Short term memory skills in children with SLI: the effect of verbal and nonverbal task content.

Abstract

Background and design: In recent years, evidence has emerged that suggests specific language impairment (SLI) does not exclusively affect linguistic skill. Studies have revealed memory difficulties, including those measured using non-verbal tasks. However there has been relatively little research into the nature of the verbal/non-verbal boundaries either at a conceptual or a task-related level. This study explores the short term memory performance of children with and without SLI on a series of tasks that involve varying degrees of verbal content, implied or explicit. In total 14 children with SLI and 20 comparison peers participated.

Results: Findings show that children with SLI performed more poorly than peers on all except the purely non-verbal block recall task. Interestingly, a task that required no verbal processing or output was as problematic for the SLI group as a traditional nonword memory span task suggesting that verbal encoding was used by the typical peers but less so by those with SLI. Furthermore, a verbal-input picture span task (involving hearing a list of words but requiring a non-verbal response) correlated strongly with a block recall task for children with SLI. This may provide preliminary evidence that visual encoding was being used as a central strategy by the SLI group to aid performance.

Discussion: The findings have implications for our understanding of the nature of SLI and also for the use of verbal and visual content in the classroom and other real life settings.

Specific language impairment (SLI) is a developmental communication disorder in which language develops atypically without identifiable cause, such as low general intelligence, neurological damage, hearing impairment, or autism (Leonard, 1998). The disorder affects around 7% of people (Tomblin et al., 1997). As well as being of interest clinically, SLI has been used as a key theoretical exemplar of dissociation, providing evidence that linguistic skill can be affected whilst leaving other cognitive skills 'intact'.

In recent years, however, a more thorough examination of the boundaries of these skills, the heterogeneity of the SLI population, and more emphasis on developmental change have revealed a less clear picture of dissociation. Research now reports a wide range of cognitive difficulties in some children with SLI, including problems with longer term procedural memory systems (Lum, Gelgic & Conti-Ramsden, 2010; Lum et al., 2012), visual/spatial short term memory (Bavin et al., 2005; Hick et al., 2005), and non-verbal executive function tasks (Henry, Messer and Nash, 2012). Botting (2005) reported on a large group of children with SLI aged 11 who were recruited to longitudinal research with normal non-verbal IQ (NVIQ) at 7 years of age. The majority of this group showed diminishing NVIQ over developmental time in relation to peers, so that by age 11, only half were still within normal limits (IQ > 85). This declining profile has also been reported elsewhere (Clegg et al., 2005; Tomblin et al., 1992) and may be directly related to memory function.

This leads to questions about how language and other cognitive skills might interact in various tasks. Do children with poor language skills start with domain general underlying cognitive issues, which only become detectable outside of language tasks as they develop? Or does limited linguistic skill in some way lead to poorer nonverbal cognitive ability? For both of these possibilities, we might expect older children with SLI to perform poorly across both verbal and non-verbal memory tasks. A third explanation for the recent literature is that difficulty with using verbal or linguistic encoding of nonverbal stimuli, which is used routinely by typically developing peers, puts children with SLI at a disadvantage even on non-linguistic tasks. If this were the case, rather than aiding this group of children, nonverbal tasks that have a hidden or implicit verbal element which most children might employ, would put children with SLI at a disadvantage compared to typically developing children of the same age. In this scenario, we might predict that children with SLI will not have a problem on tasks that are genuinely and completely non-verbal, but will show poorer results on tasks with varying degrees of explicit or implicit verbal elements. In this study we set out to investigate whether children with SLI show a STM memory deficit that crosses verbal and non-verbal modalities or whether in fact, performance is more closely related to degree of implicit verbal content.

Measuring memory

Within the short term memory literature, there are two prominent models. One is the working memory model, developed by Baddeley and Hitch (1974; see also Baddeley, 2003 for a more recent overview), which posits verbal and non-verbal skills as separate storage mechanisms. These are separate from a working memory or central executive unit, which may be aided by an episodic buffer. The contrasting model is a limited-capacity model, which was proposed by Just and Carpenter (1992) among others. It proposes that storage and executive skill exhibit trade off, and that overall capacity is important such that too much load on storage or processing at the same time will limit memory performance.

We have positioned this study mainly within the former, working memory model of Baddeley and Hitch (1974). Despite evidence of a wider profile of cognitive difficulties referred to earlier, children with SLI still appear to have difficulties predominantly with verbal tasks. There is now overwhelming evidence that tests of nonword repetition (designed originally to be a 'pure' measure of phonological loop) are extremely challenging for children with SLI (Gathercole and Baddeley, 1990; see Coady & Evans, 2008, for a review) and may even act as an effective screen for initial identification of language impairment (Conti-Ramsden, Botting & Faragher, 2001). Even focusing on one small aspect of memory, such as nonword repetition, accurate assessment is complex. There is much debate about the stimuli used and exactly what is being measured. For instance, Montgomery et al. (2010) highlighted a number of features of language and verbal material, such as input rate and decay, which might make this aspect of memory more challenging for some children with SLI. This is true even if the underlying deficit in repetition is domain general and results from an overall limited capacity for short term information of any modality.

In addition, accounts of memory development are not complete, which means that current definitions of the impairments in SLI are inadequately informed by knowledge of typical developmental expectations. On a practical level, tests of memory ability also appear to be highly susceptible to task-sensitivity and measurement artefacts. One such sensitivity appears to be the definition of a task as tapping verbal or nonverbal memory. Beyond early childhood, verbal encoding strategies are known to enhance short term memory performance and to reduce effects of phonological decay. These strategies include self-directed speech (Lidstone, Meins & Fernyhough, 2010), which is a problem-solving method involving either covert private speech or silent inner speech that older children can use to hold onto verbal material or to help manipulate temporary material. Furthermore, items that are presented visually can be translated into verbal material by typical learners who may readily apply verbal labels to nonverbal stimuli to enhance processing and recall. Thus many tasks that appear nonverbal in nature may have considerable hidden verbal load possibilities that may disadvantage children with language weaknesses. Less is known about visual encoding (i.e. encoding verbal information into visual structures), but this less efficient strategy may also be used in some tasks or by individuals with particular cognitive styles (Baddeley, 2003).

These encoding strategies have relevance not only in investigating the underlying processing mechanisms in SLI, but also for informing intervention and management. Work on inner speech has been carried out in the related field of autism (e.g., Williams et al., 2008). Despite its similar relevance for children with core language deficits, however, very little work has explored the verbal to non-verbal boundaries in children with SLI. One exception to this is recent work by Lidstone, Meins, and Fernyhough (2012), who found that children with SLI showed age appropriate interference effects of articulatory suppression when completing an executive function “Tower of London” task. This task requires children to move a series of differently sized disks from a start state to an end state in as few moves as possible. The children with SLI in their study showed the same amount of private speech behavior as peers, which the authors interpreted as an indication that private speech played a role for SLI children working on this task. Nevertheless, the clinical group still performed significantly less well on the actual test than their peers. In addition, the authors commented that the private speech was more overt and social than that observed for the typical group. This raises the question of whether the content and complexity of that self-directed speech had the same function or quality in the language impaired group and whether the articulatory task was not so much suppressing private speech as adding a more general processing load.

In a number of studies, so called “nonverbal” memory tasks used have been reported with relatively little discussion of the degree of hidden verbal load they might elicit or allow. For many of the tasks, it is possible self-directed speech or verbal encoding might have been used by children for whom such abilities come naturally. Studies by Hick et al. (2005) and Bavin et al. (2005) are exceptions in that the researchers attempted to take this factor into account by using a variety of verbal and non-verbal tasks. However, no studies to date have attempted to manipulate verbal load systematically to investigate this boundary. It is also important to note that for applied settings such as classrooms and speech-language intervention sessions, more information is needed about the nature of nonverbal tasks and the ways in which they might challenge or support children with SLI.

The present study

In the study reported here, we sought to explore a continuum of short term memory span tasks, matched in format, but differing in the degree of verbal encoding that was required or possible. We envisaged that this continuum would be increasingly difficult for children with SLI, as the tasks become increasingly verbal, whereas typically developing (TD) children more likely would experience all tasks as having similar difficulty. At the non-verbal extreme, we used a visual block span, which others have reported as particularly difficult to articulate or encode verbally (Vandieredonck et al., 2004). At the predominantly verbal extreme, we used a nonword repetition span task, which involves repetition of pseudowords to tap phonological storage and phonotactic knowledge but is hard to visually encode because the words are meaningless. In the middle of this continuum, two novel picture span tasks were used: a verbal input task in which children heard words, but responded non-verbally using pictures; and a non-verbal task in which children saw pictures placed in a particular order and were asked to repeat the same sequence using an array of pictures, with no verbal input or output involved.

The question of interest is whether the performance of children with SLI, when compared with typical peers would follow this theoretical continuum from verbal to non-verbal domain. Our prediction was that for this group, the nonword task would prove the most difficult followed by the verbal input task, the nonverbal picture span, and finally the block recall span. Importantly, although the nonverbal picture task required no verbal input or output, it was designed with familiar pictures easily labelled verbally. As a result, we expected that the use of verbal encoding would lead to better performance. Our assumption was that the children with TD would readily employ verbal encoding, whereas the children with SLI would be less efficient at verbal encoding.

Specifically, our aims were to explore whether:

i) Children with SLI perform significantly less well than peers on the different memory tasks;

ii) Within the SLI group, a pattern of decreasing performance from non-verbal to verbal content can be detected;

iii) The association of memory task performance is similar across the two groups;

iii) Memory skills are correlated with other abilities measured.

Method

Participants

Two groups of children were recruited to participate in this study: 14 children with a diagnosis of SLI (12 boys and 2 girls) and 20 typically developing children (13 boys and 7 girls) with no difference in age (TD mean = 9;1, SD = 15 mos, range 5;11 to 12;6; SLI = 8;9 SD = 16 mos; range 6;3 to 12;9: $t(32)=0.33$, $p=0.74$) or gender (Fisher's exact $p = 0.25$) between the groups. The ratio of more boys to girls is not unusual in an SLI sample and was partially replicated in the TD sample.

Children in both groups spoke English as their first language. According to the Special Educational Needs Coordinators (SENCOs; teachers in every UK school designated to provide an overview of the children requiring educational support), no TD child had any known special education needs or speech and language difficulties and all scored > 80 on standardized tests of language and cognition. All children with SLI had a diagnosis of SLI, an IQ of > 80, and were attending a specialist educational language resource (a specialist language classroom attached to a regular school).

[Table 1 about here]

Table 1 shows the mean IQ and receptive and expressive language standardized scores for each group. Unsurprisingly, significant differences were found between the groups for receptive standard scores ($t(32)=4.4$, $p<0.001$) and expressive language standard scores ($t(32)=5.6$, $p<0.001$). Differing language tests were used across children to measure each type of language skill (e.g., CELF sentence assembly / Renfrew Action Picture Test- see below). This was due to limits on the availability of assessments for each child. Because of this, group comparisons were repeated using non-parametric tests for each individual test and the same pattern of results was observed. No difference was seen between groups on nonverbal cognition scores ($t(32)=1.8$, $p=0.09$) although it is acknowledged that this is only marginally non-significant as is often the case even when children with SLI have normal range IQ. See table 1 below for means and SDs.

Measures

Expressive language tasks

Three different expressive language tasks were used due to limits on the availability of assessments, so the results were converted into standard scores for purposes of comparison. In total 9 TD children completed sentence assembly from CELF 3, a further 7 TD and 8 SLI completed sentence assembly from CELF 4 and the remaining children (nTD=4; nSLI=6) completed the Renfrew Action Picture Test (see below for details).

CELF Sentence Assembly (Semel, Wiig & Secord, 1995; Semel, Wiig & Secord, 2003)

This task assesses the participant's ability to formulate grammatically acceptable and semantically meaningful sentences. Participants are presented with a series of words and are asked to make 2 logical and meaningful sentences out of them. At each stage the number of words and complexity of sentence structure increases. Before testing 1 example is given and 2 trials are carried out. The assessment consists of 20 trials in total and testing is discontinued if the participant fails on 5 consecutive trials. Responses were scored as either correct or incorrect and participants were required to construct 2 sentences on each trial to be scored as correct. Standard scores were recorded.

Renfrew Action Picture Test (RAPT; Renfrew, 1997)

The RAPT is a standardized test that measures expressive language. For the purposes of this study the grammar scores were used. The task consists of 10 coloured pictures and each picture has prompt questions on the reverse to prompt the child to describe the picture. Each question is formed in order to elicit specific grammar items. Raw scores were transformed into standard scores.

Receptive language tasks

Two separate receptive language tasks were used across the group. In total, 9 TD children were tested using the CELF subtest, Concepts and Following Directions; the remaining children were tested using the Test for Reception of Grammar (TROG-2; see details below).

CELF 3: Concepts and Following Directions (Semel, Wiig & Secord, 1995)

This task assesses the participant's ability to interpret spoken directions of increasing complexity and length. Before testing, 3 examples and 3 trials are carried out. The assessment consists of 54 trials in total and testing is discontinued if the participant fails on 7 consecutive trials. Responses were scored as either correct or incorrect. Standard scores were recorded.

Test for Reception of Grammar-2 (Bishop, 2003)

The TROG-2 is a standardized assessment that measures the comprehension of grammatical items at a sentence level. The test takes the form of a multiple choice test as it consists of pages with four pictured choices. The tester reads a sentence to the child and the child has to choose which picture matches the sentence. The test comprises 20 blocks, each assessing a different grammatical construct. Each block consists of 4 trials, and if a participant fails on 3 consecutive blocks the test is discontinued. Standard scores were recorded.

Cognitive tasks

Ravens Coloured Progressive Matrices (Raven, 1993)

This task assesses the general nonverbal cognitive ability of participants, using a multiple choice test which consists of a series of patterns with one piece missing. Each pattern is presented to the participant individually and below each pattern are 6 possible items which could be the missing piece. Participants must choose which item is correct to complete the pattern. The test consists of 36 items and participants complete all items. The participants' responses were scored as correct or incorrect. Scores were recorded as percentiles and transformed into standard Nonverbal IQ scores using a 100/15 formula.

Memory tasks

All the short term memory tasks followed a span recall design, which became increasingly difficult over trials, based on length. The four tasks are described in this section along the continuum from “no verbal content” to “high verbal content.” Two tasks were taken from the Working Memory Test Battery for Children (WMTB-C; Gathercole & Pickering, 2001) and two were novel tasks designed for this study to investigate the boundaries between verbal and nonverbal skill. In the results, raw scores and z-scores based on the TD children, and age-adjusted scores are used depending on the analyses.

No verbal content: *Block Recall Span Task (WMTB-C; Gathercole & Pickering, 2001) (no obvious or implicit means of verbal encoding)*

This task, which is designed to assess visuo-spatial short-term memory, is taken from the WMTB-C. It uses a specifically designed grey board with nine randomly located cubes (i.e. not in rows and lines). The researcher uses a finger to tap the cubes in a designated sequence, which the participant is asked to repeat. Span length starts at one and continues to 9. Each stage consists of 6 trials. Testing is discontinued when the participant makes 4 consecutive errors at a particular level. The number of correct trials is recorded.

Low verbal content*: Novel Nonverbal Input Picture Span Task (potential verbal encoding)*

This task assesses the visual short term memory of participants with the potential support of verbal information. Picture items are presented visually, and after the child watches the researcher place the cards in sequence they are removed, shuffled along with 2 or 3 distracter items (depending on the level), and handed to the child (see Appendix 1 for examples). Children are then asked to place the items back in the same order. There are 4 trials for each span length starting at 2 and increasing to 7. Levels 2, 3, and 4 include 2 distracter items alongside the target items, and levels 5, 6, and 7 have 3 distracter items alongside the target items. The assessment is discontinued if the participant fails in all of the 4 trials of one level. Responses were recorded as either correct or incorrect and the number of correct trials was used in analyses.

Part-verbal content: *Novel Verbal Input Picture Span Task (potential visual and verbal encoding)*

This task was designed for this study to assess the verbal short term memory of participants with the potential support of visual information. The pictures used are similar to but not the same as those in the nonverbal picture span task above. The names of familiar objects are read aloud to the participant and therefore this task has explicit verbal input (see Appendix 1 for items). Participants are then handed the picture cards and asked to place the picture items in the order in which they were named by the examiner. No verbal output is required from the child. The level of difficulty gradually increases, with the span starting at 2 and increasing to 7. Stages 2, 3, and 4 include 2 distracter items alongside the target items, and stages 5, 6, and 7 have 3 distracter items alongside the target items. Each level has 4 trials and the assessment is discontinued if the participant fails on all 4 trials of one level. Responses were recorded as either correct or incorrect and the number of correct trials was used in analyses.

High verbal content: *Nonword Span task (WMTB-C; Gathercole & Pickering, 2001) (explicit verbal element)*

This task, which is designed to assess the phonological short term memory of participants, is taken from the WMTB-C. Children are told they are going to hear some made-up words and are asked to repeat them back in the same order. The assessment starts with trials of 1 non-word. The level of difficulty is increased at each level by adding 1 additional non-word to the span length, up to a maximum span of 7. Each stage consists of 6 trials, and responses were recorded as either correct or incorrect. If the participant makes 4 consecutive errors in one stage, the test is discontinued. No repetitions of any words were allowed by the examiner. Responses were recorded as either correct or incorrect and the number of correct trials was used in analyses.

Procedure

Ethics approval was gained from SHS Research Ethics Committee, City University London and from the local NHS IRAS committee prior to commencing the research. Information and consent forms were sent home via school. Each child was seen individually by a single researcher for two 60 minute sessions where the assessments were carried out in a quiet room in the school. Assessments were carried out in a fixed order with the memory carried out in the first session and the language / nonverbal ability tests in the second session. All children completed all the assessments. Children were given breaks where required.

Analysis

The skewness and kurtosis of memory tasks were found to fall outside of the acceptable parametric ranges. Therefore non-parametric analyses have been used for most analyses. Because of the wide age range, age adjusted scores were created for some analyses by dividing the raw score by age in months.

Results

Group comparisons of memory

As can be seen from Table 2, children with SLI performed significantly more poorly than peers on the nonword recall task ($U=49.5$, $p=0.001$), the novel verbal input picture span task ($U=53.0$, $p=0.002$), and the novel nonverbal input picture span task ($U=60.0$, $p=0.004$). There were no significant differences on the nonverbal input block recall span task ($U=102.0$, $p=0.192$).

However, despite this finding, our prediction that the children with SLI would show a different *pattern* of performance overall (decreasing performance with increased verbal content) compared to the TD group (equal difficulty across tasks) was not borne out. Instead a mixed ANOVA (no non-parametric equivalent) revealed that both groups found verbal tasks more difficult (main effect task: $F(3,96)=99.0$, $p<0.001$) with no group x task interaction ($F(3,96)=0.67$, $p=0.57$). The overall advantage for TD children seen in the individual analyses earlier in results were also confirmed with a main effect of group ($F(1,32)=14.4$, $p=0.001$).

[Table 2 about here]

Relative difficulty of memory tasks within the SLI group

Because the overall performance and variation differed as a function of task, in order to compare the relative difficulty of tasks for the SLI group, scores were transformed into z-scores based on the TD group mean and SD. For the SLI group only, a repeated measures analysis was performed to determine whether any of the 4 tasks was more difficult than the others compared to peers. Interestingly for both the tasks with explicit verbal material, Interquartile ranges (IQRs) do not cross the normative mark (0) and have narrower ranges, whereas the two non-verbal tasks show wider variance with IQRs that cross this threshold. Table 3 also shows that the median z-scores appear nearer to the norm (0) for block recall than for other measures, but this difference was not statistically significant (Friedman χ^2 (3)=6.94; p=0.07).

[Table 3 about here]

We then explored whether more children with SLI performed at <2SD from the mean of their typically developing peers than was expected by chance. One sample chi-square analyses for each memory task revealed that all but the block recall task had more children with SLI than expected in this low scoring group.

[Fig.1 about here]

Correlations between memory tasks

Because the group sizes were small and measures skewed, Spearman Rho analysis was used for correlation analyses, however parametric r^2 effect sizes are also reported (because no non-parametric equivalent exists). For the TD group, block recall correlated most highly with the nonverbal input picture span task (Rho = 0.56, p = 0.011; $r^2 = 0.27$) and also with the verbal input picture span task (Spearman Rho = 0.45, p = 0.047; $r^2 = 0.24$). The nonword recall task correlated only with the verbal-input picture span task (Rho=0.55, p=0.013; $r^2=0.25$); the two picture span tasks were also correlated (Rho=0.65, p=0.002; $r^2=0.36$).

For the SLI group, block recall correlated most strongly with the verbal-input picture span task (Rho=0.72, p=0.003; $r^2=0.50$) perhaps suggesting increased *visual encoding* was used by this group for this task. There was a moderate, but non-significant correlation between block recall and the novel nonverbal task (Rho=0.48, p=0.08; $r^2=0.30$). Again, the two novel tasks were moderately related (Rho=0.55, p=0.04 $r^2=0.34$).

Note, that these analyses were performed on small groups (n=20 for TD and n=14 for SLI) and should therefore be treated with caution. Nevertheless, the correlation effect sizes were large and in most cases were statistically significant.

Relationship between the memory tasks, age, nonverbal IQ and language skills

Age did not correlate with any memory tasks (all Rho < 0.2, all p > 0.5; except for age and block design where Rho=0.31, p=0.07).

To explore associations between NVIQ (Raven's), language and memory tasks, standard scores and age-adjusted scores were used respectively. NVIQ correlated weakly with all age-adjusted memory scores (block recall: rho=0.35, p=0.031 – nonverbal picture span: Rho=0.36, p=0.037 – Verbal input picture span: rho=0.45, p=0.008 – nonword recall: Rho=0.34, p=0.047). Expressive language did not correlate with any memory task, and receptive language correlated with the nonverbal input picture span (Rho=0.57, p<0.001) and the novel verbal input task (Rho=0.36, p=0.034).

Discussion

Children with SLI, who by definition have verbal difficulties, have been reported to show nonverbal difficulties as well (Bavin et al, 2005; Hick et al 2005), particularly in memory span tasks. This study attempted to unpack that finding further by exploring the degree to which the visual and verbal input and response-mode elements of a task might be involved in short term memory performance for all children and whether children with SLI would differ in this regard from their typically developing peers.

Children with SLI showed difficulty on all tasks with any verbal element, whether *explicit,* as in the case of the nonword span or *implicit*, as in the case of the novel picture span tasks. They showed no reliable difference from their peers on the block span recall task, which was considered to be the most non-verbal task in that children were unlikely to be able to encode the spatial pointing sequence verbally during remembering and recall in order to replicate it. Only one child with SLI fell below 2SD from the TD mean on this task. This finding of no difference on the block span recall task between the children with SLI and their TD peers is in contrast to the finding by Bavin et al. (2005) who showed a small but reliable difference between the two groups on a computerized spatial span task. The reason for this difference is not entirely clear but may be because the sample in Bavin et al. (2005) was much younger or because they used a computerised task. The finding in the present study may indicate that many children with SLI do not experience domain-general deficits with memory load.

However, our prediction that the performance of the children with SLI would improve as the degree of verbal content decreased was not entirely borne out. That is, a task with non-verbal input and output demands that was highly likely to be verbalised by the typically developing children (the nonverbal input picture span) produced poor results from the children with SLI. Their performance on this apparently low verbal task was not significantly better than a classic nonword span task, which has been established as a clinical marker for language impairment (Botting & Conti-Ramsden, 2001; Botting et al., 2003; Conti-Ramsden, Botting & Faragher, 2001). As predicted, one explanation for these findings is that rather than experiencing limited capacity, or difficulty with short term memory storage per se, children with SLI may find verbal encoding of tasks most challenging. An alternative (but related) suggestion may be that the executive skills of the children with SLI are impaired, and when faced with the need to manipulate the input into another modality, this deficit lowers performance. If this latter explanation were true, it might partially explain the finding that both novel tasks produced similarly low performance. It also might explain low nonverbal-input picture span scores, due to the fact that children with SLI may have been less efficient at self-generating verbal labels for the sequence of pictures laid out by the examiner (this verbal encoding requiring a degree of semantic fluency). On the other hand, the children with SLI might have been using an exclusively visual strategy for the non-verbal task (rather than attempting to recode verbally) and this method could be simply less efficient than the default verbal encoding that likely was utilized by the TD group. We need to note, however, that no direct measures of verbal encoding were used here, and this area warrants further research to test which explanation might best explain the performance of both groups of children.

As mentioned earlier, Lidstone, Meins and Fernyhough (2012) have reported results on private speech in SLI problem solving that relate to this issue, but even short term memory research would benefit from video analysis, articulatory suppression paradigms, and the manipulation of span stimulus to include phonological similarity as an independent variable.

These would all facilitate the investigation into whether impaired verbal encoding and private speech are central issues for those with SLI, or whether they are less important by-products of a more general memory difficulty.

We have not assessed processing speed within this study. This element of may be usefully included in future studies since studies have also suggested both that processing speed may affect short term memory (e.g., Poll et al, 2013) and that deficits for children with SLI in this area may be affected by methodological issues (Windsor et al., 2001). In this study, a fixed order of tasks was used, but in future studies this may be manipulated to control for priming or practice effects.

As well as group differences, this small scale study detected differences in the relationships between memory skills for those with SLI compared to typical peers. The correlation between block recall and the verbal input picture span task was seen in both groups but more strongly in the SLI group. Alongside the verbal encoding that may occur for TD children, this finding may suggest increased use of *visual encoding* by children with SLI when they hear spoken input. This is likely not the main strategy used by TD peers for verbal tasks, since intact phonological memory is more efficient, and is only used in typical development when tasks such as block design are resistant to verbal encoding and further research using suppression techniques is needed. Indeed other studies with typical children have reported no correlation between purely verbal and purely non-verbal STM tasks (Gathercole et al., 2004) and this was true of both groups in this study. At the same time, the TD group showed expected associations between non-word repetition and the verbal input task, whilst this was not apparent in the SLI group. The general lack of association between nonword span and other memory tasks or with expressive language may be due to rather bimodal data for nonword span, with widespread low level achieved by the SLI group and overall ceiling effects for the TD group, and both groups showing reduced variance on this task.

We cannot rule out the possibility that the association between receptive language and novel picture-span memory tasks equates to a task effect in which some children did not adequately understand the task demands. However this seems unlikely given the very similar format of these tasks compared with the two standard memory assessments. On the other hand, we could speculate that by 10 years of age, receptive language calls on similar pathways of semantic access as was needed in the novel picture span tasks. The notion of different cognitive organisation in those with SLI has been touched upon by McGregor and colleagues in their work on 'fuzzy concepts' (McGregor, Newman, Reilly, Capone, 2002) and may warrant further investigation in relation to memory performance. As mentioned earlier a counterbalanced task order may also help to tease out any priming effects or fatigue.

This study recruited only a small group of children with SLI and also used differing measures of language across samples from different schools. A larger scale study with a more uniform and comprehensive battery of language and cognitive testing would be of interest to see whether these relationships still hold. Moreover, no direct measures of executive function or private speech were included, and these additions would enable future studies to investigate the role of verbal encoding more fully.

In spite of these acknowledged limitations, we believe there are some important clinical implications even from this preliminary investigation. If educators, parents and therapists are aiming to use non-verbal alternatives to aid children with SLI, they need to consider the role of verbal mediation and encoding, and the degree of verbal material hidden within the tasks or prompts they are using. That is not to say that visual and other non-verbal aids have no place in supporting children with language difficulties, rather that professionals must not assume that presentation of a non-verbal task to both TD children and SLI children will 'even the playing field' between them. There still will be important differences in the process and strategy used by children with and without SLI. This has particular implications for formal tests of knowledge and academic achievement in schools, but might also apply to rules and instructions in classroom settings. Children with SLI have been the focus of this study, but their performance may reveal important qualities that are relevant to other groups with educational needs. Training studies or dynamic assessment paradigms (see Hasson, Botting & Dodd, 2012 and Camilleri & Botting, in press) would also enable educators and clinicians to ascertain whether explicit teaching in verbalization would be of use in remediation.

Conclusions

In summary, this study has explored the boundaries between verbal and non-verbal content in memory tasks focusing on children with SLI. Unlike the children in Bavin et al. (2005), the children with SLI in this study did not show difficulties with a non-verbal block recall task. However, they also did not follow the predicted continuum of increasing difficulty associated with increasing verbal content in their performance across tasks, rather they showed a disadvantage on any task that contained ‘verbalisable’ elements. The task on which most children with SLI showed a clinical difficulty was a novel non-verbal task that explicitly required no verbal input or output processing. This investigation has revealed that some memory tasks have hidden verbal elements that children with SLI, and other clinical groups, may find the most difficult when compared to peers.

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Table 1: Language and Non-verbal IQ standard scores

	Group	Mean	Standard Deviation
Receptive language	Typically Developing	101.1	12.6
	SLI	80.2	14.7
Expressive language	Typically Developing	109.4	11.9
	SLI	75.9	22.6
Non-verbal IQ	Typically Developing	105.0	12.1
	SLI	97.8	10.8

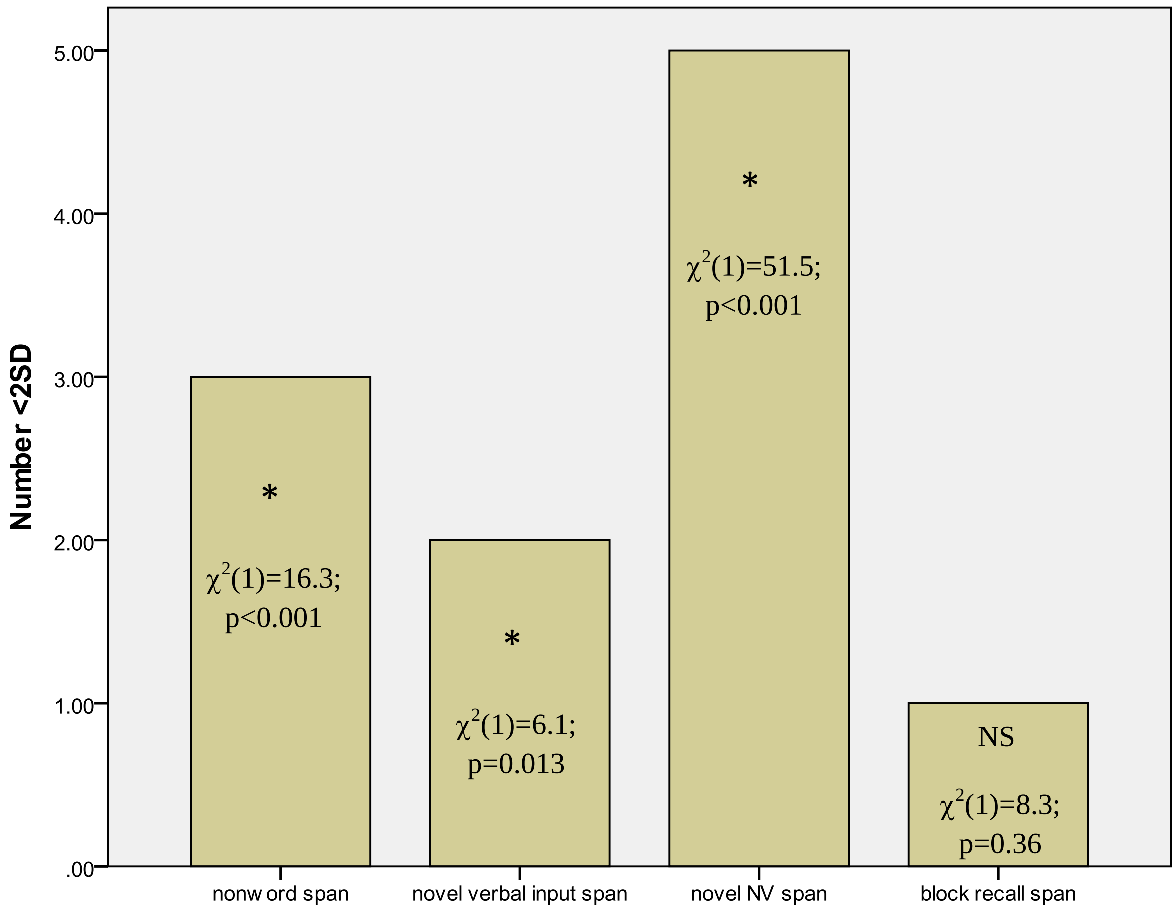
Table 2: Medians and IQRs for memory tasks

	Nonword recall	Novel verbal input	Novel Non-verbal	Block recall
SLI	12.0 (2.0)	13.0 (2.5)	18.0 (6.0)	24.0 (6.5)
TD	15.0 (3.0)	15.5 (4.75)	21.5 (4.75)	25.5 (7.0)

Table 3: Z-score medians (IQRs) for SLI group across tasks

Nonword recall	Novel verbal input	Novel Non-verbal	Block recall
-1.2 (1.0)	-1.1 (0.8)	-1.2 (2.0)	-0.42 (1.4)

Figure 1: Number of SLI children performing <2SD from peer group mean



Appendix 1: Stimulus for novel picture span tasks

Novel task 1: Verbal input picture span

Span	Word list					
2	apple	girl				
	orange	book				
	elephant	sun				
	car	trousers				
3	cup	bear	fish			
	boy	hat	chair			
	tiger	bike	flower			
	table	cat	bed			
4	sun	fish	cat	shoe		
	house	dog	chair	butterfly		
	bird	shoe	brush	cake		
	giraffe	house	mouse	flower		
5	girl	tree	giraffe	water	sun	
	shoe	present	table	boy	flower	
	frog	park	tiger	flower	shoe	
	bear	trousers	elephant	chair	butterfly	
6	cat	dog	boy	butterfly	lion	girl
	sea	dog	sun	bird	scooter	tree
	book	giraffe	fish	park	table	cookies
	giraffe	elephant	flower	house	bird	park
7	balloon	banana	baby	monkey	cup	bear	ball
	bus	umbrella	pencil	ice cream	rabbit	snake	tomato
	spoon	scissors	apple	car	t-shirt	basket	cake
	hat	book	camera	micro	key	chocolate	tv

<u>Novel task 2: Nonverbal picture span</u>

Span	Word list						
2	airplane	robot					
	jumper	plate					
	fork	train					
	jacket	dress					
3	scarf	track	doll				
	watch	boat	duck				
	blocks	sock	bag				
	crisps	TV	phone				
4	sweets	door	fire	glasses			
	windows	horse	toilet	banana			
	spoon	pan	knife	superman			
	spiderman	cow	pig	computer			
5	airplane	crisps	plate	sock	horse		
	dolly	train	blocks	fire	toilet		
	teacher	chicken	burger	egg	strawberry		
	pan	elephant	bed	girl	dog		
6	cat	present	mouse	orange	bottle	ball	
	toothbrush	key	phone	pen	bath(tub)	crocodile	
	computer	sunglasses	bus	boat	feather	chocolate	
	gun	umbrella	bag	doctor	pig	spider	
7	milk	squirrel	ladder	hat	cookie	water	giraffe
	house	keys	pushchair	teddy	bottle	phone	Icecream
	sun	clock	school	bicycle	kitchen	frog	ball
	pen	scissors	book	mouse	car	snake	laptop