The Gestural Abilities of Children with Specific Language Impairment

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Abstract

Background: Specific Language impairment (SLI) is diagnosed when language is significantly below chronological age expectations in the absence of other developmental disorders, sensory impairments or global developmental delays. It has been suggested that gesture may enhance communication in children with SLI by providing an alternative means to convey words or extend utterances. However, gesture is a complex task which requires the integration of social, cognitive and motor skills, skills that some children with SLI may find challenging. In addition there is reason to believe that language and gesture form an integrated system leading to the prediction that children with a SLI may also have difficulties with gestural communication.

Aims: The aim of the current study was to explore the link between language and gesture in children with poor language skills.

Methods & Procedure: Fifteen children with SLI and 14 age-matched typically developing children (TD) participated in this study.   The children completed measures of expressive and receptive vocabulary, non-verbal cognition, motor control, gesture comprehension and gesture production.

Outcomes & Results: TD children achieved significantly higher scores on measures of gesture production and gesture comprehension relative to children with SLI. Significant correlations between both measures of vocabulary and both measures of gesture, suggest a tight link between language and gesture.

Conclusions & Implications: The findings support the idea that gesture and language form one integrated communication system, rather than two separate communication modalities. This implies that children with SLI may have underlying deficits that not only impact on language but also on gesture production and comprehension.

What this paper adds?

What is already known?

Language and gesture are intimately related in TD children and many argue that they form an integrated communication system. However, this is at odds with the small amount of literature on gesture in children with SLI; which suggests a separable system in which gesture may be used to compensate for core language deficits.

What this study adds?

The findings indicate that children with SLI have communication difficulties that extend to measures of gesture production and gesture comprehension, even when factors such as age and non-verbal cognition are taken into account. This pattern of findings indicates that when there is a language breakdown, there may also be a breakdown in gestural communication. This supports the idea that gesture and language form one integrated communication system, rather than two separate communication modalities.

Introduction

Specific Language Impairment (SLI) is generally defined as a language impairment that occurs in the absence of other developmental concerns, sensory impairments or global developmental delays and is thought to affect around 3-7% of all children entering school (Tomblin et al., 1997). Investigating gesture use in this population is of interest because many assume that gesture can enhance communication in children with SLI by providing an alternative means to convey words or extend utterances (Iverson and Braddock, 2011). However, gesture is a complex skill which requires the integration of social, cognitive and motor skills. In children with language difficulties these skills may be impaired (Stothard et

al., 1998, Johnston et al., 1981) and it is unclear how this impacts on their ability to understand and produce gestures during communication.

Gesture and Language in Typical Development

Gesture and language typically develops in tandem, with gesture emerging slightly before the onset of spoken communication (Goodwyn and Acredolo, 1993). During the first year of life, infants produce significantly more gestures than spoken words when communicating with others (Volterra et al., 2005). Gesture enables children to create more complex utterances by combining gesture and speech together, rather than simply speech alone (Blake et al., 2008). Although in the early years, infants show a preference for gestural communication, this begins to decrease around 20 months, when verbal communication starts to become the dominant mode of communication (Capone and McGregor, 2004).

Longitudinal studies have demonstrated that early child gesture use at 14 months predicts language development at 42 months (Rowe et al., 2008). In addition Rowe et al. (2008) found parent gesture use is positively correlated with child gesture use. This implies that parental gesture use may indirectly influence vocabulary development through child gesture. This is a notion supported by Rowe and Goldin-Meadow (2009) who found differences in child vocabulary size at 54 months to be related to differences in gesture use at home at 14 months. In addition, experimental studies have demonstrated that encouraging gesture use in children improves oral language development (Namy et al., 2000). Furthermore, Goodwyn and Acredolo (1993) demonstrated that symbol use develops earlier in those children whose parents have actively modelled gesture-word pairs while interacting with their child.

As well as being of benefit to language acquisition, gesture use can promote children's learning in other areas. For example, when verbal instructions are accompanied by gesture,

children are better able to comprehend instructions, especially if the utterance is complex

(McNeil et al., 2000). Also, the act of using gesture whilst trying to solve a problem can help

to relieve the cognitive load of a task, ensuring more cognitive resources are available to solve

the task at hand (Goldin-Meadow et al., 2001). For example, Goldin-Meadow et al. (2001)

asked participants to solve a maths problem whilst also remembering letters. Those

participants who were allowed to gesture remembered more of the letters than those

participants who were prohibited from gesturing. This suggests that the act of gesturing can

lighten the cognitive load imposed by the maths problem, creating more available space in

working memory to remember the letters.

Although it is clear from the literature that gesture and language development occur

together, there is some debate as to how these two communication systems interact with one

another. On the one hand, it has been proposed that gesture and spoken language form two

separate communication systems and that gesture simply facilitates spoken communication

(Hadar et al., 1998). With regard to language impairment, if gesture and speech form two

separate communication systems, there is no a priori reason to assume that children with

language impairment would have deficits in gesture use or comprehension. As such, children

with SLI should be able to use gesture as a compensatory mechanism. However, other

researchers have suggested that gesture and speech form an integrated communication system

(McNeill, 1992). This theory would suggest that, similar to adult aphasia where speech and

gesture are seen to break down together (McNeill, 1992), children with language impairments

may also display difficulties with gestural communication.

Gesture Use and Motor Control Abilities in Language Impairment

The literature suggests that the difficulties children with SLI exhibit may not be specific to

language and may extend to difficulties with attention (Tallal et al., 1989), procedural

memory (Ullman and Pierpont, 2005), working memory (Marton and Schwartz, 2003), perception impairments (Tallal et al., 1993) and non-verbal cognitive development (Stothard et al., 1998). For example, Stothard et al. (1998) found in a follow up study, that children with persistent language difficulties also displayed non-verbal cognitive scores below the normal range, whereas children whose language difficulties had resolved did not show these below average non-verbal IQ scores. As non-verbal cognition appears to be a marker for developmental delay, this may also be an important variable to consider when exploring non-verbal communication, as it is likely that non-verbal abilities relate to gesture skill.

Studies also suggest that children with SLI perform less well than TD children on gross motor tasks (Powell and Bishop, 1992), fine motor tasks (Johnston et al., 1981), have difficulties producing hand sequences (Dewey et al., 1988), and that their motor abilities are akin to those of younger TD children (Hill, 1998). Furthermore it has been reported that the motor profiles of children with SLI resemble children with Developmental Co-ordination Disorder (DCD) (Hill, 1998). For example, Hill (1998) reported that, during a elicited representational gesture task, when children were asked to either imitate a gesture or were given a verbal command to produce a gesture (e.g. asked to gesture "brushing their teeth"), they produced less accurate gestures than age-matched TD peers. Hill reported that children with SLI made errors similar to children with Developmental Co-ordination Disorder (DCD) and a younger TD comparison group. This was true even for the children with SLI who had motor abilities within the normal range, indicating that their difficulties were not solely due to a motor impairment. As gesture use requires motor movements, it is important to establish how these two skills interact and to what extent successful gesture communication requires motor skill. It may be that the difficulties some children with SLI have using gesture for communicative purposes is attributable to co-occurring motor deficits.

Within the literature there is some debate as to how and when children with SLI use gesture during spontaneous communication. On the one hand, some studies have found that children with SLI produce significantly more gestures than their TD peers. For example, Iverson and Braddock (2011) asked children to tell stories from cartoon sequences and a wordless picture book. Iverson and Braddock (2011) found that despite saying fewer utterances per minute, producing fewer different words and having a shorter mean length of utterance than TD children, those with SLI gestured at a higher rate, suggesting that children may be using gesture to compensate for their language difficulties. This is supported by Mainela-Arnold et al. (2014) who also found that children with SLI gestured more frequently than TD peers. On the other hand, some studies have found that children with SLI do not gesture more frequently than TD children (Evans et al., 2001, Blake et al., 2008). Blake et al. (2008) asked children with SLI, age-matched TD peers and a younger TD group matched on verbal ability to the children with SLI, to complete two spontaneous communication tasks, a narrative recall task, and a classroom description task. In contrast to Iverson and Braddock (2011), Blake et al. found no differences between children with SLI and either the age-matched or language-matched comparison groups in the frequency with which they produced iconic, beat or deictic gestures, raising the possibility that children with SLI do not necessarily use gesture to compensate for their language difficulties. However, they did find children with SLI used gesture to replace words more often than TD controls. This is supported by Evans et al. (2001) who investigated gestures rates as children completed a Piagetian conservation task. Similarly to Blake (2008) they found that whilst children with SLI gestured at similar rates to TD children, children with SLI were more likely to express unique information through gesture, whereas TD children were more likely to use redundant gestures, expressing the same concepts in both speech and gesture. It is difficult to draw firm conclusions about gesture use in SLI. There are considerable differences across studies with

regard to task demands and gesture variables, as well as differences in participant characteristics, such as age. For example, the children in the Evans et al. (2001) study were aged 7-9 years, where as Iverson and Braddock's (2011) study examined children aged 2 to 6 years. As gesture use develops and changes throughout childhood (Capirci et al., 1996), it stands to reason that children with SLI of different ages and different developmental stages may use gesture in different ways. This is particularly important to the types of gestures produced at different developmental stages. For example, in the Iverson and Braddock (2011) study, predominantly, deictic and conventional gestures were produced by children, where as in the Blake et al. (2008) study the gestures were predominantly representational. These differences in methodology may help to explain the conflicting results across studies.

Although studies have investigated gesture skill in children with SLI, few have considered gesture, language and motor skill in the same cohort of children with SLI. Many previous studies for example have looked at only one or two of these elements. An exception is Botting et al. (2010) who explored motor skill and gesture in relation to SLI in school aged children (4-7 years old). In addition to exploring language, motor control and gesture production, this study also explored gesture- speech integration in a gesture comprehension task. Botting et al. (2010) found that the gesture production and motor control scores of the SLI group did not differ significantly from a group of age matched TD controls. They also found that these two skills did not correlate with each other in the SLI group. However, differences were found on the gesture comprehension task. During this task children were presented with a spoken sentence of which the last word had been replaced with a gesture. Following this they were asked to identify the missing word from a choice of four pictures (including a semantic distractor, gesture distractor and unrelated distractor). TD children achieved higher accuracy scores than peers with SLI. In addition, when children failed to integrate gestural and spoken information in an utterance, the TD group were more likely to

rely on the spoken cues and so were more likely to select the semantic distractor.   In contrast, the children with SLI were more likely to select the gesture distractor, suggesting children with SLI had failed to extract the intended gesture meaning.

A limitation of Botting's study is that the motor control task used was a bead threading task, assessing fine motor skill. Whilst fine motor skill is involved in gesture production, the nature of a bead threading task does not necessarily assess the same motor skills that are required for gesture. This may explain why no correlation between gesture production and motor control was found in the SLI group. A motor task that assesses the ability to produce non-meaningful hand positions more closely related to gesture may reveal how motor control is linked to gesture and language production. Also, although Botting et al. (2010) report that the groups did not differ significantly on measures of gesture production, motor control and non-verbal cognition, Botting et al's (2010) study suggests wide variation in performance and group differences of moderate effect size for motor control ($d = .81$) and non-verbal cognition ($d = .56$). Non-verbal cognition was also significantly correlated with gesture production ($r = .47$). As the co-occurrence of non-verbal cognitive difficulties is common amongst children with SLI (Botting, 2005; Stothard et al. 1998) it would be interesting to examine differences in the gestural abilities of children with SLI relative to TD peers when differences in non-verbal cognition are taken into account.

The research presented raises further questions of how language, gesture and motor skill relate to each other in children with SLI. Specifically, whether children with SLI use gesture as a compensatory mechanism when struggling with spoken language, or whether the language deficits associated with SLI also create difficulties with gestural communication. In the current study, we aim to replicate and extend Botting et al.'s (2010) work by exploring the relationship between gesture, language and motor skills after controlling for other important variables, such as non-verbal cognition.   Also, we assess non-symbolic motor production in a

gesture imitation task. This task enabled us to explore children's abilities to produce the hand and arm movements required for gesture production without any communicative intention or symbolic understanding.

We hypothesised that if gesture and speech form an integrated system then children with SLI will have significantly lower scores on measures of gesture comprehension and gesture production compared to TD children, after controlling for differences in non-verbal cognition and age. Specifically, we expected children with SLI to produce fewer accurate gestures during the gesture production task, make more comprehension errors during the gesture comprehension task and imitate fewer hand positions accurately during the motor control task. Also, significant positive correlations should were expected between language measures and measures of gesture production and comprehension. However, if gesture and speech form separate systems then gesture use in children with SLI was expected to be commensurate with TD peers and unrelated to language level.

Method

Participants

Twenty nine children participated in this study, 15 with Specific language impairment (SLI) and 14 age-matched typically developing (TD) children. The SLI group comprised 12 males and 3 females aged between 4; 4 and 8; 9 years old (mean = 5; 11 years old, SD = 18 months) who were recruited from the Speech and Language Therapy Department of North Tees and Hartlepool NHS Foundation Trust in Northern England and who were all being seen by a Speech and Language Therapist for language learning needs prior to the start of the study. Children in the TD group were recruited from a mainstream primary school and comprised 6 males and 8 females aged between 4; 0 and 7; 7 years old (Mean = 5; 11 years old, SD = 15months). There were no significant difference between the ages of the two

groups (t (27) = .08, p =.94). Although there were different numbers of males and females in each group no gender differences were found on any of the tasks (see Table 1)

Lancaster University Ethics Committee, the East Midlands Research Ethics Proportionate Review Sub-Committee, and the local NHS Trust Research and Development Department approved the project protocol. Written parental permission was obtained for each child in the study prior to testing and from the head teacher of the participating school.

<p align="center">***INSERT TABLE 1 ABOUT HERE***</p>

Procedure

All children were seen individually, in a quiet room, by the researcher for approximately 45 minutes and were asked to complete six tasks, including measures of non-verbal cognition, vocabulary, motor control and gesture. All 29 children completed all six tasks with the exception of two children with SLI whose data was excluded from the motor control task due to lack of co-operation. Breaks between tasks were given to ensure that children did not become tired.

<p align="center">***INSERT TABLE 2 ABOUT HERE***</p>

Background Measures

Background measures of expressive and receptive vocabulary and non-verbal cognition were completed by all children (see Table 2 for means). Expressive vocabulary was assessed using the Expressive One Word Picture Vocabulary Test (Brownell, 2000) and receptive vocabulary through the British Picture Vocabulary Scale (Dunn, Dunn, Whetton & Burley, 1998). In addition the Raven's Coloured Progressive Matrices (Raven and Court, 1998) was administered to provide an estimate of the children's non-verbal reasoning skills. The maximum score children could achieve for this task was 36.

Motor Control

The motor task comprised a meaningless gesture imitation task (Berges and Lézine, 1965) and assessed children's ability to produce 36 manual motor positions similar to that required for gesture production. During this test the researcher performed a number of gestures with her hands or arms and asked the child to imitate each gesture in turn. The task began by demonstrating 20 simple gestures, 10 hand gestures (e.g. holding one hand open and one hand closed in a fist) and 10 arm gestures (e.g. left arm vertical and right arm horizontal) , and asking the child to copy each gesture after s/he had seen it. The child was then shown 16 complex hand gestures (e.g. Index finger and little fingers of both hands touching each other) and was asked again to copy each gesture that they saw. Children were video recorded during this task so that the gestures could be coded off-line. Two points were awarded if the gesture was imitated exactly, one point if it was partially correct (e.g. hand position correct but not hand configuration and vice versa), and a score of zero if both position and configuration were inaccurate. A maximum score of 72 was possible on this task. Inter rater reliability analysis showed acceptable reliability for this task (kappa =.85, *p<*.001).

Gesture Production

The gesture production task (Botting et al., 2010) required the child to describe pictures (e.g. hat, monkey and boxing), that appeared on a laptop screen, using their hands. During this task the researcher wore head-phones so that they could not hear the child and asked the child to describe the pictures that appeared on the laptop screen to the researcher using their hands. If the child tried to describe the picture using words the researcher reminded the child that they could not hear them, and asked the child again to describe the picture with their hands, to encourage the child to complete the task. Each child was shown 20 pictures and responses were video recorded so that their gestures could be coded off-line. Each child's gesture was scored on a scale of 1-5 according to how closely related it was to the target picture, 1 being

'not related at all' and 5 being 'perfectly understandable gesture' (Botting et al., 2010, p7). A maximum score of 100 was possible on this task. Analysis indicated good inter-rater reliability for the gesture production task (kappa = .92, $p<.001$).

Gesture Comprehension

The gesture comprehension task (Botting et al., 2010) aimed to examine how effectively children were able to integrate gesture and speech in a comprehension task. Each child saw a series of video clips of a spoken sentence where the last word of the sentence was replaced by a gesture; for example 'swimming in the sea, I saw a [fish gesture]'. Following the video clip the child was shown four pictures and was asked to point to the picture that best illustrated the gesture that had replaced the missing word. The four pictures presented included a gesture based distractor, which fitted the gesture made in the video but not the semantic context (e.g. "Snake"), a semantic distractor which would be a picture of an item that fitted the semantic context of the video but not the gesture (e.g. "Boat"), an unrelated distractor that did not fit in with the context or the gesture (e.g. "Guitar") and the target picture ("Fish"). Each child saw 25 video clips in total. In between the experimental items, an animation appeared such as fireworks in order to re-focus the child's attention onto the screen before the next video clip was shown. Accuracy was recorded, as well a record of their incorrect choices (e.g. whether they chose the semantic distractor, gesture distractor or unrelated distractor instead of the target item). A maximum score of 25 was possible on this task.

Results

INSERT TABLE 3 ABOUT HERE

Shapiro-wilk test indicated a normal distribution and Levene's test revealed homogeneity of variance on experimental tasks for both groups.

We explored the relation between age and non-verbal cognition on all language, motor and gesture scores. As can be seen by Table 3 these were significantly correlated, as a result all remaining analyses used age and non-verbal cognition as covariates and raw scores as dependant variables. A series of ANCOVAs showed TD children obtained significantly higher scores, of large effect, than the SLI group on measures of expressive vocabulary ($F(1, 25) = 25.26$, $p<.001$, $d= 1.90$), receptive vocabulary ($F(1, 25) = 26.98$, $p<0.001$, $d = 2.09$), gesture production ($F(1, 25)= 20.33$, $p<0.001$, $d= 1.23$) and gesture comprehension ($F(1, 25) = 16.22$, $p<.001$, $d=.1.60$). However, no significant differences were found between groups on the motor control task ($F (1, 23) = 0.12$, $p=.73$, $d=.42$), though the effect size was moderate (see Table 4 for means).

INSERT TABLE 4 ABOUT HERE

Gesture comprehension error analysis

Of particular interest on the gesture comprehension task is the type of errors that children made when they were unsuccessful in integrating gesture and speech (see Table 5). The percentage of error types was calculated for each child (e.g. number of semantic-type errors /total number of gesture errors X 100). As these data are not independent, statistical analyses were not performed, but data were plotted to provide an indication of response preferences. As can been seen in Figure 1, the TD group tended to make semantic based errors (choosing a response consistent with the semantic content) whilst the SLI group made more gesture based errors than the other two error types. These were visually similar to the target but inconsistent with sentence meaning.

INSERT TABLE 5 ABOUT HERE

INSERT FIGURE 1 ABOUT HERE

Motor control, gesture and language.

INSERT TABLE 6 ABOUT HERE

To assess the relationship between gesture, motor and language tasks, a partial correlation was conducted, controlling for age and non-verbal ability. As can be seen in Table 6 when the two groups were combined, significant positive correlations were found between gesture production and gesture comprehension (r (25) = .62, p <.01). In addition, gesture production was significantly correlated with both expressive (r (25) = .69, p<.001) and receptive language (r (25) = .65, p<.001). Significant correlations were also seen between gesture comprehension and expressive (r (25) = .57, p<.01) and receptive language (r (25) = .53, p<.01). However, motor control was not significantly correlated with gesture production (r (23) = -.20 p=.33) or comprehension (r (23) = .01, p =.97). Due to small sample size few of these correlations remained significant when analysing the groups separately.

Discussion

The aim of this paper was to explore the relationship between language, gesture and motor skill in children with SLI. To do this we attempted to replicate the findings of Botting et al. (2010), taking into account important variables such as age and non-verbal cognition. As non-verbal cognition is a marker for general developmental delay, and the literature suggests that the co-occurrence of non-verbal cognitive difficulties is common amongst children with SLI, we reasoned that non-verbal abilities would be related to gesture skill. Indeed, there was a significant relationship between non-verbal reasoning skills and gesture scores.

We found support for the hypothesis that gesture and speech form an integrated system meaning children with SLI will display difficulties with gesture skill. Children with SLI scored significantly lower than TD children not only on verbal language tasks but also on gesture production and gesture comprehension tasks, even when controlling for age and non-

verbal cognition. This finding is consistent with others who have explored the gestural abilities of children with SLI (Dewey et al., 1988, Hill, 1998) and partially replicated the findings of Botting et al. (2010). Botting et al. (2010) also found significant group differences on the gesture comprehension task; however, they did not find significant group differences on the gesture production task. This may be explained by the differences in ages used in the two studies. The current study had a wider age range of participants, including older children. It may be that, with age, the differences between TD and SLI children's gestural abilities becomes more pronounced. This does highlight developmental changes in gesture use, something which it would be interesting to explore in future longitudinal studies. We did successfully replicate the Botting et al. (2010) finding that when children with SLI made errors on the comprehension task, they showed a preference for gestural cues on the gesture comprehension task. In contrast, TD children appeared to rely more on semantic cues. This indicates that whilst children with SLI are able to recognise motor hand movements, either they failed to extract the movement meaning or failed to integrate the gesture meaning with semantic context. This pattern of findings suggests that children with SLI are more likely to benefit from redundant gestures, in which the gesture reinforces the verbal message, as opposed to extending gestures, in which the gesture provides additional information not realised in speech. A more direct measure of gesture comprehension, not confounded with language comprehension is needed.

We also found no significant correlation between motor ability and gesture production, similarly to Botting et al. (2010). In addition, no differences were found between groups for motor control ability, which suggests that children with SLI have difficulties generating gestures even when their motor abilities are sufficient to do so. This contradicts studies such as Powell and Bishop (1992) and Dewey at al. (1998) who found children with SLI to be impaired on motor tasks. However, these results may be due to the nature of how

motor skill was assessed. For example, although (Dewey et al., 1988) also explored gross hand movements, they focused on hand sequences, which may be more challenging than imitating hand positions. A motor sequence task may also more closely correlate with gesture production. Thus, whilst children with SLI are able to make hand positions required for gesture production; they may struggle once these movements are combined into sequences (as in communicative gesturing). Further research looking at different types of motor skill task with the same cohort of children with SLI may provide further evidence as to when and if motor weaknesses associated with SLI impact on gesture skill.

The difficulties displayed by children with SLI in gesture production challenges the conclusions of Botting et al. (2010) that gestural production abilities are robust in the face of language impairment. Instead our findings suggest that gestural difficulties may be part and parcel of developmental language impairments.   We did however, find strong significant correlations between both the vocabulary (expressive and receptive) and gesture (production and comprehension) tasks. These results indicate an intimate link between gesture and language supporting studies which have found similar relationships in younger children (Rowe et al., 2008). This has implications for the suggestion that children with SLI use gesture as a compensatory mechanism and gesture more than TD children to supplement spoken language (Iverson and Braddock, 2011, Evans et al., 2001, Blake et al., 2008). However, the current study looked at accuracy of gesture production during a structured task and did not explore spontaneous use of gesture. Iverson and Braddock (2011) have reported this group to be unimpaired on the frequency of gesture production. It may be that while children with SLI have difficulties with the execution of gestures, this does not hinder their attempts or motivation to use gesture to communicate and they may use gesture more frequently than TD children. If this is the case, interventions aimed at improving the accuracy

and formation of children's gestures in relation to spoken language may help children's communication attempts.

Limitations and Future Directions

Our findings show strong relationships between language and gesture within our sample. However, one limitation of this study may be that the SLI group's standard scores on the expressive and receptive vocabulary test fall within the low average range. Although this may suggest that children with SLI did not have significant vocabulary difficulties, all children with SLI were recruited through a Speech and Language Therapy department and were all currently being seen by a Speech and Language Therapist for language learning difficulties, which were not necessarily related to vocabulary. A test of grammar would have been useful in this study and would have provided further background into the extent and quality of language deficits within the SLI group; however due to time constraints this was not possible. Nevertheless, it is theoretically interesting that despite relatively mild vocabulary deficits, this group still displayed difficulties with both gesture production and gesture comprehension in structured tasks. A second limitation is the small sample size in this study, although it is in keeping with previous research (Iverson and Braddock, 2011) on gesture, it is small and a larger sample size would allow expansion of the current study.

Although the results of the current study indicate that children with SLI have difficulties with gestural communication, the error analysis suggests that, when comprehension is difficult, children with SLI may still rely on to gestural cues over semantic cues. This suggests that accompanying speech with complementary gestures may serve as an effective way to support children who are struggling with spoken communication. Further research exploring this would enable us to examine whether children with SLI are able to utilise gesture cues in a learning environment. Goldin-Meadow et al. (1999), show that

gesture use aids typically developing children's learning, but as of yet it is unclear whether gesture cues alongside speech benefit children with SLI in the same way. If children with SLI are able to utilise gesture to aid language comprehension, then future research is needed to explore whether encouraging children with SLI to gesture has beneficial effects on understanding instructions and subsequent completion of difficult task, similarly to the TD children previous research (Goldin-Meadow et al., 1999).

In conclusion, the findings of this study indicate that children with SLI have communication difficulties that are not isolated to oral language, but extend to measures of gesture production and gesture comprehension, even when factors such as age and non-verbal cognition are taken into account. Also, the significant correlations found between both gesture production and gesture comprehension and expressive and receptive vocabulary, indicate an intimate relationship between gesture and language. This pattern of findings indicates that when there is a language breakdown, there may also be a breakdown in gestural communication. Although further research is needed to explore areas such as spontaneous use of gesture in children with SLI, and the extent to which gesture can be improved in SLI, the results of this study support the idea that gesture and language form one integrated communication system, and questions the use of gesture as a compensatory mechanism in SLI.

Table 1: Gender differences on all tasks.

Measure	Male Mean (SD) (n =18)	Female Mean (SD) (n = 11)	Comparison	*p* value
Expressive Vocabulary	73.28 (19.65)	76.55(21.83)	$F(1,27) = .17$	.68
Receptive Vocabulary	60.00 (20.57)	61.27 (21.02)	$F(1,27) = .03$	.87
Non-Verbal Cognition	17.50 (1.44)	17.82(6.00)	$F(1,27) = .03$	.87
Motor Control*	61.50 (14.04)	55.00 (7.73)	$F(1,25) = 2.4$	.13
Gesture Production	61.17 (16.00)	64.27(12.92)	$F(1,27) = .30$	.59
Gesture Comprehension	14.22(4.44)	13.91(4.97)	$F(1,27) = .03$	.86

*Two children were excluded from the motor task (Male n= 16).

Table 2: Mean (SD) raw scores and mean standard scores for all background measures.

Measure		TD (n=14)	SLI (n=15)	Cohen's d
Age		71.64 (15.11)	71.13(18.91)	.03
Expressive Vocabulary	Raw Score	88.93 (14.51)	61.07 (14.74)	1.90
	Standard Score	115.29 (10.66)	92.47 (11.57)	
Receptive Vocabulary	Raw Score	75.64 (14.34)	46.33 (13.67)	2.09
	Standard Score	115.36 (7.64)	88.67 (14.71)	
Non-Verbal Cognition	Raw Score	19.93 (5.57)	15.47 (3.25)	.98
	Standard Score	110.07 (9.70)	97.13 (15.47)	

Table 3: Correlation matrix demonstrating relationship between raw scores all measures.

	Age	Non-verbal Cognition	Receptive Vocabulary	Expressive Vocabulary	Motor Control	Gesture Production
Non-verbal Cognition	.41*	-				
Receptive Vocabulary	.40*	.74**	-			
Expressive Vocabulary	.47*	.65**	.89**	-		
Motor Control	.42*	.67**	.58**	.58**	-	
Gesture Production	.68**	.49**	.73**	.79**	.32	-
Gesture Comprehension	.51**	.71**	.78**	.79**	.52**	.76**

*p<.05 **p<.01

Table 4: Mean (SD) scores for motor control and gesture tasks.

Measure	TD	SLI	Cohen's d
Motor Control	61.07 (8.30)	56.46 (13.24)	.42
Gesture Production	70.36 (10.85)	54.87(14.20)	1.23
Gesture Comprehension	17.07 (4.27)	11.33(2.76)	1.60

Table 5: Mean (SD) raw error types and mean (SD) percentage error types for each group.

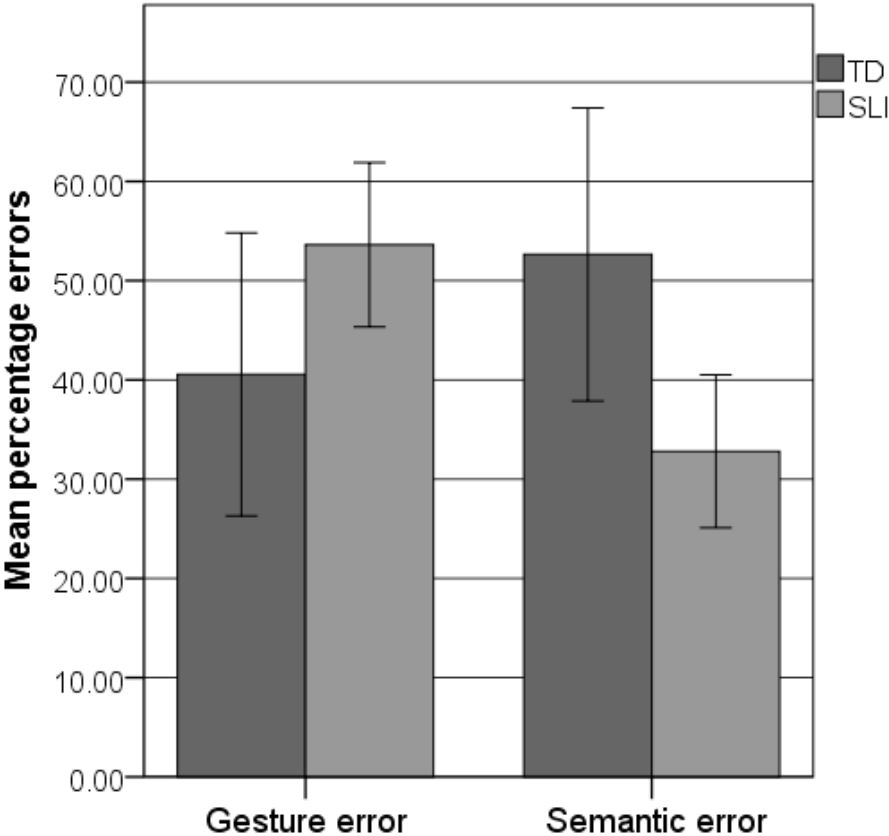| Error Type		TD	SLI
Gesture Error	Raw errors	3.14 (2.35)	7.33 (2.13)
	Percentage errors	40.55 (24.70)	53.62 (14.96)
Semantic Error	Raw errors	3.93 (2.02)	4.60 (2.44)
	Percentage errors	52.64 (25.58)	32.81 (13.93)
Unrelated Error	Raw errors	0.64 (0.75)	2.00 (1.65)
	Percentage errors	6.80(8.29)	11.58 (9.57)

Table 6: Correlation matrix demonstrating relationship between language, motor imitation and gesture tasks, controlling for age and non-verbal cognition scores.

	Receptive Vocabulary	Expressive Vocabulary	Motor Control	Gesture Production
Expressive Vocabulary	.79**	-		
Motor Control	.14	.20	-	
Gesture Production	.65**	.69**	-.20	-
Gesture Comprehension	.53**	.57**	.01	.62**

*p<.05 **p<.01

Figure 1: Mean percentage of gesture and semantic errors produced for each group.

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