Empirical Articles

The Acquisition of Spatial Constructions in American Sign Language and English

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Spatial relations in American Sign Language (ASL) are often signed from the perspective of the signer and so involve a shift in perspective and mental rotation. This study examined developing knowledge of language used to refer to the spatial relations front, behind, left, right, towards, away, above, and below by children learning ASL and English. Because ASL is a classifier language in which noun referents are placed into groups, each spatial relation also appeared with person, animal, and vehicle classifiers. Twenty-three children and adults who learned ASL before the age of 5 years and 23 native English-speaking adults and children participated. Both language groups participated in a comprehension task in which they chose which of 2 pictures depicted a signed or spoken relation. Results showed that children learning ASL acquired the constructions for spatial relations that typically involve perspective shifts and mental rotation later than constructions that do not involve these abilities and later than English-speaking children. Children learning ASL did not differ from English-speaking children in learning constructions that did not involve these abilities. Results also suggest that users of ASL initially comprehend spatial relations more accurately with person and animal classifiers than with the classifier for vehicles. The results are relevant to understanding the acquisition of spatial relations in ASL.

Talking about space is an important component of all human languages. Spatial language enables us to share a mental representation of a space in conversation with another individual and enables us to find objects and events whose locations are unknown. The ability to share information about the location of objects in space has obvious adaptive as well as practical value. Considerable research and funding has been dedicated to technology and elaborate signage systems that assist both sighted and blind people in navigating through unfamiliar spaces. In short, spatial language enables us to extract and represent the positions of objects and people relative to each other out of the infinite number of configurations in which entities can be arranged. Furthermore, spatial language has been recently placed into the forefront of the debate on the relation between language and cognition (see, e.g., Hermens, Vasquez, Spelke, & Katsnelson, 1999; Levinson, 1996; Li & Gleitman, 2002; Newcombe & Huttenlocher, 2000). Thus, understanding developing knowledge of spatial terms in American Sign Language (ASL), a visual–spatial language, should provide key insights into the developing relations between cognition and language.

There is considerable research on the acquisition of spatial language by English speakers. One of the earliest ways in which humans communicate information about space is through pointing. Preverbal children use pointing gestures to specify the location of desired objects and to achieve joint visual attention with another person. Pointing gestures continue to...
comprise a large proportion of children’s gestures even after they begin to speak. The use of pointing to reference objects has been shown to correlate with early language development. Children first understand pointing when the referent is nearby and later understand pointing with increasing distance between the point and the referenced object (Butterworth, 2001).

Whereas spatial referencing through pointing appears very early in development, using language for spatial discourse appears rather late and is usually not fully mastered until around 6 years. Studies on the acquisition of spatial terms in English have shown that these terms are acquired in a consistent order. The order of acquisition has been shown to depend both on the type of objects referred to and the reference points needed. Kuczaj and Maratsos (1975) found that children learning the English words front, back, and side as they refer to the inherent parts of objects, learn front and back simultaneously and before they learn side. Children first learn the fronts and backs of themselves before they learn the fronts and backs of other objects. Children then learn front and back, initially, for objects that have intrinsic fronts and backs and later use themselves as a reference point for identifying the fronts and backs of nonfronted objects. It is interesting to note that using oneself as a frame of reference does not appear until after children learn to use other objects as reference points.

English-speaking children typically acquire an understanding of the relations in, on, under, and next to before learning proper meanings for in front and behind (Johnston, 1984). Additionally, the acquisition of the terms in front and behind depended on the visual salience of the objects used as the reference and located objects. When the referenced object has an identifiable back and front (such as a television or a stuffed animal), children more readily use the terms in front and behind. Children are also quick to learn to use the terms in front and behind, regardless of whether it has a front or back, when the referenced object obscures the located object from view.

More recently, Sowden and Blades (1996) have shown that English-speaking children can understand some basic prepositions such as next to, beside, and near by 3 years of age. In this study, the researchers asked children to place an object next to or near another object. For both next to and near, younger children (3- and 4-year-olds) responded by placing a target object in contact with a reference object. However, 6-year-olds and adults made these contact responses more often for the locative next to than for near. These results indicate that children’s understanding of next to is similar to that of adults’ but the development of the adult form of near takes several years for young children to develop. The authors suggest that some spatial terms are slow to be acquired because the meaning of some locatives are variable and depend on the context in which it is used. Such variability in word meaning may make spatial terms difficult for young children to grasp. In sum, the studies on the acquisition of English spatial terms have shown that it is a process through which children progress in a predictable order between 2 and 6 years of age.

Although the study of spoken language acquisition has enjoyed a long tradition of research, the study of sign language acquisition prior to the 1970s was hampered by a climate that discouraged the use of sign language by Deaf children. Indeed, most early studies of language acquisition in Deaf children primarily considered the children’s acquisition of spoken English with only cursory attention to their acquisition of signs. As a result, most research on the acquisition of ASL tackles broad developmental questions such as age of milestone achievement (Bonvillian, Orlansky, & Novack, 1983), language interaction patterns between parents and their Deaf children, or the quality of language input from Deaf and hearing parents (Spencer, 2004). In addition to studying these normative patterns of development, much of the research also seeks to test widely held assumptions and theories of language development, such as the critical period hypothesis (Mayberry, 1993), or the notion that modality-specific faculties are involved in language acquisition (Goldin-Meadow, McNeill, & Singleton, 1996). Consequently, only more recently has the study of sign language acquisition focused on patterns of linguistic acquisition in children acquiring ASL. In this paper, we focus on one of the finer linguistic aspects of ASL—the acquisition of spatial constructions. We are focusing on the acquisition of spatial constructions in ASL because they seem to involve complex perspective-taking skills.
In ASL, as in many other known sign languages, spatial constructions are typically signed from the perspective of the signer. To sign the English sentence “A car is to the right of a tree,” the signer signs “TREE” with the left hand and “CAR” with the right hand, thus making the car on the right side of the tree (see Figure 1). To an addressee, this relation appears to be reversed 180°. Therefore, in order to correctly interpret this relation, the addressee seems to perform a 180° mental rotation of the signs. Because these relations are not typically expressed by a separate sign or lexicalized as they are in English, we refer to them as spatial constructions. In contrast, in English, spatial relations are lexicalized and the relevant information about location is encoded in speech rather than in space. When a speaker says “A car is to the right of a tree,” the listener may form a mental image of a car on the right and a tree on the left and no perspective shift or mental rotation is required to understand the sentence. To both the speaker and the listener the car and tree take the same relative positions. However, in ASL, a shift in perspective that involves mental rotation seems to be required for understanding spatial relations. When a signer expresses the same concept, a viewer (addressee) facing the signer must mentally transform the locations in signing space to create a mental image of the scene where the car is located to the right of a tree, even though the addressee actually sees the signs with the classifier for “TREE” on the right and the classifier for “CAR” on the left (see Figure 1).

In studies with adults, researchers have shown striking differences between ASL signers’ and English speakers’ spatial language. Emmorey (1995) found that ASL signers were less likely to lexicalize spatial prepositions such as in or next to than speakers of English, even though such forms are available in the ASL lexicon. Instead, ASL signers typically make use of classifiers to indicate both location of an object and its orientation. For example, to indicate the relation between a figure and ground object, one typically uses a classifier for both objects and indicates their places in space relative to each other by using the signing space in front of the signer. In her study, Emmorey compared native Deaf signers of ASL and native English speakers to describe the locations of geometric blocks on a grid board. Although ASL signers and English speakers did not differ in the percentage of commands that included relational directions (i.e., the relation of one block to another on the board), the manner in which they did so differed. English speakers were more likely to use lexical prepositions such as next to or to the left of than ASL signers. ASL signers were more likely to refer to a figure and ground by using classifier constructions and signer-view-dependent spatial configurations.

Past research on acquisition of ASL has not specifically examined the spatial aspects of ASL acquisition, but research has examined grammatical aspects of ASL that involve the use of space. For example, many verbs in ASL can be inflected spatially to indicate the agent and patient of a sentence. When signing, “he gave her the book” a signer inflects the verb “to give” from the space indicating “he” to the space indicating “her.” Very young children (2 years old) have been reported to use uninflected forms of the verb, and adult-like spatial inflection only appears to be complete by the age of 6 years (reported in Emmorey, 2002). Other spatial aspects of ASL acquisition also seem to present difficulties for young children. Hoffmeister (1986) found that before the age of 5 years, children often use incorrect spatial indicators for pronouns for nonpresent referents and may use the same location to refer to several actors or referents.
in discourse. These reports suggest that the complexity in the use of space as a grammatical element in ASL creates a difficulty for young children whose ability to use spatial representations may be less developed. Less attention has been focused on examining the acquisition of specific spatial relations such as above/below and left/right in ASL-learning children.

It has been shown that English-speaking children do not begin to use spatial prepositions until they have mastered basic language vocabulary, between 3 and 5 years of age. Much of the research with Deaf children examines very early emerging language; thus, little research taps later acquired language such as spatial relations. The goal of this work is to begin to understand the acquisition of constructions in ASL that refer to spatial relations. Understanding how young ASL learners develop an understanding of spatial relations in ASL has the potential to inform us about the relation between developing language and cognition. If language development does not depend on other cognitive capacities, we should see the same sequence and ages in development of spatial language for ASL learners and English-speaking children. If, on the other hand, cognition plays a role in language development, we might see that aspects of language with more cognitive demands on the learner (e.g., spatial constructions in ASL) will take longer to learn than those same constructions in a language with fewer cognitive demands (e.g., English).

Materials

Forty sets of three color picture cards each were constructed for the study. Two of the pictures depicted the same spatial relations and one picture depicted the opposite relation. For example, one set consisted of two pictures of an orange car to the left of a green car. The other picture in that set depicted an orange car to the right of a green car (see Figure 2). Each picture measured approximately 3 × 5 in. and was mounted on a 5 × 7 in. card. One set of pictures was used per trial. The 36 test trials depicted spatial relations that are typically signed from the perspective of the signer and so involve a perspective change and mental rotation in ASL (front, behind, right, left, towards, and away). We refer to these items as “rotated” constructions in ASL. Four control trials (above and below) depicted relations that do not involve a perspective change or mental rotation in ASL. We refer to these as “non-rotated” constructions in ASL. None of the relations involve mental rotation in English. Furthermore, each of the six rotated spatial relations was depicted by using three ASL classifiers (person, animal, vehicle) to determine whether some classifiers are learned earlier and therefore allow children to perform rotations earlier. Each of the rotated relations was depicted using each classifier twice; thus, six trials for each of the six relations yielded 36 test trials. The two nonrotated spatial relations were depicted by figures of shapes and each occurred twice, yielding four control trials.

Procedure

The Deaf children were tested individually at their school. The Deaf adults and all the English speakers were tested individually at a local university testing center. The children in the school were tested during school hours by a research assistant. The Deaf adults and all the English speakers were tested during a scheduled test session by the researchers. The children were tested individually in a quiet testing room with minimal distraction. The adults were tested in a quiet testing room with minimal distraction, and the English speakers were tested in a quiet testing room with minimal distraction.

Method

Participants

Twenty-three native users of ASL and 23 native English speakers participated. Of the 23 ASL users, 11 were children 9 years of age and younger (4 years 11 months to 9 years) with a mean age of 7 years 2 months (four boys and seven girls) and the remaining ASL-using participants were children over the age of 12 years and adults (seven males and five females). Of the 11 ASL-using children, 10 were deaf children attending a bilingual (ASL/English)–bicultural (hearing/deaf) day school in a large Midwestern metropolitan area and 1 was a hearing child of two Deaf parents whose first language was ASL. Children in the school used ASL as their primary medium of communication. They were also taught to read and write in English. In the older age group of ASL users, all but two participants were deaf. All the ASL users began using ASL before 6 years of age. The English-speaking children were recruited from birth announcements published in a local newspaper. The English-speaking adults were recruited through advertisements in a Midwestern university newspaper. The English speakers were selected to match the deaf participants in age and sex.
were tested in a small laboratory testing room. Each participant was tested in his/her native language by a native or fluent speaker of the participant’s language.

We used a picture selection task in which participants were presented with an English or ASL phrase and were asked to point to the picture that matched the phrase. The task worked as follows. The participant sat at a table directly across from the experimenter. At the beginning of the first trial, the experimenter placed the two pictures depicting opposite spatial relations face up, in front of the participant. The experimenter would place the third picture face down in front of herself. Then the researcher looked at her own card and told the child what her picture looked like. For the ASL-signing children the experimenter signed at eye level to indicate her own perspective. The experimenter then asked the child to identify which one of their two pictures matched the researcher’s picture. The ASL and English sentences were translational equivalents. The sentences were scripted so that all the ASL participants received exactly the same sentences in ASL and all the English speakers received exactly the same sentences in English. See Appendix A for the English sentences and Appendix B for the ASL gloss.

Results

We recorded the percentage of correct responses for each spatial relation by each participant. For each spatial relation, there were six trials, two for each classifier. Analyses by gender revealed no gender differences; thus, gender was omitted from further analysis. We conducted a 2 (age) × 2 (language) × 8 (relation) analysis of variance (ANOVA). Results showed significant main effects of language ($F = 32.8$, $p < .001$), age ($F = 9.8$, $p < .01$), and relation ($F = 14.3$, $p < .01$). We also observed a reliable interaction between language and relation ($F = 8.3$, $p < .01$). The two-way interaction between age and language approached significance ($F = 2.15$, $p < .15$). No other reliable interactions were found. The main effect of language revealed overall better comprehension of spatial relations by English speakers than by ASL users (94.2% vs. 67.0% correct). The main effect of age showed that adults in both language groups understood the spatial relations better than children (88.0% correct by adults vs. 73.1% correct by children). We discuss the main effect of relation in the context of the interaction between relation and language, which was further analyzed by post hoc tests (Tukey’s HSD, $p < .01$). Table I shows the percentage

<table>
<thead>
<tr>
<th>Relation</th>
<th>Target</th>
<th>Correct</th>
<th>Incorrect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Above: My picture shows a star above a square.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Below: My picture shows a rectangle below a diamond.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>In front: My picture shows a red motorcycle in front of a green tractor.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Behind: My picture shows a boy behind his grandmother.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Towards: My picture shows Tigger jumping towards me.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Away: My picture shows a boy walking away from me.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Left: My picture shows a woman on the left.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Right: My picture shows a boy on the right.</td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

Figure 2 Example picture sets for each relation.
of correct answers by each language group for each relation for both age groups.

For users of ASL, above and below—nonrotated relations—were best understood. This finding demonstrates that relations that do not involve a perspective change or rotation in ASL are easier to understand than relations that do involve either. In contrast, there were no significant differences in English speakers’ knowledge of any of the relations. English speakers’ performance on all the relations (none of which involve a perspective shift or mental rotation) was similar. Significantly, ASL signers and English speakers performed similarly on the relations above and below, the relations that do not need to be mentally rotated in ASL. ASL users differed reliably from English speakers in their performance on all the other relations, which involve mental rotation in ASL. Although post hoc tests on nonreliably significant results are usually not conducted, an analysis of simple effects on the marginally significant two-way interaction between age and language suggested a significant effect of age for the users of ASL ($F = 10.89$, $p < .002$) but not among the users of English ($F = 1.50$, $p = .228$). Visual inspection of Table 3 suggests that ASL knowledge of above and below, the nonrotated constructions, is similar to the knowledge that English speakers possess of all the relations, both in absolute numbers and in terms of developmental differences. However, the rotated ASL relations seem to be difficult, especially for the ASL-learning children.

Table 2 shows the number of individual participants who showed knowledge of each spatial construction. A participant was considered to have knowledge of a spatial construction or term if he or she answered correctly 83.3% (five out of six questions) on each relation. The pattern of responses from individuals corresponds to the results from the ANOVA. The numbers in Table 2 also suggest no differences among the rotated relations by younger users of ASL. Adults, however, may have more difficulty with the rotated ASL construction for away. English-speaking children also seem to have more difficulty with away (see Table 1).

One possible reason for the difficulty with away in ASL is that the signer uses himself as a reference point (by using the body as a self-classifier). This requires the addressee to use an additional reference point, as well as rotating the configuration of signs. When using spatial terms, children typically have difficulty using

<table>
<thead>
<tr>
<th>Group</th>
<th>Above</th>
<th>Below</th>
<th>Front</th>
<th>Behind</th>
<th>Left</th>
<th>Right</th>
<th>Towards</th>
<th>Away</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASL</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Children ($n = 11$)</td>
<td>10</td>
<td>9</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Adults ($n = 12$)</td>
<td>12</td>
<td>12</td>
<td>9</td>
<td>9</td>
<td>7</td>
<td>8</td>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>English</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Children ($n = 11$)</td>
<td>10</td>
<td>11</td>
<td>10</td>
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<tr>
<td>Adults ($n = 12$)</td>
<td>11</td>
<td>11</td>
<td>12</td>
<td>12</td>
<td>12</td>
<td>12</td>
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<td>12</td>
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</table>
themselves as a reference point, and this difficulty may be accentuated when the signer has to be used as a reference point. However, if this were the difficulty, we would expect ASL users to have trouble with both towards and away constructions. Yet they seem to have only difficulty with away. Because English-speaking children also had difficulty with away, the problems we report with away most likely reflect a specific problem with pictorial depictions of away relations. Pictorial depictions of towards seem to clearly indicate movement in one direction, directly toward the midline of the viewer. On the other hand, pictorial depictions of away typically depict motion away from the viewer in many different directions, directly away from the midline area at any number of angles.

Table 3 shows the number of ASL users who systematically misinterpreted the signs and consistently chose the picture that matched the opposite relation described by the experimenter (83.3% incorrect or more of the time). Visual inspection of Table 3 suggests that for most constructions, ASL users were not systematically choosing the incorrect picture. It also confirms that children learning ASL had difficulty with the rotated ASL constructions but not the constructions for above and below. However, it appears that ASL-using children only systematically chose the incorrect, opposite relation for the ASL constructions of left and away.

Our final analysis examined the use of ASL classifiers. A 2 (age) × 2 (gender) × 3 (classifier: person, animal, vehicle) ANOVA revealed a significant effect of age ($F = 4.233, p < .05$); older participants performed significantly better on all three classifier constructions. Table 4 shows the percent correct for each age group on each classifier. Again, no significant effect of gender was found. No other effects were significant; however, there was a trend toward a reliable Age × Classifier interaction ($p = .07$). Younger children showed a trend toward learning spatial relations using person and animal classifiers first. Vehicle classifiers appeared to be more difficult for younger ASL learners. But there appears to be no difference in classifiers for adult signers.

### Discussion

We began this research by asking how children learning ASL acquire spatial constructions that seem to involve a perspective shift and mental rotation. Our main finding is that children acquire an understanding of constructions that do not involve these abilities, such as above and below, easily and quickly. However, spatial constructions that are performed from the perspective of the signer and involve mental rotation, such as front, behind, towards, away, right, and left, are learned slower and appear later than the corresponding English terms. Additionally, even though the constructions are acquired later, the order in which they are acquired in some ways mirrors the order of acquisition of the corresponding spoken words for English-speaking children. Children learning English have been reported to acquire on/above and under/below earlier than they acquire front and behind, and left and right continue to be difficult for many English-speaking adults (see, e.g., Johnston, 1984). However, for users of ASL, there seems to be an even longer lag between knowledge of the spatial constructions for above and below and the other spatial relations.

<table>
<thead>
<tr>
<th>Group</th>
<th>Above</th>
<th>Below</th>
<th>Front</th>
<th>Behind</th>
<th>Left</th>
<th>Right</th>
<th>Towards</th>
<th>Away</th>
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<tbody>
<tr>
<td>ASL</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>2</td>
<td>2</td>
<td>5</td>
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<tr>
<td>Children (n = 11)</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

### Table 4

<table>
<thead>
<tr>
<th>Classifier</th>
<th>Percent correct</th>
</tr>
</thead>
<tbody>
<tr>
<td>4–9 years</td>
<td></td>
</tr>
<tr>
<td>Person</td>
<td>52.7</td>
</tr>
<tr>
<td>Animal</td>
<td>48.4</td>
</tr>
<tr>
<td>Vehicle</td>
<td>35.0</td>
</tr>
<tr>
<td>12 years to adult</td>
<td></td>
</tr>
<tr>
<td>Person</td>
<td>69.5</td>
</tr>
<tr>
<td>Animal</td>
<td>66.0</td>
</tr>
<tr>
<td>Vehicle</td>
<td>67.0</td>
</tr>
</tbody>
</table>
What could account for the longer lag we observed? Schick (2005) suggests that adding layers of complexity to grammatical structures in a language may make acquisition difficult. Perhaps the movement or physical space in ASL spatial constructions adds to their overall grammatical complexity and thus makes acquiring them more difficult. However, we must be aware that grammatical complexity by itself does not cause difficulties in acquisition. The German case system has four cases, each with three genders and singular and plural forms, requiring 24 different forms of an article for children to learn. This is clearly more complex in structure than the English system. Yet children learning German do not appear to be delayed in acquiring this complex system (MacWhinney, 1978). However, perhaps adding complexity in an extralinguistic domain such as spatial cognition may add a layer of difficulty that is not observed in the acquisition of the German case system.

Along these lines, we suggest that there are several components to ASL comprehension that may contribute to the delay. Although we did not find a statistically reliable difference between the English-speaking and the ASL-using adults in their understanding of rotated constructions, it appears that these relations are more difficult for ASL adult users. There are two possible explanations of this observation. One possibility is that adults, like children, have difficulty with perspective shifts and mental rotation. We believe this is the most like possibility, and address it after we discuss an alternative explanation.

An alternative explanation is that there are more spatial formats to choose from when using ASL. As Emmorey (2002) discusses, English speakers tend to speak from the addressee’s point of view when describing spatial layouts. ASL signers, by contrast, do not typically sign from the addressee’s point of view when describing a nonpresent environment. However, when describing the present environment, ASL signers may use what is called “shared space” to reference the objects. Rather than reversing the location of the referenced objects, signers will use the actual locations of the objects as reference points. Thus, for two signers standing face to face, an object to the right of one signer is referenced by pointing to her right. That same object for the other signer is on his left and is referenced by pointing to his left where the object is actually located, not to his right where the object is from the perspective of his addressee. Because we used pictures that were physically present in real space, one could argue that the performance of the ASL signers is due to interpreting the signs from a shared space perspective, which lead the signers to interpret the opposite relation.

There are two reasons why this is an unlikely explanation of our results. First, the results from ASL adults do not support this explanation. If adults using ASL were using shared space, they should have been consistently incorrect on the rotated constructions. Yet most ASL signers did not misinterpret the relations (see Table 5). Most adult signers correctly interpreted most of the relations. The other reason why we do not believe this was occurring is that a signer can indicate that he is signing a nonpresent environment from his own perspective by signing at eye level. The experimenter in this study indicated the signer’s own perspective by signing at eye level.

We now turn to the explanation of the ASL signer’s difficulty that we believe most likely to be correct. As we stated earlier, correctly interpreting spatial relations involves a 180° mental rotation. Such mental rotation skills are difficult for young children to acquire. Studies on the development of mental rotation in young children have shown clear developmental patterns (Halpern, 1992). Emmorey (2002) argues that children learning ASL “must become proficient in spatial memory” in order to understand and correctly produce ASL. However, research on spatial memory has revealed weak developmental effects. Some studies show little difference in spatial memory between 5-year-olds and adults (Schneider & Pressley, 1997). Thus, it may well be that mental rotation rather than spatial memory plays a large and essential role in the acquisition of ASL in young Deaf children.

However, it is also possible that the difficulties with ASL spatial constructions reflect more general difficulties with perspective shifts, which would include difficulties with visual changes in perspective as well as other kinds of perspective shifts. Children and adults have been shown to have difficulty in many different kinds of tasks that require a perspective shift, not just visual tasks. There are numerous reports of “false consensus” effects in adults. For example, if an
adult Democrat is asked to estimate the number of Democrats in a room, she/he will state that most people in the room are Democrats. If a Republican is asked the same question, she/he will state that most people in the room are Republicans. In these cases, it is not one’s visual perspective that is overestimated but one’s political values. Perhaps the difficulty with rotated ASL spatial constructions reflects general difficulties with perspective shifts.

The use of classifiers may also play a role in children’s understanding of spatial relations in ASL. It appears that children understand the relations that involve the use of person classifiers before animal and vehicle classifiers. It is not readily apparent why this should be so. All three classifiers have an inherent front and back indicating the fronts and backs of the objects. Thus, it does not appear to be more difficult for a child to understand a classifier with an inherent front and back. More research using classifiers that refer to objects without inherent fronts and backs is needed. One possibility is that references to people are more common in everyday speech, especially in the language used by children (Wetman & Hauss, 1969). Thus, children using ASL may have more opportunities to receive feedback about their use and understanding of spatial constructions involving person classifiers than for other objects. Alternatively, it could be that children’s conceptions of persons, animals, and vehicles play a role in their understanding of the use of classifiers, in general, and is not limited to spatial relations. Clearly, more research is needed in children’s development of understanding classifiers to confirm and explore this result.

Our findings may also have important implications for ASL educators. Instructors of ASL often note the difficulty of teaching spatial relations to hearing adult learners. A task similar to the one we used may give ASL students a sense of their competence in interpreting rotated ASL spatial constructions or may be used as practice exercises. Because of the difficulty in acquiring the mental skills needed for ASL, it is important that children are exposed to it early. Furthermore, understanding how normative ASL acquisition progresses is an important step in determining which children may benefit from interventions, what types of interventions are needed, and when in a child’s development they might be most useful. Young children may not benefit from explicit instruction in interpreting rotated signs because they may not yet have the requisite perspective-taking and mental rotation skills. Instead, young children’s sign language development may benefit from practice with mental rotation and general perspective-taking skills.

In sum, it appears that the mental skills required for the acquisition of spatial constructions in ASL initially delay their acquisition. On the other hand, studies with Deaf adults suggest that the use of ASL spatial constructions may later boost some of these mental abilities (Emmorey & Kosslyn, 1996). It appears then that although Deaf children may acquire an understanding of rotated constructions later than English-speaking children acquire the lexical terms for spatial relations, there may be a point in development where these mental abilities that are necessary in ASL, although difficult for young children, become more efficient in older ASL users.

Supplementary Material

Supplementary material is available at http://jdsde.oxfordjournals.org/.

Appendix A  The English sentences that were used on each trial. Each description is introduced with the phrase “My picture shows ...”

<table>
<thead>
<tr>
<th>Relation</th>
<th>English sentence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Above</td>
<td>the square above the star</td>
</tr>
<tr>
<td></td>
<td>the circle above the triangle</td>
</tr>
<tr>
<td>Below</td>
<td>the circle below the star</td>
</tr>
<tr>
<td></td>
<td>the rectangle below the diamond</td>
</tr>
<tr>
<td>In front</td>
<td>the red motorcycle in front of the green tractor</td>
</tr>
<tr>
<td></td>
<td>the red car in front of the blue car</td>
</tr>
<tr>
<td></td>
<td>the black horse in front of the brown horse</td>
</tr>
<tr>
<td></td>
<td>the spider in front of the worm</td>
</tr>
<tr>
<td></td>
<td>the baby in front of the mom</td>
</tr>
<tr>
<td></td>
<td>the girl in front of the boys</td>
</tr>
<tr>
<td>Behind</td>
<td>the red tractor behind the blue motorcycle</td>
</tr>
<tr>
<td></td>
<td>the yellow car behind the pink car</td>
</tr>
<tr>
<td></td>
<td>the yellow duck behind the brown duck</td>
</tr>
<tr>
<td></td>
<td>the girl in the green dress behind the girl in the orange dress</td>
</tr>
<tr>
<td></td>
<td>the boy behind the grandmother</td>
</tr>
</tbody>
</table>
Appendix B Glosses for ASL sentences

Gloss Legend

- Capitalized words indicate translational equivalents (e.g., STAR).
- Small font indicates essential hand location or palm orientation for forthcoming word (e.g., point to location low in signing space).
- Words in single quotation indicate movement pattern of preceding sign (e.g., ‘rectangle’).
- Italicized letters indicate which hand is signing (e.g., lt).
- 3/CL indicates vehicle classifier.
- V:-CL indicates animal classifier.


ABOVE

The square is above the star.
Point to location low in signing space STAR, point to location high in signing space outline-CL ‘square’

The circle is above the triangle.
Point to location low in signing space (2h) outline-CL ‘triangle’, point to location high in signing space outline-CL ‘circle’

BELOW

The circle is below the star.
Point to location high in signing space STAR, point to location low in signing space outline-CL ‘circle’
The rectangle is below the diamond.
Point to location high in signing space outline-CL ‘diamond’, point to location low in signing space outline-CL ‘rectangle’

AWAY

The horse is walking away from me.
HORSE (2h)V:-CL ‘animal moving away from body’
The deer is bounding away from me.
DEER (2h) V:-CL ‘animal moving away from body’
The boy is going away from me.
BOY 1-CL ‘person moving away from front of body’
The boy is going away from me.
BOY 1-CL ‘person moving away from front of body’
The car is going away from me.
CAR 3/CL ‘vehicle going away to front’
The boat is going away from me.
BOAT 3/CL ‘vehicle going away from front’

BEHIND

The yellow duck is behind the brown duck.
DUCK BROWN V:-CL palm out, DUCK YELLOW V:-CL palm out, hand closer to body
The baby giraffe is behind the mother giraffe.
MOTHER GIRAFFE V:-CL palm out, BABY GIRAFFE V:-CL palm out, hand closer to body
The girl in the green dress is behind the girl in the orange dress.
GIRL ORANGE DRESS 1-CL palm in, hand close to body, GIRL GREEN DRESS 1-CL palm in, hand farther from body
The boy is behind the grandmother.
GRANDMOTHER 1-CL palm in, close to body, BOY 1-CL palm in, hand farther from body

The yellow car is behind the pink car.
rt CAR PINK 3→CL palm in, hand close to body,
rt CAR YELLOW 3→CL palm in, hand farther from body

The red tractor is behind the blue motorcycle.
lt MOTORCYCLE BLUE 3→CL palm in, hand close to body, lt TRACTOR RED 3→CL palm in, hand farther from body

FRONT

The baby is in front of the mother.
MOTHER 1-CL palm in, hand far from body, BABY V:-CL palm in, hand close to body

The girl is in front of the boys.
BOYS 2 2-CL palm in, hand far from body, GIRL 1-CL palm in, hand close to body

The black horse is in front of the brown horse.
HORSE BROWN rtV:-CL palm out, hand farther from body, HORSE BLACK lt V:-CL palm out, hand close to body

The spider is in front of the worm.
WORM rt 1:-CL palm out, hand close to body, SPIDER lt 2:-CL palm out, hand farther from body

The red motorcycle is in front of the green tractor.
CAR GREEN rt 3→CL palm in, hand far from body,
MOTORCYCLE RED rt 3→CL palm in, hand close to body

The red car is in front of the blue car.
CAR BLUE 3→CL palm in, hand far from body, CAR RED 3→CL palm in, hand close to body

LEFT

The gray cat is on the left of the yellow cat.
CAT YELLOW rt V:-CL palm facing left, CAT GRAY lt V:-CL palm facing right

The black dog is to the left of the gray dog.
DOG GRAY rt V:-CL palm facing in, DOG BLACK lt V:-CL palm facing in

The doctor is to the left of the nurse.
NURSE rt 1-CL palm facing left, DOCTOR lt 1-CL palm facing right

The girl is to the left of the boy.

BOY rt 1-CL palm facing in, GIRL lt 1-CL palm facing in

The blue car is on the left of the black car.
CAR BLACK rt 3→CL palm facing left, CAR BLUE lt 3→CL palm facing right

The yellow boat is to the left of the orange boat.
BOAT ORANGE rt V:-CL palm facing left, BOAT YELLOW lt V:-CL palm facing right

RIGHT

The cat is to the right of the dog.
DOG lt V:-CL palm facing right, CAT rt V:-CL palm facing left

The turtle is to the right of the bug.
BUG lt V:-CL palm facing right, TURTLE rt V:-CL palm facing left

The boy is to the right of the girl.
GIRL lt 1-CL palm facing right, BOY rt 1-CL palm facing left

The boy is to the right of the two girls.
GIRLS TWO lt 2-CL palm facing in, rt BOY 1-CL palm facing in

The pink plane is to the right of the green plane.
AIRPLANE GREEN lt 3→CL, PLANE PINK rt 3→CL

The yellow car is on the right of the pink car.
CAR PINK lt 3→CL, CAR YELLOW rt 3→CL

TOWARDS

Tigger is jumping towards me.
TIGER T-I-G-G-E-R V:-CL ‘bounding toward body’
The frog is jumping towards me.
FROG V:CL ‘bounding toward body’
The boy is walking towards me.
BOY 1-CL ‘person coming towards from front’
The boy is walking towards me.
BOY 1-CL ‘person coming towards from front’
The car is coming towards me.
CAR 3→CL ‘vehicle coming towards from front’
The boat is coming towards me.
BOAT 3→CL ‘vehicle coming towards from front’
References


Received December 11, 2005; revisions received May 25, 2006; accepted May 25, 2006.