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Identifying specific language impairment in deaf children acquiring British Sign Language: Implications for theory and practice

Kathryn Mason[1,2]*, Katherine Rowley[1,2], Chloe R. Marshall[1], Joanna R. Atkinson[2], Rosalind Herman[1], Bencie Woll[2] and Gary Morgan[1,2]
[1]Language and Communication Science, City University London, UK
[2]Deafness, Cognition and Language Research Centre, University College London, UK

This paper presents the first ever group study of specific language impairment (SLI) in users of sign language. A group of 50 children were referred to the study by teachers and speech and language therapists. Individuals who fitted pre-determined criteria for SLI were then systematically assessed. Here, we describe in detail the performance of 13 signing deaf children aged 5–14 years on normed tests of British Sign Language (BSL) sentence comprehension, repetition of nonsense signs, expressive grammar and narrative skills, alongside tests of non-verbal intelligence and fine motor control. Results show these children to have a significant language delay compared to their peers matched for age and language experience. This impaired development cannot be explained by poor exposure to BSL, or by lower general cognitive, social, or motor abilities. As is the case for SLI in spoken languages, we find heterogeneity within the group in terms of which aspects of language are affected and the severity of the impairment. We discuss the implications of the existence of language impairments in a sign language for theories of SLI and clinical practice.

In the general population, approximately 7% of children have a marked impairment in acquiring language compared to their peers, and are diagnosed with specific language impairment (SLI; Tomblin *et al.*, 1997). This developmental disorder is specific to language and is not part of a more general cognitive impairment. The SLI population is extremely heterogeneous, with considerable variation in both the severity and the linguistic pattern of impairment. Deficits have been diagnosed in syntax, morphology, phonology, the lexicon and pragmatics, and in receptive and productive language. There is widespread disagreement as to the underlying cause of SLI (for a review, see Leonard, 1998).

**Correspondence should be addressed to Kathryn Mason, Language and Communication Science, City University London, Northampton Square, London EC1V 0HB, UK (e-mail: kathryn.mason.1@city.ac.uk).*

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A diagnosis of SLI is given if a language learning impairment exists despite normal non-verbal IQ (NVIQ), neurological function, motor development, social interaction, no impairments in facial–oral structure and function, and normal hearing (Leonard, 1998). The requirement for normal hearing means that profoundly deaf children are excluded from a diagnosis of SLI by default. Yet given that 7% of the general hearing child population have SLI, this would also be expected to be the case for deaf children, including those whose primary mode of communication is a sign language.

There have been very few previous studies of deaf signing children with developmental language impairments. Morgan (2005) described impairments in both English and British Sign Language (BSL) in a hearing bilingual child with deaf parents and native exposure to both languages. Morgan, Herman, and Woll (2007) documented a similar case of a deaf child with deaf signing parents who at the age of 5.2 years performed very poorly on standardized measurements of BSL comprehension (Herman, Holmes, & Woll, 1999) and production (Herman *et al.*, 2004). His signing was comparable to a child of 2–2.6 years despite having been exposed to fluent sign language models from birth. Morgan *et al.*'s. (2007) case study raised several questions: (1) Can SLI be reliably identified in a group of sign language users? (2) What are the demographic variables for this group? and (3) What are the linguistic characteristics of SLI in BSL? Our study represents the first attempt to answer these questions.

Typical acquisition of sign language in deaf children

Children who are exposed to sign languages from early childhood show remarkable parallels in onset, rate, and patterns of development compared to children learning spoken languages (see Chamberlain, Morford, & Mayberry, 2000; Morgan & Woll, 2002; Schick, Marschark, & Spencer, 2005, for reviews). Infants exposed to sign language from birth produce manual babbling at the same age as vocal babble emerges (Petitto *et al.*, 2001). The first 10 signs are produced around 12 months of age, and the 50 sign milestone is recorded from 20 months onward (Mayberry & Squires, 2006). Children combine signs from 18 to 24 months, initially using uninflected noun and verb forms (Morgan, Barriere, & Woll, 2006; Newport & Meier, 1985). 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, Herman, Barriere, & Woll, 2008).

Moving the hands, arms, body, and face during signing is more effortful than the small articulators required for speaking. This means that the articulation of individual signs is about 1.5 times slower than for words (Emmorey, 2002). However, propositional rate is identical in sign and spoken language, as signers distribute grammatical devices across both hands and the face simultaneously, rather than in a linear sequence of words as in spoken language.

One way in which sign languages appear very different to spoken languages is that they exploit physical space for grammatical purposes. For example, grammatical markers of agreement appear on a discrete 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 (see Sutton-Spence & Woll, 1999).

Sign languages also exploit polymorphemic structures that arguably resemble noun classifiers in spoken language (Emmorey, 2003; Morgan & Woll, 2007). Entity classifiers represent classes of nouns (e.g. flat entities, humans, animals, stick-like entities, etc.). Entity classifiers are essential components of spatial verbs (verbs of location and motion). The handshape encodes the figure and appears throughout the construction rather than only in one fixed position within the utterance (for more details, see Sutton-Spence & Woll, 1999).

Despite differences between spoken and signed languages that are due to their modality, research with deaf adults has examined the neural underpinnings of sign language knowledge and has found remarkable overlap in how linguistic structures (including phonology and syntax) are processed in the two modalities (see MacSweeney, Capek, Campbell, & Woll, 2009).

Language impairment versus language delay

Every year around 840 children in the UK are born with moderate to profound deafness (www.rnid.org). Deafness has serious consequences for literacy, educational achievement, social-emotional development, and ultimately employment (Marschark, 2007). School provision for deaf children in the UK is varied and depends on local authorities rather than a national standard. Deaf children can be educated with other deaf children in a unit or specialist deaf school, or in a mainstream hearing school with different levels of support. The language addressed to deaf children is therefore mixed, and can comprise the bilingual use of BSL and English, the use of key lexical signs alongside spoken English sentences (Sign Supported English, SSE), or the use of spoken English only.

Over 90% of deaf children are born to hearing parents who have no prior experience of sign language (Mitchell & Karchmer, 2004). Therefore, many parents do not know sign language prior to their child's birth and cannot provide fluent sign language input to their children. It is the case that most deaf children are non-native signers but do go on to be fluent users of the language. Differences between native and non-native signers are subtle and appear under tasks designed to provide linguistic and cognitive burdens (Mayberry & Eichen, 1991). In addition, the deaf population used to provide the norms for sign language assessments is made up of both native and non-native signers who have learnt to sign in early childhood.[1]

Deaf children may be exposed to fluent models of sign language outside of the family, for example, if they attend nurseries where they are exposed to signing. However, for some children, the first contact with signing will be when they attend school at age 4 onwards, meaning that their language could already be delayed by this point. This makes investigating the causes of language impairment in signing deaf children more complex (particularly for those from non-native signing backgrounds), due to the fact that poor language skills may be explained by sign language being offered late (often only after failure with spoken English) and exposure to poor models of sign language, as most parents and teachers are non-native signers.

For these reasons, in the current study, we focus on deaf children whose teachers and/or parents have expressed concern for their sign language development when they are compared with deaf children in the same school who have had the same

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[1] *For example, the norms for the BSL receptive skills test (Herman* et al.*, 1999) came from a mixed population of signers. There were 135 children tested with 78 from deaf families and 57 non-native signers from hearing families.*

exposure to sign language over the same periods. The children referred to our study were identified as having language learning problems compared with other typical deaf children (not native signers). Since these children have been exposed to good sign language models at school and socially after school, but are failing to develop BSL at a rate equivalent to their deaf peer group, they present as clearer candidates for a diagnosis of SLI.

Theories of the underlying cause of SLI

Several theories have been proposed to account for SLI in hearing children, but there is little consensus as to which provides the best empirical coverage. The existence of SLI in signed languages could potentially shed light on this debate. Theories of SLI can be roughly divided into those that propose an underlying sensory processing deficit (e.g. Tallal, 2003) and those that propose a cognitive deficit. Those that argue for a deficit in cognition differ over whether the deficit is domain-general, i.e. in the speed of general cognitive processing (e.g. Kail, 1994), or domain specific, either in the working memory systems that directly support language acquisition (e.g. Gathercole & Baddeley, 1990) or within the linguistic system itself (e.g. van der Lely, 2005).

The oldest theory of SLI is the rapid auditory processing deficit hypothesis (Tallal, 2003; Tallal & Piercy, 1973). This hypothesis claims that the language deficit in SLI stems from difficulties in processing the rapid temporal changes that characterize speech. This deficit impacts most severely on the processing of acoustically non-salient material, such as inflections and function words, which in spoken English are often short in duration and unstressed. However, even though group effects are reported for many studies of auditory perception, generally only a minority of children in the SLI group contribute to those effects (see discussion in Rosen, 2003). As it stands, the rapid auditory processing deficit hypothesis is a speech-based hypothesis and does not predict the existence of SLI in children exposed to sign languages.

The generalized slow processing hypothesis argues that children with SLI are slower to process information than are typically developing children across all cognitive domains, not just language (Kail, 1994). This theory is not specific to the modality of speech, but could be adapted to account for SLI in sign languages too.

Two theories of SLI that have received increasing attention in recent years are domain-specific rather than general in nature. The limited phonological working memory hypothesis (Gathercole & Baddeley, 1990) was proposed in order to account for robust findings that children with SLI have great difficulty in repeating non-words, particularly those of four syllables or longer. The hypothesis claims that children with SLI have reduced working memory capacity, and are prevented from storing a large amount of phonological information during novel word learning. This in turn leads to difficulty in forming robust representations in the lexicon and so affects the understanding of language. Limited phonological working memory also impedes the processing of novel and complex syntactic structures. The current form of this hypothesis is not limited to spoken languages, because sign languages also have phonological structure: every sign can be broken down into a set of phonological parameters (handshape, movement, and location) that are meaningless in isolation. Signers store the phonological properties of signs and access these properties during lexical retrieval and production. Consequently, sign language processing recruits phonological working memory (Emmorey, 2002).

Sign languages offer an exciting possible extension to the limited phonological working memory hypothesis because they make use of visuospatial working memory for phonological purposes that spoken languages, by their very nature, do not. Some studies have shown that hearing children with SLI learning a spoken language have an impairment in visuospatial working memory (e.g. Bavin, Wilson, Maruff, & Sleeman, 2005), but it is not clear whether or how this affects their language development.

Several hypotheses propose that the deficit in SLI is within the language system itself rather than in the cognitive processes, such as working memory, that support language acquisition (e.g. the computational grammatical complexity hypothesis, van der Lely, 2005). Trying to tease apart whether SLI is caused by a specific linguistic deficit or a phonological working memory deficit is difficult because the two models make very similar predictions as to which aspects of language will be the most difficult to process and acquire: structures that are linguistically more complex also place more working memory demands on language processing. For sign languages, we predict these would include morphologically complex clause structures involving verb agreement and classifier constructions. Just as cross-linguistic research on SLI in spoken languages has provided valuable evidence for understanding the disorder (Leonard, 2009), so the characterization of SLI in sign languages promises to open a new window on to the debate over the underlying deficits causing SLI.

The study

The present study was based on research carried out in two phases. Phase 1 involved the creation and distribution to schools of a screening questionnaire designed to identify deaf children with possible impairments in BSL. Teachers and speech and language therapists (SLTs) working with deaf children were asked to identify children about whose BSL abilities they expressed concern compared with other deaf children in their school, and to provide background information and describe particular areas of difficulty in using BSL. Cases that did not fit our inclusion criteria for SLI (see below) were excluded. Once we had a group of children who were potentially language impaired, we carried out a battery of assessments of language and cognitive skills. We refer to this second period of detailed assessment and analysis of signing skills as Phase 2 of the study. In this paper, we report on the results of both phases.

Phase 1 screening questionnaire: Method

A detailed SLI screening questionnaire was created and sent to 72 schools for the deaf, mainstream schools with specialist units, and 17 SLTs working with deaf children in the UK. Inclusion criteria specified children over the age of 7 years with at least 3 years of consistent exposure to sign language. This age and length of exposure were chosen since it was expected that after 3 years language patterns might be expected to be reasonably well-established in this age group. Any children referred to the study from deaf families, thus having native sign language exposure, were included regardless of their age. As described in the section ‘Language impairment versus language delay’, it was not the intention to study SLI only in native signing deaf children as the deaf population is made up of 90–95% of late sign language learners. Consequently, the children referred to the study were mostly non-native signers, but they had been exposed to at least 3 years of sign language from deaf adults, other deaf children, and hearing professionals with at least level 2 BSL qualifications. We compared these children with same age peers in the same language-learning situation. These criteria were designed to enable us to more confidently identify language disorder in a population where some degree of language delay is the norm.

Our questions to the teachers and language therapists were designed to pinpoint a child who, while having the same amount and quality of signing input as his peers, was significantly behind in terms of language development. The questionnaire yielded the following information:

(1) Degree of hearing loss.
(2) Use of cochlear implant and/or hearing aids.
(3) Age of first exposure to signing.
(4) Means of communication: BSL, SSE, and other spoken or sign languages used at home and at school.
(5) Exposure to fluent signers either at home or at school.
(6) Medical history that would exclude the child from our sample (e.g. neurological impairments or head injury).
(7) Pre-existing diagnosis of autism, epilepsy, learning difficulty, language impairment, or dyslexia.

The questionnaire also probed for areas of language weakness based on impairment profiles of hearing children with SLI and the case study of a deaf child with sign SLI (Morgan *et al.*, 2007). In terms of understanding sign language, we asked whether the child:

(1) Has difficulty understanding what is being signed in sentences, questions, and stories.
(2) Often asks for signs to be repeated.
(3) Has poor recall of information presented in sign language.
(4) Responds best to visual aids and non-language cues.

In terms of producing sign language, we asked whether the child:

(1) Shows hesitation and frustration during signing.
(2) Sometimes has difficulty finding the correct sign to use.
(3) Uses extensive gesture and facial expression in preference to signs.

Phase 1: Results

From the 72 schools we contacted, 20 returned one or more completed copies of the Phase 1 screening questionnaires. These schools identified 48 children with suspected SLI who were suitable for follow-up. An additional 2 children were referred to the study by specialist SLTs, making a total of 50 referrals. Of these 50, 1 child had a diagnosis of autism, and was excluded from our sample, as is standard for the diagnosis of SLI. Information and consent letters were sent out by the schools, and parents of 44 of the 49 children selected agreed that their child could take part in the study. The high take up rate indicates the perceived need for evaluation of these children by parents and professionals. Full demographic information of the 44 children is presented in Table 1. It is important to note that almost all the children in this sample had been exposed to signing by 5 years or younger.

Table 1. Demographic information for 44 children with potential SLI whose parents gave consent for further testing, and the same information for the subset of 13 with SLI

	Potential SLI group ($N = 44$)	SLI group ($N = 13$)
Gender		
Male	29	9
Female	15	4
School		
Specialist deaf school	12	4
Mainstream school	32	9
Deafness		
Profound	34	12
Severe	5	1
Profound/severe	2	0
Amplification		
Hearing aids	25	6
Cochlear implant	17	7
None	1	0
Family background		
Hearing parents	30	9
Deaf parents	2	1
Hearing family with deaf sibling	10	3
Type of signing used by child		
BSL	6	2
SSE	3	2
BSL and SSE	35	5
BSL, SSE, and total communication	0	4
Exposure to a fluent sign language user at		
School	33	4
Home	1	0
Other	1	1
Non-native signers at school	8	7
Both home and school	1	1
Age of exposure to sign language		
From birth	3	1
5 years or younger	34	12
Above 5 years	2	0

Note. Not all information was available for all children.

From the questionnaire sent out to schools, the areas of language weakness indicated by teachers and SLTs for the 44 children are summarized in Table 2.

Phase 2: Non-verbal, motor, and language assessments – methods

In Phase 2 of the study, we carried out in-depth non-verbal, motor, and language testing, in schools or homes, on a subset of 26 children identified by questionnaire.[2]

[2] *We were overwhelmed by the response to our questionnaire in Phase 1 of the study, and lacked the resources to follow up every single child who was referred to us. The decision of who to follow up was based on the schools' level of enthusiasm for participating in the study.*

Table 2. Responses by professionals to questionnaire items relating to language weakness for 44 children, with SLI children in a separate column

		Potential SLI group ($N = 44$)	SLI group[a]
Does the child have difficulty following instructions given in sign language?	Yes	36	12
	No	7	0
Does the child have difficulty understanding things signed to them?	Yes	30	9
	No	9	1
	Unsure	4	2
Does the child frequently ask for signs to be repeated?	Yes	26	4
	No	13	7
	Unsure	4	1
Does the child produce more gesture than sign language?	Yes	23	8
	No	12	3
	Unsure	8	1
Does the child respond better when visual aids are used?	Yes	39	11
	No	1	0
	Unsure	3	1
Does the child have poor memory for language information?	Yes	31	7
	No	6	2
	Unsure	6	3
Does the child show hesitation when signing?	Yes	15	2
	No	19	9
	Unsure	9	1
Does the child show frustration when signing?	Yes	12	2
	No	28	10
	Unsure	3	0

[a] Information not available for one member of the SLI group who was referred by a speech and language therapist.

Further background information was collected on the language learning experiences of each potential participant from teachers and SLTs to confirm exposure to good BSL models over an extended period of time. Individual assessments were completed over 2–3 sessions and all language data were recorded on digital video for later analysis.

Children were tested by two testers: the first author (a hearing fluent signer and psychologist) and the second author (a deaf native signer and linguist). Each testing session began with a short conversation in BSL between the child and the deaf native signer. This covered general topics such as hobbies, family, school, and friends. As well as establishing rapport, the conversation enabled informal assessment of pragmatic and discourse skills.

Non-verbal cognitive ability

We assessed NVIQ using the non-verbal composite subtests of the British Ability Scales (2nd Edition), specifically *matrices, recall of designs*, and *pattern construction* (Elliot, Smith, & McCullouch, 1996). These subtests are deemed suitable for use with deaf children in the test manual and have been administered to large numbers of British deaf children in recent studies (e.g. Kyle & Harris, 2006). Our criterion for inclusion in the SLI group was a combined z score of -1.2 or higher.

Test of motor dexterity

A bead-threading task (White *et al.*, 2006) was administered to investigate whether participants had fine motor problems that might account for problems with sign language production. In the test, the children were timed twice as they threaded 15 large coloured beads on to a piece of string, and the faster time recorded. This time was then compared to data collected for typically developing deaf and hearing children[3] aged 3–11, reported in Mann, Marshall, Mason, and Morgan (2010).

BSL receptive skills test

This is a video-based test that assesses the comprehension of BSL sentences of increasing grammatical complexity, with norms derived from deaf children acquiring BSL aged 3–13 years (Herman *et al.*, 1999).

The child watches a series of pre-recorded signed sentences, and after each sentence has to identify the picture representing the sentence from a choice of three/four alternatives. The child's selections are noted by the test administrator, and information can be derived about the children's strength and weaknesses in different areas of BSL grammar such as negation, spatial verbs, and number.

The cut-off for impaired performance on this task was set at a z score of -1.3 or below.

BSL production skills test

This test assesses deaf children's expressive language by eliciting a narrative. The child watches a short language-free story acted out by two deaf children, which is presented on a DVD. The child is then asked to tell the story, which is video-recorded for subsequent scoring. The assessment is scored in three parts: (1) the propositional content of the story (i.e. how much information children include in their narrative), (2) structural components of the narrative (i.e. introducing the participants and the setting, reporting the key events leading up to the climax of the story, and telling how the story ends), and (3) aspects of BSL grammar (including use of spatial location, person, and object classifiers and role shift (see Sutton-Spence & Woll, 1999, for details of these aspects of BSL linguistics). The test is standardized on deaf children aged 4–11 years, and percentile scores can be calculated for each of the three parts individually (Herman *et al.*, 2004).

The two testers independently scored the children and subsequently compared scores. There was over 90% agreement and in the small number of disagreements the two raters arrived at a consensus after discussion. The cut-off for impaired performance on each of the three parts of this task was set at a percentile score of 10.

The nonsense sign repetition test

This test is designed to be similar to non-word repetition tests used with hearing children (e.g. children's test of non-word repetition, Gathercole & Baddeley, 1996), and assesses phonological working memory and phonology in BSL. The test consists of

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[3] Mann et al. *(2010) reported no significant differences between deaf and hearing children on this task, hence we combine the results of the two groups.*

forty 'nonsense' signs, all of which are phonologically possible in BSL. It is important to note that signs in BSL (and other signed languages) are predominantly made up of one major movement and thus are akin to monosyllabic words in speech. Signs with two movements (akin to disyllabic words) are not common, and signs with more than two movements are impossible (Brentari, 2007). Unlike non-words in spoken language repetition tests, which are created by manipulating the number of syllables, the nonsense signs in the nonsense sign repetition test (NSRT) were created by manipulating the phonological complexity of two phonological parameters – handshape and movement. Children are required to reproduce each nonsense sign immediately after it has been presented to them on a DVD. Their responses are videoed throughout the test and scored for accuracy in handshape, internal hand movement, and path of movement. The test is normed on deaf children aged 3–11 years (Mann *et al.*, 2010).

The two testers independently scored the children and subsequently compared scores. Agreement was over 90%, and in the small number of disagreements the two raters arrived at a consensus after discussion. The cut-off for impaired performance on this task was set at a z score of -1.3 or below.

Phase 2: Results

As a result of this testing, we excluded 13 children because they did not fit our criteria for SLI (e.g. low non-verbal IQ, language scores within the normal range, motor problems, or too much reliance on oral communication).[4] Therefore, we report data on the remaining 13 children whom we are claiming have SLI. With regards to laterality, all of these 13 children are right-handed. Full demographic information for these 13 children is presented in Table 1. It is important to note that all of the children in this sample had been exposed to signing by 5 years or younger.

Non-verbal cognitive ability

All 13 participants met our criteria of NVIQ of a combined z score of -1.2 or above. Their z scores ranged from -1.2 to 0.7. Scores are shown in Table 3.

Motor dexterity

The scores for motor dexterity, in comparison with typically deaf and hearing children, are shown in Table 4. Bead-threading times for all our participants were within the normal range for typically developing deaf and hearing children, with the exception of Child 6. Two other children, Child 8 and Child 12, were close to the upper range for threading times.

Language tests

All participants had low scores ($z \leq -1.3$; $\leq$ 10th percentile) on at least one task assessing BSL skills. We describe the results for each language measure in turn.

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[4] *Non-verbal IQ testing was carried out in the first session, and for children who failed to reach our criterion, no subsequent testing sessions took place.*

Table 3. Scores for children with SLI, for non-verbal IQ, and language tests

				BSL production test percentile scores			
Child	Age	BAS z score	BSL receptive test z score	Narrative content	Narrative structure	BSL grammar	Non-sign repetition test z score
1	13.11	− 0.6	0.3[a]	25[a]	50[a]	10[a]	0.6[a]
2	7.04	− 0.6	< − 2.1	< 10	< 10	< 10	− 1.3
3	14.02	− 0.1	1.1[a]	10[a]	10[a]	25[a]	0.5[a]
4	14.08	− 0.9	− 1.8	10[a]	10[a]	10[a]	− 0.1[a]
5	7.04	0.6	− 2.1	< 10	< 10	< 10	1.1
6	11.00	− 0.7	0.1	25	10	50	− 1.7
7	5.10	− 1.2	< − 2.1	< 10	10	25	0.7
8	8.01	− 1.2	0.6	< 10	< 10	25	− 2.0
9	9.01	− 0.6	− 2.3	10	25	10	0.9
10	10.06	0.3	− 1.5	< 10	< 10	< 10	0.2
11	10.09	− 0.5	< − 2.1	< 10	< 10	< 10	− 1.4
12	9.08	0.7	1.1	<25	10	<25	− 0.5
13	11.03	− 1.0	− 0.7	10	50	10	− 0.3
Range	5.10 to 14.08	− 1.2 to 0.7	− 2.3 to 1.1	< 10 to 25	< 10 to 5 0	< 10 to 50	− 2.0 to 1.1

[a] Represents children who are older than the standardization sample. Thus, the magnitude of their poor performance is underestimated.

Child 7, who is the youngest in the group, is the sole child of deaf parents amongst the children in our sample.

BSL receptive skills test

Scores for the 13 participants are shown in Table 3. Seven children scored below our cut-off of − 1.3 standard deviations below the mean, indicating poor performance on this test.

BSL production test

The majority of the children scored poorly on this test, as shown in Table 3. Out of 13, 10 failed the narrative content, 10 failed the narrative structure, and 8 the grammar elements of the test, and every child failed at least one element.

The following examples illustrate the type of errors SLI children made on the BSL production test. The first example is of a typically developing child aged 13;11, 'setting the scene' of the story in the BSL production skills test:

> WHEN FIRST BOY LIE-DOWN-REST ON SOFA IN LIVING ROOM WATCH TV WATCH HIS SISTER 'SHRUG' GIRL BRING-TRAY PUT-DOWN FOOD THERE ORANGE JUICE (POINT TO LOCATION) PLATE CAKE (POINT TO LOCATION) PLATE BREAD CLASSIFIER (FLAT OBJECT-BREAD).

The setting of the story is explained clearly, and the characters and their actions are introduced. The child's use of placement and classifiers (see section 'Typical acquisition of sign language in deaf children') makes it easy to understand where things are located and who is doing what to whom.

In contrast, the next example is of a SLI child aged 12;09, describing the same part of the story:

> SIT SIT BOY LAZY WATCH TV HE DEMAND DEMAND

In contrast to the typically developing child's narrative, the SLI child shows no clear use of placement. The signing is unclear, the setting is not explained and there is no clear introduction of the characters.

Table 4. Motor dexterity

Child	Bead-threading time (seconds)	Comparison group mean (*SD*) (s)	Comparison group range (s)	Comparison group age	Comparison group *N*
1	82	*63 (15)	44–103	11–11;11	18
2	110	98 (37)	49–200	7;0–7;11	17
3	45	*63 (15)	44–103	11–11;11	18
4	66	*63 (15)	44–103	11–11;11	18
5	112	98 (37)	49–200	7;0–7;11	17
6	104	63 (15)	44–103	11–11;11	18
7	111	135 (49)	70–265	5;0–5;11	16
8	97	74 (17)	50–104	8;0–8;11	10
9	68	76 (17)	44–108	9;0–9;11	16
10	51	64 (19)	39–118	10;0–10;11	27
11	50	64 (19)	39–118	10;0–10;11	27
12	107	76 (17)	44–108	9;0–9;11	16
13	53	63 (15)	44–103	11–11;11	18

* Children who are older than the standardization sample are compared to the group of 11–11;11-year-olds.

In summary, the scores from the BSL receptive skills and production tests show clear impairments in narrative skills and knowledge and use of BSL grammar within the group as a whole. This is made more salient as norms for the BSL receptive and productive tests have been collected for children only up to the age of 11 years and several children tested were older than this. SLI children aged above 11 years performed at a level typical of 8- to 9-year-olds.

Non-sign repetition test

Scores are shown in Table 3. Of the 13 participants tested, 4 performed at or below our cut-off of -1.3 standard deviations below the mean.

More detailed profiles of sign language impairments

We observed heterogeneity in the nature of SLIs. Children displayed difficulties in different areas of sign language comprehension and production. Two children with similar demographic backgrounds are described in more detail here.

Child 6 is a profoundly deaf boy aged 11 from a hearing family who use basic sign language with him at home.[5] He attends a mainstream school and has learned to sign within a specialist deaf unit where he has been exposed to BSL and SSE from nursery age. He does not have contact with adult native signers within school, but attends deaf groups outside of school where he sees native signers. He has limited vocabulary but understands signed instructions as long as the information is kept simple and within his vocabulary range.

Child 11 is a profoundly deaf boy, aged 10. He also comes from a hearing family who use basic sign language with him at home. He has attended a specialist deaf unit in a mainstream school from the age of 4 years and is exposed to both SSE and BSL. He also

[5] *These children's codes correspond to those in Tables 3 and 4.*

receives language input from a deaf BSL tutor. His teachers reported that he is inattentive in the classroom. He has limited vocabulary and will often use signs in the wrong semantic contexts. He uses extensive gesture and his BSL understanding is at a two sign level, making it hard for him to follow instructions or stories. He has poor memory for information presented to him through sign and relies on pictorial cues.

These two children are of a similar age and background. While neither has any diagnosis of a cognitive, social, or neurological disability, their signing is clearly delayed in comparison to non-native signing children who have experienced the same exposure to BSL. However, their language profiles differ somewhat. Child 6's age-appropriate score on the receptive skills test (standard score 101) contrasts with Child 11's very poor comprehension of morphosyntax (standard score 56). In language production both children's scores for narrative content and structure indicate language impairment, but Child 6 performs age appropriately for use of BSL grammatical structures. Thus, while Child 11 has problems with both the comprehension and production of BSL, Child 6 is significantly better in comprehension than production. However, both score poorly on the NSRT (Child 6's standard score is 74; Child 11's is 79). For Child 6, this poor nonsense sign repetition might arguably be linked to poor motor dexterity, as evidenced by a slow bead-threading time, but this cannot be explanation in Child 11's case, as his bead-threading time is close to the mean for his age group.

Discussion

The aim of our study was to identify SLI in deaf children who are acquiring BSL, and our findings have implications for both theory and practice. In particular, we set out to answer the following questions:

(1) Can SLI be reliably identified in a group of sign language users?
(2) What are the demographic variables for this group?
(3) What are the linguistic characteristics of SLI in BSL?

We discuss questions (1) and (2) in the section 'Identification and epidemiology of SLI in deaf children', and discuss (3), together with the implications of our results for theories of SLI, in section 'Characterizing the sign language SLI profile'. Finally, in section 'Implications for practice', we discuss the implications of our findings for clinical practice.

Identification and epidemiology of SLI in deaf children

Having targeted children over the age of 7 years with adequate exposure to sign language, we have identified a group of children whose sign language difficulties cannot be explained by language delay or cognitive deficit. Formal epidemiological data about the prevalence of SLI in the deaf population does not exist. At this stage in our testing, we have identified 13 children with SLI. The number of deaf children who attend these children's schools is 203 and thus the SLI group represent 6.4% of the larger group. This finding mirrors the 7% prevalence seen in the general hearing population.

An issue of real practical importance is how to ascertain whether SLI in sign language affects children's acquisition of English, above and beyond the affects of deafness *per se*. Children in bilingual environments have been shown to have SLI in both their spoken languages (Paradis, Crago, & Genesee, 2006).

It is possible that for some children, SLI will be masked by deafness, and as a consequence they will not receive suitable intervention. More routine use of our screening questionnaire by parents and professionals is one way to begin to address the problem of identifying SLI in deaf signing children. The availability of assessments that have been standardized on deaf children is another significant step towards identification of those with persistent language difficulties. There are currently only three normed assessments available for BSL, although this is better than the situation for other signed languages. Two of these assessments are only normed on children up to the age of 11 years, and the other up to 13 years. Standardization on older children is needed in order to extend the age range over which these assessments can be used. Furthermore, these assessments focus on grammar, phonology, and narrative, and there is currently no standardized test of BSL vocabulary.

Characterizing the sign language SLI profile

Our findings from 13 signers tested to date add to the previous research from the cross-linguistic study of language impairment (reviewed in Leonard, 2009) and the individual case studies of SLI in children acquiring sign languages (Morgan *et al.*, 2007). The characteristics of SLI in deaf signers, despite the modality difference, are strikingly similar to those found for hearing children, with mixed strengths and weaknesses across different areas of language structure and use. We observed children with particular problems with comprehension, others with marked expressive difficulties, and some with problems in all areas of language. We are currently developing other measures to further explore these difficulties and the processes that underlie them.

Cross-linguistic comparisons of SLI have revealed that language deficits affect different aspects of acquisition depending on the particular typology of the language (Leonard, 2009). Although sign languages share many of the same linguistic features as spoken languages, the instantiation of these features often looks very different, due to the fact that the visuo-gestural modality allows signers to exploit space to represent both topographic space (i.e. space in the real world) and syntactic space (where the location of referents may be arbitrary; see Sandler & Lillo-Martin, 2006, for a thorough overview of linguistic similarities and differences between spoken and signed languages).

Our finding that SLI can be identified in children who use sign language has clear implications for at least one theory of SLI. The Rapid Auditory Processing theory (Tallal, 2003) claims that children with SLI have language impairments because they cannot process sounds as quickly as their age-matched unimpaired peers. This does not apply to sign languages: visual processing is much slower than auditory processing, because the visual system does not have the same temporal resolution that the auditory system does. Therefore, a hypothesis that *only* rapid temporal processing deficits cause SLI would predict no SLI in sign language. Finding SLI in BSL does not of course prove that rapid temporal processing deficits do *not* cause SLI in spoken languages, but it provides support for the view that there might be more than one underlying cause of SLI in spoken languages.

Another theory of SLI, the limited working memory hypothesis (Gathercole & Baddeley, 1990), would predict that deaf signing children with SLI would perform poorly on tests of phonological working memory. Indeed, non-word repetition tests are frequently used to identify SLI in hearing children (for a review, see Coady & Evans, 2008). It is therefore an important issue that only 4 children performed poorly on this task. A clue as to this rather puzzling result comes from the finding that even typically developing deaf children find the task challenging (Mann *et al.*, 2010). Mann and colleagues found a very wide spread of scores, meaning that a child has to achieve a very low score in order to fall outside the normal range; this may therefore reduce the sensitivity of the assessment in identifying children with real impairments in phonology and phonological working memory. Nevertheless, the fact that some of the children we tested did score poorly suggests that NSRT may have some utility in identifying SLI in deaf signing children as part of a wider battery of tests, and offers some support for the limited phonological working memory hypothesis.

Implications for practice

Up until now, case studies (Morgan, 2005; Morgan, Herman, & Woll, 2007) and anecdotal evidence from SLTs have suggested that SLI exists in deaf signing children. The present study has shown that SLI does indeed exist in BSL, and that deaf children's impaired language development cannot necessarily be explained by poor exposure to BSL, or by lower general cognitive, pragmatic, or motor abilities. Furthermore, SLI can be reliably identified in deaf children on a larger scale by SLTs and teachers through the administration of a screening questionnaire. We therefore suggest that SLI should be at the forefront of professionals' minds when dealing with language development concerns regarding this group.

It is essential to distinguish cognitive impairments and inadequate exposure from SLIs. Understandably, professionals have thus far been wary of attributing a diagnosis of SLI to deaf children due to traditional diagnostic criteria and the heterogeneity of their language backgrounds and input; however, this has led to the potential for under-diagnosis of SLI. In the general population of deaf children late exposure to language is typical. Our study has highlighted that SLI can exist alongside language delay.

Based on our findings, we suggest that 3 years after the onset of a child's exposure to sign language, specialist teachers of the deaf should routinely screen deaf children using the SLI screening questionnaire that we have developed as part of this study. SLTs should also be encouraged to use the questionnaire to screen referrals or in instances where particular concern has been raised by parents or teachers. If concerns are identified through the questionnaire, a more detailed assessment of the child's sign language skills can be carried out using tests such as the ones described in the present study.

In instances where SLI is identified, it is vital that assessments and interventions are conducted by SLTs who are fluent in sign language. Ideally, deaf native or near-native signers should be trained to assess and deliver appropriate sign language intervention under the guidance of SLTs. This would avoid potential issues with the assessment of a child in a tester's weak language.

Research over the past 25 years documenting sign language acquisition has shown the same patterns, timescale, and error types as in spoken languages. In addition, at this stage in our testing the study reported here suggests that disturbances to normal language acquisition have similar outcomes and approximately the same incidence rate across the signed and spoken language modalities.

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