Identifying Specific Language Impairment in Deaf children acquiring British Sign Language: Implications for theory and practice

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RUNNING HEAD: SLI in sign language

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Abstract

This paper presents the first ever group study of specific language impairment (SLI) in users of sign language. A group of 44 children were referred to the study by teachers and speech and language therapists. This sample represented 6% of the wider deaf child population we contacted. Individuals who fitted pre-determined criteria for SLI were then systematically assessed. Here we describe in detail the performance of 15 signing deaf children aged 7-16 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, pragmatic or motor abilities. As is the case for SLI in spoken languages, we find heterogeneity in 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.

1. Introduction

In the general population, approximately 7% of children have a marked impairment in acquiring language compared to their typically developing peers, and are diagnosed with specific language impairment or SLI (Tomblin et al, 1997). This developmental disorder is specific to language and is not part of a more general cognitive impairment. There is wide disagreement as to the underlying cause of SLI (for a review, see Leonard, 1998). 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 (Leonard, 1998).

A diagnosis of SLI is given to children if a language learning impairment exists despite normal nonverbal 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 & 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 standardised measurements of BSL comprehension (Herman, Holmes & Woll, 1999) and production (Herman, Grove, Holmes, Morgan, Sutherland, & Woll, 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?

2. 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 ten signs are produced around 12 months of age, and the 50 sign milestone is recorded from 20 months onward (Woolfe, Herman, Roy & Woll, in press). Children combine signs from 18 to 24 months, initially using uninflected noun and verb forms (Newport & Meier, 1985; Morgan, Barriere & Woll, 2006). 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. Another 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 and Woll 1999).

Sign languages also exploit polymorphemic structures that 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.). Spatial verbs are polymorphemic and include entity classifiers. 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).

3. 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: including bilingual (BSL and English), a mixture of visual and oral communication systems (Sign Supported English (SSE) – the use of key lexical signs alongside spoken English sentences) or spoken English only.

Over 90% of deaf children are born to hearing parents who have no prior experience of sign language (Mitchell and 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. Deaf children may be exposed to fluent models of sign language outside of the family at nursery or school. Many deaf children attend nurseries where they are exposed to signing or have input from adult deaf signers. For some children though the first contact with signing will be when they attend school at age 4 onwards meaning 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 despite early and protracted exposure to fluent BSL. Since these children have been consistently exposed to good sign language models, 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.

4. 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 & Piercy, 1973; Tallal, 2003). 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 Generalised 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). Although as a group, children with SLI have been shown to have slower responses than their age-matched peers on a range of linguistic and non-linguistic speeded tasks it is also the case that some children with SLI have fast reaction times on both types of tasks (Leonard, Weismer, Miller, Francis, Tomblin & Kail, 2007). Because this hypothesis predicts that individual differences in reaction time measures should predict individual differences in language ability, the theory is not just 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 longer than 4 syllables. 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, and their processing recruits phonological working memory (Emmorey, 2002; Mann, Marshall, Mason & Morgan, in press).

Every sign can be broken down into a set of phonological parameters (the handshape, the movement and the place of articulation or location) that are in isolation meaningless but when combined together make lexical signs. Signers store the phonological properties of signs and access these properties during lexical retrieval and production. For example, in “tip of the finger” states signers may select the correct movement and location for the sign but not be able to access the right handshape (Emmorey, 2002).

Sign languages offer an exciting possible extension to the Limited Phonological Working Memory hypothesis because they make use of visuo-spatial 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 visuo-spatial 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. For example, the Computational Grammatical Complexity hypothesis (van der Lely, 2005) claims that the deficit lies in the core components of grammar that rely on the computation of linguistic rules (i.e. syntax, morphology and phonology). This affects the acquisition and processing of complex structural representations in those components. Linguistic structures that are syntactically, morphologically and phonologically complex, such as the English regular past tense, tend to be the most severely impaired (Marshall & van der Lely, 2007).

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 characterisation of SLI in sign languages promises to open a new window onto the debate over the underlying deficits causing SLI.

5. Method

The present study was 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, 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 and the remaining children were assessed individually on a range of language, cognitive and motor tasks. We refer to this second period of detailed assessment as Phase 2 of the study. In this paper we report on the results of both Phase 1 and group results from Phase 2.

5.1 Phase 1 Screening questionnaire

A detailed SLI screening questionnaire was created and sent to 72 schools for the deaf, mainstream schools with specialist units, and 17 speech and language therapists working with deaf children in the UK. Inclusion criteria specified were exposure to sign language before the age of 7 years with at least 3 years of consistent exposure. This length of exposure was chosen since it was expected that after 3 years language patterns might be expected to be reasonably well established. These criteria were designed to enable us to more confidently distinguish language delay from language disorder. Questionnaire respondents were asked to report their views of the child’s language and cognitive abilities compared with other deaf children in the same classroom who had experienced similar opportunities to learn BSL from the same language models. 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, Sign Supported English (SSE – the use of key lexical signs alongside spoken English sentences) 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 (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 does the child:

1. Have difficulty understanding what is being signed in sentences, questions and stories?
2. Often ask for signs to be repeated?
3. Have poor recall of information presented to them in sign language?
4. Respond best to visual aids and non-language cues?

In terms of producing sign language does the child:

1. Show hesitation and frustration during signing?
2. Sometimes have difficulty finding the correct sign to use?

3. Use extensive gesture and facial expression in preference to signs?

5.2 Participants

21 of the 72 schools returned one or more completed copies of the phase 1 screening questionnaires. These schools identified 44 children with suspected SLI who were suitable for follow-up. An additional 7 children were referred to the study by specialist SLTs, making a total of 50 referrals. We excluded, as is standard for the diagnosis of SLI, 5 children who had known developmental syndromes such as autism, general learning difficulties associated with low NVIQ and motor impairments. Thus the number of children referred to the study with perceived language problems represents 6% of the total deaf child population we contacted. Information and consent letters were sent out by the schools and parents of all the children selected agreed to take part in the study. The extremely high take up rate indicates the perceived need for evaluation of these children by parents and professionals. Full demographic information is presented in table 1.

[insert table 1 here]

In phase 2 we have tested 15 children to date. Full demographic information is presented in table 2.

[insert table 2 here]

5.3 Phase 2 Assessment procedures

During the assessment phase of the project, schools or homes were visited to carry out detailed assessments on the children identified. 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 was 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 sign linguist). Each testing session began with a short conversation in BSL between the child and the deaf native signer which was recorded on digital video for later analysis. 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.

5.3.1 Non-verbal intelligence (*NVIQ)*

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 (Kyle & Harris, 2006).

5.3.2 Test of motor dexterity

A bead threading task (White et al. 2006) was administered to ensure that participants had no 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 onto a piece of string. The fastest time was compared to those collected for 90 typically developing deaf children aged 3-11, reported in Mann et al (in press).

5.3.3 BSL Receptive Skills Test (Herman et al 1999).

This is a video-based test looking at comprehension of BSL sentences of increasing grammatical complexity, with norms derived from deaf children acquiring BSL as a first language aged 3-13 years. 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. Correct and incorrect selections made by the child are noted by the test administrator, and from this, information can be derived about the children's strength and weaknesses in different areas of BSL grammar such as negation, spatial verbs and number.

5.3.4 BSL Production Skills Test (Herman et al, 2004).

This test is designed to assess deaf children's expressive language and is based on an elicited 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 from the story do children include in their narrative), (2) structural components of the narrative (i.e. introducing the participants and the setting of the story, 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 standardised on deaf children aged 4-11 years, and percentile scores can be calculated for each of the three parts individually.

5.3.5 The Nonsense Sign Repetition Test (NSRT) (Mann, Marshall, Mason & Morgan, in press).

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 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 monosyllabic. Disyllabic signs are not common, and signs with more than two syllables 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 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 4-11 years (Mann, Marshall, Mason & Morgan, in press).

The two testers independently scored the children on all tests 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.

6. Results

6.1 Phase 1 Screening Questionnaire

From the questionnaire sent out to schools, the areas of language weaknesses indicated by teachers and speech and language therapists are summarised in table 3.

[Insert table 3 here]

6.2 Phase 2 assessments

6.2.1 Non verbal intellectual ability

All 15 participants met SLI diagnostic criteria of NVIQ within the normal range (z-score range -1.2 to 1.1.). Scores are shown is figure 1.

[insert figure 1 here]

6.2.2 Motor dexterity

Task completion times for bead threading were within the normal range for typically deaf children reported by Mann et al (in press) (range between 45 – 180 seconds).

6.2.3 Language tests

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

6.2.3.1 BSL Receptive Skills Test

Four children had standard scores falling below 70 (-2 SD below the mean) indicating a particularly poor performance on this test. Standard scores for the 15 participants are shown in figure 2.

[Insert figure 2 here]

6.2.3.2 BSL Production Test

The majority of the children scored extremely poorly on this test as shown in figures 3-5.

[insert figures 3-5 here]

In summary the scores from the BSL Receptive Skills and Production tests showed clear impairments in narrative skills and knowledge and use of BSL grammar. 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 of typical 8-9 year olds.

6.3 Non-sign repetition test

Of the 15 participants tested, 8 performed below the normal range on the NSRT (between 70-130). Scores are shown in figure 6.

[insert figure 6 here]

6.4. More detailed profiles of sign language impairments

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

‘A’ is a profoundly deaf boy aged 11 from a hearing family who use basic sign language at home. He attends a mainstream school with a specialist deaf unit and 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. A’s teachers report that he does not benefit from his cochlear implant to the extent that would be expected, given that he was implanted at the age of two years. He has limited vocabulary but can hold conversation and understand signed instructions as long as the information is kept simple and within his vocabulary range.

‘T’ is a profoundly deaf boy, aged 10. He also comes from a hearing family who use basic sign language 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 receives language input from a deaf BSL tutor. T’s teachers reported that he was inattentive in class and did not benefit from his hearing aids, which he would frequently turn off. T 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 both do not have any diagnosis of learning 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. A’s score of 101 on the Receptive Skills Test is age appropriate (standard score 100). On the same test T scores very poorly (56) indicating problems in comprehension of morpho-syntax. In language production both children’s scores for narrative content and structure indicate language impairment, but A performs age appropriately for use of BSL grammatical structures. Thus while T has problems with both the comprehension and production of BSL, child A is significantly better in comprehension than production. In phonological development both children’s scores (A = 74, T= 79) are within the normal range for their age although at the low end of the scale (70-130).

7. 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 section 7.1, and discuss (3), together with the implications of our results for theories of SLI, in section 7.2. Finally, in section 7.3, we discuss the implications of our findings for clinical practice.

7.1 Identification and epidemiology of SLI in deaf children

The present study has identified 6% of deaf signing children with significant impairments in BSL through the use of parent and teacher questionnaires and available BSL assessments. 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.

It is vital that we continue to improve identification in this population to ensure that SLI is not masked by deafness and as a consequence, suitable intervention is not delivered, with catastrophic consequences for these children's language development and education. The high overlap between language and literacy impairments in the hearing population (see Messaoud-Galusi & Marshall, in press, for a review) is likely to be a feature of the population of deaf signing children too; an issue of real practical importance is how to ascertain whether SLI in BSL might also affect children's acquisition of written English comprehension, above and beyond their difficulties in the acquisition of spoken English that are a direct result of deafness

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 standardised 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. Standardisation 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 standardised test of BSL vocabulary (one is in preparation - Mann & Morgan in prep). Continued development of language assessments is crucial.

Formal epidemiological data about the prevalence of SLI in the deaf population does not exist, but our findings in terms of questionnaire response rate was 6%, which would suggest that SLI exists among deaf signers to an extent that mirrors the 7% prevalence seen in the general hearing population.

7.2. Characterising the sign language SLI profile

Our findings from 15 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. There is, of course, a sequential element in sign language, but single signs are articulated more slowly than spoken words, and sign languages exploits the opportunities for simultaneous processing afforded by the availability of multiple and visible articulators (hands, face and torso). 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 about half of the children tested on the nonsense sign repetition test performed within the normal range.

At first glance, these results are similar to those reported for SLI in Cantonese. Despite non-word repetition being severely impaired in children with SLI in a wide variety of languages, Stokes and colleagues found that Cantonese-speaking children with SLI did not repeat Cantonese non-words less accurately than age-matched controls (Stokes, Wong, Fletcher & Leonard, 2006). However, as Stokes et al reported, the phonology of Cantonese is very straightforward, with a limited syllable inventory. In the nonsense sign repetition test that we used however, the phonological complexity of some of the items was considerable. Whereas the typically developing children and children with SLI that Stokes and colleagues tested did well overall on the Cantonese non-words, even our typically developing deaf children found the task challenging (see Mann et al, in press). As discussed further by Mann and Marshall, there was a wide spread of scores amongst these children, which means 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 (Mann & Marshall, in press). Nevertheless, the fact that half the children we tested did score below the average range suggests that the nonsense sign repetition test may have some utility in identifying SLI in deaf signing children, and offers some support for the Limited Phonological Working Memory hypothesis. A sentence repetition measure currently under development may be able to shed further light on this area

7.3 Implications for practice

Up until now, case studies (Morgan 2005; Morgan, Herman & Woll, 2007) and anecdotal evidence from SLTs has 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 with this group.

It is essential to distinguish cognitive impairments and inadequate exposure from specific language impairments. 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.

Based on our findings, we suggest that three 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 and is shedding light on the amazing plasticity of child language acquisition. In addition, 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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Tables and figures

Table 1: Demographic information for 44 children referred to the study during phase 1 (N.B not all information was available for all children)

		Number of children
Gender	Male	29
	Female	15
School	Specialist Deaf school	12
	Mainstream school	32
Deafness	Profound	34
	Severe	5
	Profound/severe	2
Amplification	Hearing aids	25
	Cochlear implant	17
	None	1
	Unknown	0
Family background	Hearing parents	30
	Deaf parents	2
	Hearing family with deaf sibling	10
Type of signingused by child	BSL	6
	SSE	3
	BSL & SSE	35
Exposure to a fluent sign language user at		
	School	33
	Home	1
	Other	1
	Non-native signers at school	8
	Both home and school	1
Age of exposure to sign language	From birth	3
	5 years or younger	34
	Above 5 years	2

Table 2: Demographic information on 15 children in phase 2.

		Number of children
Gender	Male	10
	Female	5
School	Specialist deaf school	7
	Mainstream school	8
Deafness	Profound	14
	Severe	1
Amplification	Hearing aids	7
	Cochlear implant	8
Family	Hearing parents	12
	Deaf parents	0
	Hearing family with deaf sibling	3
Type of sign language used by child	BSL	3
	SSE	1
	BSL & SSE	7
	BSL SSE & Total communication	4
Exposure to a fluent sign language user at	School	8
	Home	1
	Non-native signers at school	6
Age of exposure to sign language	From birth	1
	5 years or younger	14

Table 3. Responses by professionals to questionnaire items relating to language weakness for 44 children

Does the child have difficulty following instructions given in sign language?	Yes	36
	No	7
Does the child have difficulty understanding things signed to them?	Yes	30
	No	9
	Unsure	4
Does the child frequently ask for signs to be repeated?	yes	26
	no	13
	unsure	4
Does the child produce more gesture than sign language?	yes	23
	no	12
	unsure	8
Does the child respond better when visual aids are used?	yes	39
	no	1
	unsure	3
Does the child have poor memory for language information?	yes	31
	no	6
	unsure	6
Does the child show hesitation when signing?	yes	15
	no	19
	unsure	9
Does the child show frustration when signing?	yes	12
	no	28
	unsure	3

Figure 1. Performance indicated by Z scores on the British Ability Scales.

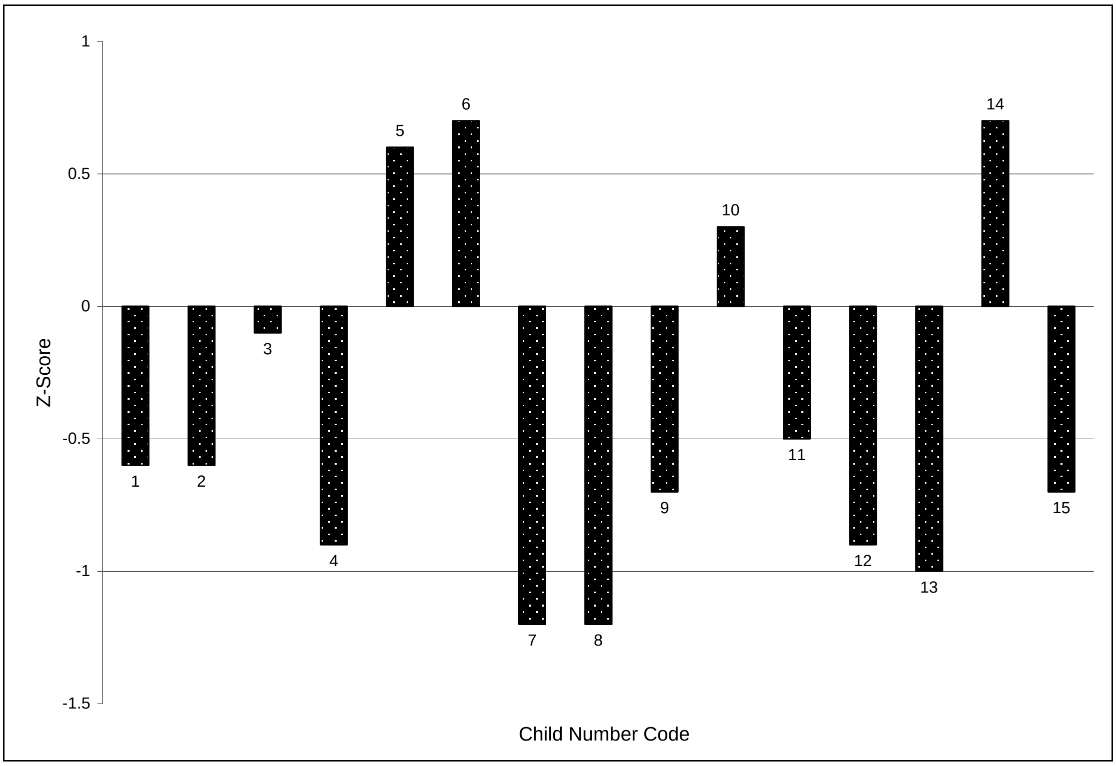

Figure 2. Performance on the BSL Receptive Skills Test.

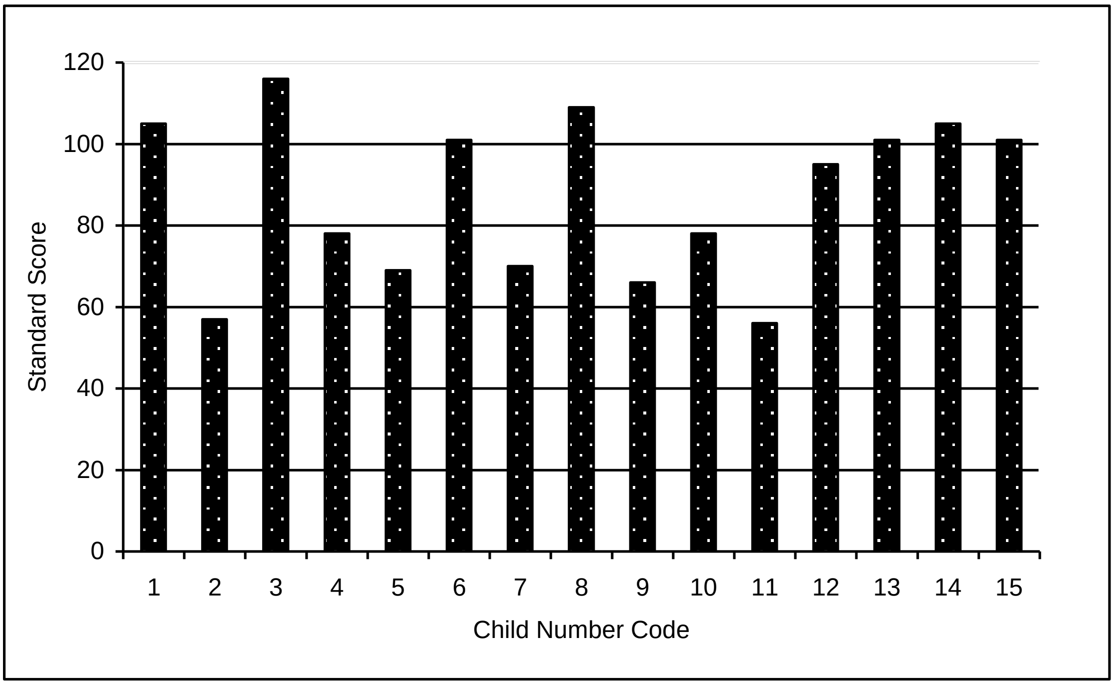

Figure 3. BSL Production Test: percentile scores for BSL grammar.

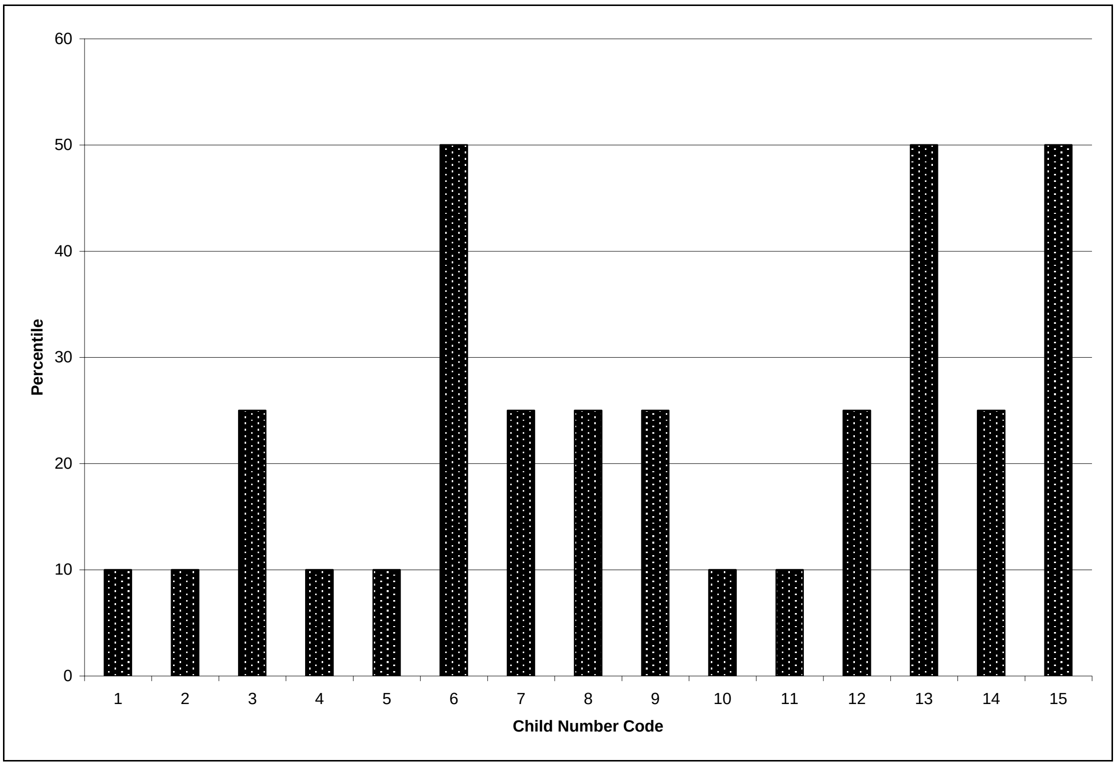

Figure 4. BSL Production Test: Percentile scores for narrative content.

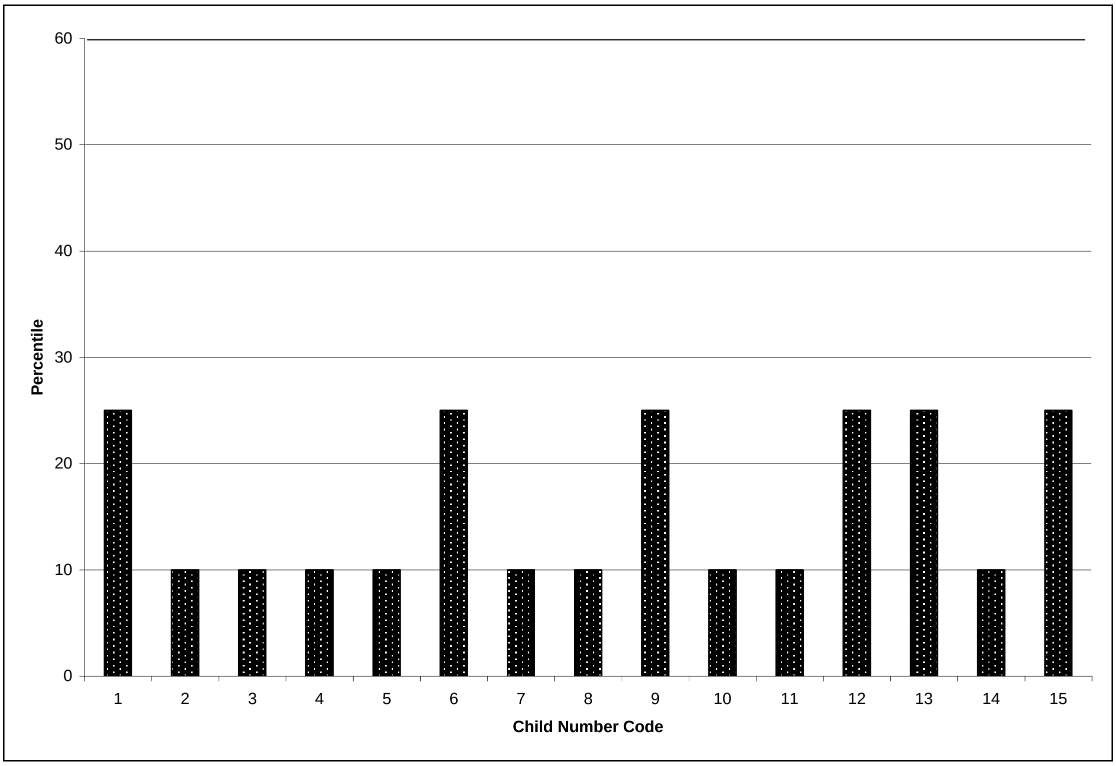

Figure 5. BSL Production Test: Percentile scores for narrative structure.

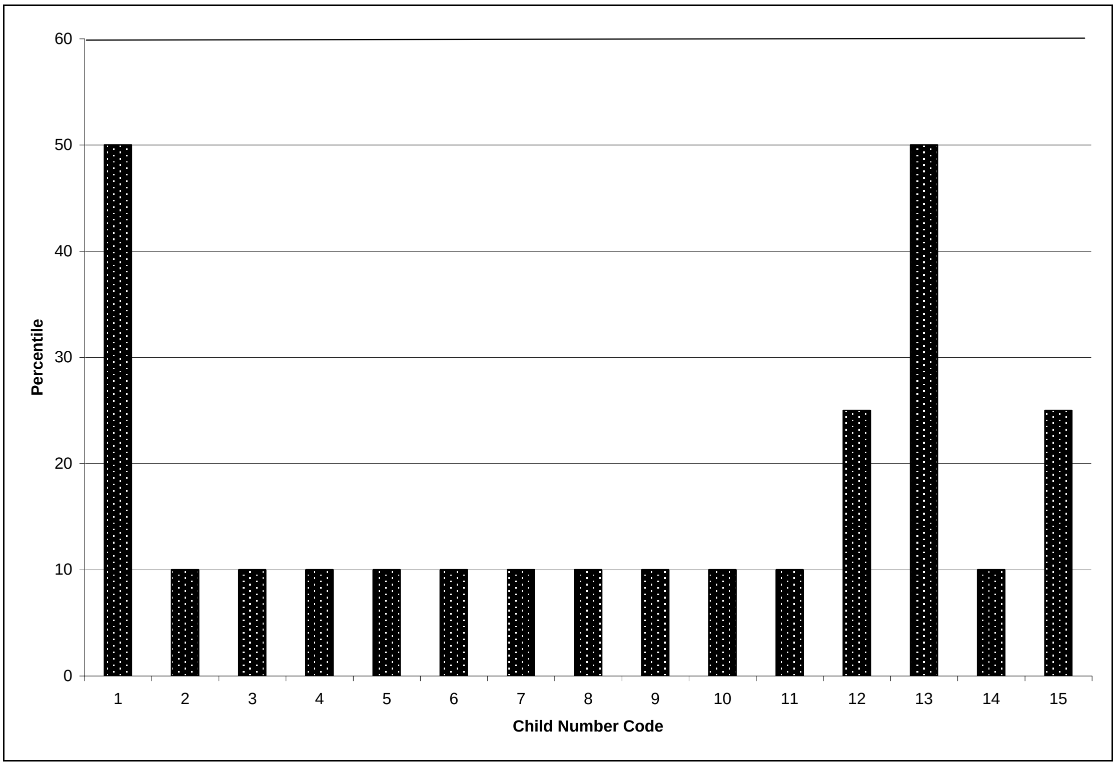

Figure 6: Non-sign repetition test: Standard scores.