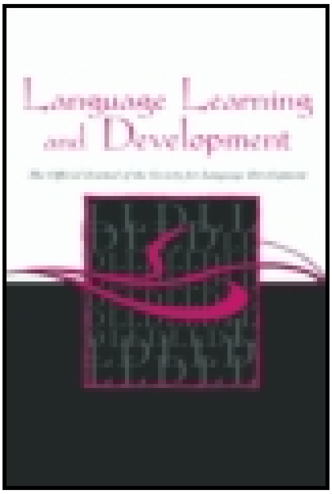

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Children with specific language impairment (SLI) perform poorly on sentence repetition tasks across different spoken languages, but until now, this methodology has not been investigated in children who have SLI in a signed language. Users of a natural sign language encode different sentence meanings through their choice of signs and by altering the sequence and inflections of these signs. Grammatical information is expressed through movement and configurational changes of the hands and face. The visual modality thus influences how grammatical morphology and syntax are instantiated. How would language impairment impact on the acquisition of these types of linguistic devices in child signers? We investigated sentence repetition skills in a group of 11 deaf children who display SLI in British Sign Language (BSL) and 11 deaf controls with no language impairment who were matched for age and years of BSL exposure. The SLI group was significantly less accurate on an overall accuracy score, and they repeated lexical items, overall sentence meaning, sign order, facial expressions, and verb morphological structures significantly less accurately than controls. This pattern of language deficits is consistent with the characterization of SLI in spoken languages even though expression is in a different modality. We conclude that explanations of SLI, and of poor sentence repetition by children with this disorder, must be able to account for both the spoken and signed modalities.

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INTRODUCTION

About 7% of children have a specific language impairment (SLI) (Tomblin et al., 1997) with a diagnosis made when they demonstrate a marked impairment in language despite normal non-verbal IQ, neurological function, motor development, social interaction, and hearing (Leonard, 1998). SLI is a heterogeneous disorder, with considerable individual variability in the severity and profile of linguistic impairments. There are also some differences across languages and age groups. Deficits have been reported in all aspects of language, including phonology, morphology, syntax, discourse, and semantics (Leonard, 1998; Schwartz, 2008), and a robust finding across languages and age groups is impaired sentence repetition (e.g., for English: Conti-Ramsden, Botting, & Faragher, 2001; Cantonese: Stokes, Wong, Fletcher, & Leonard, 2006; Italian: Contemori & Garraffa, 2010; Shaalan, 2010).

Listening to a sentence such as "The dog is hiding under the box" and repeating it verbatim pose little difficulty for most native adult speakers of English. The task is more difficult for less able language users, including young children. While it is possible to repeat short sentences exclusively by means of phonological short-term memory, longer and/or more syntactically complex sentences require the support of linguistic representations (Slobin & Welsh, 1968). Consequently, sentence repetition tasks are a good proxy for language processing and development (Chiat et al., 2013). Indeed, a sentence repetition subtest is included in many standardized language assessments for children (e.g., Gardner, Froud, McClelland, & van der Lely, 2007; Semel, Wiig, & Secord, 2003), and poor performance on the task is considered a clinical marker for specific language impairment (Conti-Ramsden et al., 2001).

The causes of sentence repetition difficulties for children with SLI are the subject of substantial debate in the literature. Some theories propose that a deficit in phonological short-term memory and/or a deficit in linguistic knowledge make language processing difficult (see Riches, Loucas, Baird, Charman, & Simonoff, 2010, for a recent review). Another possibility is more domain general in nature: the generalized slow processing hypothesis (Kail, 1994; Miller et al., 2006) proposes subtle differences in dealing with complex information, including language.

Whatever the cause, children with SLI produce errors of morpho-syntax, particularly verb morphology. For example, numerous studies of both spontaneous speech and sentence repetition have demonstrated that English children with SLI omit inflectional morphology, for example, past tense *-ed* (as in *talked, hugged*) or third person singular *-s* (as in *likes, hides*) (Chiat & Roy, 2008; Joanisse, 2004; Leonard, McGregor, & Allen, 1992; Rice & Wexler, 1996, among others). Verbal morphology might be particularly fragile because it presents complex processing and linguistic computation demands (e.g., feature checking and linguistic movement; see Rice & Wexler, 1996).

In languages which, unlike English, have extensive verb morphology, typically developing children grasp these patterns quickly and with few errors (Pizzuto & Caselli, 1992). Similarly, studies of SLI in Italian-speaking children show that these children deal better with grammatical inflections than children with SLI who are acquiring English (Leonard, Caselli, Bortolini, McGregor, & Sabbadini, 1992). Sign languages have highly complex verb morphology, and this opens up the question of what verb morphology might look like in children who have SLI in the visual modality.

Signed languages have all the linguistic hallmarks of spoken languages (see Sandler & Lillo-Martin, 2006) and are processed using phonological short-term memory (Hall & Bavelier, 2010). SLI is hard to identify in deaf children and is often overlooked because hearing impairment is associated with spoken language delay (Cleary, 2008). The deaf child population is also ignored in explanatory theories of SLI. But what about children who are exposed to a signed language and who have no visual or cognitive impairments but nevertheless fail to develop sign language to a level commensurate with their same-age peers? Leonard (1998, p. 9) predicted that if SLI is not specifically linked to the auditory modality of speech, then a similar proportion of deaf and hearing children should have SLI in their signing. That was a prediction made in the then absence of any empirical studies.

Research on sign SLI is in its infancy, but several studies indicate that it does exist. Morgan, Herman, and Woll (2007) reported the case of a deaf 5-year-old boy of normal non-verbal intelligence with SLI in British Sign Language (BSL). He had no difficulty understanding single signs and short sentences, but he scored at a 3-year-old level on standardized BSL grammar assessments. In a larger study, Mason et al. (2010) identified a group of deaf children who performed poorly on standardized BSL comprehension and production tasks relative to their peers, despite nonverbal IQ in the average range. Moreover, 6.4% of the larger group recruited was identified as having SLI, a similar proportion to Tomblin et al.'s (1997) study, confirming Leonard's (1998) prediction. Recently, sets of case studies of deaf children who do not readily acquire American Sign Language have also been reported (Quinto-Pozos, Forber-Pratt, & Singleton, 2011).

An important issue is that although signing children of deaf parents follow similar milestones of language development compared with hearing children acquiring spoken language, more than 90% of deaf children are born to hearing parents who are usually not able to provide fluent sign language input in the early years (Marschark, 1997). Deaf children may be exposed to fluent models of sign language outside the family if they attend preschools with deaf signing staff (these were the types of children recruited in the current study), but for most their first contact with fluent sign language will be when they start school. Thus delay in exposure for the majority is the norm rather than the exception.

This overlap between language delay and language impairment also exists in some hearing children exposed to two spoken languages at different rates. While there is a large and growing literature on bilingual children showing no delays at all in rate of acquisition (Genesee, Paradis, & Crago, 2004), some bilingual children do have reduced input of one language temporarily during early language acquisition which slows down acquisition of one of their languages. A proportion of these children also have developmental language impairment, and it is challenging to diagnose SLI in children with uneven bilingual exposure (Peña & Bedore, 2008). There are similar challenges to diagnosis in monolingual children where input is reduced for reasons related to low socio-economic status (Roy & Chiat, 2013).

Studying SLI in sign language development is equally complex but still achievable. It is not possible to exclude from such studies deaf children who do not have deaf parents, as this strategy would rule out 90% or more of the population. The majority of nonnative signers go on to be competent language users, confirming that delays in sign language exposure do not cause SLI. Rather, late acquisition results in a pattern of fluent expressive signing but with slower processing speed and less efficient comprehension of complex syntax compared with native signers (Mayberry, 2010).

Given the challenges of separating SLI from language delay in deaf children, Mason et al. (2010) used the most logical comparison for identifying a language disorder in sign. They compared children with suspected sign SLI with their nonnative signing peers who had similar quantity and quality of exposure to BSL. If this approach identifies significant differences between the groups, even if both groups perform poorer on language tests than their native signing peers, we can confirm a diagnosis of SLI. This is exactly the approach taken in the current study. The repetition of sentences in BSL was compared in two groups of nonnative signers. We aimed to further profile the language difficulties of children with sign SLI by including morphological structures known to be challenging for hearing children diagnosed with disorders.

To provide stronger evidence that SLI exists in sign and to compare the disorder with what is known for spoken languages, more detailed studies of the language characteristics of such children are needed. Do the deficits that characterize SLI in spoken languages also characterize the disorder in signed languages? Some differences, due to the different demands of processing language in different modalities, might be expected, but the more similarities we find, the more confident we can be that SLI has a *supramodal* origin and is not caused by difficulties with the particular characteristics of the perceptual signal. Mason et al. (2010) reported scores for SLI signers on a nonsign repetition (single signs without meanings) task. Nonword repetition is, like sentence repetition and the use of the tense system, a clinical marker for SLI in English and many other spoken languages (Chiat & Roy, 2008; Conti-Ramsden, 2003). Based on comparison with a large group of typically developing signers (Mann, Marshall, Mason, & Morgan, 2010), Mason et al. (2010) found that some but not all deaf SLI children scored worse than one standard deviation below the mean on the task. Mason et al. (2010) concluded that impaired non-sign repetition can be part of the profile of language impairments in some deaf children with SLI, but is not characteristic in the way that it is in many, but not all, spoken languages (e.g., Cantonese is an exception; Stokes et al., 2006).

More recently Marshall, Rowley, Mason, Herman, and Morgan (2013) compared lexical organization of semantically related signs, using a semantic fluency task, in deaf signers with SLI and a group of deaf children with typically developing sign language. Although some hearing children with SLI do have word-finding difficulties (Dockrell, Messer, George, & Wilson, 1998), poor performance on semantic fluency is not itself a characteristic of SLI and Marshall et al. (2013) concurred with this profile for signers. Although some of the children with sign language SLI made word-finding errors, and although the group as a whole was slower at starting to generate words on the task, their overall performance was not different from that of the controls. Thus previous studies suggest similar general profiles for children with spoken and signed language SLI, which suggests that the disorder may not be markedly different across modalities. However there are several areas of linguistic ability, in particular morphosyntax, which we know much less about in cases of sign SLI. Here we introduce and describe a set of linguistic structures common in BSL and other sign languages which were included in the current experiment.

When one looks at morphosyntax, many sign languages use rich and complex devices which are similar to how polysynthetic spoken languages work (Meier, Cormier, & Quinto-Pozos, 2002; Sandler & Lillo-Martin, 2006). For example, verb inflections are extensive and syntax follows a topic-comment order. Signers might introduce a topic and follow this with the predicate information WEEK-PAST Pro1 CAR BUY: "last week I bought a car." While there are linguistic similarities between modalities, BSL does use other devices that are connected to the visual channel. Often signers mark topics by grammatical devices expressed on the face, for example, by raised eyebrows, which have scope across the manual components of the sentence. The face markers are used in conjunction with spatial inflections expressed on the hands and thus sentence meanings can be modified by hands and face markers simultaneously (Sandler & Lillo-Martin, 2006).

Because BSL has rich verb morphology and classifier constructions, signers can change word order quite freely, relying on information being carried by directional modifications to incorporate locations associated with core arguments. These are known in the literature as "agreement verbs" (Meier, 2002; Padden, 1988). Verbs mark person agreement with arguments associated with different locations in the signing space. For example, signers mark verb agreement (i.e., show who does what to whom on the verb) by modifying the direction the sign moves, either toward present referents or toward abstract locations in the signing space in front of the signer. A noun phrase can be introduced into the discourse along with a pointing sign (glossed IX). The location in sign space of the NP can then be used as a starting point to move a verb from or towards, in order to encode the inflection, for example, BOY_j $IX_j GIRL_k$ IX_k $_kASK_j$ 'The girl asks the boy.' (See also example figures in the appendices.)

Another feature of BSL and many other sign languages are classifier constructions which express position, stative description (size and shape), and how objects are handled manually (Engberg-Pedersen, 1993; Brentari & Benedicto, 1999; Glück & Pfau, 1999). The particular hand shape used to express different meanings is what functions as the classifier. Various hand shapes can represent whole entities; show how objects are handled or instruments are used; represent limbs; and be used to express various characteristics of entities such as dimensions, shape, texture, position, and path and manner of motion. For example, a signer describes the location of three objects on a table: a cup, a pen, and a bunch of keys, each using classifiers. The BSL convention is for the ground referent to be mentioned first, and so the sign TABLE is signed in space in front of the signer by moving two flat hands apart at waist height to create a representation of a surface. As each object is mentioned, the noun is articulated first, followed immediately by a corresponding classifier handshape located in the space in front of the signer. The signer uses the following signs: CL-curved-hand (round object), CL-extended-index-finger (straight-thin object) and CL-spread-and-bent fingers (bunched object). (See also example figures in the appendices.)

The sentence stimuli used in the current study thus included all the previously described linguistic devices. We asked if sentence repetition is impaired in sign SLI and if so what areas of the language will be particularly impaired?

METHOD

Participants

SLI group. Eleven deaf children (7 boys) who used BSL as their primary language were identified. Their average age was 10;0 (range 7;4-12;9 SD = 1;7). None were the children of deaf parents, but they had been exposed to native signers via educational programs for a mean duration of 6;1 years (SD=1;8). Table 1 sets each child's age, length of exposure to BSL, and type of school placement. Sign language SLI was identified on the basis of referral by their teachers and subsequent impaired performance on standardized tests of BSL, defined as a z-score of -1.3 or worse on the BSL Receptive Skills Test, which tests sentence comprehension (Herman, Holmes, & Woll, 1999), and /or the BSL Production Test, which is a narrative task (Herman et al., 2004). None of the children had other cognitive and/or social impairments according to teacher report, and furthermore all had non-verbal abilities within the normal range (defined as a z-score of -1 or better) as measured by a composite measure of two spatial subsets (recall

TABLE 1
Participants

	Child	*Years of BSL*	*Age (years; months)*	*School*
SLI group	1.	3	7;4	Mainstream with specialist unit
	2.	7	10;0	Mainstream with specialist unit
	3.	5	9;1	Mainstream with specialist unit
	4.	6	10;6	Mainstream with specialist unit
	5.	8	12;9	Mainstream with specialist unit
	6.	4	9;8	Deaf school
	7.	7	9;11	Deaf school
	8.	7	11;1	Deaf school
	9.	7	9;1	Mainstream with specialist unit
	10.	8	11;3	Mainstream with specialist unit
	11.	5	8;1	Deaf school
Control group	12.	5	6;10	Mainstream with specialist unit
	13.	8	12;7	Deaf school
	14.	6	9;1	Mainstream with specialist unit
	15.	9	9;9	Deaf school
	16.	3	13;0	Deaf school
	17.	5	9;9	Deaf school
	18.	4	10;0	Deaf school
	19.	8	12;7	Deaf school
	20.	6	8;5	Mainstream with specialist unit
	21.	1	11;10	Deaf school
	22.	7	7;6	Deaf school

of designs, pattern construction) and one nonverbal reasoning subtest (matrices) of the British Ability Scales II (Elliott, Smith, & McCulloch, 1996). None had a history of head injury or impaired neurological function.

Control group. The control group consisted of 11 deaf children (7 boys) from hearing parents who used BSL as their primary language. Using the same set of assessments described previously all demonstrated BSL and nonverbal abilities in the normal range, with no history of head injury or impaired neurological function. See Table 1 for further details. The mean age was 10;1 (range 6;10 – 13;0; SD = 2;1). An independent samples t-test revealed no significant difference in age between the SLI and the control groups, $t(20) = -0.181$, $p = 0.858$. Children in the control group had been exposed to good models of BSL from native signers for a mean duration of 5;7 years (SD = 2;7). An independent samples t-test revealed no significant difference in BSL exposure between the two groups ($t(20) = 0.442$, $p = 0.665$). Therefore, any differences found in sentence repetition performance between the groups cannot be explained by differences in their age, and both groups have comparable quality and amount of exposure to BSL.

Stimuli

A Deaf native signer and linguist (the third author) designed 20 sentences with differing degrees of complexity attuned to the language age-range of the participants (using information from

Herman et al., 1999; Morgan, Herman, Barriere, & Woll, 2008). The sentences differed in length and contained a range of linguistic structures. The stimuli, along with an indication of the verb agreement and classifier signs, are glossed in Appendix 1, and two of the sentences are shown with video-still images in Appendix 2.

Stimuli sentences, as well as task instructions played to each child before testing were signed by the same native signer with natural speed and prosody and video-recorded. Video clips of test sentences and test instructions are available on request.

Procedure

Children were tested by a Deaf native signer (third author). The sentences were presented once to children on a 15.4-inch laptop computer and all responses were video recorded. Each child watched the task instructions and was able to ask clarificatory questions. Participants then watched three practice sentences and after each were encouraged to repeat it as exactly as possible. A further 17 sentences of increasing length were then shown and responses were video recorded for later scoring and analysis (see Appendix 1).

Scoring

Overall score. If the sentence was an exact repetition of the whole target, it was scored as 1. If there was any deviation from the target, such as omission, substitution or addition of signs, a repetition of signs in the incorrect order, a phonological error (e.g., handshape incorrectly articulated) or incorrect non-manual features, the sentence scored 0. The maximum possible score for the task was 17. Each sentence was also scored in greater detail for different linguistic devices.

Lexical content. Participants were awarded a point for exact replication of the lexical items in the target sentence, regardless of order. Any omissions, additions or substitutions of signs received a 0. The maximum possible score was 17.

Sign order. If sentences were repeated with all elements in the same order as the target sentence, even allowing for omitted signs, participants scored 1 point. The maximum possible score was 17.

Meaning. One point was awarded if the overall meaning of the sentence was accurately reproduced, even if some omissions or substitutions of lexical items were made. The maximum possible score was 17.

Facial expression. In some cases, lack of facial expression would alter the meaning of the sentence. Therefore the child would lose points for either facial expression omissions or meaning changes through lack of facial grammar. Only the correct use of the face was scored correctly and face markers were counted independent of the rest of the sentence. The maximum possible score was 17.

Verb morphology. Within each of the nine sentences that contained verb agreement (VA) and classifiers (CL), 1 point was available for correct repetition of verb morphology (see underlined sentences in Appendix 1). Only the correct use of the inflection was scored correctly and inflections were counted independent of the rest of the sentence. The maximum possible score for morphology was 9.

RESULTS

Mean overall scores for exact whole sentence repetition in both groups were low. The highest possible score was 17, but for the SLI group, the mean number of sentences repeated correctly was only 1.36 (SD = 1.44, range 0-4), and for the control group it was 3.55 (SD = 2.94, range 0-8). Under an independent samples t-test, with reduced degrees of freedom to account for unequal variances, the group difference was significant, $t(14.486) = 2.209$, $p = 0.044$. Nevertheless, there was an overlap in scores in the two groups, as shown in Figure 1, which presents the correlation between overall score and age. The correlation between overall score and age is marginally significant, at $r(22) = 0.422$, $p = 0.050$, but, as Figure 1 reveals, this is driven by the improvement with age in the control group only.

Larger differences between the groups also appeared when instead of scoring exact whole sentence repetition, a more fine-grained linguistic scoring system was used. Significant group differences were found for each linguistic element coded for: lexical content ($t(20) = 2.605$, $p = 0.017$), sign order ($t(20) = 3.176$, $p = 0.005$), sentence meaning ($t(20) = 3.506$, $p = 0.002$), and facial expression ($t(16.73) = 2.586$, $p = 0.019$). The full set of results is shown in Figure 2.

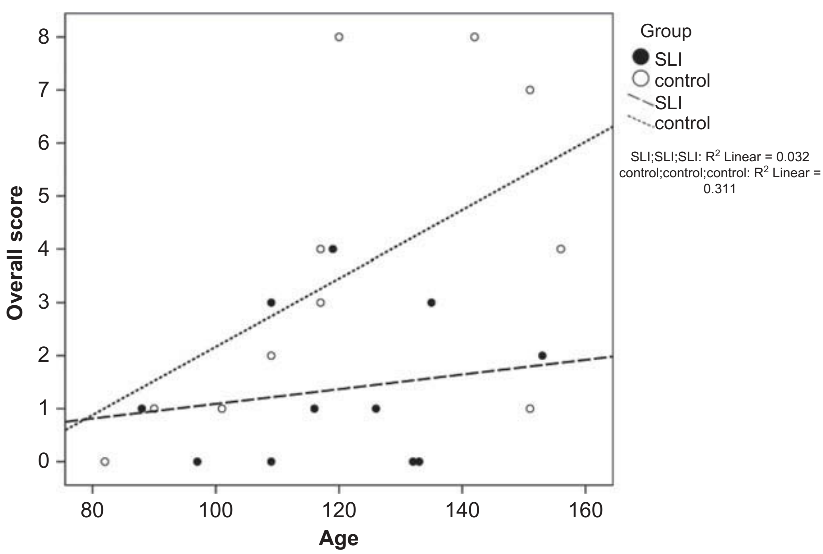

FIGURE 1 Scatterplot showing overall score (out of 17) plotted against chronological age (in months).

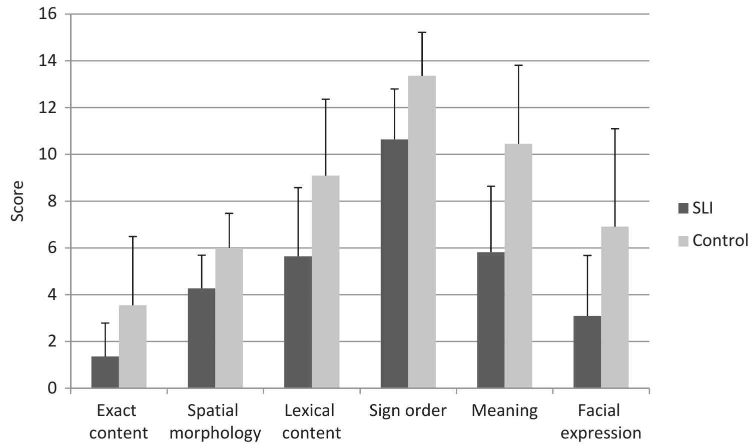

FIGURE 2 Sentence repetition scores for both groups. All scores are out of a total of 17, except for spatial morphology (total of 9). Error bars represent one standard deviation from the mean.

Because previous studies of sentence repetition in spoken languages have highlighted verb morphology as a significant difficulty for children with SLI, we looked in more detail at this feature in BSL. For sentences that included classifiers and agreement verb morphology, the highest possible score was 9. The SLI group's mean on this measure was 4.27 (SD = 1.42, range 1-6), and for the control group the mean was 6.00 (SD = 1.48, range 3-8). This group difference was significant under an independent samples t-test, $t(20) = 2.789$, $p = 0.011$.

Children made two types of errors with classifiers and verb agreement: omissions, where no attempt was made to encode spatial or agreement information in a particular sentence, and substitutions, where an attempt was made to encode information, but this was unclear or incorrect. There were many of both error types in the SLI group for example, the sentence TEDDY CL-curved-hand-ON TOP OF CUPBOARD BOY WANT WANT was repeated by one child as CUPBOARD BOY WANT WANT WANT, thus the classifier was omitted. As an example of a substitution error, one child (with SLI) repeated the sentence BOOK LOTS CL-flat-hand-ROW ROW ROW as BOOK CL-index-LINE ROW, by replacing the flat-hand object classifier in the stimulus sentence with a an index finger sign showing linearity – a finger point tracing a line.

Errors with verb agreement were also common in the SLI group. For example another child (with SLI) repeated BOY NAUGHTY BATH WATER CUP-SCOOP-WATER POUR-OUT as NAUGHTY BOY, BATH, ALL-OVER-FLOOR with incorrect verb agreement as no direct object was encoded in the inflection POUR-OUT, and this was coded as a substitution. The verb POUR-OUT was replaced by a locative description ALL-OVER-FLOOR. Although less frequent there were similar types of errors from children from the control group e.g. TREE BUSH FLOWER ME PLANT-SEED was repeated with the right classifier for BUSH, but not at the correct location in signing space, which was coded as a substitution.

The proportion of error types were broadly the same across both groups. The SLI group produced (out of 9 sentences with verb morphology) a mean total of 3.09 omissions (SD = 1.51) and

1.64 substitutions (SD = 0.67), while the control group produced a mean total of 2.00 omissions (SD = 1.40) and 1.00 substitutions (SD = 1.18). Although both groups produced more omission than substitution errors, this difference reached significance only for the SLI group on a paired samples t-test, t(10) = 2.589, $p = 0.027$. For the control group the difference between the two error types was not significant, t(10) = 1.483, $p = 0.169$.

DISCUSSION

Much previous research has revealed that hearing children with SLI perform poorly on sentence repetition tasks, with particular difficulties in the area of verb morphology (Contemori & Garraffa, 2010; Conti-Ramsden et al., 2001; Shaalan, 2010; Stokes et al., 2006; van der Lely et al., 2007). What exactly causes these difficulties in processing language is the subject of much debate. While sentence repetition difficulties have been demonstrated for a wide range of spoken languages, this profile has not previously been tested in sign language SLI. This comparison is interesting because much of sign language grammar is instantiated through visual-spatial devices on the hands and face. We hypothesized that if the group with SLI repeated sentences less accurately than the control group matched for age and BSL exposure, then this would indicate similar consequences of sign language SLI for the repetition of sentences that requires processing of BSL signs and morpho-syntax. Poor sign language sentence repetition could be attributed to differences in how efficiently children use their phonological loop, linguistic computation or information processing abilities and this will have impacted their sign language acquisition.

It could have been the case that sentence repetition is uniquely difficult for spoken language SLI, as visual-spatial information in sign grammar might have been processed via supporting cognitive systems outside of the language faculty. This result would have suggested that SLI is a disorder of spoken language only rather than of *language* per se. What is dramatic is that the results of SLI on sentence repetition are strikingly similar across modalities, reinforcing the notion that visual space is grammaticalized in sign languages and processed as such in the brain (e.g., Emmorey, McCullough, Mehta, & Grabowski, 2011). Perhaps more compelling is that taken together with Marshall et al. (2013), the current findings show children with sign SLI have a profile that is characteristic of the disorder, that is, strengths in semantic knowledge and weaknesses in sentence repetition, including the repetition of verb morphology. A further overlap with the spoken SLI literature is that the typically developing control group's score increased with age while that of the impaired signers did not (Ebbels, Dockrell, & van der Lely, 2012; Rice, Redmond, & Hoffman, 2006).

We do not have norms for native signers on this task so we cannot say exactly how well children of this age should repeat the sentences. However when success on the test was determined by exact repetition, even though the SLI group scored significantly lower, scores were in fact low for both groups. This finding suggests that the task is difficult for children who experience non-native acquisition and more so for children with SLI. Late language acquisition has been shown to have implications for language processing in studies of adults (Mayberry, 2010) and second language acquisition in general (Newport, 1990).

By scoring in a more fine-grained fashion for repetition of different linguistic elements of the sentence, performance differences between the groups remained and were larger. This more detailed analysis revealed that in all aspects of the task the SLI group performed worse than the controls. Accuracy on a sentence repetition test is linked to several levels of language. It is not clear exactly what sequence the processing occurs in sentence repetition. Presumably children have to access individual sign meanings quickly and interpret possible utterances given the syntactic context. Children who understand the sentences easily rather than just repeating what they see would be able to use this to predict and rehearse these signs in the phonological loop more efficiently (Riches et al., 2010). If this is what sentence repetition relies on, then a sign language disorder in the acquisition of the morphosyntax would slow down or impair this processing.

In a sign shadowing task, which resembles sentence repetition but contains reduced working memory demands, late language acquisition causes adult ASL signers to spend more time processing the surface form of signs rather than accessing the underlying meanings in sentences (Mayberry, 2010). The nonnative signers in the current study in both experimental groups are thus using a less efficient system, but we see that language impairment leads to more frequent errors compared with non-native but unimpaired signers. Furthermore, an analysis of the morphosyntactic errors revealed that the types and proportions of errors were similar across groups.

In the types of sentences used in the test, meanings were determined by verb morphology, spatial devices or emphasis marked by facial expressions. Nonnative skills in the control group are still better able to deal with this high level of linguistic processing than children with SLI. In order to deal with these sentences children have to process several pieces of information produced simultaneously over different articulators. The result from our analysis of morphosyntactic errors is that late but unimpaired language acquisition differs only in degree from sign SLI. The sentences used in the experiment were generated from a corpus of stimuli used in the BSL grammatical comprehension test (Herman et al., 1999). This gave us information about the age of acquisition of these structures and also examples of child-friendly sentence types. However, there was no control for sentence position of morphological information or sentence length. Different sentences might have made different demands on working memory. Future studies would benefit from manipulating this factor more systematically.

One potential concern about our results is that testing native signers would be the ideal option for studying language impairment in sign language users. However, such children are rare, making up only 5–10% of the population of deaf children, and recruiting an even smaller number of these children with SLI would be exceptionally challenging. We addressed this issue in our study by using a comparison group of deaf children who had similar experiences of learning BSL, and none of whom were native signers. Therefore, it is remarkable that given that the majority of the research literature on spoken SLI is on monolingual children who are learning their language from birth, the deaf SLI group demonstrated the same characteristic impaired sentence repetition and impaired repetition of comparable structures as hearing children with SLI.

This study contributes to a growing body of cross-linguistic evidence demonstrating that despite differences in the presentation of SLI related to language-specific properties, the general profile looks broadly similar across spoken languages (Schulz & Friedmann, 2011). We also understand more about how sign language SLI presents itself: the disorder influences language processing in similar but more extreme ways to late language acquisition. We previously touched on the debate about the causes of SLI, and our data do not allow us to tease apart the competing theories. Nevertheless, considering signing children moves the field closer to a supra-modal explanation of SLI, that is, a disruption to language processing in both the visual and auditory modalities.

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APPENDIX A. ENGLISH GLOSSES OF BSL SENTENCES. VERB AGREEMENT IS INDICATED BY VA AND CLASSIFIERS BY CL

1. BOY WAIT 'the boy is waiting'
2. GIRL WRITE 'the girl is writing'
3. BOOK LOTS CL-flat-hand-ROW ROW ROW 'lots of books in a line'
4. BOY DON'T LIKE DRINK VA-PUSH-AWAY 'the boy doesn't like the drink and he moves it away'
5. MAN CYCLE ENJOY BREEZE 'the man is riding along happily in the nice breeze'
6. BOOK BOY VA-GIVE 'the boy gives the book away'
7. DOG DISAPPOINTED BONE SMALL 'the dog is disappointed with his small bone'
8. BOY EATS CRISPS ENJOY DELICIOUS 'the boy is enjoying eating the tasty crisps'
9. DOG CL-bent-v-hand-UNDER-BOX HIDING DOG-PAWS 'the dog is hidden under the box with his legs out'
10. TEDDY CL-curved-hand-ON-TOP-OF-CUPBOARD BOY WANT WANT 'there is a teddy-bear on top of the cupboard that the boy really wants'
11. COT BABY SLEEP LIE-BACK-SLEEPING 'the baby is sleeping flat-out in the cot'
12. TREE BUSH FLOWER ME CL-pincer-hand-PLANT-SEED 'Between the tree and the bush the seeds were planted in a line'
13. BROTHER IX SISTER IX VA-HIT-BROTHER 'there is a brother and a sister and she hits the brother'

14. BOY NAUGHTY BATH WATER VA-CUP-SCOOP-WATER POUR-ON-FLOOR ‘there is a naughty boy in a bath and he throws water on the floor’
15. MAN WOMAN CL-index-finger-extended-WALK-TOWARDS-EACH-OTHER SEE-EACH-OTHER WALK-AWAY ‘the man and woman walk up to each other, meet and then turn away and depart’
16. MUM CHAIR READING VA-BOY-SAME-CHAIR-READING ‘the mum is in the chair reading to the boy who is in the same chair’
17. GIRL WALKS SUDDENLY RAIN CLOTHES AWFUL WET ‘the girl is walking along when all of a sudden there is a big rain storm and she gets really soaking wet’

APPENDIX B: FIGURES OF SPATIAL MORPHOLOGICAL DEVICES USED IN THE SENTENCES

Sentence 6. BOOK BOY VA-GIVE

Sentence 15. MAN WOMAN CL-index-finger-extended-WALK-TOWARDS-EACH-OTHER SEE-EACH-OTHER WALK-AWAY

(Color figure available online.)