms further out and palms up	upward
	Movement	ALLIGATOR with horizontal movement	horizontal
		EGG with reversed movement	upward
		TOMATO with reversed movement	upward
		HOUSE upside-down	upward

**These signs were also analyzed under the movement parameter.*

Table 14. ASL-like nonsense signs used in the imitation task.

Only 23 signs were used in the imitation task; this is because if the palm orientation parameter is reversed on the sign BATHROOM, it looks like an existing ASL sign (TUESDAY).

In general, the existing ASL sign was modified in its test parameter, and in some cases in one other parameter. Thus, for signs that were used in the elicitation task to test inward/outward palm orientation, the opposite palm orientation was modeled for the imitation task. If this one change was deemed insufficient to appear totally novel to the child, an additional parameter was changed. For example, the direction of movement for the sign FLOWER was reversed, but the location was also changed from under the nose to the forehead. These changes permitted several of the signs to be analyzed for more than one parameter; in particular, the signs GIRL, CANDY, and ICE-CREAM became test items for the movement parameter in addition to the location parameter.

6.2.4.2 Methods

The researcher again sat directly across the table from the subject. The child was given the following instructions about the task: "Now I'm going to make up some signs. They're not real signs. I'm going to make a sign, and then I want you to copy me."[13]

Items were coded in relation to the parameter being tested, and items were coded as either an error or no error. The dominant hand used (for one-handed signs and two-handed asymmetrical signs) was also coded. A deaf signer of ASL re-coded 25% of the data for reliability, and inter-coder disagreements were discussed until a consensus was reached.

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[13] In ASL: NOW ME INVENT SIGN. REAL? NO. FAKE. ME SIGN. YOUR-TURN YOU-COPY-ME.

6.2.4.3 Results and Discussion

Seven children in the ASD-DoD group, 10 children in the ASD-DoH group, and 12 children in the TD group completed the task. One child in the ASD-DoD group was eliminated because he failed to understand the task: instead of imitating each nonsense sign, he produced the ASL sign that was closest to it, "correcting" the researcher.

As expected, the imitation task yielded a higher error rate than the elicitation task: 115 phonological errors were counted out of 728 tokens, for an overall error rate of 16%. Of these, 95 errors were made on test items (82.6%) and 20 errors were made on control items (17.4%). The overall error rate on test items was 24% (95 errors out of 392 tokens) while the overall error rate on control items was 6% (20 errors out of 336 tokens). The error rates (and frequencies) for the individual parameters, item difficulties, and subject groups can be seen in the following table:

	TEST			**CONTROL**		
Group	Loc	Palm	Move	Loc	Palm	Move
ASD-DoD	.13 (3/24)	**.44 (8/18)**	**.48 (20/42)**	.13 (3/24)	.13 (3/24)	.17 (4/24)
ASD-DoH	.13 (5/40)	.13 (4/30)	**.23 (16/70)**	.00 (0/40)	.03 (1/40)	.08 (3/40)
TD	.04 (2/48)	.06 (2/36)	**.42 (35/84)**	.00 (0/48)	.06 (3/48)	.06 (3/48)

Table 15. Error rates (and frequencies) on the imitation task, by parameter, item difficulty, and subject group. Error rates over 20% in bold.

Notable in the table above are the high error rates for the movement parameter, and the low error rates for palm orientation in all but the test items produced by the ASD-DoD group.

The two autism groups were collapsed for additional analyses. Error rates were analyzed using generalized estimating equations for repeated measures multinomial logistic regression. *P*-values reported are for the Wald chi-square. There was a main effect for group, with autistic subjects making significantly more imitation errors than control subjects, $\chi^2(1, N = 28) = 83.27, p < .001$. There was a main effect for item type, with subjects making significantly more imitation errors on test items than control items, $\chi^2(1, N = 28) = 212.08, p < .001$. There was a main effect for parameter; $\chi^2(2, N = 28) = 163.59, p < .001$. A cross-tabulation by parameter revealed that the movement parameter was responsible for this effect; subjects made more errors on movement than either palm orientation or location. There was a significant interaction between group and parameter; $\chi^2(2, N = 28) = 212.73, p < .001$. Pairwise comparisons indicated that the autistic group produced significantly more errors on palm orientation than the control group. The interaction between group and item type was also significant, with the autistic group producing significantly more errors on test items than control items; $\chi^2(1, N = 28) = 85.93, p < .001$. Finally, there was a three-way interaction between group, parameter, and item type; pairwise comparisons indicated that the autistic group made significantly more errors on the test items for palm orientation than on any of the other item types or parameters; $\chi^2(1, N = 28) = 6.03, p < .05$.

Once these effects had been determined, age was added as a covariate to determine whether older subjects demonstrated improved performance, and the parameter factor was no longer included in the analysis. Analyzing the data in this way again yielded a main effect for item difficulty; $\chi^2(1, N = 28) = 4.56, p < .05$. There was also a main effect for age, with younger subjects making more errors than older subjects; $\chi^2(1, N = 28) = 10.8, p < .001$. Though the main effect for group was not significant, there was a significant interaction between group and age, indicating that younger autistic subjects made significantly more imitation errors than either older autistic subjects or young TD subjects; $\chi c^2(1, N = 28) = 4.73, p < .05$.

These results uphold the hypotheses formulated: subjects made more errors on items thought to be difficult to imitate due to perspective shifts, younger autistic subjects made more errors than TD subjects or older autistic subjects, and autistic subjects made more errors than TD subjects on items thought to be difficult to imitate due to perspective shifts. Also, palm orientation test items were uniquely difficult for autistic subjects, but not for TD subjects, while movement test items were difficult for both groups. These results indicate that some signs are more difficult to imitate than others; in particular, test signs involving the movement parameter yielded an exceptionally high error rate. Furthermore, the data indicate that young autistic subjects had more difficulty imitating signs requiring perspective shifts than did TD subjects, but improved with age.

Since the palm orientation parameter appeared to differentiate the autistic group from the control group, an examination of the subjects who made imitation errors on the palm orientation parameter in relation to performance on the visual perspective-taking tasks could shed light on the relationship between imitation skills and visual perspective-taking. Seven subjects in the autistic group – Raymond (5;8), Brock (6;6), Cameron (8;11), Olga (11;9), Cale (12;6), Jaden (12;8), and Jonathan (14;1) – made palm orientation errors on test items, while only two TD subjects – SW (3;7) and RK (3;11) – made such errors. In relation to the visual perspective-taking tasks, it is notable that all of these subjects failed the level 2 task. That is, none of these subjects demonstrated an understanding of another person's visual perspective. By contrast, none of the subjects who passed the level 2 task (including the four subjects with autism) made any imitation errors on palm orientation test items.

A separate analysis was conducted with regard to hand-switching. Switching hands (i.e., imitating with the left hand) can be viewed as a way of avoiding having to perform a perspective shift and mental rotation, since locations and movements can be mirrored directly if the other hand is used. Since the experimenter modeling the nonsense signs was right-handed, it was important to understand if subjects would switch hands in imitation on some signs and not others. In particular, it was predicted that autistic subjects would switch hands more often than control subjects, and that all subjects would switch hands more often on test items than control items. For the purposes of this analysis, four left-handed subjects were eliminated, under the hypothesis that hand-switching could be a strategy to avoid difficult perspective shifts for right-handed subjects, but not left-handed subjects, when imitating a right-handed model.

Hand-switching rates were analyzed using generalized estimating equations for repeated measures multinomial logistic regression. *P*-values reported are for the Wald chi-square. There was no effect for group; $\chi^2(1, N = 25) = .75$, *NS*. However, there was a main effect for item type: subjects made significantly more hand-switches on test items than control items; $\chi^2(1, N = 25) = 13.74$, $p < .001$. The interaction between group and item type was not significant; $\chi^2(1, N = 25) = .94$, *NS*. Mean percentage hand-switching rates for both groups on test and control items can be seen in the graph below:

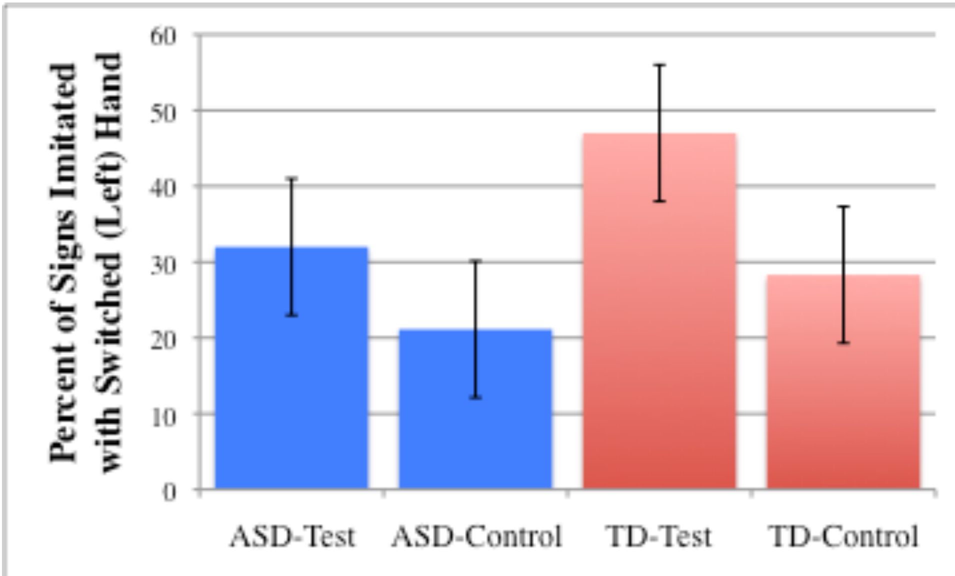


Figure 40. Hand-switching rates for ASD and TD groups on the nonsense sign imitation task. Error bars = +/- 1 SE.

Therefore, both TD and ASD children switched hands when imitating ASL-like nonsense signs, and they did so with greater frequency on signs hypothesized to be difficult for perspective-taking (test items) than signs that were not hypothesized to be difficult for perspective-taking. It thus appears that hand-switching is a strategy for imitating difficult signs for all deaf children, not just those with autism.

The effect of age was also considered in analyzing the results of this task. Since the ASD-DoH group was on average much older than the other two groups, the autism group was redivided into ASD-DoD and ASD-DoH subjects. Once this was done, it became clear that the older DoH group switched hands less often than either the ASD-DoD group or the TD group; see Figure 41.

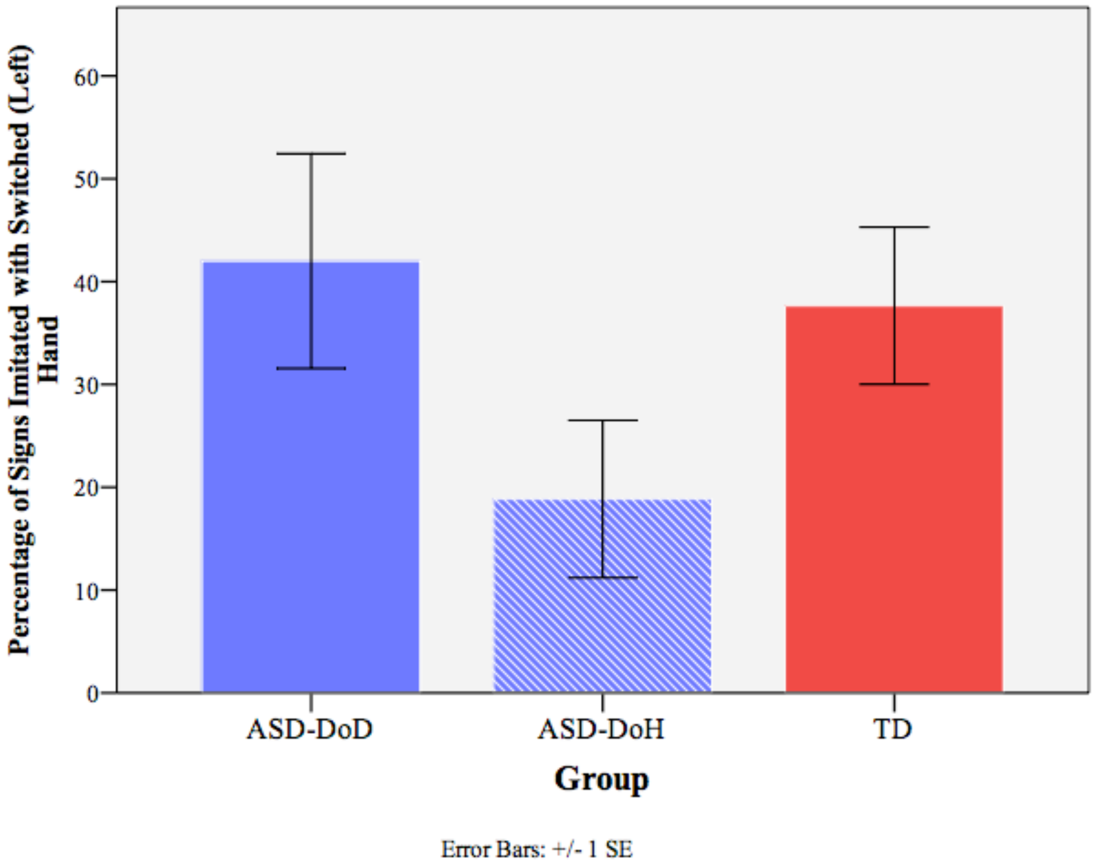


Figure 41. Switches on Imitation Task by Group.

With the older ASD-DoH group factored out, the ASD-DoD group and TD group remained comparable in terms of the percentage of control and test signs on which they imitated with the left hand; see Figure 42.

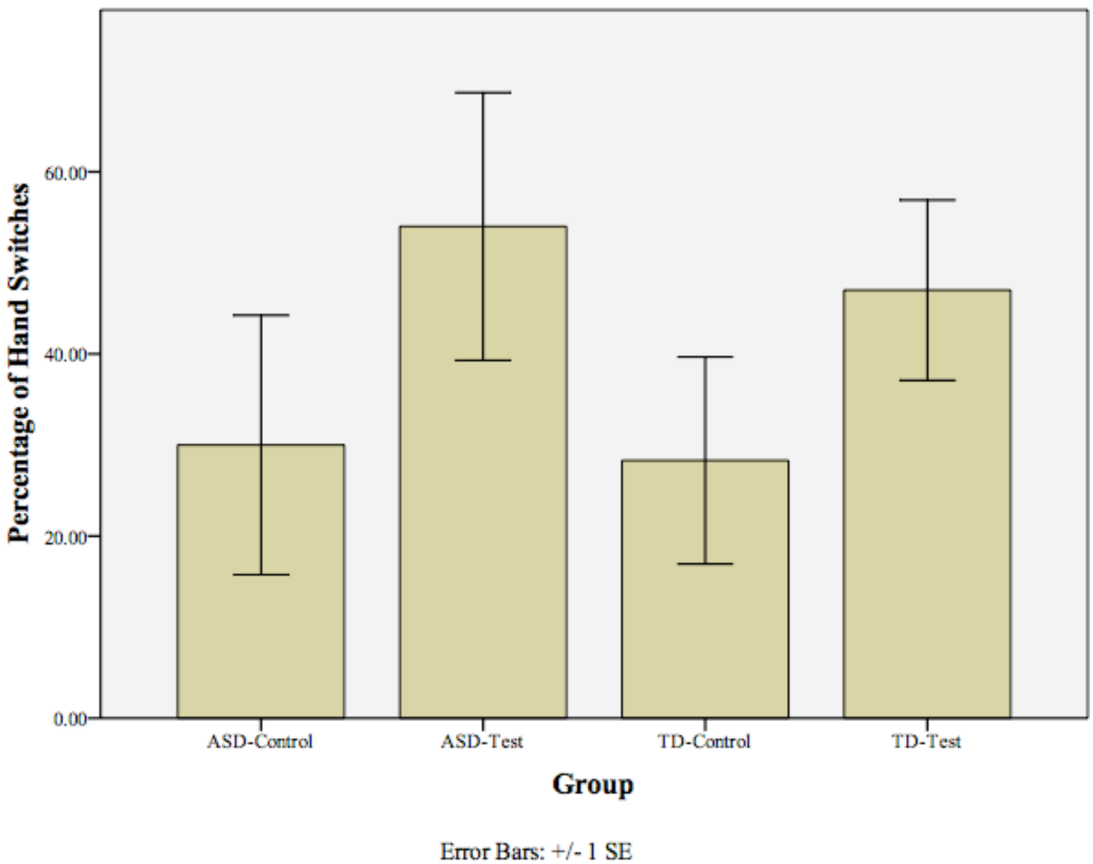


Figure 42. Hand Switches on Imitation by Item Type and Group.

Thus, an analysis of hand-switching on the imitation task revealed that hand-switches were more common on test than control items, but did not support the hypothesis that children with autism would switch hands more often than typically-developing deaf children.

This last finding notwithstanding, the results of the nonsense sign imitation task support the general hypotheses advanced in this dissertation. Specifically, the imitation task showed that certain kinds of signs (i.e., those hypothesized to be difficult to learn due to the form of specific phonological parameters) yielded (a) more errors than control signs, and (b) more hand-switches than control signs. Furthermore, there were significant differences between the control group of TD children and the test group of children with autism, with the autistic group making more errors (but not more hand-switches) than the control group. Finally, imitation errors and hand-switches decreased with age, consistent with the hypothesis that autism entails a delay, rather than an absence, of certain cognitive skills.

6.2.5 Novel Sign Learning Task

6.2.5.1 Introduction

The final task sought to test how the phonological forms of novel, invented signs referring to novel objects are learned. Three novel objects were introduced to subjects and labeled by the researcher. The objects were so-called "Uglydolls"®, each of which presented a different facial configuration. Pictures of the three stimulus dolls used appear in Figure 43 below:

Figure 43. Stimulus dolls used in the Novel Sign Learning Task.

Novel signs were invented to label each of these dolls. In this way, children could be shown the dolls and immediately told what their "names" were. These signed labels were novel signs that the children had presumably never seen before. Each nonsense sign was based on the particular configuration of the eyes of each doll. The sign for the doll on the left, which I refer to as "Two-Eyed Stack", consisted of both hands forming an "O" handshape (to represent the eyes), placed one on top of the other over the face, so as to represent the two eyes in a vertical configuration.

Figure 44. The invented sign (left) used to refer to "Two-Eyed Stack" doll (right).

Since the position of the hands are on the midline, this sign does not entail a perspective shift.

The sign for the doll known as "OX" consisted in producing an "X" over one's left eye with both hands:

Figure 45. The invented sign (left) used to refer to the “OX” doll (right).

Since the hands are positioned over the left eye, this sign entails a perspective shift. A child seated across from the researcher would have to perform a mental transformation in order to reproduce the sign on the left side of the face. A failure to do so would result in producing the sign on the right side of the face.

Finally, the sign for the doll referred to as “Cyclops” consisted of both hands forming a large oval over the eyes, to represent the single eye of the doll.

Figure 46. The invented sign (left) used to refer to the “Cyclops” doll (right).

Like the “Two-Eyed Stack”, this sign does not require a perspective shift, since it is produced on the midline.

6.2.5.2 Methods

The task was performed in two parts. At the beginning of the testing session, the dolls were introduced to the children one at a time. The child was allowed a few moments to look at the doll and play with it. Then the researcher introduced the sign label as a name for the doll and asked the child to repeat the name. After all three dolls had been introduced, the dolls were put away and the other tasks in the protocol were conducted. At the end of the testing session, the dolls were brought back out and the child was asked if they recalled the signed names for each doll. In this way, the novel signs were elicited. If the child did not remember the signs, the researcher again produced the target signs and asked the child to copy the signs.

Items were coded as either being correct or an error on both the imitation and elicitation portions of the task. For the test item (OX), it was noted which side of the face the sign was produced on, either left or right. A deaf signer of ASL re-coded 25% of the data for reliability, and inter-coder disagreements were discussed and resolved.

6.2.5.3 Results and Discussion

It was hypothesized that deaf children with autism might make a location error by producing the sign for the test item (OX) on the right side of the face rather than the left side, where it was modeled by the experimenter. However, the results of this task did not support the hypothesis proposed.

Subjects were first shown the novel signs and asked to imitate, and later asked to recall these signs and produce them. Even in the imitation stage, nearly all subjects (including the controls) produced the test item (OX) on the right side of the face:

Group	N	Produced Test Item on Right (error) - Imitation	Produced Test Item on Left (correct) - Imitation	Produced Test Item on Right (error) - Elicitation	Produced Test Item on Left (correct) - Elicitation
TD (Control)	14	11	0	10	1
ASD-DoD	7	5	1	5	2
ASD-DoH	10	5	2	5	3

Table 16. Results on Novel Sign Learning Task test trials.

A logistic regression was performed to detect group differences in performance on the test trials; age, sex, and autism status were not significant.

There are several factors that may have caused the majority of subjects in all groups and at all ages to reproduce the sign modeled on the right side of the face rather than the left side. First, and perhaps most significantly, crossing the face to produce a sign over the left eye may be phonologically constrained in ASL. Secondly, signs are not typically specified for right and left, but rather as ipsilateral and contralateral. Even if the target sign was defined as having a contralateral rather than a left side location, there are no signs in ASL that are produced above the neck and that are specified for a contralateral location only. Nor are the eyes typically a possible location for signs in ASL (except in cases of extreme iconicity, such as the sign PIRATE, in which one hand covers the ipsilateral eye like a patch). Thus, this task appears to have been flawed in its design such that respondents may have been prevented from producing the target sign by phonological rules on the formation of signs in ASL.

6.2.6 General Discussion

The battery of experimental tasks produced mixed results. Certain tasks, such as the imitation task and fingerspelling task, produced robust results in support of the hypotheses advanced in this dissertation. Other tasks, such as the visual perspective-taking tasks and the novel sign-learning task, either did not support the hypotheses (in the case of the former) or may have been hampered by design issues (in the case of the latter).

The results of the imitation and elicitation tasks provide strong evidence that the phonological form of certain signs – those involving shifts in perspective – are generally more difficult for deaf children to learn; this was true both for autistic and typically-developing subjects. Despite a low error rate on the elicitation task, a statistical analysis showed that subjects made significantly more errors on test items than control items, $\chi^2(1, N = 24) = 3.81$, $p < .05$. The results for the imitation task were even more dramatic: subjects made significantly more imitation errors on test items than control items, $\chi^2(1, N = 28) = 212.08$, $p < .001$.

On a qualitative level, young deaf-of-deaf children with autism produced certain phonological errors that were unlike the phonological errors produced by the typically developing deaf children or the older autistic children. Most obviously, inward/outward palm orientation reversals were produced by young deaf-of-deaf autistic children in a variety of different contexts: in naturalistic observation, in elicitation of lexical signs, in fingerspelling, and in imitated nonsense signs. By contrast, typically-developing deaf children never produced such palm orientation errors while fingerspelling, and rarely

(6%) in the imitation of nonsense signs. Moreover, such errors have rarely been described in the literature on the typical development of ASL.

The elicitation task also provided some evidence that inward/outward palm orientation reversals sometimes crystallize into the child's mental representation of certain signs. However, the signs elicited are among the most basic in the lexicon and the task yielded few errors overall. Data from all tasks were thus pooled in order to determine if the deaf-of-deaf autistic group made significantly more errors on the palm orientation parameter than the TD group. Subjects were classified into one of three groups: those who made no palm orientation errors, those who made just one palm orientation error, and those who made two or more palm orientation errors. Results showed that the ASD-DoD group made significantly more palm orientation errors than the TD group ($p < .01$, Freeman-Halton extension of the Fisher exact probability test).

Group	**No errors**	**1 error**	**2+ errors**
TD	12	1	0
ASD-DoD	3	3	4

Table 17. Contingency table showing the number of subjects in each group producing palm orientation errors.

There is less evidence of impaired phonological acquisition by autistic children in the location and movement parameters. Location errors were rare in both the elicitation and imitation tasks, and were observed in only a few instances in naturalistic observation. This fact may be explained by the markedness of producing contralateral sign locations on the face; most lexical items tested for the location parameter involved a facial location. In addition, the location parameter's interaction with hand dominance complicates a straightforward analysis of phonological acquisition.

Finally, the movement parameter proved to be the most difficult for both autistic and TD children: it yielded the highest error rates on both the elicitation and imitation tasks. Like the location parameter, cross-body movements interact with handedness in complicated ways. Thus, it is not clear from the data gathered in these experiments whether the phonological acquisition of the movement parameter is specifically impaired in autistic children. Rather, it appears that certain kinds of movements are difficult to learn, perhaps due to the need for more complex spatial reasoning. I will revisit this theme in the next chapter with a sign imitation experiment conducted on non-signing, hearing undergraduate students.

The results of these experiments also clearly demonstrate that phonological errors occur in deaf autistic children under the age of 10, but do not appear to be characteristic of older deaf autistic children. Not all deaf children with autism make such errors, but the strong tendency of several young deaf-of-deaf autistic children to commit the types of phonological errors predicted lends support to the idea that such errors are characteristic of deaf children with autism, or a sub-population thereof. It is worth taking a closer look at the profiles of the specific children who tended to commit these errors, in order to better understand who these children are.

Three young native-signing boys with autism (two deaf-of-deaf and one CODA) showed a particular tendency to reverse inward/outward palm orientation. In Table 18 below, I summarize what is known about these three subjects.

Subject	**Hearing status**	**Age**	**Autism diagnosis and instrument**	**Language level (LPP-2)**	**Non-verbal intelligence**
Raymond	Deaf-of-deaf	5;8	CARS: 35 (>30 indicates autism) GARS-2: 106	32	Leiter-R: 143 (99th percentile)
Brock	Hearing (CODA)	6;6	CARS: 32.5	26	n/a
Cameron	Deaf-of-deaf	8;11	PDD-NOS @ Mayo Clinic	52	Leiter: 97

Table 18. Profile information for three subjects with strongest palm-reversing tendencies.

A few generalizations can be made about these three subjects. First, they are all native signers with two deaf parents and exposure to ASL since birth. As such, any impairment in their signing cannot be attributed to lack of exposure to language. Second, their language level as reflected by LPP-2 score is extremely low (> 2 standard deviations below the mean of the TD sample). Third, they are all under the age of 9. And finally, in the case of Raymond and Cameron, they are of average or above-average intelligence (Brock's non-verbal IQ scores were not available). Indeed, there is an evident dissociation between verbal and non-verbal intelligence in the case of both Raymond and Cameron. This fact makes the findings all the more striking, as the phonological errors demonstrated cannot be attributed to low intelligence. They are likely to be the result of autism.

With regard to performance on the individual tasks, all three subjects failed both the level 1 and level 2 visual perspective-taking tasks. On the elicitation task, Brock made five errors: one palm orientation error, three movement errors, and one location error. Cameron also made five errors: one location error, one palm orientation error, and three movement errors. Raymond made one error: a palm orientation error on the sign BUTTERFLY. As described in Section 6.2.3, all three subjects made consistent palm orientation errors on the fingerspelling task. Finally, on the imitation task, Brock made 6 errors, Cameron made 8 errors, and Raymond made 8 errors. Each of them made at least one palm orientation reversal error on test items on the imitation task.

Although the autistic group could not be matched for chronological or language age with the TD group, it is instructive to look at two TD subjects with very low language scores. The control group of TD children had a mean LPP-2 score of 90, with a standard deviation of 16.35. There were two outliers in the TD group: BR, a male age 5;7 who scored 59 on the LPP-2, and TW, a male age 4;9 who scored 63 on the LPP-2. Both of these subjects' LPP-2 scores were only slightly above 2 standard deviations below the mean of the TD group, and both of their scores were actually below the mean of the autistic group (M = 66.25; SD = 31.49). Thus, comparing these two subjects to the autistic subjects can help provide insight into whether the phenomena observed are indeed attributable to autism, or might be the by-product of low language skills.

Both TW and BR failed the level 1 and level 2 visual perspective-taking tasks, a result which strengthens the hypothesis that success on these tasks was predicated on language skill. Crucially, however, neither TW nor BR produced the palm orientation errors found in the autistic group. There were no palm orientation reversals in elicitation, fingerspelling, or imitation of nonsense signs. Neither were there location errors or movement reversals. Therefore, the performance of these two typically-developing subjects provides additional support for the hypothesis that the errors are observed are specific to autism, and are not a result of underdeveloped language skills.

As for the specific cognitive mechanisms implicated by the results of these experiments, it is not clear at this point which process or processes may lie at the heart of the autistic impairment in sign language acquisition. Visual perspective-taking is not clearly implicated by the results of these experiments. Imitation skills are clearly impaired in autism (as has previously been found), but the reasons for this impairment remain mysterious. I will discuss these findings, as well as possible directions for future research, in Chapter 8. Before proceeding to such a discussion, however, in the next chapter I will introduce evidence from a variety of sources that lend further credence to the hypotheses formulated in this research.

Chapter 7: Additional Studies and Supporting Evidence

The previous chapter described how experimental data were collected from typically-developing and autistic deaf children using a battery of tasks: two visual perspective-taking tasks, a sign elicitation task, a fingerspelling task, an imitation task, and a novel sign-learning task. Results were presented and discussed.

There are three additional sources of information that are pertinent to this research. The first comes from an imitation experiment conducted with non-signing, hearing undergraduate students. The second source of information derives from interviews with Deaf mothers of signing children with autism, and the third source of information comes from reports contained in the educational records of deaf children with autism.

7.1 Undergraduate Sign Imitation

7.1.1 Introduction

As indicated by the movement errors committed by both TD and autistic deaf children on the imitation task described in Section 6.2.4, it is possible that some signs might be more difficult to learn than others – not just for autistic children, but for all learners. An initial hypothesis was that perception of certain kinds of movements places a greater demand on learners, especially with respect to the learner's capacity for spatial processing. For this reason, I tested cognitively normal adults on a gesture imitation task (both ASL signs and ASL-like nonsense signs).

7.1.2 Methods

Twenty-four hearing, right-handed, non-autistic undergraduate students naïve to sign were asked to imitate a series of 48 manual gestures. All subjects were prescreened online using a modified version of the Edinburgh Handedness Inventory (Oldfield, 1971) to ensure that they were right-handed; this was important so that subjects would not simply mirror the researcher's right-handed movements with their left hand. In addition, subjects were excluded if they had had any exposure to ASL or any other sign language, or had been diagnosed with an autism spectrum disorder or Asperger Syndrome, or had any vision problems uncorrected by lenses. Additionally, the researcher had each subject perform the Turtle Perspective-Taking Task (Masangkay et al., 1974) prior to being tested. This was to ensure that the subjects could pass a basic perspective-taking task typically passed by normal hearing children by age 4 (*Ibid.*). All subjects passed the turtle task.

The researcher stood facing each subject as he produced each gesture. Subjects were instructed simply to imitate each gesture as closely as possible; no other instructions were given. If the subject missed the gesture the first time, the researcher would repeat the gesture so that it could be imitated. Twenty-four of the gestures were the same ASL signs as those elicited in the sign elicitation task described in Section 6.4.3. The other 24 were similar to the ASL signs but employed a different handshape; however, the palm orientation, location, and movement parameters remained the same. Thus, just as in the elicitation task, half of the gestures were hypothesized to be more difficult to imitate than the other gestures. The crucial question was whether these intellectually normal college students whose theory of mind was fully-developed and intact would be more successful at imitating certain signs over others.

Items were coded as either being an error or correct for the parameter being tested. A deaf signer of ASL re-coded 20% of the data for reliability, and inter-coder disagreements were discussed until a consensus was reached.

7.1.3 Results

Ten males and 14 females completed the experiment. One male and one female were eliminated from the analysis because they imitated each sign with their left hand, thus obviating the perspective-taking problem. The remaining 22 subjects' error rates were analyzed using generalized estimating equations for repeated measures multinomial logistic regression. *P*-values reported are for the Wald chi-square.

There was no significant difference between male and female subjects; $\chi^2(1, N = 22) = .074, p = .79$. Subjects were more successful at imitating control signs than test signs; $\chi^2(1, N = 22) = 165.19, p < .001$. There was a main effect for parameter; $\chi^2(2, N = 22) = 274.43, p < .001$, and a significant interaction between parameter and difficulty; $\chi^2(2, N = 22) = 736.81, p < .001$. A cross-tabulation revealed that the movement parameter was responsible for this effect. Subjects made significantly more errors on signs in which the movement parameter was the test parameter. No other interactions were significant.

Condition	**Location**	**Palm Orientation**	**Movement**
Test	9.1%	5.7%	30.7%
Control	3.4%	0.0%	4.5%

Table 19. Error rates on imitated signs by hearing undergraduates.

Certain signs proved to be extremely problematic for the subjects. The movement parameter of two signs in particular, BLACK and FLOWER, were exceptionally difficult: 14 of 22 subjects produced a movement error on BLACK, while 7 of 22 produced a movement error on FLOWER. An additional 9 errors were produced on the variant of BLACK with a different handshape (a B-hand), as were 9 additional errors produced on the variant of FLOWER with an alternative handshape (an 8-hand), yielding an overall error rate for BLACK of 52% (23 errors out of 44 tokens) and 36% (16 errors out of 44 tokens) for FLOWER. In all of these cases, the error was made in the direction of movement. The sign BLACK (Figure 40) moves from the contralateral side of the forehead to the ipsilateral side; in the errors produced, movement was reversed from the ipsilateral to the contralateral side of the forehead. The sign FLOWER (Figure 40) exhibits the opposite movement, from the ipsilateral side of the upper lip to the contralateral side; errors produced exhibited the opposite movement.

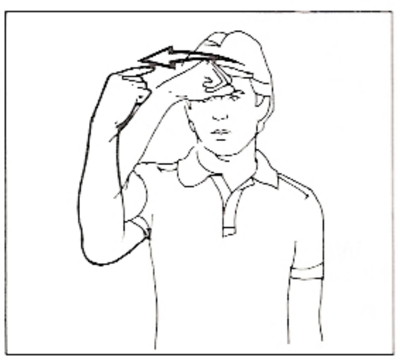



Figure 47. The ASL signs BLACK (left) and FLOWER (right; reproduced from Humphries et al., 1980).

The other signs that yielded numerous errors were BED (10 errors out of 44 tokens; error rate = 22%) and DOG (4 errors out of 44; error rate = 9%). Unlike BLACK and FLOWER, however, the movement parameter was not at issue in these cases. The test parameter for BED was location; the target location was the ipsilateral side of the face, while it was erroneously produced on the contralateral side of the face. The test parameter for DOG was palm orientation; the target parameter should have been an inward palm orientation, while it was erroneously produced with an outward palm orientation. Finally, BUTTERFLY was produced by one subject with palm orientation reversed (palms facing outward rather than inward); this subject produced the same error on both the standard ASL sign and the handshape variant.

A few errors were produced on control items. ICE-CREAM was produced by two subjects with movement reversed (from up-down to down-up); similarly, EGG was produced by one of these same subjects with the same movement reversal (from up-down to down-up). BUG was produced by one subject with palm orientation reversed (from facing the midline to facing away from the midline); this is a particularly marked error due to its articulatory awkwardness.

7.1.4 Discussion

The data indicate that certain signs are indeed difficult to imitate: specifically, signs that are specified for movements across the face were problematic for hearing undergraduate students to imitate, often resulting in reversed movement. These results cast doubt on the idea that such movement reversals are unique to autism, insofar as they also appeared in the imitated gestures of TD deaf children and hearing undergraduates. It seems likely that signs with movements across the face entail a spatial component that is difficult to process. Additionally, the finding that hearing undergraduates imitated control signs more accurately than test signs shows that the phonological forms of signs entailing shifts in perspective are more difficult to imitate, regardless of whether or not the person imitating these signs is autistic.

The results of this study are mostly consistent with a previous study of the phonological errors made by hearing adults learning ASL as a second language. Using a "Cognitive Phonology Model," Rosen (2004) predicted that L2 adult learners would make certain kinds of errors based on either perceptual or articulatory factors. He noted that perceptual errors would be rooted in "the physical stance from which the learner views the input source such as the teacher" and would occur "when signers either mirror or make parallel their signs with those of the teacher" (38). Such perceptual errors could then lead to a situation wherein "signers may reverse the handshape, location of contacts, direction of movements, and the orientation of palms within lexical signs as compared to their teacher"(38). Briefly summarized, Rosen made some of the same predictions for L2 learners that I made earlier for autistic learners, namely, that they might make location, movement, and palm orientation errors based on what he called "mirrorization".

Among the movement errors described by Rosen were errors involving "movement mirrorization" in which learners switched the movement to its opposite. Mirrorization errors occurred within the location and movement segments to reflect the place of location and direction of movement in the teacher's sign formulations.

Rosen also found palm reversal errors in L2 sign learners on signs such as DOOR (in which an inward palm orientation is substituted for an outward palm orientation) and WINDOW (in which an outward palm orientation is substituted for an inward palm orientation).

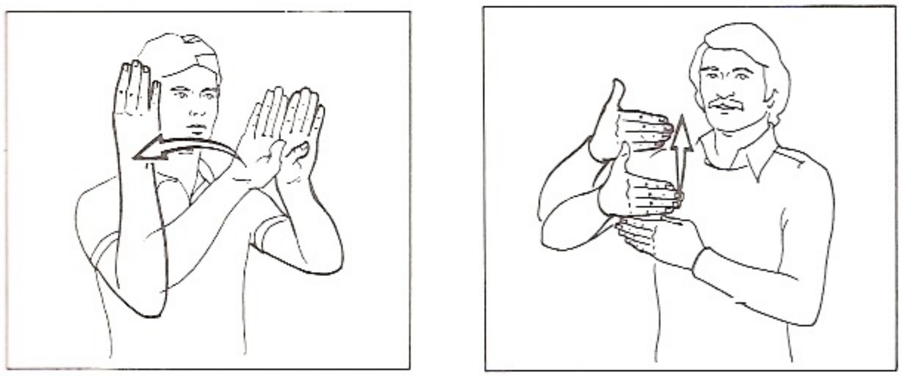


Figure 48. The ASL signs DOOR (left) and WINDOW (right; reproduced from Humphries et al., 1980).

Rosen rightly explains that there errors are perceptual in nature rather than articulatory; they seem to reflect the difficulty of reproducing signs as originally produced by the teacher. Rosen calls such errors “parallelization”:

> Parallelization errors appear when the learners produce signs that parallel with the sign formulations of the teacher, found in particular with respect to palm orientation. Learners switched from the symmetrical orientation for both hands to the opposite orientation. In addition, they oriented their palms in the way that they perceived the orientation of the teacher’s palms. In both cases, the palms of the learners faced in the same direction as the teacher’s as in parallel, but not in reverse, form. (56)

In other words, adult L2 learners would produce an inward-facing palm orientation on a sign such as DOOR because they saw the teacher’s (outward-facing) palms; these are the same kind of palm orientation reversals observed in deaf children with autism. However, it is difficult to evaluate how pervasive these errors are, since Rosen gives no indication of their frequency or whether learners persisted in making them. Palm orientation reversals were made by just four subjects out of 24 in my imitation study of hearing undergraduate students, while 18 out of 24 subjects reversed the direction of path movements. It appears from my data that certain kinds of movements (such as the cross-facial movement in the sign BLACK) are quite difficult for hearing, adult L2 learners to imitate, at least upon minimal exposure. Palm orientation appears to be relatively easy for adults to imitate, though some signs (such as DOG) resulted in a small number of errors.

Thus, the results of the undergraduate imitation study provide further evidence that the movements of certain lexical signs are difficult to imitate, and reversed movements on such signs cannot be considered (solely) the result of autism.

The next section will provide additional evidence for areas of weakness in the signing of deaf children with autism through interviews with Deaf mothers of such children.

7.2 Interviews with Deaf mothers of signing autistic children

In the course of conducting this research, I had the good fortune to meet several Deaf mothers of signing autistic children who were extremely helpful to me. I quickly realized that they were a significant resource in understanding the effects of autism on sign language development; they knew their children better than anyone and had witnessed their entire linguistic development. Also, these mothers were native ASL signers whose instincts and intuitions were far more developed than my own. Thus, I decided to interview a few of these mothers about their observations of their children's language. I had not spoken to these mothers in detail about my hypotheses prior to interviewing them, so that they would not be biased in their reporting of their children's signing.

Two separate interviews were conducted, each with two mothers at the same time. The first was conducted in Indianapolis in March 2009; the second in Austin, Texas in August 2009. A deaf research assistant conducted the second interview. The interviews were videotaped as a conversation between the two mothers. I prepared a list of questions, written in English, which I showed the mothers beforehand. The mothers took these questions as a point of departure to discuss their children's signing. The questions provided to the mothers were the following:

Questions for Deaf Mothers of Signing Children with Autism

1) What have you noticed about your child's signing that you think is unusual? Try to be as specific as possible (for example, give examples of specific signs that your child may have produced in an unusual way).

2) How has your child's signing changed over time? Has he/she stopped making some or all of these errors?

3) Does your child point at things? Does he/she point to him/herself to mean "ME"? Does he/she point to you to mean "YOU"?

4) Have you noticed anything unusual about your child's looking behavior? Does he/she look at you and make eye contact when you are signing to him/her?

5) How does your child do with facial expressions (i.e. raising/lowering eyebrows to ask a question)?

6) Do you ever change the way that you sign to better help your child understand you? If so, what exactly do you do?

7) What do you think can help an autistic child learn to sign better?

The mothers came up with a variety of examples of signing structures that lend additional support to my hypothesis about how perspective-taking affects autistic signing. The types of errors they report are grouped into sections below, and each will be discussed separately.

7.2.1 Reported Errors in Lexical Phonology: Palm Orientation

Arguably the most significant finding of this research is the discovery of palm orientation reversals in the signing of deaf children with autism. Although I observed many of these errors first-hand, the Deaf mothers gave examples of several lexical signs on which their children had exhibited reversed palm orientation that I had been unable to capture on film. In one interview, the mother CW stated that her son, then five years old, tended to produce the sign WATER with an inward palm orientation. The other mother, BE, then corroborated that her son, now seven, used to sign WATER with a reversed palm orientation as well, but had stopped after about three years. Both mothers also demonstrated that their sons had made errors in the contacting region of the sign; in the citation form, the index finger contacts the chin, but the two mothers demonstrated contact with the ring finger (CW) and thumb/pinky (BE).

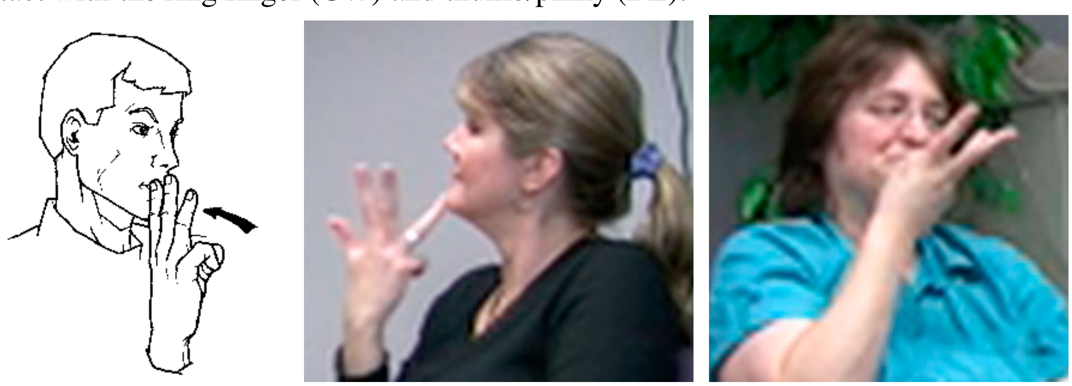


Figure 49. The citation form of WATER (left) and with palm orientation and contacting region errors, as reported by two Deaf mothers of deaf children with autism (center and right). Citation form reproduced from http://www.lifeprint.com.

A second example of a reversed palm orientation came from the same interview: one mother reported that her son used to sign BIRD with a reversed palm orientation for about a year, but no longer produced the sign this way. This is particularly interesting because the sign BIRD is an iconic representation of a beak, and the palm orientation reversal obscures the iconicity of the sign.

Figure 50. The ASL citation form for BIRD (left; from http://www.lifeprint.com) and a Deaf mother's depiction of how her deaf autistic son would sign BIRD with reversed palm orientation (right).

CW mentioned that her son would sign the days of the week with an outward palm orientation rather than the correct inward palm orientation. This maternal report corroborates the instances of the days of the week produced with reversed palm orientation by Ricky reported in the initial pilot data collected at Texas School for the Deaf in 2007.

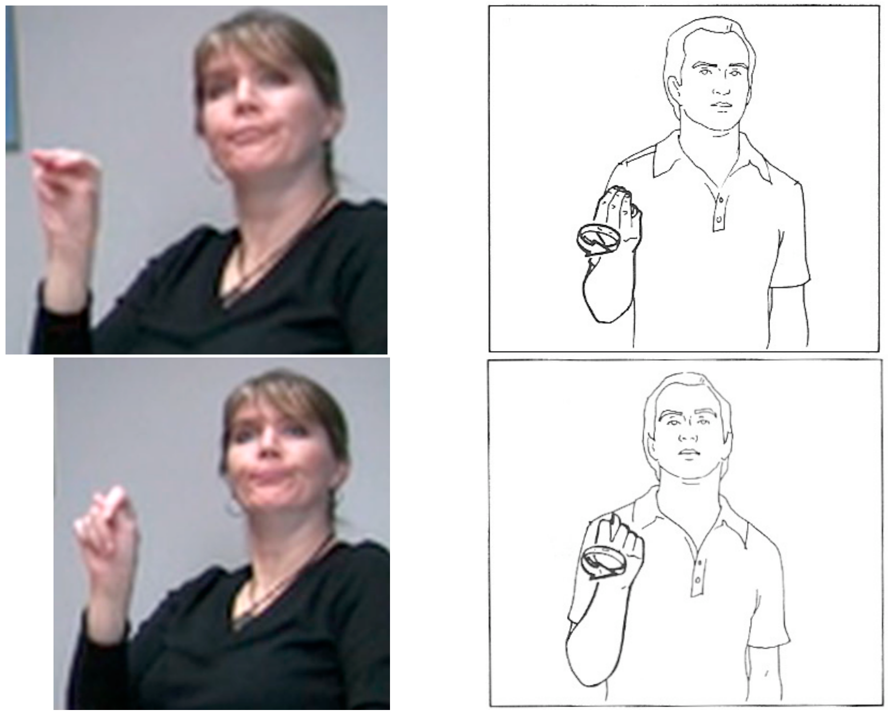


Figure 51. A Deaf mother reporting how her deaf autistic son would produce the signs MONDAY (top left) and TUESDAY (bottom left) with reversed palm orientation compared to citation forms (top right and bottom right, respectively; line drawings reproduced from Humphries et al., 1980).

Finally, in a different interview, a Deaf mother of an eight-year-old deaf boy with autism, RJ, confirmed his tendency to fingerspell with reversed palm orientation. Her co-interviewee, MK, a Deaf mother of a six-year-old hearing boy with autism, added that her son did the same:

> *RJ:* My son fingerspells his name and other words with his palm orientation facing towards himself. I think it's because I fingerspell words to him, and he sees my hand with the palm orientation facing him and he copies it like a mirror. It's hard to rotate his hand so the palm orientation will face outwards, away from the signer. It's hard. So I leave it alone until he feels comfortable to change it on his own….
>
> *MK:* With [my son], he fingerspells the same way [your son] does. I didn't notice it until you mentioned it a while ago. I didn't notice it with [my son] until he was

> about 3 1/2 years old. He fingerspells his name and also signs TOILET towards himself.[14]

These maternal reports are important for several reasons. First, they confirm that the data collected do not represent an isolated incident or abnormality. Second, they demonstrate the utility of parental reports of children's signing. The first mother not only had noticed her child's tendency to fingerspell with reversed palm orientation, but even offered a theory about why he did it and had attempted to correct it.

Thus, the mothers interviewed confirmed the hypothesis that deaf children with autism exhibit reversed palm orientations on signs specified for inward and outward palm orientations, and offered several examples, including signs that had not been directly observed during data collection.

7.2.2 Reported Errors in Lexical Phonology: Movement

As illustrated at length in earlier chapters, I hypothesized that deaf autistic children would make errors in the direction of movement of lexical signs specified for movement toward or away from the body. The interviews with Deaf mothers of signing autistic children provided additional support for this hypothesis and provided some examples of signs that might be susceptible to such errors.

In one particularly suggestive example, CW reported that her child reversed movement on the sign PAPER, which led to lexical confusion, since the sign CLEAN contrasts with PAPER in direction of movement only:

> *CW*: You know the sign PAPER? [My son] signs it like CLEAN, with outward movement instead of inward movement. He signs PAPER with the opposite movement. He understands if I sign CLEAN something and he does it, but when he signed PAPER this way, I misunderstood him. He threw a fit and I realized he didn't mean CLEAN, he meant PAPER. I saw that his sign for PAPER had the

[14] All quotations from interviews have been translated from ASL into English.

wrong movement…. Now he doesn't do it anymore. Around age 4 or 5, he started not to do it. How did it stop? It just happened, like a complete flip.

BE: For CLEAN, my son produces the sign so that it looks like the sign PAPER. It's the opposite.

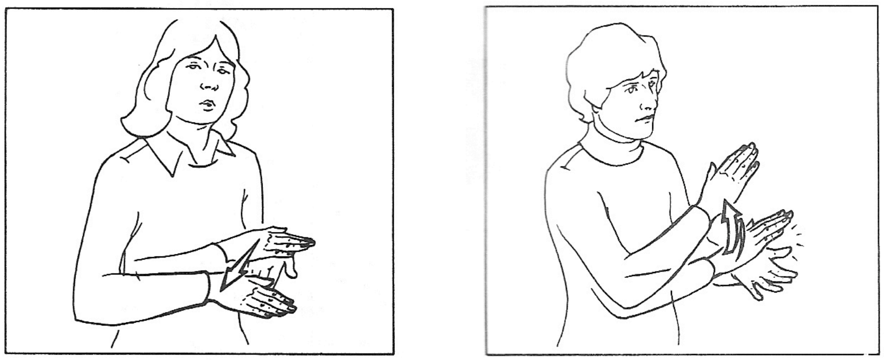


Figure 52. The ASL signs CLEAN (left) and PAPER (right), which differ only in the direction of movement. Line drawings from Humphries et al. (1980).

This example also provides additional evidence supporting the hypothesis that the movement parameter will be affected in autistic signing, with both mothers reporting the predicted kind of error. Furthermore, it demonstrates that such errors could lead to confusion, in cases where minimal pairs contrast in the direction of the movement parameter (such as CLEAN and PAPER).

CW showed that she was aware of her son's difficulty with the movement parameter in particular, stating:

> Oh, if there's a sign that requires left or right movement, he gets confused. So I stand by him so we are facing in the same direction. I sign and he looks at me from the side, and he understands better. For example, he signs PAPER for CLEAN. I sign CLEAN for CLEAN. But his signs are not perfect after this. He signs PAPER for CLEAN, I sign CLEAN for CLEAN. Over and over again.

Thus, CW has attempted to obviate the problem of differing visual perspectives by standing next to her son so that he would not have to shift perspectives. Still, she acknowledged that this did not immediately fix the problem.

7.2.3 Other Phenomena: Agreeing Verbs and Pronouns

The mothers interviewed reported that their sons had a variety of problems with grammatical structures that could be difficult due to an impairment in perspective shifts. The mothers commented on the use of agreeing verbs and pronouns. Although these structures were not analyzed in this dissertation, they remain an important area for future research into this population.

As noted in Section 3.3.2, Morgan, Smith, et al. (2002) reported that Christopher, the hearing autistic language savant, had difficulty producing verbs inflected for agreement in British Sign Language, systematically reversing the direction of movement between 1st and 2nd persons. Two Deaf mothers, BE and CW, reported that their sons acquired verb agreement relatively late and continued to produce errors with some agreeing verbs. For example, BE reported that her son does not inflect the sign HELP. He appears to produce the verb GIVE with inflected movement, but he does not seem to understand the meaning of movements in directional verbs such as GIVE. CW reported that her son *reverses the movement* in agreeing verbs, which is the kind of mistake that would be predicted if the hypothesis that perspective-shifts are difficult for children with autism is correct.

With regard to pronouns, maternal reports indicated a tendency to refer to oneself with a name sign rather than an indexical point (pronoun):

> *RJ*: [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 3 or 4 years ago [when he was between the ages of 4 and 5]. Now he points to himself. Sometimes he alternates between pointing to himself and signing his name sign…. 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 pronominal point.

MK reported that her son did not use points to refer to people, but did use points to make requests:

> *MK*: I don't see the 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.
>
> *RJ*: [My son] also used to point to communicate, just like [your son]. If [my son] wanted food, he'd point to the refrigerator. He used to inform me that he wanted something by pointing.

These reports suggest that pronominal reference in sign may be a difficult area for deaf children with autism. However, it is worth noting that none of the mothers reported pronoun reversals in their children – e.g., pointing at someone else to refer to oneself. Such pronoun reversals are one of the most distinctive characteristics of the speech of hearing autistic children (Lee et al., 1994). The absence of such reversals in my data, as well as the lack of reports of such reversals by the Deaf mothers of deaf autistic children, suggest that pronoun reversal may not be a characteristic of autistic sign language. Though systematic study is needed, it is in line with the theory advanced in this dissertation that deaf children with autism would not make pronoun reversal errors, even if they demonstrate a tendency to make palm orientation reversals. Though this may be counterintuitive at first, there is good reason to think this. In ASL, the pronominal points YOU and ME could actually be interpreted correctly by the deaf autistic child who fails to shift perspectives. From the deaf child's point of view, the sign YOU points inward toward himself. Even if he interprets the sign holistically as his name (as happens in pronoun reversals in speech, when a hearing child might refer to himself as "you"), this would lead to the correct articulation of the sign ME, which also points inward toward the child.

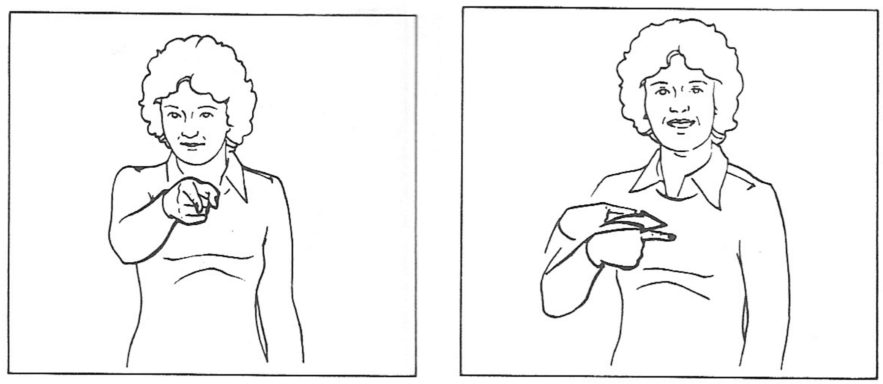


Figure 53. The ASL pronouns YOU (left) and ME (right), reproduced from Humphries et al. (1980).

Thus, it is striking that pronoun reversals do not appear, either in my extensive naturalistic and experimental data, or in the reports of Deaf mothers of signing autistic children. Pronominal use by deaf autistic children should be systematically investigated in the future in order to test the hypothesis advanced here. If found to be true, then this would be a stark point of contrast between the linguistic characteristics of autism in sign and speech. Additionally, it could help reveal how general cognitive mechanisms that are impaired in autism affect language in the visual-spatial and vocal-auditory modalities differently.

In the next section, I will use maternal reports to comment on several other phenomena that could be fruitful and interesting areas of future research into the signing of deaf children with autism.

7.2.4 Other phenomena: Neologisms

One well-documented characteristic of the speech of hearing autistic children is the tendency to create neologisms, or make up new words. This appears to be a characteristic of autistic signing as well, according to one maternal report:

> RJ: Some home signs like #TACOBELL, [my son] can't fingerspell it but he did produce a home sign that resembles the long pole holding the Taco Bell sign. He prefers to use his sign that he created instead of fingerspelling it. Every time he signs it, I add the fingerspelled word….When he sees something he does not know the sign for, he'll make up his own sign. That's what happened with Taco Bell…[My son] used to sign this [*she demonstrates a pair of S-handshapes with repeated movement on both sides of the head*] which meant "mad, frustrated, upset", anything with negativity. He made it up himself. I didn't understand why he did that. He signed it whenever he was mad, frustrated, or upset. I didn't like the sign and attempted to discourage him from using it. Now he stopped using it but once in a while he does. He is signing the ASL sign MAD – I taught him to sign it. That's how his signing is improving.

It is not surprising that deaf children with autism would create novel signs to refer to things, just as hearing children with autism do in speech. Such a phenomenon appears to be independent of language modality.

7.2.5 Other phenomena: Prosody and facial expression

An investigation into how deaf autistic children perceive and produce grammatical and affective facial expressions could be a fruitful area for future research, given the well-documented deficits that people with autism have with understanding and using facial expressions, as well as their irregular face-gazing behavior. Since sign language uses the face for grammatical as well as affective purposes, an investigation into facial grammar could be of particular importance.

The mothers interviewed indicated that their children did in fact have difficulty with facial expressions. BE and CW both reported that their sons were able to comprehend non-manual markers but were limited in their ability to produce grammatical facial markings. This appears to be true both for affective and grammatical facial expressions. Affective facial expressions can convey emotion and give color to signed utterances, much like the use of prosody can in speech.

> MK: I don't see a lot of facial expressions in [my autistic son], compared with [my non-autistic son]… [My autistic son] is more stoic when he signs. He points to what he wants, just communication for basic needs. He doesn't elaborate his point with facial expressions. I don't see that in him… 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 comparison to previous descriptions of prosody in the speech of hearing people with autism is apt: recall that the prosody of autistic children has been described as "improperly modulated, dull, and wooden" (Baltaxe & Simmons, 1985: 104) or "atonal, arrhythmic, and hollow" (Ornitz & Ritvo, 1976). It appears that such characteristics appear in the visual-spatial modality of sign, and are not limited to speech:

> MK: Take swinging. I push [my autistic son] on the swing. He's very monotonous in telling me to push more. He can't say MORE, FASTER, MORE, FASTER (*she demonstrates the sentences with strong affect*). He signs FASTER (*she demonstrates the sentence in a monotonous tone*). PUSH. FASTER. But [my non-autistic son], he says, MORE! FASTER, FASTER! (*she demonstrates it with strong affect*). He says it with feeling.

> RJ: [My autistic son] loves swimming, but he'll sign MORE, HIGHER, PUSH without facial expressions (*she demonstrates his signing in a monotonous tone*). He enjoys it but he doesn't show it. MORE, HIGHER, PUSH (*she demonstrates the same flat signing again*). [My non-autistic son] is more emotional about it.

The mothers also reported specifically on their children's ability to produce facial morphemes, such as the question-marking facial expression used for Wh-questions, which is signified by a furrowed brow and squinted eyes:

> RJ: 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. No. The facial expressions he makes are more for feelings.

Thus, it appears that a parallel exists between descriptions of the prosody of hearing autistic children and the facial markers of deaf autistic children. The perception and production of grammatical and affective facial expressions by deaf children with autism appears to be an interesting area of future investigation.

7.2.6 Conclusions from Maternal Interviews

The interviews conducted with four Deaf mothers of deaf children with autism yielded an abundance of information about their children's signing, much of which could not be directly observed. In general, the information provided by these mothers supported the conclusions from direct observation, and in any case did not provide evidence against what had been directly observed. In the next section, I will add to this evidence by introducing information gleaned from the educational records of certain test subjects.

7.3 Pertinent information from subject's educational records

Subjects' school files were consulted in order to get important background information about each subject with regard to their educational, medical, and family history. Some files included detailed reports about the subject's abilities in ASL. Some of these reports are suggestive of the kind of deficits in ASL that this dissertation seeks to investigate. Although I did not conduct tests on grammatical structures such as verb agreement, I hypothesize that these structures, too, could be impacted in autism. And indeed, there is some indication from certain subjects' school files that this may be the case.

At least two subjects' records indicated difficulties with verb agreement. The first was a 14-year-old deaf-of-deaf male, Jonathan. His neuropsychological evaluation noted: "He reverses directions in signing… He does not use directionality in signing correctly, often making errors in the direction with which he produces signs." The second was a ten-year-old deaf-of-hearing male, Peter. An ASL assessment in 2007 noted difficulty producing correct verb agreement signs, as he often imitated the action from the video or signs from the instructor. Alternatively, he would often produce signs in neutral space without showing agreement between subject and object.

A third subject, Dana, a nine-year-old deaf-of-deaf female, showed particular weakness on a verb agreement test, on which she scored significantly below average on several different kinds of verbs that marked agreement through locations in space.

Although anecdotal, these extracts from educational records of deaf children with autism are suggestive of potential areas of future research. There is some indication from these records that verb agreement could be a fertile area for future study, in line with the hypotheses formulated in this dissertation.

Chapter 8: Conclusions, Limitations, and Directions for Future Research

8.1 Claims

The naturalistic and experimental studies described in Chapters 5 and 6, along with the secondary evidence provided by school records and interviews with Deaf mothers in Chapter 7, provide a confluence of evidence about the nature of the cognitive impairment in autism, how autism affects sign language acquisition, and what cognitive skills are needed for the normal acquisition of sign language phonology. In the sections that follow, I will state the major findings of this research as well as its theoretical and practical implications.

8.1.1 Palm orientation errors are characteristic of deaf autistic children

The most robust – and suggestive – finding of the studies reported here is that a subset of young deaf children with autism show a tendency to reverse the palm orientation parameter from inward to outward and vice versa. I have shown that this phenomenon occurred consistently across six different subjects (not counting marginal or questionable errors), most of whom had Deaf parents and were thus exposed to sign language since birth (Ruben, age 4;6, Ricky, age 5;3 – 6;1, Brock, age 5;1 – 6;6, Raymond, age 5;8, Logan, age 7;2, and Cameron, age 7;5 – 8;11). Thus, their phonological errors could not be attributed to a lack of normal exposure to language. These subjects produced these palm orientation reversals in a variety of different tasks: in naturalistic observation, in elicited signs, in fingerspelling, and in the imitation of ASL-like nonsense signs. One subject (Logan) was not observed making palm orientation errors directly, but his mother reported that he used to make such errors when he was younger.

The appearance of such errors across various subjects and in different contexts and tasks suggests that palm orientation reversals are characteristic of the signing of young deaf autistic children. This claim is consistent with prior research on the imitation of gestures by hearing autistic children, who also made palm orientation reversal errors in multiple studies (Brown, 1996; Hobson & Lee, 1999; Ohta, 1987; Whiten & Brown, 1998). Such errors distinguish autistic children from their chronological- and mental-age-matched peers and appear to be a unique and characterizing feature of autism.

There are several implications of this finding which I will outline in the sections that follow. First, palm orientation errors of this type (inward/outward) do not appear to be part of the typical acquisition of sign language phonology. If this is indeed the case, then it is likely that whatever cognitive mechanism is responsible for such errors in autism is intact in typical development from a very early age. Theory of mind, therefore, is unlikely to be responsible, given its relatively late emergence with regard to the acquisition of phonological representations in sign. I will suggest that another aspect of cognition – identification – is a more likely candidate.

Second, the finding of phonological errors in autistic signing shows an important modality difference between sign and speech: autism affects sign language on the phonological level. This claim implies that the acquisition of phonological forms in sign language requires certain cognitive skills that are not required for the acquisition of phonological form in speech, and which are impaired in autism.

Third, the results of these studies lend additional evidence to the theory that an impairment in self-other mapping is responsible for the imitation deficit in autism. Further, these studies help clarify the nature of the imitation deficit in autism, and specifically refute certain claims in the literature about such a deficit, such as the idea that the addition of meaning facilitates gesture imitation in autism.

Fourth, the appearance of these errors in a subset of the sample (deaf-of-deaf autistic children under the age of 10), as well as the absence of such errors in older autistic children, appears to confirm the assertions of researchers such as Baron-Cohen and Tager-Flusberg, who have argued that autism entails a delay in the development of certain cognitive skills rather than an absence outright.

8.1.2 Inward/outward palm orientation errors are unique to autism

While there is abundant evidence of inward/outward palm orientation reversals in the signing of deaf children with autism, there is very little evidence that young typically-developing deaf children or deaf children with other kinds of cognitive impairments make palm orientation errors of this sort very frequently. They have not been reported in the literature. A search of a database of early signs produced by very young typically-developing deaf-of-deaf children yielded a few instances of these errors in 10- to 16-month olds, but there is no evidence of such errors occurring past infancy. In my data, TD deaf subjects did not make errors of this type in lexical signs, fingerspelling, or imitation of ASL-like nonsense signs. The sole error of this type found in a TD child in my data was produced by a two-and-a-half-year-old CODA whose older brother is autistic. This child produced the sign BUTTERFLY with outward palm orientation rather than inward. However, his mother indicated that the older brother also used to produce the sign BUTTERFLY with reversed palm orientation. Thus, this example is confounded due to the possible influence of the older, autistic brother. Still, a study of very young TD deaf children under the age of 3 would help put this issue to rest, since the TD deaf children in the present study were typically between the ages of 3 and 7, which may be too old to capture any errors, if they occur.

Even if additional evidence surfaces that TD deaf children do make palm orientation reversals of this type, it is very unlikely that such errors will appear frequently or persist over time. If anything, such errors may appear for a short time in development and disappear quickly. Otherwise, the numerous studies in the literature on the acquisition of phonology in ASL and other signed languages would certainly have reported them.

The practical implications of this finding are obvious: inward/outward palm orientation reversals may be considered an early indicator or marker of autism in young deaf children. Indeed, at least one teacher at a school for the Deaf is already screening young deaf children in this way (C. Wood, personal communication, February 2, 2010). Instruments used in the diagnosis of autism in deaf children should include phonological criteria, including palm orientation reversals, in their evaluation of the risk or possibility of an autism spectrum disorder.

Additionally, this finding could inform approaches to sign language training and intervention with deaf autistic children. There is already some limited evidence that teaching signs while seated in a side-by-side (rather than face-to-face) configuration could obviate the perspective-taking problem, and thus facilitate the acquisition of phonological representations. For example, Morgan, Smith, et al. (2007: 1350) found that Christopher was slightly more successful in replicating classifier constructions when seated next to the teacher (scoring 20% correct) than when facing her (scoring 0% correct). In addition, naturalistic studies of Deaf mothers' behavior with their deaf children have found that when children are seated on the mother's lap, mothers tend to sign in front of the child or on the child's body (Holzrichter & Meier, 2000; Meier, 2008). This would also help with the perspective-taking problem. It is possible that Deaf mothers, in other words, have intuited that perspective shifts are difficult for very young deaf children, and modify their signing to their children in this way in order to facilitate acquisition.

8.1.3 Theory of mind is not responsible for phonological errors in autism

From the outset, I believed that a delay in the development of theory of mind could be to blame for errors observed in the signing of deaf autistic children. I adopted this hypothesis because of the abundance of attention that ToM has received in the study of autism. Though ToM is a powerful theory capable of accounting for many of the strengths and weaknesses of perhaps a majority of autistic people, there are two major weaknesses to the theory: (1) it does not account for the repetitive, stereotyped behaviors that are characteristic of autism, and (2) it does not explain the minority of autistic people who pass ToM tasks (such as false belief) at a normal age. ToM impairments are certainly evident in many autistic people, but the idea that ToM is the primary deficit in autism spectrum disorders is far from a foregone conclusion.

Although I did not include a battery of tests to comprehensively test subjects' ToM abilities, this dissertation does not lend much support to the ToM hypothesis. The two visual perspective-taking tasks failed to show a significant difference between TD and autistic deaf children's performance, although performance was correlated with language age. More importantly, there appears to be a virtual absence of inward/outward palm orientation reversal errors in typically-developing deaf children. If a properly developed ToM were in some way responsible for the acquisition of phonological representations in sign language, then very young TD children might also produce palm orientation reversals before their ToM had developed fully. This does not appear to be the case; there is scant evidence that TD deaf children ever make these errors systematically, even when they are extremely young. Indeed, the emergent nature of ToM skills does not fit the pattern of acquisition of phonological representation, which occurs earlier in development and could not be predicated on skills that are either late-emerging or complex.

What, then, is a more plausible explanation?

The data suggest that a much more basic process is both implicated in the acquisition of sign language phonology and impaired in autism. I must repeat at this point that more research is needed, but I believe that the most likely hypothesis at this point is that of Peter Hobson, who has suggested that the ability to identify with others is impaired in autism.

8.1.4 Identification as a possible responsible mechanism

Hobson and colleagues (Hobson, 1984; Hobson & Hobson, 2007; Hobson & Meyer, 2006; Hobson & Lee, 1999; Hobson & Meyer, 2005; Meyer & Hobson, 2004) have conducted a number of studies that are particularly valuable for understanding what the imitation deficit in autism may be, as well as for its possible implications for sign language acquisition. In one study, Hobson and Lee (1999) tested the ability of autistic children not just to imitate object-directed movements, but also the way (manner) in which the movement was executed, and found that children with autism were significantly less likely to imitate the style of movement (i.e., the same movement executed either harshly or gently), even if they were capable of imitating the movement itself. This finding led them to speculate that the imitation impairment in autism may be related to a failure to *identify with another person*, rather than to a problem executing the movement to be imitated. In a later paper (Hobson & Hobson, 2007), identification with another person was defined as the process by which "an observer registers and assimilates another person's bodily anchored psychological stance (whether in feeling or action or some other way of relating to the world), in such a way that the stance becomes a potential way of the observer relating to the world from his or her own position" (411). In other words, the problem with imitation in autism may be one of intersubjective relationality, an inability to relate the actions of others to one's own actions such that the actions of others can correctly be reproduced from one's own point of view. In spoken language, this problem can be seen in pronoun reversals, which reflect a failure to acknowledge the shifting perspectives entailed in the use of "I" and "you". Of course, pronoun reversals are a hallmark of autistic speech. Spoken language is merciful in this respect compared to sign language, limiting itself largely to deictics. By virtue of being anchored in a visual-spatial medium, by contrast, signed languages fundamentally rely on the ability of signers to not only observe the gestures of others but also to then be able to relate these gestures to one's own body. This fact requires not just a shift in physical perspectives, but a recognition of the relationality between the two bodies – an *identification*. Typically-developing children learn to identify with others very early on, first by spontaneously imitating others' facial expressions in the first few months of life (Field, Woodson, Greenberg, & Cohen, 1983; Meltzoff & Moore, 1983, 1999), and later by imitating adult actions and showing things to others. Hobson and Hobson explain:

> In waving good-bye, for example, or in feeding an adult with a spoon (Bråten, 1998), the child shows role reversal and responds in kind to the actions shown toward the self by someone else… One way of describing such events is to say that the child *identifies with* the person who waves or feeds, so that waving goodbye to the other, or feeding the other, is not only perceived but also assimilated into the child's own repertoire of actions." (412)

Meyer and Hobson (2004) specifically investigated the ability of autistic children to replicate the "self-/other orientation" of actions on objects performed by others, finding that the autistic children were significantly less likely to replicate this self-/other orientation. Indeed, 5 of the 16 children with autism produced "reversal errors" in which they replicated actions as observed from their own point of view, rather than shifting to the point of view of the other person. Crucially, none of the children in the age- and language-matched control group made such errors.

Thus, the appeal of the identification hypothesis is twofold: first, it is consistent with the types of reversal errors observed, and second, the early emergence of identification skills in TD children explains the near-absence of palm orientation reversal errors in TD deaf and hearing children. I did not specifically test for identification in this dissertation because I came to this conclusion post hoc. However, this hypothesis should be tested in the future.

8.1.5 Autism affects sign on the phonological level

One of the unique findings of this research is that autism appears to affect how children perceive and store the phonological representations of lexical signs. This does not appear to be the case in speech, as various studies (e.g., Bartolucci, Pierce, Streiner, & Eppel, 1976; Rapin & Dunn, 1997, 2003) have found that phonological development in autism parallels normal development, though it may be delayed.

The evidence is particularly strong for the palm orientation parameter, as outlined above; however, there is evidence that the movement and location parameters are also affected by autism, though these findings are complicated by a variety of factors. For the location parameter, phonological constraints on possible forms (especially on the face) may limit the number of errors observed in deaf children with autism; also, the ability to switch hands may provide an alternative to difficult perspective shifts. For movement, it appears that both TD deaf children and hearing undergraduates, as well as deaf children with autism, have difficulty imitating certain cross-body movements; thus, the acquisition of the movement parameter may involve additional cognitive skills that render it more susceptible to phonological errors.

These data suggest that it is not so much the case that phonological ability *per se* is intact in autism, but rather that phonological acquisition in spoken languages does not happen to employ any of the cognitive skills that are impaired in autism. By contrast, phonological acquisition in the visual-spatial modality of sign appears to call on cognitive skills that are impaired in autism. Therefore, it is likely that impairments in general cognitive mechanisms are responsible, rather than language-specific mechanisms. I have tentatively suggested that the ability to identify with others is one possible general cognitive mechanism that could be at the heart of this impairment; however, more research is needed.

8.1.6 Additional evidence for a self-other mapping deficit

As outlined in Section 2.4, various proposals have been advanced as to the nature of the imitation deficit in autism. Of six major theories in the literature, Williams et al. (2004) concluded that "a specific deficit in self-other mapping ability", as proposed by Rogers & Pennington (1991), was most consistent with the data presented in 21 studies. The reversal errors found in the gesture imitation literature (e.g., Ohta, 1987, Brown, 1996; Hobson & Lee, 1999) were a prime motivator for this conclusion, insofar as they appear to reflect an inability to alter perspectives and correctly replicate the body movements of others. Furthermore, such errors do not appear to occur in either typically-developing children or other developmentally-disabled populations.

This research lends robust support to the self-other mapping deficit hypothesis. The same kinds of reversal errors described in the studies above were also found in the signing of deaf children with autism in a variety of contexts. This finding also refutes the notion that the addition of meaning to gesture could facilitate autistic gestural imitation, a proposal advanced by some researchers (e.g., Rogers, Bennetto, McEvoy, & Pennington, 1996), since reversal errors were evident in both meaningful signs and meaningless nonsense gestures.

"Self-other mapping" is a useful concept to apply to sign. The complicated process of translating observed movements from others to oneself is likely to include various skills, among them identification, visual perspective-taking, spatial reasoning, and motor imitation. This concept should be used as a starting point for future research on sign language in autism, and the hypothesized component skills should each be tested separately in an attempt to identify specific deficits. All sign language learning entails some form of self-other mapping, since sign necessarily involves the imitation of the body movements of others; however, this dissertation has demonstrated that the phonological forms of certain classes of signs are more difficult to imitate than others. The same is likely to be true for superlexical structures such as verb agreement and classifier constructions, which could be fruitful areas of future research.

8.1.7 Autism entails a delay, not an absence

Baron-Cohen (1989) argued that theory of mind is delayed, rather than absent, in autism, a claim that is supported by Steele et al.'s (2003) finding that individual autistic subjects showed improvement on ToM tasks over time. Though the results of these studies do not have direct implications for the study of ToM, they are consistent with the idea that development is delayed in autism but not necessarily absent.

The main evidence for this claim is the fact that none of the subjects over the age of 10 made phonological errors of the types described at length in this dissertation. The oldest autistic subject who consistently made palm orientation reversal errors was just under 9 years old. Though this is much older than would be expected for phonological errors in typically-developing deaf children, it suggests that most deaf children with autism do eventually master lexical phonology. A longitudinal study of phonologically-impaired deaf autistic children would be informative as to the nature of how such children develop over time, as well as when and how phonology is mastered.

8.2 LIMITATIONS OF THIS RESEARCH

The research presented in this dissertation must be accompanied by several caveats that limit the interpretability of the data. These limitations will be discussed in the next section, after which directions for future research will be discussed.

8.2.1 Problems related to the sample

Several concerns about the sample of subjects should be noted in the interpretation of the data presented.

First, the current study's sample size was not large enough to perform statistical analyses of sufficient power to be able to draw solid conclusions about the reliability of the phenomena observed. Ideally, at least 20 subjects should be included in each test group in order to be able to perform statistical analyses of sufficient power.

Second, the age range of the autistic groups was not adequately matched to the control group. The DoH group did not include any subjects under the age of 10, the critical age for observing the kinds of errors that are relevant to a discussion of the effects of autism on the lexical phonology of ASL. A related issue is that the control group of TD deaf children may not have been young enough to observe any of the predicted error types. The youngest control subjects were over the age of 3. Future investigations should carefully analyze the signing of TD deaf children under the age of 3, in order to confirm that TD deaf children do not make the kinds of errors observed in autistic children.

Third, the results of the DoH group are confounded by the fact that deaf children of hearing parents are known to lag behind DoD and hearing children in ToM development. Therefore, the interpretability of these results is limited since it is unclear if any abnormalities observed are attributable to autism or to cognitive delays associated with growing up in an impoverished linguistic environment. Since this research represents the first attempt to collect data from the population of deaf children with autism, and it was not known at the outset how many subjects would be found or how much data could be collected, DoH subjects were not excluded from data collection or anlaysis. However, in the future, data should only be collected from DoD children with autism in order to avoid such confounds. Still, the inclusion of DoH subjects in this dissertation does not invalidate the claims advanced, since all of the claims rest on evidence collected from the DoD group, not the DoH group.

8.2.2 Problems related to methodology

The experiments were conducted by the author, a hearing, non-native signer. Although proficient in ASL, I do not possess the fluency required for ideal experimental conditions. Children may have been aware that they were interacting with a hearing person, and this could have influenced the way that they responded to tasks. Furthermore, I may not have understood all of the nuances of their signing, leading to experimental error. In the future, experiments should be performed by a native deaf signer in order to avoid these types of errors.

Another serious consideration has to do with how subjects were diagnosed with autism. There are two major problems with how subjects were identified as autistic. The first and most significant problem is that there exists no diagnostic instrument developed especially for or normed on deaf children. Neither of the two "gold standards" for diagnosing autism, the Autism Diagnostic Interview-Revised (ADI-R; Lord et al., 1994) and the Autism Diagnostic Observation Schedule (ADOS; Lord et al., 1989) has been validated for deaf subjects. Moreover, the ADOS has components that may be inappropriate for deaf children. For example, several episodes require the manipulation of objects, which may not be directly translatable because the hands are occupied by the task. Furthermore, the ADOS does not provide for the coding of nonverbal expression, gesture, or prosody.

Given this state of affairs, existing instruments developed for use with hearing children must be used and adapted. Though this is certainly possible, it would be preferable to employ a diagnostic instrument specifically developed for use with deaf children. None of the children diagnosed with autism in this sample had been diagnosed with the ADOS or the ADI-R. Instead, most diagnostic determinations were made by using either the Gilliam Autism Rating Scale (GARS; Gilliam, 1995) or the Childhood Autism Rating Scale (CARS; Schopler, Reichler, DeVellis, & Daly, 1980). Of these two instruments, the CARS has been shown to be a valid and reliable indicator of autism

(Garfin & McCallon, 1988), but several studies (Lecavalier, 2005; South et al., 2002) have called the utility and sensitivity of the GARS into question.

A second, related problem is that autism diagnoses were not confirmed independently by the researcher. Rather, diagnoses were confirmed through the consultation of educational and medical records. This was done because I did not have the training or qualification to be able to make such an assessment.

Thirdly, I hypothesized that an impairment in the ability to successfully imitate the body movements of others ("self-other mapping") would result in specific errors in sign language phonology. However, I only tested one non-linguistic cognitive skill thought to be entailed in self-other mapping: visual perspective-taking. My results do not support the hypothesis that visual perspective-taking is specifically impaired in autistic children. I did not test any other related cognitive skills which might yet prove to be impaired in autism, such as identification. Future research should attempt to disentangle the various cognitive processes implicated in self-other mapping in order to identify specific processes that are impaired or intact in autism.

Finally, no measure of non-verbal intelligence was included in the research. A measure of non-verbal intelligence that has been validated for use with deaf children, such as the Wechsler Intelligence Scale for Children-Fourth Edition (WISC-IV; Wechsler, 2003), should be used in future research in order to properly match subjects from different test groups and control for differences that could be attributed to different levels of intelligence. The WISC has been used widely with deaf children (Gibbins, 1989) and obtains similar performance IQs in deaf and hearing children (Maller & Braden, 1993), unlike other tests such as the Leiter International Performance Scale-Revised (LIPS-R; Roid & Miller, 1997), on which deaf children tend to score lower than hearing children (Marschark & Spencer, 2003).

These methodological limitations must be kept in mind when considering the significance of the data presented.

8.3 Directions for future research

There is ample room for future research into the population of deaf children with autism. The current studies suggest a variety of different directions that this research could take. In this section, I will outline a few of the directions that appear to have the greatest potential for future studies.

First, a comprehensive, nationwide recruitment effort could yield a larger sample of DoD autistic children, especially those under the age of 10. This could be done through outreach to all of the schools for the Deaf in the United States, as well as recruiting through the Deaf Autism parent network or other social networking means. The current sample included only six DoD children under the age of 10; the majority of my conclusions were drawn based on data collected from these subjects.

Second, this dissertation focused on sign language production only, and did not attempt to test perception. Rather, hypotheses about how deaf children with autism perceived signs were made via inferences based on their production. However, the perception skills of such children should also be tested directly in order to determine if they are capable of detecting differences in the sign parameters (handshape, location, movement, and palm orientation). One possible test could involve a “same/different” paradigm, in which subjects are shown two signs and asked to report whether the two signs are the same or different. Pairs of identical signs would be interspersed with signs that differ in just one parameter; these variables could be systematically manipulated to see whether deaf children with autism are capable of perceiving subtle differences in the formation of signs. Such a task could be done with nonsense signs or actual ASL signs, and controls groups of typically-developing deaf children and non-signing hearing adults could also be tested. Children's overall perception skills as determined by such a task could then be correlated with performance on sign production tasks, non-linguistic cognitive skills and overall language level. This task would also be useful in determining if certain kinds of phonological differences are harder to perceive or less salient than others.

Third, numerous areas of sign language structure remained unexplored in this dissertation which are likely to interact with autism in interesting ways. This dissertation focused on lexical phonology, but other structures implicated in self-other mapping could be instructive as to how exactly autism interacts with sign language structure. In particular, future studies should focus on agreement patterns for verbs, classifier constructions, and pronominal reference. Hypotheses and potential experiments for each of these experiments will be described briefly in the paragraphs that follow.

In ASL, many verbs can inflect to indicate subject and object by moving in space between the location of the subject and the location of the object. References to non-present arguments in a discourse can be made by points to empty locations in the signing space; once these locations are established, a verb can incorporate them into its path movement in order to specify subject and object. Verb agreement is typically acquired by age 3½ (Meier, 1982). I predict that ASD children will differ in their ability to replicate 1st and 2nd person agreement patterns from TD controls due to a self-other mapping deficit. However, autistic children and TD controls will not differ in their ability to reproduce verb agreement between two 3rd person referents, since such patterns do not entail a perspective-shift.

Classifier constructions are another aspect of sign language structure that could be a particularly fruitful area of investigations. Classifier predicates are constructions in which the position of the hands in signing space schematically represents spatial relations among objects. As these constructions are typically signed from the point of view of the signer, they entail perspective-shifts on the part of the addressee, particularly in constructions in which objects are described in relation to each other on a horizontal plane (e.g., "to the right/left of" as opposed to "above/under"). Concrete predictions can be made about how an impairment in self-other mapping will yield specific errors in the comprehension and production of classifier predicates, and a variety of tasks could be created to test these structures. To give just one example, the comprehension of classifier constructions used to represent simple configurations of non-present objects could be tested by showing participants videotaped sign utterances of classifier constructions. In the control condition, the vertical relationship of two objects (e.g., a cup on top of/under a table) could be described using classifiers. In the test condition, the horizontal relationship of two objects (e.g., a car parked next to a house) could be described using classifiers. Comprehension could be tested using a picture-matching task in which various configurations of the objects described are presented to participants. I predict that autistic subjects will make more errors on descriptions of horizontal arrays than TD controls, and will make more errors on horizontal arrays than on vertical arrays.

Pronominal reference in sign language is accomplished by indexical points to present and non-present referents. However, the form of these points actually suggests that pronominal reversal – one of the most distinctive hallmarks of autistic speech – will *not* occur in autistic signing. This is because the form of the point YOU, as observed from the autistic child's perspective, will be replicated as ME, *even if the child fails to engage in self-other mapping*. In other words, a failure to understand other people's perspectives and the shifting referential meanings of pronouns in sign language is not predicted to lead to the kinds of reversals observed in speech. Still, signed pronouns should be carefully studied in autistic subjects, in order to verify whether or not deaf autistic children do in fact reverse pronouns. If not, then this would be another important modality difference between the characteristics of autistic signing and autistic spoken language.

In addition to these constructions related to self-other mapping ability, another rich area of possible investigation is the use of the face in signed languages and how deaf people with autism perceive, process, and produce such facial markings. Such research could take several different directions: (1) a series of tasks testing subject comprehension of grammatical morphemes produced on different areas of the face, in particular the mouth and eye regions; (2) comprehension of grammatical facial expressions in contrast to non-linguistic affective facial expressions; and (3) the use of eye-tracking equipment to compare the eye gaze behavior of deaf children with autism with that of typically-developing deaf children.

Future research should also focus on the relationship between linguistic skills and other cognitive skills implicated in self-other mapping such as imitation, theory of mind, and identification, in order to disentangle various cognitive skills involved in sign-learning to see if there are specific deficits or strengths in each of these skills. The concept of identification as described by Hobson and colleagues (Hobson & Hobson, 2007; Hobson & Meyer, 2005, 2006; Hobson & Lee, 1999) is particularly important from the perspective of this research. Various tasks from Hobson's studies could be replicated in order to test whether there is evidence of an identification deficit in deaf children with autism, and whether such a presumed deficit correlates with sign language deficits.

Furthermore, a variety of tasks could be used to test various aspects of ToM that are precursors to false belief, such as understanding other people's desires (Wellman & Liu, 2004), the ability to infer knowledge from perceptual access (Pratt & Bryant, 1990), and unexpected contents false belief (Perner et al., 1987).

Yet another area of potential research is pragmatics, which has consistently been shown to be a weakness of autistic children. In sign language, one modality-specific aspect of pragmatic understanding is that signing children must come to understand that their articulators must be visible to others in order to be understood. Hence, there is a pragmatic component in the production of sign language that has no correlate in speech: signers must constantly adapt their signing to the changing physical conditions involved in signing configurations between two (or more) people. To my knowledge, no research has specifically aimed to understand how deaf children come to make such understandings.

I hypothesize that deaf children with autism will show impairment in their ability to pragmatically alter their signing in order to facilitate perception by others. This could be tested by systematically varying signing configurations and recording how subjects modify or fail to modify their signing. For example, signs could be elicited in a face-to-face condition, a side-by-side condition, and a condition with physical obstructions blocking the experimenter's line of vision, so as to test whether TD deaf children and deaf children with autism understand how their signing must be modified in order for it to be perceived by others.

Finally, a naturalistic study of deaf mothers interacting with their deaf autistic children could be informative. By analyzing the accommodations or modifications that deaf mothers make in signing to their deaf autistic children, clues about the nature of such children's cognitive needs could be revealed.

In sum, there is ample room for future research into this poorly-understood and under-researched population. Hypothesis-driven, systematic, and experimental research will be fundamental if the needs of deaf children with autism are ever to be adequately addressed. The interaction of known impairments in autism with the cognitive skills necessary for mastering a signed language is a promising area of research for addressing questions of core theoretical significance in understanding how autism affects cognition in both deaf and hearing children. This dissertation represents a first step towards that lofty goal.

Appendices

APPENDIX A: STIMULI USED FOR ELICITATION TASK

All pictures made with Boardmaker® software and printed on 5” x 7” laminated cards.

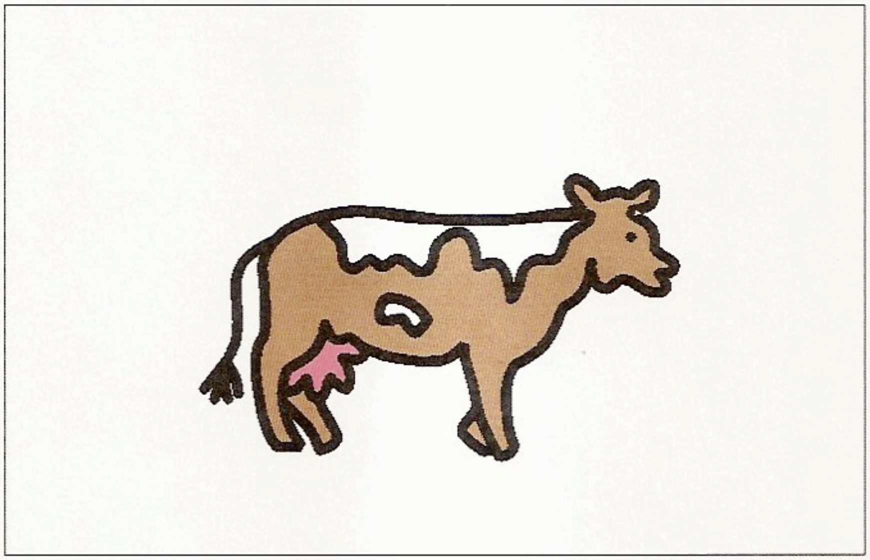
Top row, left to right: GIRL, BED, APPLE, CANDY, BATHROOM, BIRD.

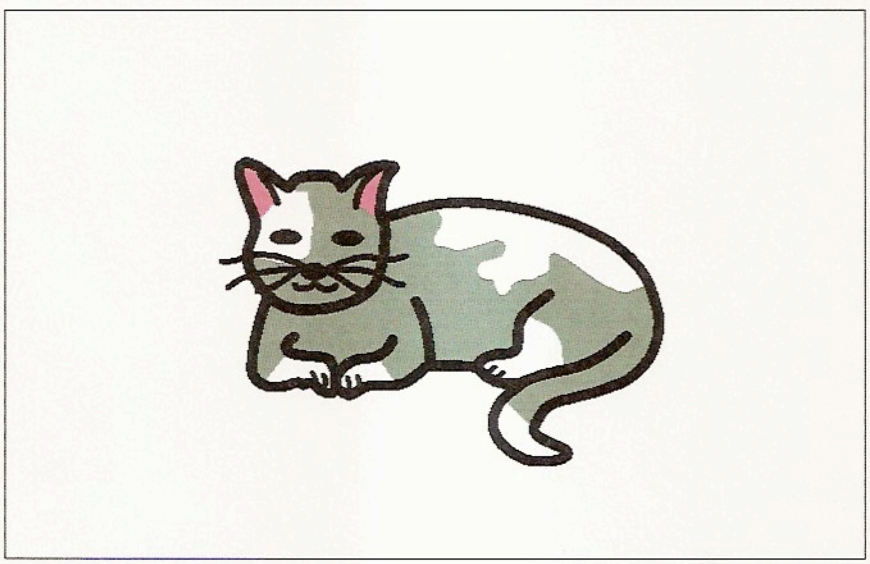
Second row, left to right: DOG, BUTTERFLY, FLOWER, MOUSE, BLACK, AIRPLANE.

Third row, left to right: ICE-CREAM, BUG, BOY, BEAR, BOWL, TRAIN.

Bottom row, left to right: SHOES, TABLE, ALLIGATOR, EGG, TOMATO, HOUSE.

APPENDIX B: STIMULI USED FOR LEVEL 1 VISUAL PERSPECTIVE-TAKING TASK





Pictures made with Boardmaker® software and printed on 8.5” x 11” laminated cards. Each image took up one side of a double-sided card, so that only one image was visible at a time.

Appendix C: Screening form with modified Edinburgh Handedness Inventory

PARTICIPANT SCREENING FORM

Child's Name: ___________________________________ DOB: _____/_____/______

1) What hand does your child normally use for the following activities?

Writing/drawing:		LEFT	RIGHT
Throwing:		LEFT	RIGHT
Using a toothbrush:		LEFT	RIGHT
Using a spoon:		LEFT	RIGHT
Signing (dominant hand):		LEFT	RIGHT
2) Which hand do you normally write with?		LEFT	RIGHT
If you sign, which hand is normally dominant?		LEFT	RIGHT
3) Which hand does your spouse (if any) write with?		LEFT	RIGHT
If your spouse signs, which hand is dominant?		LEFT	RIGHT
4) What is your hearing status?	DEAF	HH	HEARING
What is your spouse's (if any) hearing status?	DEAF	HH	HEARING

5) What language(s) do you primarily use with your child? (Circle all that apply.)

ASL	ENGLISH	TOTAL COMMUNICATION
CUED SPEECH	HOME SIGNS	Other (please describe):

____

6) Has your child ever been diagnosed with autism or Asperger Syndrome?

YES NO

7) Have you ever suspected that your child might have autism or Asperger Syndrome?

YES NO

8) Does your child have any vision problems that cannot be fixed by corrective lenses?

YES NO

If you answered 'yes' to question #8, please describe:

____

Thank you for your participation.

APPENDIX D: RECRUITMENT LETTER TO PARENTS OF POTENTIAL SUBJECTS

DEPARTMENT OF LINGUISTICS
THE UNIVERSITY OF TEXAS AT AUSTIN

Aaron Shield

1 University Station • B5100 • Austin, Texas • 78712-0198
Voice: 512-471-1701 • Fax: 512-471-4340

Assistant Instructor & Ph.D. Candidate

Dear Parents,

My name is Aaron Shield and I am a Ph.D. candidate in the linguistics department at the University of Texas at Austin. I specialize in sign language development under the direction of Dr. Richard Meier. Currently, I am conducting my dissertation research on the use of sign language by deaf children on the autism spectrum as well as typically-developing deaf children. I hope that my research will help us understand how sign language is learned by autistic children, and that this knowledge will lead to improved communication and better educational strategies.

I am writing to you because I would like to have your permission to observe your child. I will be conducting a series of short sign language tests at your child's school. This will entail showing 24 pictures of everyday objects (such as a train, a table, or an apple) to your child and asking him/her to produce the sign for each picture. I will then produce 24 nonsense signs and ask your child to imitate me. If your child completes both of these tasks, I will also perform a short task that tests your child's ability to learn new signs for objects he/she has never seen before, as well as a fingerspelling task (if your child can fingerspell). All of these tasks will take no more than one hour. The experiment will be videotaped and the analyzed tape will be compared to data collected from autistic and typically-developing deaf children.

I have received permission from your child's school as well as the University of Texas to conduct this research. The consent forms attached give more details as to the research procedures as well as the steps that will be taken to ensure confidentiality. If you agree to participate, please sign and return the attached consent forms promptly. There is also a short screening form and Questionnaire about your child's communication skills that we request that you fill out. If you allow your child to participate and return these forms, I will send a $20 gift card to you after my visit to your child's school. This visit will take place within the next few months. For the exact date, please contact the researcher at ashield@mail.utexas.edu.

Once the research is completed, I will provide a summary of my results to you. These results will not include individual information about your child, but will include information about the group of subjects as a whole. Of course, I will not involve your child in my research if you do not wish him/her to participate for any reason. Should you have questions or concerns please feel free to contact me at the email address or phone number below.

Sincerely,

Aaron Shield
ashield@mail.utexas.edu [redacted]

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