

Children With Specific Language Impairment: Linguistic Impairment or Short-Term Memory Deficit?

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This study is concerned with characteristics of short-term memory (STM) in children with specific language impairment (SLI). The linguistic requirements of the test procedure, the characteristics of the test materials, and the development of linguistic representations were considered. Two experimental tasks were used: a verbal-repetition and a picture-pointing procedure. The tasks used auditory presentation and were designed to explore different underlying processes during immediate recall. The linguistic characteristics of the test materials were designed to explore the influence of semantic, lexical and phonological factors on STM. SIX SLI children (aged 6;1 to 9;6) (years months) were individually matched on comprehension and expression of language to 17 younger children (age 3;4 to 6;5). Both groups were differentially influenced by the materials as a function of the test procedure. In general, both group and individual analyses found no significant difference between the performance of the SLI children and language-age (LA) controls. The implications of the results in relation to previous findings from investigations of STM and the underlying cause of SLI in children are discussed.

KEY WORDS: specific language impairment, children, short-term memory, language disorders

For many years characterizations of the language impairment in children with specific language impairment (SLI) have emphasized their severe problems in the development of expressive language. Recent studies have stressed that the focus of SLI children's expressive deficit is in the phonological and morpho-grammatical aspects of language (e.g. Chiat & Hirson, 1987; Clahsen, 1989; Gopnik, 1990; Leonard, 1989). However, their deficit in this area is not uniform. Particular impairments have been found for specific aspects of inflectional morphology and for some grammatical function words. These impairments include difficulties with subject-verb agreement, auxiliaries, copulas, and definite and indefinite articles. Despite these difficulties, SLI children show comparative strengths in other areas of morphological processing. That is, in comparison to language-age matched control children, SLI children show a similar or more advanced level of development in some areas of their expressive language. These morphological strengths include expressing plural nouns, past tense forms of irregular verbs, the progressive aspect marking of verbs (-ing), use of modals, and correct word order within phrasal constituents (e.g. Clahsen, 1989; Clahsen, Rothweiler, Woest, & Marcus, 1992; Gopnik, 1990; Gopnik & Crago, 1991; Leonard, 1989; van der Lely, 1990).

Recently there has been increased interest in investigating the receptive language abilities of SLI children (Bishop, 1979, 1982; van der Lely, 1993; van der Lely & Dewart, 1986; van der Lely & Harris, 1990). These investigations, like those of the expressive abilities of SLI children, have found particular strengths and weaknesses in comparison to language age-matched control children. For example, comprehen-

sion of single words is relatively unimpaired in comparison to comprehension of sentences (Bishop, 1979, 1982; van der Lely & Dewar, 1986; Connell, 1986; Precious & Conti-Ramsden, 1988; van der Lely & Harris, 1990), SLI children's deficits in sentence comprehension are revealed when they are required to process "semantically reversible" sentences, in which word order plays a particular role (in English) in signaling the assignment of syntactic functions (e.g., subject, object) to thematic roles (e.g., agent, patient/theme).

For more than 20 years there have been reports that SLI children have some sort of memory problem that may underlie their linguistic impairment (e.g., Griffiths, 1972; Graham, 1980; Tallal & Piercy, 1978; Worster-Drought, 1965). Although some investigations have indicated that their memory deficit may be of a general nature (Eisenson, 1972; Johnston & Smith, 1989; Tallal, Stark, & Millits, 1985), other investigations have pointed to the specifically linguistic nature of their memory impairment. It is these latter investigations that are of particular interest to this study. SLI children's immediate memory, in comparison to children matched on chronological age, has been found to be impaired for the storage and recall of word strings (Ceci, Ringstrom & Lea, 1981; Kail, Hale, Leonard & Nippold, 1984; Stark, Poppen, & May, 1967) However, interpretation of the findings have differed, Ceci et al. (1981) suggested that the impairment was due to "diminished semantic processing." Thus, they imply that the deficit is caused by the underlying linguistic deficit in the children.

Alternatively, Stark et al. (1967) noted that their SLI children made an unusual number of errors recalling the first word in a series and suggested that this indicated an underlying impairment in "rehearsal strategies." This interpretation suggests that it is one of the mechanisms for controlling and/or maintaining memory that is impaired.

Kirchner and Klatzky (1985) specifically investigated verbal rehearsal in SLI children and compared their performance with a group of children matched on chronological age who were developing normally. Lists of items were pictorially presented. The children had to rehearse aloud, following presentation of each item. From the rehearsal periods and recall performance, 12 variables were calculated, these included retention and order of items, semantic organization, repetition, and intrusion errors. The predominant difference between the SLI children and control children was in capacity and intrusion errors. Kirchner and Klatzky's initial interpretation of the data suggested that SLI children were less able to maintain and regenerate items in STM. However, Kirchner and Klatzky point to the scope of the deficit in processes related to short-term memory; that is, of the components assessed, almost all were deficient to some extent. Following factor analysis, they concluded that the findings were due to "diminished verbal capacity." Thus, they implied that it was the linguistic nature of the task and the materials to be rehearsed that were responsible for the deficits.

Sininger, Klatzky, and Kirchner (1989) followed up this previous study and investigated memory scanning speed using the Sternberg (1966) paradigm to try to specify the locus of the deficit more precisely. The children had to identify whether a probe item occurred in a list of digits that had been previously verbally presented. The speed of the

yes/no responses provided the measure of "Scanning speed." Sininger et al.'s study showed that SLI children scan items held in STM almost four times more slowly than linguistically normal children. The authors suggested that it is neither the encoding of auditory messages into a format for STM nor the accessing of items for STM processing, but the speed of access to items in memory that is limiting the SLI children's performance.

The Sternberg paradigm used by Sininger et al. has the advantage in that it is conducted with digits and that it is an "error free" paradigm, the dependent variable being the reaction time to respond yes/no. As there is little reason to believe verbal processing or linguistic representation has any effect on reaction time measures, this task may be a particularly good paradigm to use with SLI children, even if the comparison group differs on verbal ability. However, Monsell (1984) pointed out that the Sternberg paradigm may not depend on the same STM processes as those used in tasks of immediate serial list recall. For example, the phonological similarity effect has little effect on recognition accuracy (Wickelgren, 1977) or on reaction times (Monsell, 1973) in the Sternberg paradigm. Thus, it is unclear whether this probe task taps the same short-term memory processes that are the focus of this study.

In this investigation we examine the linguistic processes and representations in relation to STM in SLI children and compare these with children at a comparable stage in language development. It is well known that children at varying levels of language development use different strategies to complete experimental tasks (e.g., Bever, 1970). In addition, their performance on both language and STM tasks may reflect the use of different underlying linguistic processes at different stages of their development (e.g., Dempster, 1981; Hulme & Tordoff, 1989) It can be argued, therefore, that comparisons between SLI children and chronological age controls may reveal little about the specific nature of the SLI children's linguistic difficulties, as SLI children tend to perform below chronological-age control children on the majority of tasks in which linguistic processing is involved. Furthermore, even with careful control of the linguistic characteristics of the materials and testing procedure, it is unclear how language abilities may affect performance on largely (but not totally) nonlinguistic tasks. This is because SLI children's language impairment may interact with different components of language (i.e., syntax, semantics, pragmatics, phonology), and therefore could affect many if not all of their language functions to some extent. Thus, this results in a generally impaired level of language development for their age. However, comparisons with children matched on language abilities reveal specific, selected areas of deficits that are disproportionately impaired in relation to their general level of language development (e.g., Bishop, 1982; Leonard, 1989; van der Lely & Harris, 1990). It is these areas of specific impairment that may be found in SLI children that this paper aims to investigate. Thus, the relevant comparisons are between SLI children and children matched on language abilities. (See Snowling, 1983, who discusses developmental reading disorders, for further explanation of this rationale). Comparison of the performance of SLI children with language-matched controls provides a strong test

for any claim that SLI children are qualitatively different from children developing normally. Clearly, though, by comparing SLI children with necessarily younger, but linguistically normal children presents a problem in that the two groups are not matched in nonlinguistic cognitive development and experience. However, by careful task selection it is possible to ensure that the task demands fall within the abilities of the younger control children.

In contrast to some previous studies of STM, Gathercole and Baddeley (1990) compared the performance of SLI children with children matched on language abilities. Gathercole and Baddeley compared a group of SLI children with normal control children matched on a screening test of comprehension of single-word vocabulary and reading abilities. They found that the SLI children were impaired in verbal repetition of single nonwords of one to four syllables.¹ In addition, Gathercole and Baddeley report that, in a serial recall task using verbally presented material with a picture-pointing response paradigm, SLI children were significantly impaired in their recall of lists of words. However, it can be noted that none of their main statistical comparisons showed that the SLI children were significantly impaired relative to their language-age controls, although their data clearly show a trend in this direction. Gathercole and Baddeley interpreted their findings as indicating that SLI children had an immediate memory deficit. In terms of the working memory model, the deficit was identified to be in the capacity of the phonological store, rather than in the articulatory rehearsal processes that maintain items in the store. Before considering Gathercole and Baddeley's hypothesis further we shall put their findings in the context of Baddeley's (1986) working memory model and the pertinent developmental findings.

Baddeley's (1986) version of the working memory theory is based on three structurally distinct temporary storage devices. A supervisory control system, the central executive, has a general-purpose capacity divisible between storage and processing. It is aided by two "slave" systems that are capable of storage: the articulatory loop, which is concerned with auditory-verbal material, and the visuo-spatial scratch pad. It is the articulatory loop that is of relevance to this study. This consists of two components: the phonological short-term store (PSTS) and articulatory rehearsal. Auditory input gains obligatory access to the phonological store. Information in this store is subject to passive decay over time, but can be maintained by rehearsal using articulatory or motor-speech programs. (See Baddeley, 1986, for further details and justification of these structures.)

The effects of the phonological and lexical characteristics of the materials in immediate recall experiments has been taken to indicate the use of different underlying processes and/or representations in STM (Baddeley, 1966, 1986; Monsell, 1984, 1987). For example, Baddeley argues that the phonological similarity effect, in which acoustically similar items are recalled less well, arises from confusion between

similar memory traces in the phonological STS. The word length effect stems from articulatory rehearsal; long words are more poorly recalled because they take longer to articulate during rehearsal, thus allowing more time for information in the phonological STS to decay (Baddeley, 1986; Baddeley, Lewis & Vallar, 1984). However, Monsell (1987) argues for a model that distinguishes between input and output buffers that are linked by the processes involved in rehearsal. He argued that the word length effect may be due to the storage limitations of the output buffer; that is, long words are more phonologically complex than short words and so take up more "space" in the buffer. It is evident therefore that some tasks, such as verbal repetition, cannot differentiate whether articulatory rehearsal and/or the word length effect is associated primarily with output and storage or just output processes. Although previous investigations have stressed the predominantly phonological characteristics of STM, an influence of semantic-cognitive processing on short-term recall has also been found, but to a lesser extent. Baddeley (1966a) found that semantically similar words are recalled less well primarily in delayed recall, but are also significantly less well-recalled than unrelated words in immediate recall. Thus, it is possible that semantic-cognitive representation and processing may affect recall, and this may be particularly so in the child with a developing semantic system and/or when recall involves other modalities such as visual processing. The influence of factors other than prelexical phonological representations is also revealed by the "lexicality effect". That is, non-words are recalled less well than real words (Brenner, 1940). Thus lexical knowledge appears to facilitate recall.

The literature on the development of STM emphasizes two factors that may account for the increase in repetition span of lists of items that is found as children mature. First, it is suggested that the increase in speech rate accounts to a large extent for increase in span (Hitch & Halliday, 1980; Hulme, Thomson, Muir, & Lawrence, 1984; Hulme & Tordoff 1989). The second suggestion is that improved item identification may be responsible for the increasing span (Dempster, 1981; Hitch, Halliday, & Littler, 1989). Dempster (1981) reviewing 10 possible sources for developmental changes in STM performance (which included rehearsal, grouping, retrieval strategies, item identification, search rate, and capacity), concluded that improved item identification was the major source of the changes. Hitch et al. (1989) suggested that item identification and rehearsal effects indicate development of different subsystems involved in increasing STM span.

It can be seen from the overview of the working memory model and the developmental factors influencing change that both output processes and stored representations could well affect STM performance. So let us now reconsider Gathercole and Baddeley's (1990) findings not only within the working memory model (as they themselves considered them), but also within a developmental perspective. That is, we shall consider the possible underlying reasons for decreased capacity in phonological storage found in the sample of SLI children. From the developmental literature it appears that increasing storage capacity cannot be wholly responsible for developmental changes in STM in children.

¹This finding is based on two tasks that Gathercole and Baddeley (1990) carried out. The first consisted of repetition of one- and three-syllable nonwords and the second, one- to four-syllable nonwords. The SLI children showed significant impairment in the first task but a significant impairment was found only on the three and four syllables in the second task.

Previous research would suggest that two possible sources for a decrease in capacity are impaired rehearsal and/or item Identification. Impaired rehearsal could be due to a difficulty with output processes such as articulatory-motor production, or higher level phonological output processes, such as those put forward by Bishop (1985). Gathercole and Baddeley (1990) tested the first of these possibilities (i.e. articulatory-motor processing) by assessing the children's articulation rate. The SLI children were found to have an equivalent articulation rate to the language age-matched controls. However, this finding does not preclude the possibility that higher level phonological output processes may have been impaired. For example, it is possible that repeated repetition of a small set of sounds may be carried out via a "link" between input and output buffers that do not involve "higher" linguistic output processes. In addition, the necessarily limited set of items in Gathercole and Baddeley's task may only tap a restricted area of phonological output and higher phonological processes. Thus, it could be that speed of articulation rate with a phonologically more extensive set of items could reveal a deficit in phonological representations or processing.

Alternatively, can difficulties in item identification account for Gathercole and Baddeley's data? An important factor in Item Identification may be the quality of stored representations that can match the input items. Thus, when any form of auditory-linguistic material is used, very careful control of the linguistic demands of the test materials and the test paradigm in conjunction with the linguistic abilities of the child are of paramount importance. And this may be particularly so with an SLI child, when the relationship between STM and language development may not be following a normal pattern.

Although Gathercole and Baddeley controlled for the linguistic factors of the materials and the test paradigm, other linguistic factors may have influenced their findings and could account for the memory deficits found in SLI children. This is because the matching procedure used by Gathercole and Baddeley to select a language-age control group is open to criticism. SLI children are typically heterogeneous (i.e., subgroups exist that are characterized by different linguistic characteristics) and within a sub-group, performance across a range of standardized language tests may vary in relation to 'normal' functioning. Some children may show severe impairments on some language tests at the same time as a normal range of abilities on other tests (van der Lely & Harris, 1990). Gathercole and Baddeley matched their control sample on the basis of identification of single words, an appropriate test because that is the relevant linguistic variable that has been found to vary with growth in memory span (Dempster, 1981). However, Gathercole and Baddeley used the short form of the British Picture Vocabulary Scale (BPVS) (Dunn, Dunn, Whetton, & Pintillie, 1982), which aims only to screen comprehension of single words (an area of relative strength in many SLI children)². It can be noted that in this short form of the BPVS a correct or incorrect score on one

Moreover, the confidence level for this screening version shows large variation. For example, for a raw score giving an equivalent age of 6:8 years, the 95% confidence interval covers 3:4 years. This can be compared to the long form of the BPVS; for a score giving an equivalent age of 6:8 years the 95% confidence interval is reduced to 2:0 years. Therefore, assessing "language abilities" on the basis of this test may be subject to error. It should also be noted that 1 of Gathercole and Baddeley's 6 SLI subjects was impaired only in his reading development and not on any of the tests of language that were administered. However, Gathercole and Baddeley also matched their language controls on the basis of reading age. But, although reading age may develop in parallel with language abilities in children developing normally, it is not possible to assume this is so with children not developing normally (cf. the case of hyperlexic children, Snowling & Frith, 1986). Thus, one cannot assume that the two groups in Gathercole and Baddeley's study were of comparable linguistic abilities. It remains a possibility that one explanation for Gathercole and Baddeley's data is that the underlying linguistic abilities of the SLI children result in difficulties of item identification and this caused the deficit in phonological capacity.

It is evident that the picture of SLI children's STM abilities and the relationship of an STM deficit to a developmental language impairment is still far from clear. This study extends previous work to investigate STM in SLI children to try to clarify the issue.

The main questions addressed in this study were (a) Does the STM performance of SLI children differ from that of their language-level peers? (b) If so, does the pattern of performance across the various tasks differ for SLI children and their language-level peers?

Method

This study compares STM in SLI children and language age (LA) control children when, first, the SLI children were carefully matched to a group of language-control children on the basis of three standardized language tests. To achieve more thorough matching of subjects, 3 language-control children were selected for each SLI child. Secondly, the materials used were also selected to fall within the SLI children's language abilities. Where appropriate, the materials (i.e., the words) had a high frequency and an early age of acquisition. Two experimental tasks were employed that used auditory presentation of materials and were designed to tap different underlying processes during recall. The tasks were verbal list repetition and a picture-pointing response task. In this study the linguistic characteristics of the test stimuli were designed to explore the influence of (a) semantic similarity, (b) lexicality, and (c) phonological similarity on STM. It can be noted that the picture-pointing paradigm *requires* lexical and semantic access, and so should especially stress "identification." It was predicted that if SLI children had particular difficulties in item identification, their performance would be impaired on these tasks. The repetition paradigm, on the other hand, requires verbal output

² The BPVS is a British vocabulary test, similar to the Peabody Picture Vocabulary Test. The short form represents a shortened screening version of this test

storage and processing. It also enables testing STM of nonwords (the lexicality effect), which requires prelexical phonological processing. Immediate serial recall of nonwords should reveal if SLI children have a memory deficit for prelexical phonological storage. The phonological similarity effect, which was tested using both paradigms, allows the "quality" and maintenance of items in the phonological short-term store to be assessed.

Subjects

Two subject groups participated in the experiments: a group of children with specific language impairments and a group of younger children matched on receptive and expressive language abilities.

SLI Children

There were 6 children with specific language impairment (SLI), 5 boys and 1 girl, who were selected from a larger group that had been under investigation for the previous 2 years. Although the original selection criteria have already been documented (van der Lely & Harris, 1990), because of their importance to the interpretation of the data, some details will be given again here.

The SLI children had been identified by speech-language pathologists and educational psychologists as having persistent difficulties with language comprehension and expression. That is, their scores fell more than 1.5 standard deviations below the normal range of abilities based on their chronological age on some standardized language tests, and they were undergoing their education in language units (see van der Lely & Harris, 1990). In addition, the SLI children were selected according to a set of criteria based on those proposed by Stark and Tallal (1981). To provide a uniform measure of language abilities and a criterion for inclusion in the group, two tests of comprehension and two of expressive language abilities were administered. Only children who had a mean comprehension age at least 6 months lower than their chronological age or mental age (whichever was the lower) and a mean expressive language age at least 12 months below their chronological or mental age were included in the group (Stark & Tallal, 1981). The articulatory-phonological abilities of the SLI children were assessed by their speech and language pathologists. SLI children were excluded from the study if they displayed any of the following articulatory-phonological characteristics: articulatory dyspraxia, phonological impairment of the severity to make their speech partially unintelligible, and/or omission of final phonemes. This latter criterion was included for two reasons: first, children with articulatory-phonological impairments *may* constitute a different subgroup of SLI children. (At the present time, it is unclear to what extent these subgroups may be related.) Second, the test paradigms to be used in the study included verbal repetition. Therefore, including children with articulatory disorders could have differentially impaired these children's recall scores.

The nonverbal abilities of the children had also been assessed by educational psychologists using nonverbal

subtests of standardized 10 tests (e.g., WISC-R). In contrast to their low verbal abilities as measured by the verbal subtests, their nonverbal abilities fell within the normal range. To provide a uniform measure of "mental age" on which to base the children's language age, an additional two tests were used to screen their nonverbal abilities. These tests were the Block Design from the British Abilities Scale (Elliott, Murray, & Pearson, 1978) and the Draw a Man Test (Harris, 1963). Only children who obtained an IQ of above 85 on both tests were included. Medical records revealed that all the children met the criterion of normal development with respect to hearing, neurological development, socio-emotional behaviour, and development as described by Stark and Tallal (1981). Further details of the raw scores for the original selection of the group can be found in van der Lely and Harris (1990).

The 6 SLI children in this study were selected to be representative of the original group. Therefore, the severity of their original language impairment and their rate of progress on standardized tests of language over the previous 2 years varied. The SLI children were reassessed on the same four standardized language tests to provide a current description of the children's language abilities. The choice of these tests was determined by their reliability in identifying SLI children, previous use for research purposes, and ability to tap different aspects of linguistic skills (Bishop & Adams, 1989; Bishop & Edmundson, 1987; van der Lely & Harris, 1990), rather than adherence to any theoretical notions on which the tests were based. The two tests of comprehension were the Comprehension section of the Reynell Developmental Language Scales (Reynell, 1977) (a general test of understanding commands of graded difficulty) and the *long* form of the British Picture Vocabulary Scale (Dunn, Dunn, Whetton, & Pintillie, 1982) (a more specific test of comprehension of single words). The two standardized measures of expressive language were the Grammatical Closure subtest from the Illinois Test of Psycholinguistic Abilities (ITPA) (Kirk, McCarthy, & Kirk, 1968) (a test of grammatical morphology) and the Expressive Vocabulary subtest from the British Ability Scales (BAS) (Elliott et al., 1978). Some of the SLI children now performed within normal limits on *some* of the tests. Although all the children met the criterion of falling at least 1.5 SD below the mean when originally selected, one child (OC) now performed within normal limits on all the standardized tests. However, this was taken to reflect the inability of many standardized tests to tap the very specific nature of SLI children's language deficit. (OC'S language problems were still of the severity to warrant full-time attendance at a specialized education language unit for children with language impairment.) In addition to the test scores used for description and matching purposes, all the SLI children were impaired in their grammatical comprehension of reversible sentences in comparison to chronological age and younger language-control children (see van der Lely & Harris, 1990, for details). All 6 SLI children were still undergoing their education in language units and were judged by speech language pathologists to be continuing to have persisting language deficits.

An estimate of the SLI children's language ages was used to identify an initial pool of normally developing children from

which children could then be matched on test performance as measured by raw scores. The SLI children's chronological ages ranged from 6;1 to 9;6 and their language ages were on average 1;10 years below their chronological ages. A summary of subject details can be found in Table 1 and further details of the language Scores for each of the children on the four tests can be found in Appendix A.

Language-Age Control Group

Each child in the SLI group was individually matched to 3 language-control children on the basis of individual raw scores from three standardized language tests. The tests were the British Picture Vocabulary Scale (BPVS), The Grammatical Closure sub-test from the ITPA, and the Expressive Vocabulary from the BAS. The tests were administered to 55 children whose chronological ages approximated the language ages of the SLI children. The control children came from an infant school and private day nursery in a rural city. Seventeen matched control children (9 boys and 8 girls) were selected from this sample. Two of the SLI children, OC and SJ (who had identical overall language ages) shared 1 control child. All the LA controls' scores fell within the normal limits on the three language tests. It can be seen from Appendix A that the raw scores from at least two of the three tests for each SLI child were closely matched to those of their controls', that is, their scores fell between +/- 6 points of their controls' with the majority of scores falling between +/- 3 points. Analysis revealed no overall significant differences between the LA controls and the SLI children on the raw scores of the three standardized tests of language abilities. For the BPVS, $t(21) = 0.15$, $p > 0.8$; for the Grammatical closure, ITPA subtest, $t(21) = 0.35$, $P > 0.5$; and for the Expressive Vocabulary, BAS, $t(21) = 0.51$, $P > 0.5$. Therefore the LA control group were highly representative of the language abilities of the SLI children as measured by these tests. The mean language ages for the LA controls ranged from 3;1.5 to 6;6 (years:months).

TABLE 1. Summary of subject details for the SLI children and language-age control children.

	Chronological age Mean (range)	Language tests raw scores		
		BPVS Mean (SD)	ITPA Mean (SD)	BAS Mean (SD)
SLI children (n = 6)	7;2(6;1-9;6)	46.83 (14.68)	14.83 (5.71)	14.00 (2.00)
LA controls (n = 17)	5;2(3;4-6;5)	45.88 (12.34)	15.71 (5.08)	14.52 (2.24)

Note. BPVS = British Picture vocabulary test; ITPA = Grammatical closure sub-test from the Illinois Test of Psycholinguistic Abilities; BAS = Expressive Vocabulary sub-test form the British Abilities Scales. Standard deviations of the mean scores are in parenthesis.

EXPERIMENT 1: SEMANTIC-COGNITIVE PROCESSING

Method

Experiment 1 was designed to investigate the use of semantic-cognitive processing in the immediate recall of words. It also investigated whether this processing was affected by the use of different testing paradigms. The recall of semantically unrelated and semantically similar words were compared. Baddeley (1966a, 1966b) found that semantically similar words were recalled less well than unrelated words in both immediate and delayed recall. However, this was most pronounced in the delayed-recall condition, where Baddeley argued that long-term memory was involved- It was predicted that if semantic-cognitive processing was involved in immediate recall of items, then recall on semantically similar items should be poorer than recall of semantically unrelated items. Thus, if the SLI children are using semantic processing to a greater extent for STM and recall of words, then differences between the two subject groups should be apparent.

Design

The two recall paradigms were used in Experiment 1: verbal repetition and picture pointing. Subject group (SLI children, LA controls) constituted a between-subject variable in the experiment. There was one within-subject variable that related to the semantic characteristics of the words (semantically unrelated, semantically similar). The different probabilities of a correct response in the two paradigms prevented combining the paradigms in a mixed 2 x 2 design

Materials

A "pool" of 28 words was selected from the names of the Snodgrass and Vanderwart (1980) pictures for each of the two semantic conditions (unrelated, similar)- The following criteria were adhered to; The words had to have an early age of acquisition and high frequency. All the words were mono syllabic and the majority of them had a CVC construction, but a few words were included that contained consonant clusters either initially or finally- Where data were available, the words had an acquisition age of below 3;0 (Snodgrass & Vanderwart, 1980) - For the semantically similar condition the words were selected to fall into one of four semantic categories, that is, animals, eating utensils, clothes, and body parts- These categories were chosen as it could be expected that they would be familiar to all children of the ages of those in the study.

Each pool of 28 words was divided into four sets of seven items- For the semantically similar condition, these sets concurred with the four semantic categories named above. Appropriate numbers of items from these sets were selected so that there were four lists for each span tested. No word appeared more than once in anyone list, with each word appearing with approximately equal frequency throughout the lists. Lists with lengths of two to seven items were

prepared. The 28 items for each condition can be found in Appendix B.

For the picture-pointing response paradigm, 2 x 2-inch pictures from the Snodgrass and Vanderwart (1980) pictures were assembled onto 29.7cm x 21cm response cards. There were seven pictures on each card that corresponded to one of the four lists for each span. Therefore, in total, eight response cards were constructed for the two conditions.

Procedure

Each child was tested individually in a quiet room. The child was seated opposite the examiner at a small table. The two conditions were presented in the same order for the repetition and the picture-pointing paradigms, with the semantically unrelated words preceding the semantically similar set of words.

All the stimuli were spoken by the experimenter at a rate of one item per second. The four lists for a particular span length were all administered. Testing did not proceed to the next span unless a child scored two or more out of four correct for a given span. The responses were recorded on individual test sheets. In addition, for the repetition paradigm the responses were audiotaped for later verification of the responses.

Presentation for the repetition paradigm followed the procedure set out below. The procedure was designed to make the experiment as pragmatically plausible as possible to the child and to increase motivation, thereby maximizing performance. A number of puppets, which matched the number of items in a given span, were placed in front of the child. It was explained that each of the puppets was going to be given a word by the experimenter. The child was told to listen carefully and remember who "said" each word. Using two practice words, the experimenter said the words, pointing to each puppet in turn. The child was instructed to tell the experimenter, in the same order, the words the puppets had said. The child was encouraged to point to the puppets as he or she repeated the items, but this was not enforced. A further practice list was presented if there was any doubt that the child did not fully understand the task.

Before testing using the picture-pointing paradigm, the child was presented with each of the response sheets in turn and asked to point to the pictures as they were named to ensure correct recognition. An explanation of the procedure followed, emphasizing the need to point to the items in the same order as they were spoken by the examiner. A practice list of two items was presented. If the child did not point to the correct items in the list, or the order was incorrect, the experimenter repeated the list, pointing to the pictures as she did so. The practice list was then repeated for the child to respond again. If the child did not appear to understand the task, then two further practice trials were given following the same procedure outlined above. Following a correct response by the child, the first of the four response sheets for one of the conditions was placed upside down in front of the child. After auditory presentation of the items in a particular list, the sheet was immediately turned over for the child to point to the pictures.

If the child requested repetition of the items for either test paradigm this was given, but the following response was not scored. Few children made any such requests during the testing sessions.

Scoring

The number of correct responses from the maximum number of 24 lists was calculated. A response was scored as correct if both the items and their order concurred with that of the presentation list. For the main analyses, all other responses were scored as incorrect. However, the number of items correctly recalled irrespective of their ordering was also calculated for the semantically dissimilar words for a subsidiary analysis.

For the repetition paradigm, in addition, the responses were transcribed from the audiotape and the response scores were verified. There was virtually no disagreement (less than 1 %) between the scores transcribed at the time of testing and those later transcribed from the audiotape. Any recognizable, unambiguous attempt to say the target word was scored as correct. Thus, normal phonological assimilation between items was accepted. Ambiguous responses (approximately 1 %) were excluded from the analysis.

Results and Discussion

The total number of correct responses (i.e., correct item and order) were calculated for each subject for the two test paradigms. Two separate analyses were carried out—one for each of the test paradigms—using a two-way ANOVA, with language abilities (based on raw scores of the language tests) covaried out. There was one between-subject variable (subject group: SLI children, LA controls) and one repeated-measure (semantic characteristic: unrelated, semantically similar). Table 2 shows the mean scores and standard deviations for the two groups for the two semantic conditions for the repetition and picture-pointing paradigms; it also shows in parentheses the mean span of each group of children in each condition. The span score was calculated by dividing the number of lists correctly recalled at each length by 4.0 and then adding a constant of 1.5. The constant of 1.0

TABLE 2. Experiment 1. Semantic-cognitive processing: Mean number of lists correctly recalled for the semantically unrelated and semantically similar words for the two subject groups.

Test paradigm	SLI children			LA controls		
	<i>M</i>	<i>SD</i>	Span	<i>M</i>	<i>SD</i>	Span
Repetition						
Unrelated words	7.33	2.65	(3.33)	8.52	2.45	(3.63)
Semantically similar words	7.66	2.87	(3.45)	9.11	2.44	(3.88)
Picture pointing						
Unrelated words	6.50	3.78	(3.13)	6.58	2.64	(3.17)
Semantically similar words	6.0	3.89	(3.00)	5.70	3.86	(2.93)

Note- The corresponding mean span is shown in parentheses. Maximum score = 24.

was required as no single-word lists were tested, and the additional constant value of 0.5 conforms to the recommended span calculation procedure (see Woodworth, 1938).

In the repetition paradigm the mean score of the SLI children was below that of the LA controls on semantically unrelated and related words (Table 2). However, neither the main effect of subject group [$F(1, 20) = 1.86$], the main effect of semantic similarity, nor the interaction were significant. Thus the SLI children's lower performance on the repetition task than the LA controls' was not statistically reliable.

Alternatively, the lack of significant support for the difference between the two groups may reflect the small numbers of subjects in the SLI group (although there were almost three times as many children in the LA control group). Thus, caution is expressed in the interpretation of these results.

A slightly different pattern of results can be seen from the data from the picture-pointing paradigm. First, it can be seen from the mean scores in Table 2 that there was no trend for the SLI children to perform below the LA controls. Analysis revealed that there was not a significant main effect of subject group [$F(1, 21) = 0.01, P = .953$]. Both groups performed more poorly with recall of the semantically similar words, but again analysis revealed that the main effect of semantic similarity was not significant [$F(1, 21) = 1.83, P = .191$], nor was the interaction [$F(1, 21) = .14$].

The pattern of performance on the two paradigms for the two groups (see Table 2) indicates that there was not a general learning effect from the order of presentation that could have caused the children to perform better on the semantically similar words. If such learning occurred it should have affected both paradigms equally, which it did not.

A further analysis was carried out on the total number of words correctly recalled regardless of their order to see if this would reveal differences between the two groups' performance. It has been suggested (e.g., Conrad, 1964) that ordered recall may more directly tap phonological processes in STM than unordered recall. Therefore, if the SLI children have a general deficit in STM and/or the processes incurred in verbal output it would be expected that a similar trend of a lower performance would be found in the unordered recall as the ordered recall of words. The total number of words correctly recalled for the semantically dissimilar words for the two test paradigms was calculated.

It can be seen from Table 3 that the performance of the two subject groups was very similar for both the repetition and picture-pointing task. Analysis confirmed that the two groups did not differ in the number of words recalled for either the repetition paradigm [$t(21) = .16$] or the auditory picture-pointing paradigm [$t(21) = .98$]. Thus, there was no reliable

difference between the groups in ordered recall in the repetition task. The data, therefore, suggest that the two groups may differ specifically in their phonological processing in STM and that this may account for the marginally lower level of performance of the SLI children for ordered recall of items. Experiment 3 investigates this possibility following the investigation of lexical processing (Experiment 2).

The results from the analysis of the ordered recall, together with those from the unordered recall, indicate that with careful selection of materials and procedure for matching language abilities, the SLI children do not show a significant general impairment in their immediate recall of words relative to LA controls using either a repetition or picture-pointing paradigm. Moreover, the SLI children appeared to be affected in the same way as the LA controls by the semantic characteristics of the materials and the test procedure. Semantically similar words were recalled less well for both subject groups, but only when the task involved pictorial serial recall. However, the semantic similarity effect was not significant for either paradigm. It is possible that visual similarity between some of the items (e.g., the coat and shirt) may have contributed to the worse performance on the semantically similar items in the picture-pointing paradigm. Visual similarity has previously been found to affect the performance of young children (Hitch, Halliday, Schaafstal, & Schraagen, 1988).

The lack of semantic similarity effect for either the repetition or picture-pointing paradigm suggests that, in tasks involving auditory input, if semantic processing does occur it has little influence on storage and/or recall. It is interesting that Baddeley's (1966) findings, in which a semantic similarity effect had only a relatively small, though significant, effect in decreasing STM in the fully developed semantic-cognitive system in adults, were based on written serial recall. It may be that written recall (i.e., a *learned* cognitive process requiring recoding from a phonological into an orthographic form) increases the amount of semantic processing involved in the STM task.

In summary, Experiment 1 indicates that the SLI children in this study appeared to be performing at a similar level and in the same way to the test paradigms and the different semantic characteristics of the materials as the younger normally developing children who were matched on comprehension and expression of language. Thus, importantly, these data suggest that the SLI children were not relying to a greater extent on semantic-cognitive processing than their LA controls for short-term storage and recall of words.

EXPERIMENT 2: LEXICALITY EFFECT

Experiment 2 was designed to explore the effect of lexical processing and representations in immediate serial recall in SLI children and LA-matched controls. Performance on sets of words and nonwords were compared. It was predicted that if lexical knowledge was used to facilitate recall, performance with nonwords should be poorer than with real words. The repetition paradigm was used to investigate this.

TABLE 3. Experiment 1. Semantic-cognitive processing: Mean number of unordered words correctly recalled for the semantically unrelated condition for the two subject groups.

Test paradigm	SLI children		LA controls	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Repetition	29.66	8.57	30.41	10.45
Picture pointing	35.50	14.41	29.59	12.39

Note. Maximum score = 74.

TABLE 4. Experiment 2. The lexicality effect: mean number of lists correctly recalled for the words and non-words for the SLI children and the LA controls.

Test paradigm	SLI children			LA controls		
	<i>M</i>	<i>SD</i>	Span	<i>M</i>	<i>SD</i>	Span
Repetition						
Words	7.33	2.65	(3.33)	8.52	2.45	(3.56)
Nonwords	4.33	1.36	(2.58)	5.24	1.48	(2.81)

Note. The corresponding mean span is shown in parentheses. Maximum score = 24.

Method

Design and Materials

The performance of the children on unrelated words was to be compared with a set of dissimilar nonwords. Therefore, a further pool of 28 even monosyllabic nonwords was constructed. The nonwords were divided into four lists of seven items. Any phonological similarity between the items in any list was avoided. Span lengths of two to seven items were prepared with four lists for each length. (See Appendix B for the list of items.)

Presentation

The nonwords were presented a week (or more) after the unrelated words had been presented. The procedure was identical to that set carried out in Experiment 1.

Scoring

Responses were scored as correct if the correct items and order were repeated by the child. The scoring criterion followed that set out in Experiment 1. An audio-recording of the session was used to verify the scoring of the responses. Again, agreement between the scores was over 98%.

Results and Discussion

The total number of correct responses to the words and nonwords were analyzed using an ANOVA with language ability covaried out. The analysis of these data from the repetition paradigm revealed a significant main effect of lexicality [$F(1,21) = 41.21$ $P < .001$]. It can be seen from Table 4 that this was due to the nonwords being recalled less well than the words, and concurs with previous research findings (Brener, 1940). However, no significant difference was found for the main effects of subject group or the interaction. Thus, this indicates that the two groups were equally sensitive to the lexical characteristics of the materials and were performing at a similar level.

It is interesting that despite the significant lexicality effect, again no differences were found between the performance for the SLI children and the LA controls. This finding contrasts with that of other investigators who found that SLI children were impaired in their immediate recall of words in

comparison to age-matched controls (e.g., Kamhi & Catts, 1986; Kamhi, Catts, Mauer, Apel, & Gentry, 1988). Gathercole and Baddeley (1990) also found that SLI children were severely impaired in their nonword repetition in the sound mimicry subtest of the Goldman-Fristoe-Woodcock (1974) battery. On further testing Gathercole and Baddeley revealed significantly poorer performance for the repetition of single nonwords in comparison to language age-matched control children. In one of the tasks involving the immediate repetition of one syllable, even nonwords SLI children showed a significant impairment, whereas in the second task, using nonwords that varied from one to four syllables, difficulties were evident only with the three- and four-syllable nonwords. As Gathercole and Baddeley point out, repetition of polysyllabic nonwords effectively involves the immediate serial recall of sequences of phonemes and is an immediate memory span task (Gathercole & Baddeley, 1990). The difference between the findings of Gathercole and Baddeley's study and the findings from this study will be further discussed in the general discussion below.

To summarize: Experiment 2 showed that for immediate recall of unrelated words and nonwords, using a procedure tapping storage and output processes, SLI children's performance is similar to that of younger children matched on comprehension and expressive language abilities. The contrast between the findings in this study and some previous investigations cited above suggests that underlying linguistic abilities, not tapped in this experiment, could possibly account for impaired performance in immediate recall tasks in SLI children. Experiment 3 investigated this possibility.

EXPERIMENT 3: PHONOLOGICAL PROCESSING

Phonological processing in STM by SLI children was investigated by comparing performance for immediate recall of phonologically unrelated and phonologically similar words using both the repetition and picture-pointing procedures.

A phonological similarity effect, whereby acoustically and phonologically similar words and nonwords are recalled less well than phonologically unrelated items, has been taken to indicate the phonological nature of STM (Baddeley & Hitch, 1974). More recently this effect has been attributed to a separate component of the articulatory loop, the phonological input store (Baddeley, 1986). Information in this store is subject to passive decay over time. The store can be maintained by rehearsal involving reactivation of articulatory or motor-speech programs. However, this experiment aimed to investigate the phonological short-term storage abilities of SLI children and not articulatory rehearsal.

Method

Materials

Rhyming monosyllabic even words with the initial onset varying were selected. Because of the difficulty in finding sets of phonologically similar words that could be pictorially pre

sented and, as far as possible, meet the selection criterion set out in Experiment 1, the pool of words consisted of only 20 items with some CV words or words containing a consonant cluster. The pool was divided into four lists of five rhyming words. Four test lists for each span length between two and five items were prepared.

Procedure

Exactly the same procedures as set out in Experiments 1 and 2 were used for the presentation of the repetition and picture-pointing paradigms in this experiment. Testing followed approximately 1 week after Experiment 2. For each task, testing was stopped if the child failed to give two or more correct responses out of the possible four lists for a given span length. By presenting the phonologically similar words after the phonologically dissimilar words, any possible practice effects are loaded against the predictions.

Scoring

This followed the same procedure as the previously reported experiments for both the repetition and picture-pointing paradigms. That is, correct scores were those in which the correct items were indicated in the correct serial order. The scores from the repetition paradigm were verified following transcription of responses from the audiotape. Agreement between the scores approached 100%.

Results and Discussion

Correct scores for unrelated words from Experiment 1 were compared with those for the phonologically similar words from this experiment. Table 5 shows the mean scores for the two subject groups for the two paradigms. Two separate ANOVAs, with language ability covaried out, were administered to investigate the phonological similarity effect for words in the repetition and picture-pointing-paradigms. Subject group (SLI children, LA controls) was the between subject variable, and the phonological characteristic of the materials (phonologically unrelated and similar words) the within-subject variable.

The main effect of phonological similarity was significant for the repetition paradigm [$F(1,21) = 13.78, P < .001$] and for the picture-pointing paradigm [$F(1,21) = 18.50, P < .0001$]. It can be seen from Table 5 that this reflected the lower performance for the phonologically similar words. It can also be seen from Table 5 that the two groups appeared similar in their recall performance of the materials in the two paradigms. This was confirmed by the analysis, which showed that neither the main effect of subject group in the two tasks [repetition, $F(1,20) = .76$; picture pointing, $F(1,20) = .05$] nor the interactions were significant.

These data indicate that in both paradigms, auditorily presented words and nonwords are processed and held in an acoustic or phonological store for immediate recall. These findings concur with those of previous research investigating adults (Baddeley, 1966; Conrad, 1964) and those investigat-

TABLE 5. Experiment 3. Phonological processing: Mean number of lists correctly recalled for the phonologically dissimilar and similar words for the two groups using the repetition and picture-pointing paradigms.

Test paradigm	SLI children			LA controls		
	<i>M</i>	<i>SD</i>	Span	<i>M</i>	<i>SD</i>	Span
Repetition						
Unrelated words	7.33	2.65	(3.33)	8.52	2.45	(3.63)
Phonologically similar words	5.83	1.94	(2.96)	6.00	1.54	(3.00)
Picture-pointing						
Unrelated words	6.50	37.8	(3.1.3)	6.58	2.64	(3.15)
Phonologically similar words	4.50	1.64	(2..62.)	4.53	2..32.	(2.63)

Note. The corresponding mean span is shown in parentheses
Maximum score = 24

ing children (e.g., Hulme & Tordoff, 1989). Furthermore, the SLI children appear to be affected in the same way as the younger language-age controls by the phonological characteristics of the materials, which supports the findings of Gathercole and Baddeley (1990). The finding of a phonological similarity effect in SLI children is important in aiding our linguistic characterization of SLI children. It indicates that these SLI children have a similar capacity and storage of phonological material and suggests that the quality of item within the store is similar to that of their language peers who are developing language normally.

In conclusion, the findings from Experiment 3 investigating phonological processing are consistent with the view that SLI children are sensitive to the phonological similarity of the, to-be-remembered items, and concur with Gathercole and Baddeley's (1990) findings.

Before we discuss further the overall implications for the findings from these experiments, a further matter must be considered: SLI children are typically heterogeneous. Therefore, it is important to establish whether individual SLI children conform to the general findings from the group analyses. Further analyses were undertaken to investigate this.

Individual Analysis

One way of assessing the individual performance of the SLI children is to calculate *Z* scores for each SLI child based on the mean and standard deviation of the LA controls' scores relative to their language age for a particular task.

Analysis of scores from the repetition and picture-pointing response paradigms were carried out to see if the *Z* score for the "effect sizes" for semantic similarity, lexicality, and phonological similarity fell within the normal range predicted on the basis of the performance of the LA control children.

In order to unconfound the effects of language ability, language ability was partialed out from the analysis (Howel 1992) and each of the SLI children's effect scores (e.g., the score for the phonologically unrelated words, minus the score for the phonologically similar words) were adjusted accordingly. The *Z* scores were then calculated: the proba-

bility for a significantly different Z score was set at $Z = 1.96$, $P < .05$ (two tailed).

Five analyses were carried out, giving an overall total of 30 Zscores for the 6 SLI children. It would be expected that with 30 comparisons at a significance level of .05, between one and two Z scores would fall above or below the 1.96 level. The analysis revealed three Z scores that fell outside the $Z = 1.96$ level. One subject showed a significantly larger effect of semantic similarity ($Z = + 2.22$) and phonological similarity ($Z = +2.06$) in the repetition and picture-pointing paradigms respectively. A further subject showed a significantly smaller effect of semantic similarity for the repetition task ($Z = -2.50$). All the other Z scores fell within the "normal" limits that were set for this analysis. These results indicate that the SLI children in this study were largely homogeneous with respect to the tasks under investigation and that the group means are not "hiding" possible outliers, or any child who is consistently impaired in his STM abilities.

In conclusion, the individual analysis supported that of the group analysis. The results indicate that generally the SLI children are affected by the linguistic characteristics of the to-be-remembered materials to the same extent as the younger LA control children. Thus, overall the results indicate that none of the SLI children show qualitative differences in their short-term storage of words and nonwords in comparison to a younger group of children matched on comprehension and expressive language abilities.

General Discussion

This study has considered linguistic factors in STM experiments and the processing demands in testing STM, and has carefully controlled for the level of language development by comparing each SLI child with 3 LA control children. The findings provide further characterisation of the STM abilities of SLI children and the underlying nature of their disorder. Specifically these relate to linguistic processing and linguistic representations that appear to be differentially important in different STM tasks. In this general discussion we will first summarize the findings from the three experiments, before discussing in further detail their implications for the underlying nature of SLI in children.

To summarize: Recall is not significantly worse for semantically related lists than unrelated lists in STM tasks using either a picture-pointing response or a verbal repetition-response paradigm. Performance is better for real words than nonwords in paradigms tapping storage and output processes, that is, in the repetition paradigm.

For auditorily presented speech sounds, sensitivity to the acoustic-phonological nature of the materials was found for both the test paradigms in which input processes and storage for immediate recall was involved. This concurs with many previous findings (e.g., Baddeley, 1966, 1986) and may be taken to indicate the linguistic-phonological nature of the short-term storage of speech sounds.

Generally, SLI children performed at a similar level, and were equally sensitive to the form of the testing paradigm and the linguistic demands of the task, when compared with a group of younger children carefully matched on comprehen-

sion and expressive language tasks. However, it can be noted from the group analyses that, although in the picture-pointing tasks there were clearly no differences between the performance level in the two groups, in the repetition paradigm in every case the mean recall of the SLI children was below that of the LA controls for ordered recall of items (see Tables 2, 4, and 5); this difference, although consistently present in all the experiments, did not in any case approach statistical significance. One possibility is that this difference could reflect small differences between the SLI children and LA controls in output processing or higher level representations, as has been suggested in investigations of phonologically disordered children (Bird & Bishop, 1992). However, when the total number of unordered items recalled was considered the SLI children and LA controls were equal. It has been suggested that phonological processing, on which ordered recall is particularly reliant (Conrad, 1964), may lie at the root of the differences between the groups (Gathercole & Baddeley, 1990). The conclusion drawn from the data from this study contrast with that of Gathercole and Baddeley (1990). It can be recalled that Gathercole and Baddeley found an impaired performance on the repetition of nonwords of one to four syllables. In one view (e.g., Gathercole & Baddeley, 1990) repetition of such polysyllabic nonwords has been taken to be essentially equivalent to the recall of longer lists of single-syllable nonwords. Therefore, it could have been expected that the SLI children in this study would have been impaired in their recall of nonwords. However, this was not so. Therefore, the data from this study do not support Gathercole and Baddeley's conclusion that SLI children necessarily have an impaired capacity for phonological storage as reflected by recall of nonwords. It remains a possibility that if phonologically or syllabically more complex words had been investigated, significant differences would have been revealed. Further detailed research comparing SLI children with children matched on language abilities is needed to investigate this possibility.

The overall findings from analysis of the SLI group of children was supported by the individual analysis of Z scores for the effect sizes for the various tasks. It appears that even when individual variation of this group of SLI children is considered, few differences are found in relation to that expected for the child's level of language abilities.

These findings reveal some differences with previous investigations of the STM abilities of SLI children. For example, not only did Gathercole and Baddeley find impaired performance for their group of SLI children in the repetition of nonwords, but also in ordered recall of unconnected words of one and three syllables in a picture-pointing paradigm. There are three possible reasons for the different findings. First, as mentioned earlier, Gathercole and Baddeley's use of the short form of the BPVS for matching purposes may be an insensitive language measure for children who may show a variable pattern of strengths and weaknesses in different aspects of language (cf. Clahsen, 1989; Gopnik & Crago, 1991). Assessment on a range of language tests, such as those used in this study, that tap different aspects of comprehension and expression, may provide a more sensitive measure of language abilities for matching purposes. In addition, the methodology used in this study with three LA

controls per SLI subject may provide a stronger basis for comparing the performance of SLI children.

Another consideration is that the children in this study were on average 1 year younger and had an average language age a year below those of Gathercole and Baddeley's subjects. However, it seems unlikely that if the underlying *cause* of SLI is due to an impairment in memory *capacity*, as proposed by Gathercole and Baddeley (1990), that this deficit would not also be apparent at younger stages of development. Also, it could be expected that a deficit would be found with long lists of monosyllabic words and nonwords, such as those presented in this study, as well as with syllabically complex words.

Finally, although on the surface the data from this study appear to conflict with the findings of Gathercole and Baddeley, closer inspection suggests that in some cases it is the conclusions drawn rather than the data themselves that differ. In Gathercole and Baddeley's study, statistical analysis also showed no significant main group effects reflecting impaired performance by the SLI children in comparison to the language-age controls for recall of words in the comparable picture-pointing task (i.e., the phonological similarity task). However, a post hoc comparison in the absence of a significant main effect revealed that the SLI children were significantly impaired relative to the LA controls on lists of length four. Ceiling and floor effects may have prevented possible differences being revealed at longer or shorter span lengths. Moreover, Gathercole and Baddeley did not generally find significant interactions between subject group and the characteristics of the materials. The only significant interactions to be found were with list lengths that were very much greater than the subject's span where performance

was approaching chance. From these data it appears that Gathercole and Baddeley's findings were generally similar to those of this study. Thus it could be argued that for the picture-pointing paradigm Gathercole and Baddeley's data do not provide strong support for their conclusion that SLI children "have dramatic impairments of immediate phonological memory" (Gathercole & Baddeley, 1990, p. 355). However, our finding that SLI children did not differ significantly from the controls in repeating *lists* of nonwords appears to contradict Gathercole and Baddeley's (1990) results more directly. Their language-disordered subject showed significant impairment in repeating *single* nonwords, particularly when these had three or four syllables. One possible reason for this difference is that there may be substantial differences in the task requirements of repeating a list of short nonwords or a single long nonword, although as Gathercole and Baddeley (1990) point out, this seems unlikely. The second possibility is that this difference in outcome reflects some procedural differences between these studies or in the children involved. It does, however, seem clear that a difficulty in nonword repetition—a task that particularly involves phonological STM—does not *necessarily* occur in SLI children.

A further consideration is the heterogeneity in the population of SLI children that could account for the differences. With increasing research it is becoming increasingly evident that the population of SLI children is inherently diverse. Some subgroups have clearly differing linguistic characteristics, for example, "semantic-pragmatic SLI" children who have rela-

tively fluent speech and good grammatical comprehension (Bishop & Adams, 1989) versus the SLI children in this study who exhibit grammatical deficits in both their comprehension (van der Lely & Harris, 1990) and expression of language (van der Lely, 1990). However, other subjects from the SLI population share some but not all linguistic characteristics (cf. Gopnik & Crago's [1991] group characterised by familial aggregation). The possibility that different groups of SLI children may have different characteristics in STM tasks and language abilities has important implications for the underlying cause of SLI in children. It would appear unlikely that a single underlying cause could account for the wide range of deficits found. At the same time, it is as yet unclear to what extent the underlying cause of SLI in different groups of children who share some but not all linguistic characteristics may be related. Only with further research with clearly defined subject groups will it be possible to establish this.

Gathercole and Baddeley (1990) indicate that the finding of a STM deficit suggests that this deficit may be an underlying cause of specific language impairment in children. It is interesting to note that although no group differences were found in the STM tasks, the SLI children in our study were found to be significantly impaired in comparison to the same group of LA controls on a number of linguistic tasks, for example, sentence comprehension, and using syntactic cues to help constrain and learn the assignment of thematic roles for a novel verb (van der Lely & Harris, 1990; van der Lely, 1993). Thus, these data do not support the hypothesis that an underlying STM deficit can account for the specific language impairment, at least with this group of children. The data from this investigation suggest that hypotheses that indicate a causal relationship between a memory deficit and SLI in children should be viewed with caution. It appears that this hypothesis cannot be generalized to SLI children as a whole. Moreover, the data suggests that the underlying deficit in SLI children is not of a general nature but is confined to specifically linguistic processes and/or representations.

Conclusion

SLI children were not found to have impaired STM in comparison to younger language-matched control children when tested using two test paradigms. The SLI children were also found to be equally sensitive to the linguistic characteristics of the to-be-remembered items and the processing demands made by the different test paradigms as their matched LA controls.

The interpretation of the data from this study contrasts with many previous findings in which an impairment in immediate recall in SLI children has been attributed to defective STM or subcomponents of STM (e.g., Eisenson, 1972; Gathercole & Baddeley, 1990). We have claimed that the linguistic abilities of the SLI children (i.e., their linguistic processing and previous linguistic representations) contribute to their performance in immediate recall of linguistic material. Therefore, SLI children are likely to be impaired relative to chronological age controls in STM tasks. The claim above places strong demands on matching procedures if SLI children are to be compared with language-matched control children. The

methodology used in this study, in which each SLI child was matched to 3 control children on the basis of raw scores from three tests of language, may explain why differences in STM performance between the two subject groups were not found in contrast to previous investigations.

The investigation into STM in this study also highlights the necessity of considering possible cognitive and linguistic demands of the experimental paradigms that may influence performance, particularly in children who are still developing or children who have specific areas of impairment in development. Performance in skills apparently unrelated to SLI children's language deficit may, on closer inspection, be attributable to their underlying linguistic impairment.

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Appendix A

Raw scores and standard scores for the language tests for the SLI children and LA controls.

Subject	Chronological age (Months)	Language tests			
		RDLs Mean (Z-S)	BPVS Mean (SS)	ITPA Mean (SS)	BAS Mean (Z-S)
SLI children					
MP	114	62*	68 (81)	22 (22)	15*
OC	78	64 (-0.1)	49 (89)	15 (31)	16 (-0.23)
SJ	84	64 (-0.2)	51 (85)	10 (20)	16 (-0.44)
AS	80	63 (-0.5)	49 (86)	21 (38)	13 (-1.56)
SW	73	62 (-0.4)	41 (84)	13 (30)	13 (-1.34)
DL	88	46 (-7.8)	23 (50)	8 (15)	11 (-2.05)
LA controls					
MP1	77		49 (91)	18 (36)	17 (0.81)
MP2	76		57 (108)	19 (37)	16 (0.08)
MP3	66		68 (114)	26 (57)	16 (0.20)
OC1	66		55 (105)	22 (50)	14 (-0.88)
OC2	65		54 (103)	20 (47)	15 (-0.38)
OC2/SJ1	76		53 (96)	16 (32)	17 (.081)
SJ2	71		53 (87)	14 (30)	16 (-0.23)
SJ3	66		56 (97)	18 (43)	16 (0.20)
AS1	62		43 (94)	13 (37)	16 (0.55)
AS2	67		51 (100)	19 (45)	15 (-0.41)
AS3	66		50 (99)	17 (41)	14 (-0.88)
AW1	56		36 (92)	16 (47)	15 0.00
AW2	56		36 (92)	11 (38)	13 (-0.50)
AW3	63		41 (92)	13 (38)	15 (0.00)
DL1	40		25 (97)	6 (39)	9 (-0.36)
DL2	40		25 (97)	11 (52)	13 (0.77)
DL3	41		28 (98)	8 (44)	10 (0.00)

Note. RDLs = Reynell Developmental Language Scales, BPVS = British Picture Vocabulary Scale, ITPA = Grammatical closure sub-test from the Illinois Test of Psycholinguistic Abilities, BAS = Expressive vocabulary from the British Ability Scales, The RDLs was used to provide a further description of the subject details and was not used for matching purposes.

Where available the SS (= Standard Score) is given for each subject based on the raw score and chronological age for each test as provided by the respective test manuals, The BPVS test has mean standard score of 100 and SO of 156. The ITPA has a mean standard score of 36 and SO of 6- For the RDLs and BAS the Z-S (= Z-Score) is given as no overall mean SS and standard deviation is provided by these tests.

*Z-scores for the RDLs and BAS are not available for this child's chronological age,

Appendix B

Dissimilar words

(a) mouth pig spoon lamp bed pen doll (b)
nose ball fork horse bag duck book (c) sock
hand cup fish drum house bus (d) foot knife
coat dog leaf watch bell

Semantically similar words

(a) duck sheep cat pig horse fish dog
(b) glass bowl jug spoon cup knife fork (c) belt
boot shirt dress skirt coat sock (d) leg hand
thumb head mouth nose foot

Phonologically similar words

(a) bee key sea tree pea
(b) rat hat mat bat cat
(C) sheet meet sweet seat feet
(d) floor door saw four paw

Dissimilar non-words

(a) sart bof yol neek tem tIV kal (b) cug
jid fen zav mip pon shos (c) rit kem lat
yop seg tek gol (e) hap vus wid das fef
noop barn