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Language impairments in sign language: breakthroughs and puzzles

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Abstract

Background: Specific language impairment has previously solely been documented for children acquiring spoken languages, despite informal reports of deaf children with possible sign language disorder. The paper reports the case of a deaf child exposed to British Sign Language (BSL) from birth, who has significant developmental deficits in the comprehension and production of BSL grammar based on formal assessment and linguistic analyses of his sign communication in comparison with age-matched unimpaired signers.
Results: It is shown that linguistic difficulties with BSL verb morphology underlie the child's poor performance compared with same-age native signers.
Conclusions: The appearance of linguistic impairments in sign and spoken languages in comparable domains supports cross-linguistic and modality free theories of specific language impairment.

Keywords: British Sign Language, Development, Disorder.

What this paper adds

Much research has documented the spoken language of children diagnosed as having specific language impairment.

It is now known that specific language impairment can and does exist in deaf signers suggesting language disorder goes beyond the disruption of speech perception.

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Introduction

Specific language impairment (SLI) is diagnosed where a deficit in normal spoken language acquisition is found with no apparent cognitive, social or neurological cause (Leonard 1998). Children with SLI typically have difficulty with the acquisition of phonology and morpho-syntax. Since hearing loss is specifically excluded in diagnosing SLI, deaf children are never included in studies of SLI. However, if the incidence of SLI is the same in children who are born deaf (or are the hearing offspring of deaf signing parents) as in the general population, then at least 5–7% of children learning sign language are likely to have SLI (Leonard 1998).

There has been little consideration of whether a child exposed to sign language could have SLI (Morgan 2005). However, with increased knowledge about sign language acquisition and the differences between sign language, gesture, and artificial sign based communication systems including recent work on sign language assessment (Herman *et al.* 1999, 2004), we are now in a better position to consider the question of whether sign language SLI does indeed exist.

Nature of specific language impairment (SLI)

All theories of SLI attempt to explain the disproportionate difficulty with phonology, syntax and grammar found in SLI but differ in whether they posit a deficit at the level of general cognitive processing or the child's understanding of the language rules of phonology and grammar.

The processing deficit accounts include problems with underlying low-level auditory processing. In this view, children with SLI have difficulty processing the temporal characteristics of rapidly changing acoustic signals (at around 60 ms) of any sort, including speech and non-verbal auditory signals. This difficulty leads to unstable representations of speech sounds and so interferes with encoding and producing speech (Tallal 2000, but see Bishop *et al.* 1999). This theory would exclude the possibility of language impairment in a child exposed to a sign (non-auditory) language. A second auditory based explanation focuses on a reduced ability to store information in a separate cognitive system that deals with phonological short term memory (Gathercole and Baddeley 1990). A poor phonological memory will constrain the development of speech, which depends heavily on phonological storage capacity.

Other processing accounts can encompass sign language impairments (e.g. Kail 1994, Leonard 1998). Leonard makes a distinction between salient and non-salient morphemes where children with SLI are predicted to have difficulties with non-salient ones. Because this approach is cross-linguistic it can be applied to both spoken and sign languages. Saliency in spoken language is defined in each spoken language differently (e.g. Dromi *et al.* 1999). Limited processing capacity affects those morphological targets that involve several co-occurring underlying operations. According to Kail's (1994) 'Generalized Slowing Hypothesis', children with SLI process linguistic and non-linguistic input at a slower rate than typically developing children, and this affects the acquisition process. In considering different competing theories most SLI researchers acknowledge that because SLI is a heterogeneous disorder no one account could claim to explain all cases of language disorder.

Sign language overview

Grammar

Because signing is about 1.5 times slower than speaking, grammatical devices are often articulated across both hands and the face simultaneously, rather than in a linear sequence of words (Emmorey 2002). The main linguistic devices we discuss here are: agreement, pluralization and classifiers. Grammatical markers of agreement appear on a discreet set of verbs in the lexicon that move between indexed locations in space. Agreement (co-location) links pronouns and noun phrases to their dependent referents and verb arguments, thereby indicating who did what to whom (Sutton-Spence and Woll 1999). In British Sign Language (BSL), plurals can be morphologically marked (through classifiers — see below) as well as lexical e.g. MAN TWO or BOOK MANY.

Sign languages also exploit polymorphemic structures that resemble noun classifiers in spoken language. Classifiers (CL) represent classes of nouns (e.g. flat entities, humans, animals, stick-like entities, etc.) In the sentence shown in figure 1, the handshape on the signer's right hand represents the class of 'flat entities' to which the noun 'car' belongs; the left hand CL encodes the class of 'curved entities' (the bridge) and its location. The movement of the right hand encodes the start location and path of the verb. This construction is glossed:

> Right hand: CL (car)-MOVE-UNDER-IN-STRAIGHT-LINE
> Left hand: CL (bridge)
> 'the car goes under the bridge'.

The verb contains 5 morphemes: the two entities, the starting location, 'under' and the path 'straight-line'. BSL exhibits non-concatenative morphology. Signs are made up of several morphemes but the morphemes are not arranged in joined linear sequences like English or Spanish but instead spread through the word as in Hebrew. The handshape that encodes the figure 'car' appears throughout the contraction rather than only in one fixed position within the utterance (for more details, see Morgan *et al.* 2006).

Figure 1. 'The car goes under the bridge.'

Acquisition

Infants exposed to sign language from birth babble with their hands at the same age as vocal babble emerges (6–12 months). The first ten signs are produced around 12 months of age, and the 50 sign milestone is recorded from 24 months onward. Children combine signs from 18 to 24 months, initially using uninflected noun and verb forms. Following the two-sign stage, children begin to produce more complex aspects of sign language grammar: articulating the location and movement of signs in space to express linguistic relations, marking plurals and using a rich set of morphological markers (e.g. Morgan *et al.* 2006). By age 5;0–6;0 children can select the appropriate handshapes for different classes of objects and start to distinguish the beginning and end locations of actions in verbs of motion and location.

Atypical development of BSL

The study of sign language impairments must be placed in the context of late first language learning. The deaf offspring of hearing parents represent the vast majority of the signing community (around 90–95%). Within this group there is variation in terms of age of exposure to BSL and the quality and quantity of BSL input compared with native signers. Care is needed to distinguish language delay as a result of late exposure to sign language from atypical development stemming from language disorder.

To date there have been no published reports of abnormal sign language development comparable with spoken language SLI in otherwise cognitively normal deaf children. In this paper we describe assessment of a deaf child exposed to fluent adult models of BSL from birth. He has normal general cognitive abilities but very restricted BSL grammar. Any deficiencies in his signing could therefore be attributed to a developmental language disorder and not environmental factors that are related to the nature of input.

Methods

Participant

Paul is a deaf male aged 5;2, born with a profound bilateral sensori-neural hearing loss. Both of his parents are deaf, first generation signers and have communicated in BSL with Paul from birth. Paul attended a mainstream school with sign language support and more recently a bilingual BSL-English school with full access to the curriculum through BSL. He was referred for assessment by the school because of worries about his BSL development. The Snijders–Oomen non-verbal intelligence test at 5;0 revealed no cognitive impairments (Snijders *et al.* 1989). He thus represents a unique case in which language delay cannot be explained by cognitive impairments or poor access to sign.

Language

An initial language assessment was carried out using video recordings of Paul interacting in BSL with his parents, teachers and speech and language therapist.

These were supplemented by further observations and structured BSL assessments carried out at home and at school by a deaf native BSL user.

Receptive language

We assessed Paul's receptive vocabulary using a non-standardized BSL version of the BPVS (Dunn *et al.* 1982). Paul's receptive BSL vocabulary was normal for his age. Norms were based on scores collected from groups of normally developing signing children. In studies of spoken language SLI, most children have poor expressive vocabulary while some have relatively better receptive vocabulary (e.g. Rice 2000). However, normal vocabulary development is not a characteristic of SLI in spoken language.

Analyses of spontaneous interaction revealed that Paul had difficulties in understanding complex signing. We evaluated receptive grammar using the BSL Receptive Skills Test (Herman *et al.* 1999), a test standardized on children aged 3–11 years. Paul scored −1.3 standard deviations below the mean, approaching the standard for a language disorder (typically>1.5 SD below the mean). In addition, his performance was atypical, with success on some difficult items, and failure on many easier ones. His performance could *not* be characterized as a slower learner as by failing early items and passing more difficult ones his performance appeared random rather than like a younger child.

This atypical signing for his age was very obvious in his everyday signing. In spontaneous interaction, Paul used exaggerated gestures and facial expressions to compensate for his poor linguistic competence, so his impairments were less noticeable. He often used pointing to pictures, his self and others to avoid proper sentence structures and more affective facial expression rather than using the face in coordination with the hands to mark questions, negations or manner modifications with verbs. Because signing and gesturing are produced in the same modality and look superficially similar it is possible that difficulties in expressing ideas through grammatical means can be circumvented through elaborate gestures. This compensation relies on more work from his conversation partner in figuring out what the non-specific gestures refer to, however it can with practice become an efficient way of communicating (cf. extended gesture used by some adults with aphasia; Cocks *et al.* 2006).

The test because it cannot be solved through gesture alone pinpointed specific areas of difficulty within BSL grammar. Paul's area of strength was in lexical plurals; his weaknesses were in grammatical constructions used to encode negation, noun–verb distinctions, spatial verbs and classifiers, all linguistic forms which encode meanings through morpho-syntactic rules. In contrast to morphologically simple lexical items, the latter set of devices rely on the use of polymorphemic signs. BSL verbs of this type are made up of several morphemes packaged together in overlapping or non-concatenative patterns. Importantly, verb morphology emerges and is acquired at least 12 months earlier in typically developing children (3–4 years), compared with Paul. Classifier constructions are comprehended by children from 3 years (Herman *et al.* 1999).

Expressive language

Paul's expressive BSL was assessed through the initial video samples described above, additional interaction with his mother, picture description tasks and the BSL

Production Test (Herman *et al.* 2004). The latter is an analysis of BSL grammar and story structure based on an elicited narrative.

Analysis of the initial sample revealed that Paul's expressive BSL was restricted to small sentences made up of one or two signs with very limited grammar. Despite this, Paul clearly enjoyed communicating and provided a range of appropriate affective (but non-linguistic) facial expressions and gestures.

Paul's performance on the BSL Production Test was at the 25th centile for all criteria (grammar and story structure elements). When we separated the grammar and story structure scores (introducing the characters, building up to a climax, providing a story coda etc.) he scored significantly higher in these elements (22/34=65%) than in his BSL grammar (9/30=30%). Thus his low score on this test was in fact worse than it appeared due to his more preserved ability in structuring information. Consideration of just the grammatical aspects of the test was more strikingly impaired. He mostly produced a series of single signs with few grammatical inflections. At times he produced gestures in direct imitation of actions performed on the video. As with the receptive test, he demonstrated knowledge of lexical plurals. Below are examples of Paul's descriptions from the picture tasks to an adult Deaf native signer, compared with similar age typically developing deaf children.

Target picture: a dog in a box.
Paul: DOG whole body gesture with hands on the head (top of box)
Adult: DOG WHERE?
P: whole body gesture to show looking up
A: PICTURE WHAT?
P: BOX
A: AND?
C: DOG
A: DOG WHERE?
P: looks away and changes topic

Typically developing native signer aged 4;6
C: POINT (picture) CL-(cube)-CL-(small animal)-SIT-IN-BOX
English Translation: 'there, the dog is in the box'

Target picture: a man giving a boy a letter.
Paul: GIVE GIVE SQUARE GIVE (citation forms)
A: SQUARE GIVE WHO?
C: GIVE GIVE POINT (picture) LETTER
A: PICTURE WHAT?
C: LETTER POINT

Typically developing native signer aged 4;6
C: MAN LETTER GIVE-3rd person agreement
English Translation: 'the man gives the letter to (him/her)'

Since disordered phonology often accompanies spoken language SLI, an adult Deaf native signer assessed the phonological well-formedness of Paul's signs from video. Some signs were produced with immature handshapes but overall phonology was judged to be age appropriate.

Finally, Paul's expressive signing was plotted onto the BSL scales of the Common Monitoring Protocol (DfES 2004), indicating an approximate level of

functioning for a normally developing native signing child of 24–30 months of age, i.e. a delay of 2 years and more which by all criteria implies SLI.

Discussion

Paul's signing deficit cannot be explained by late access to BSL as his parents are deaf and have used BSL with their child from birth. Our analyses revealed a significant delay in both comprehension and production of certain BSL grammatical constructions, but with normal phonology and receptive vocabulary. We are still investigating how the range of different sub-types of developmental language disorder reported in hearing children will manifest in deaf children exposed to sign, however this case does suggest some reconsideration of the major tenets of current theories of SLI based in auditory deficits.

While Tallal (2000) and Gathercole and Baddeley (1990) are auditory based theories of SLI and have been developed and tested in exclusively auditory presentation both theories locate the SLI deficit at the phonological level, which can be accessed by other input modalities. The underlying argument in the auditory deficit explanation of spoken language SLI (Tallal 2000) is that language-impaired children cannot efficiently process rapid temporal changes in the signal. If we substitute speech for a rapid 'verbal' signal perhaps a rapid processing deficit will explain sign language impairments. Sign language, however as a result of the use of larger and slower articulators (hands and arms) as compared with the tongue, lips, etc, has much slower temporal resolution than spoken language, with the speed of phonological contrasts about 1.5 times as slow in sign. Thus, difficulties with rapid temporal processing of the signal are unlikely to be problematic in BSL and so not a core feature of SLI in general (unless the focus is only on hearing children).

The speech based working memory account of SLI argues that poor representations of phonemes through limited phonological memory capabilities cascade down through to later problems with difficulty with grammar and morphology (Adams and Gathercole 2000). This theory locates the SLI deficit at the phonological level and could explain language difficulties in other input modalities. It is known that phonological memory for sign language uses spatial arrays rather than sequences of linearly ordered phonemes (cf. Emmorey and Wilson 2005). One difficulty with accounting for Paul's profile would be that a deficit in phonological memory causing poor representation of phonemes would lead to comparable poor phonological production problems. Our assessments suggest that his phonology and indeed vocabulary are within normal limits. This is the first case of SLI in sign to be reported and while he appears to have no problems with phonology if this were the general finding in all cases of sign language impairments, then a theory whose core SLI problem resides in phonological memory will need to be revised to account for this.

The modality difference in signal speed may mean that SLI in signing children will be restricted to problems with linguistic structures beyond the phonological and lexical level. This captures some of the features of Paul's language, specifically the dissociation between good phonology/lexicon and impaired grammar. Paul's greatest areas of difficulty were with polymorphemic constructions such as agreement morphology and the classifier system. While these constructions emerge gradually in typical development, Paul, at age 5, should have been accurately understanding and producing many of them.

Modality free theories of SLI are more able to account for Paul's impairment and findings from BSL provide additional support for these positions. His performance may be compared with SLI studies in a number of different spoken languages where non-salient grammatical inflections (e.g. words endings) and structures involving dependency relations (e.g. pronominal binding) have been highlighted as particularly difficult (e.g. Leonard 1998, Dromi *et al.* 1999, Van der Lely 2005). These approaches to SLI take a strong cross-linguistic perspective where impairments are tracked across different languages within one linguistic domain. Dromi *et al.* (1999) discussed the idea that the limited processing capacity in children with SLI, affects those morphological targets that involve several co-occurring underlying operations. The candidate linguistic constructions in BSL for complex operations are those involving polymorphemic verbs (both agreement and classifier type). Classifiers in BSL involve both morphological and syntactic abilities. Within the verb several morphemes need to be brought together and packaged in a simultaneous manner additionally this is not linearly ordered but instead spread throughout the verb construction. A difficulty in separating out and analysing non-discreet or non-salient morphemes would cause a specific difficulty with using and comprehending classifier constructions in BSL. Equally the agreement system in BSL is based on the non-concatenative arrangement of morphemes in the inflected verb.

Conclusions

The present data, while preliminary, support modality-free notions of language impairment. Further research on signing children can help us further define what are the core features of SLI and not only the acquisition of one type of language. Ongoing research is documenting sub-types of sign language impairments comparable with those already identified in the spoken language disorder literature. Therapists working with deaf clients should be aware that deaf children with language delay may have an intrinsic language impairment rather than a problem arising from limited language exposure to sign or speech.

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