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The role of sentence recall in reading and language skills of children with learning difficulties

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Abstract

The present study explores the relationship between sentence recall and reading and language skills in a group of 7-11 year old children with learning difficulties. While recent studies have found that performance on sentence recall tasks plays a role in learning, it is possible that this contribution is a reflection of shared resources with working memory. In order to investigate whether sentence recall was uniquely associated with reading and language skills, differences associated with IQ and working memory capacity were statistically controlled. A sample of 72 children was tested on measures of verbal complex memory, verbal short-term memory, sentence recall, expressive vocabulary, verbal and performance IQ, reading and language skills. Both sentence recall and verbal complex memory shared unique links with reading skill, and sentence recall was uniquely associated with language skills. This finding indicates that resources in long-term memory also play an important diagnostic role in reading and language abilities. The implications for educational practice are discussed.

The role of sentence recall in reading and language skills of children with learning difficulties

Sentence recall has been increasing recognised as a useful indicator of learning difficulties. For example, sentence recall has been found to be an effective psycholinguistic marker of both children with specific language impairment (Briscoe, Bishop, & Norbury, 2001; Conti-Ramsden, Botting, & Faragher, 2001; Tomblin, Freese, & Records, 1992) and individuals with dyslexia (Plaza, Cohen, & Chevrie-Muller, 2002). Performance in sentence recall tasks is also related to reading comprehension skills (Marshall & Nation, 2003; also Nation, Adams, Bowyer-Crane, & Snowling, 1999). The present study investigates whether this association between sentence recall and learning difficulties is due to common mechanisms shared with verbal short-term memory, or if sentence recall taps a unique aspect of cognitive ability. Specifically, we explored the link between sentence recall and reading and language skills in children with learning difficulties.

As sentence recall is a task that involves the integration of semantic information with structural aspects of a sentence such as the word order and inflectional markers, it has been suggested that it taps both short-term and long-term memory. One view is that the conceptual or semantic component of sentence recall is associated with long-term memory, while the lexical or phonological component is associated with verbal short-term memory. Evidence of the involvement of long-term memory in sentence recall can be found in studies by Potter and Lombardi (1990, 1998). Participants were likely to be confused with a semantically-related distracter to a target word occurring in an earlier sentence. Potter and Lombardi (1990, 1998) suggested that this occurred because regenerating a sentence relies on recently activated lexical entries from conceptual information in long-term memory (see also Lee & Williams, 1997). Studies using similar methodology also found that phonological information (indexing verbal short-term memory) plays an important role in the accuracy of verbatim sentence recall (Engelkamp & Rummer, 1999; Rummer & Engelkamp, 2001).

Further evidence of the role of phonological memory capacity in sentence recall has been established in developmental populations. For example, Willis & Gathercole (2001) found that increasing the length and number of words in a sentence significantly affected sentence recall. Furthermore, Alloway & Gathercole (in press) observed marked differences between high and low phonological memory groups in the overall accuracy of sentence recall. Interestingly, an error analysis revealed that the high phonological memory group retained the structural aspects of the sentence, such as word order, significantly better than the low phonological memory group, who were more likely to commit errors of omissions and insertions. One explanation is that phonological memory assists in the preservation of the structure of a sentence (see Caramazza, Basili, Koller, & Berndt, 1981).

One model that can accommodate the separate contributions of verbal short-term memory and long-term memory in sentence recall is Baddeley’s (2000) model of working memory. The central executive component of the model is a flexible system responsible for the control and regulation of cognitive processes including temporary activation of long-term memory (Baddeley, 1998), coordination of multiple tasks (e.g., Baddeley, Della Sala, Gray, Papagno, & Spinnler, 1997), shifting between tasks or retrieval strategies (Baddeley, 1996), and selective attention and inhibition (Baddeley, Emslie, Kolodny, & Duncan, 1998). This component is linked directly with three other subsystems: the phonological loop is responsible for temporary storage of verbal information, the visuo-spatial sketchpad stores representations of visual or spatial nature, and the episodic buffer is responsible for integrating information from different components of working memory and long-term memory into unitary episodic representations.

Evidence that sentence repetition measures the capacity of the episodic buffer can be found in developmental research. In a study of four- to six-year old children who had just started formal schooling, Alloway, Gathercole, Willis, and Adams (2004) found that sentence repetition ability formed a separate construct from both the central executive and the phonological loop. Rohl and Pratt (1995) also found that sentence recall loaded on a different factor from verbal working memory tasks in a study of young children. Although distinct from short-term and working memory factors, sentence repetition ability has also nonetheless been found to be associated with measures of verbal short-term memory such as nonword repetition (Alloway et al., 2004; Conti-Ramsden et al., 2001). This pattern of findings is consistent with the view that sentence repetition taps the episodic buffer (e.g., Baddeley & Wilson, 2002), and that the buffer integrates information from temporary memory subsystems such as the phonological loop to support the verbatim recall of individual words and their order, with semantic and syntactic information held in long-term memory.

A different account of sentence recall has been advanced by Martin, Lesch, & Bartha (1999; also Hanten & Martin, 2000). In this model (based on neuropsychological evidence, Martin et al., 1999; McCarthy & Warrington, 1987; Vallar & Baddeley, 1984), knowledge structures in long-term memory are closely linked with separate buffers supporting phonological, lexical, and semantic domains. During a sentence recall task, activated representations in the knowledge base are fed forward to the temporary phonological and semantic storage buffers. In contrast, Martin et al. (1999) propose that comprehension of a sentence relies principally on the semantic storage buffer.

Recent research has found links between performance on sentence recall tasks and children's abilities in learning. Theoretical accounts of this link though, have been contrasting. One view is that that skills stored in long-term memory, such as prior language knowledge, are linked with learning deficits. For example, Marshall and Nation (2003) found that children who demonstrate difficulties in reading comprehension despite displaying normal levels of reading accuracy and speed struggle in sentence recall tasks. Compared to an age-matched control group, the poor comprehenders recalled fewer sentences, as well as a smaller percentage of words within the sentences. In contrast, they performed within age-appropriate levels in verbal short-term memory tasks. They suggest that it is the contribution of long-term memory to sentence recall that plays a major role in differentiating children with comprehension deficits from those without any difficulties.

An alternative account of the contribution of sentence recall to learning is that the storage component of sentence recall associated with short-term memory is linked with difficulties in literacy and comprehension. Conti-Ramsden et al. (2001) suggest that sentence recall is an effective psycholinguistic marker of children with specific language impairment as a consequence of the involvement of short-term memory in the task.

It is well-established that individual differences in the capacity of working memory have important consequences for children's scholastic ability. For example, verbal short-term memory has been found to be closely linked to reading skills (Alloway, Gathercole, Adams, & Willis, in press; Brady, 1997; de Jong & van der Leij, 1999; Garlock, Walley, & Metsala, 2001; Griffiths & Snowling, 2002; Swanson, 1994; Wagner, Torgesen, & Rashotte, 1994). One measure of phonological memory capacity, nonword repetition, a task which requires the participant to repeat an unfamiliar sequence of phonemes, is closely linked with vocabulary acquisition in young children (Gathercole & Baddeley, 1989). One explanation for this relationship is that the storage and manipulation of phonological information is critical in supporting the phonological structure of new words (see Baddeley, Gathercole, & Papagno, 1998, for a review).

Children who struggle in broader aspects of language skills such as sentence comprehension often do not show deficits in verbal short-term memory tasks (Cain, Oakhill, & Bryant, 2000; Hanten & Martin, 2000; Nation & Snowling, 1998; Willis & Gathercole, 2000). They do however, typically have marked impairments on measures of complex memory tasks which involve both storage and processing of information, such a reading span (Daneman & Carpenter, 1980; Nation, Adams, Bowyer-Crain, & Snowling, 1999; Signeuric, Ehrlich, Oakhill, & Yuill, 2000; Swanson, 1994; Yuill, Oakhill, & Parkin, 1989).

The aim of the present study was to investigate whether the association between performance on sentence recall tasks and learning is unique or a reflection of shared resources with short-term memory and working memory. In order to gain a better understanding of the contribution of sentence recall to learning, we recruited children identified by the schools as having learning difficulties. They were administered with a reading test battery (Wechsler Objective Reading Dimensions; Wechsler, 1993) and a language test battery (Wechsler Objective Language Dimensions; Wechsler, 1996). Measures involving simultaneous storage and processing of information such as backwards digit recall, listening recall and counting recall (Pickering & Gathercole, 2001), were used to assess verbal complex memory. Phonological memory was measured by digit recall, word recall and nonword recall (Pickering & Gathercole, 2001). For the sentence recall task, items from the Test for

Reception of Grammar (TROG; Bishop, 1989) were adapted for computerised presentation. The sentences varied in grammatical structure and complexity. Additional measures included in this study are verbal and performance IQ (Weschler, 2003) and a measure of expressive vocabulary (Williams, 1997). The present study investigates whether performance on sentence recall is uniquely associated with reading and language skills, while statistically controlling for verbal short-term memory, working memory and IQ.

Method

Participants

Data are reported here for 72 children (20 girls, 52 boys), with a mean age of 9.0 years (range 6.5 to 11.00 years, *SD* = 12 months) recognised by their schools as having special educational needs that required additional educational support to succeed in a regular classroom, according to the guidelines of the Special Educational Needs Code of Practice (DfEE, 2002). All children were attending state schools in the North-East England.

Procedure

Each child was tested individually in a quiet area of the school for six sessions lasting up to 30 minutes per session across six weeks. Tests were administered in a fixed sequence designed to vary task demands across the testing session.

Working memory tasks. Three verbal complex memory measures from the Working Memory Test Battery for Children (WMTB-C, Pickering & Gathercole, 2001) were administered: backwards digit recall, counting recall, and listening recall. In backwards digit recall, the child is required to recall a sequence of spoken digits in the reverse order. The number of digits in each list increases across trials, and the number of lists correctly recalled is scored. In counting recall, the child is required to count the number of dots in an array, and then recall the tallies of dots in the arrays in the sequence in which they were presented. The number of dots in the array increases across trials, and the number of correct trials completed by each child is scored. In listening recall, the child listens to a series of short sentences, determines the veracity of the statements by responding ‘true’ or ‘false’, and recalls the final word of each sentence in sequence. The number of sentences in each block increases across trials, and the number of correct trials is scored.

Three measures of phonological short-term memory from the WMTB-C (Pickering & Gathercole, 2001) were administered. Digit recall and word list recall both involve spoken recall of sequences of spoken items (either single digits or high frequency monosyllabic words). In each case, the number of items in each sequences increases across trials, and the number of correct trials is scored. Word list matching involves the child detecting whether words in a second list are in the same order as in the first word list. The number of lists increases in each block, and the number of correct trials is scored.

Sentence recall task. A modified version of the Test for Reception of Grammar (TROG; Bishop, 1989) was used to asses sentence recall. This consists of 60 items from sets F to T in the TROG test battery. The sentences varied in grammatical complexity, ranging from simple active constructions to more complex embedded ones. Examples of simple sentence constructions include items such as ‘*The man is eating the apple’* (set F) and ‘*The cow is looking at them’* (set G). More complex constructions include sentences such as ‘*The girl has not only food but also a drink’* (set Q) and ‘*The pencil is neither long nor red’* (set S).

All sentences were presented auditory while the child faced a 21 cm by 28 cm (8” x 11”) coloured screen of a laptop computer, using EPrime software (2000). All audio files were recording using a minidisk player and then edited on the GoldWave program (2004). The sentences appeared with either the correct picture representing the action in the sentence, one of the three distractor pictures shown in the TROG, or with a blue square in the middle of the computer screen. The variation in visual stimuli accompanying the sentence was included in order to explore whether recall would be improved or disrupted with different visual images. A score of 1 was given for each sentence that was repeated correctly. The maximum possible score was 60.

Vocabulary. The *Expressive Vocabulary Scale* (Williams, 1997) was used to assess the child's receptive language skills.

General intelligence. The Wechsler Intelligence Scale for Children - 3rd UK Edition (WISC-III; Wechsler, 1992) was administered. This test consisted of five verbal (Information, Similarities, Mathematics, Vocabulary and Comprehension) and five performance measures (Picture completion, Coding, Picture arrangement, Block design and Object assembly).

Reading. The Wechsler Objective Reading Dimensions (WORD; Wechsler, 1993) provided assessments of reading, spelling and reading comprehension abilities.

Language. The Wechsler Objective Language Dimensions (WOLD; Wechsler, 1996) contained measures of listening comprehension and oral expression.

Results

Table 1 about here

As the sentence recall task was presented with one of the three distractor pictures, we first present results of performance for this task. A repeated-measures ANOVA indicated that performance on sentence recall did not differ as a function of whether a correct picture, distractor picture, or blue square was shown during sentence presentation, $F(2,136)=1.32$, $p=.27$. Thus, the following analyses were based on the total score of correctly recalled sentences (maximum score of 60).

Descriptive statistics for children on the cognitive measures are shown in Table 1. Composite scores of the verbal complex memory and verbal short-term memory measures were calculated by averaging the standard scores of the corresponding tasks. Skewness and kurtosis values for all measures indicated normal distributions of scores. When comparing the children's performance to the test standardised score of 100, average scores of verbal short-term memory tasks fall within one standard deviation of the mean (i.e., 15 points from the norm of 100), and so are within the age-expected level. Performance levels of the verbal complex memory are considerably lower, with the majority of children scoring below one standard deviation of the mean. Performance on expressive vocabulary and the verbal and performance IQ measures all fall slightly below age-appropriate levels. Although the majority of reading scores are low, performance on the language test battery are within one standard deviation of the mean.

Table 2 about here

The correlation coefficients between the cognitive measures are shown in the lower triangle of Table 2. Partial correlations with verbal and performance IQ partialed out are shown in the upper triangle. In the zero-order correlational analyses among the cognitive measures, correlation coefficients between verbal complex memory and fluid intelligence were moderately high. However, the link between verbal short-term memory and was non-significant. Strong links were found between sentence recall and verbal short-term memory (r=.60). Expressive vocabulary was most strongly associated with verbal IQ (r=.59), and less so with performance IQ (r=.28).

With regard to the achievement measures, correlation coefficients were significant between reading and measures of verbal complex memory (r=.41), and sentence recall (r=.26). For the language tests, there were significant links with verbal complex memory measures (r=.31), expressive vocabulary (r=.54), verbal IQ (r=.64), and performance IQ (r=.39). Once IQ measures were partialed out, correlation coefficients between reading and language tests and cognitive measures were diminished (with the exception of verbal short-term memory and reading and language, where coefficients were only slightly smaller). The links between reading and measures of verbal complex memory and sentence recall, and between language skill and expressive vocabulary remained significant once variance associated with IQ was partialled out. However, the association between verbal complex memory measures and language tests was non-significant in the partial correlations.

A series of hierarchical regression analyses were performed to examine the specific contributions of working memory and sentence recall to reading ability (WORD) and language skills (WOLD). Composite scores were used for verbal working memory and short-term memory measures. In each case, age of child, verbal and performance IQ were entered at the first step, expressive vocabulary scores at the second step. The target set of variables was entered as the last step in the function, with the remaining tasks entered as the penultimate step. For example, the relationship between sentence recall and reading was assessed after the variance shared with IQ and working memory has been taken into account. Any final steps that account for significant additional portions of variance thus share unique links with the dependent variable. It should be noted that this fixed-order hierarchical regression procedure is a highly conservative means of assessing unique relationships when different variable sets are themselves highly correlated with one another, as in the present case. However, this method does have the advantage of providing stringent tests of specificity of relationships that are valuable for interpretation of the data, and any residual associations that do meet the criterion for statistical significance are therefore of particular note. The outcomes of these analyses are summarised in Table 3.

Table 3 about here

Steps 1 and 2 (age, IQ and expressive vocabulary) accounted for a large proportion of variance (58% in total) in the language scores, but shared much weaker links with the reading score (10% in total). The particular focus of interest here is in the significance of variable sets when entered as the final (fourth) step in the regression equation. Sentence recall accounted for a significant amount of additional variance in reading after all other predictors were taken into account (p=.02). Of the working memory tasks, only verbal complex memory was uniquely associated with reading skills (p=.004).

For the language measures, sentence recall accounted for a significant percentage of unique variance (p=.02). In contrast, working memory skills did not add any unique variance to the prediction of language abilities after sentence recall performance was controlled.

Discussion

The aim of the present study was to investigate whether the link between sentence recall and learning difficulties is mediated by performance on verbal short-term memory and working memory tasks. To that end, children identified as having learning difficulties were administered with reading and language skills. The findings indicate that both working memory and sentence recall tasks share unique links with reading skills. However, only sentence recall predicted performance in language skills when IQ and working memory were controlled.

The link between verbal complex memory and reading skills is consistent with the findings of many other studies (e.g., Alloway, et al., in press; Hulme, et al., 2002; Swanson & Howell, 2001). While the storage component of working memory tasks is critical at the point at which the child is beginning to acquire and apply phonic knowledge to guide reading and writing (Ellis & Large, 1988; Frith, 1985), the active monitoring of information involved in complex span tasks are a good index of a child's capacity to coordinate and integrate resources in complex activities such as reading (Gathercole, Lamont, & Alloway, in press; Swanson & Saez, 2003).

One of the major outcomes of this study is that sentence recall is uniquely predictive of reading ability. One proposal is that long-term memory can mediate the link between working memory and reading ability (Roodenrys & Stokes, 2001). Long-term knowledge plays a role in short-term memory tasks, as evidenced by the lexicality effect (Hulme, Maughan, & Brown, 1991) and the redintegration process (Hulme, Quinlan, Bolt, & Snowling, 1995, Schweickert, 1993). Some researchers have suggested that the reason children with reading deficits perform poorly on working memory tasks is related to an inability to access long-term phonological and semantic knowledge relating to reading. Support for this view can be found in studies of children with reading difficulties (Roodenrys, Hulme, & Brown, 1993; Roodenrys & Stokes, 2001), as well as studies on illiterate adults (e.g., Morais et al. 1979; also Morais & Kolinsky, 1994). The findings from the present study confirm that long-term memory skills make significant contributions to reading skills.

Another interesting finding is that sentence recall is uniquely linked with language skills. In contrast, there were no significant unique associations between working memory and language skills when differences associated with sentence recall were controlled. Research on adult populations has established the influence of semantic knowledge in comprehension. For example, Hambrick and Engle (2002) found that knowledge of a topic was the better predictor of comprehension compared to working memory capacity. The role of long-term memory in language skills can be accounted for by either the Baddeley working memory model (Baddeley, 2000) or the one proposed by Martin et al. (1999). Both these models involved the integration of semantic and phonological information with knowledge stores in long-term memory. In the Baddeley model, the episodic buffer component is responsible for integrating phonological information from temporary stores with lexical and semantic information from long-term memory systems. In the Martin model, separate storage buffers for semantic and phonological information contribute to performance in sentence recall.

The association between performance on sentence recall tasks and reading and language skills demonstrated here establishes that resources involved in repeating sentences share specific links with attainment. The findings of the present study are in-line with recent research on sentence recall and learning (e.g., Conti-Ramsden et al., 2001; Marshall & Nation, 2003; Plaza et al., 2002), and indicates that sentence recall tasks can be an important diagnostic tool for learning difficulties.

The view that sentence recall integrates knowledge from long-term memory and short-term memory has important implications for learning. In particular, the present study indicates that the interface between knowledge representations in long-term memory and phonological and semantic information in short-term memory is crucial to academic progress. While intervention techniques focused on working memory demands in the classroom have been proposed (Gathercole & Alloway, 2004), corresponding strategies for accessing information from long-term memory would also be useful for children struggling in the classroom with reading or language skills. These include mnemonic strategies that can bolster the efficiency of accessing knowledge stores in long-term memory (Ericsson & Kintsch, 1995).

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Table 1

Descriptive statistics of standard scores for cognitive measures

Variable	Mean	Std. Deviation	Range (min-max)	Skewness	Kurtosis
Verbal Complex Memory:					
Backward Digit Recall	79.46	11.37	56 - 124	1.09	2.15
Counting Recall	73.93	13.05	55 - 106	0.24	-0.71
Listening Recall	81.79	14.26	55 - 117	0.43	-0.05
Composite	78.40	9.47	62 - 104	0.46	-0.39
Verbal STM:					
Digit Recall	91.89	15.91	56 - 123	-0.24	-0.24
Word List Recall	89.12	11.35	65 - 117	0.12	-0.10
Word List Matching Recall	92.53	14.57	55 - 133	-0.10	0.96
Composite	91.18	10.20	58 - 117	-0.18	0.86
Sentence recall tasks	43.72	6.93	24 - 54	-0.50	-0.23
Expressive Vocabulary Test	84.38	9.80	56 - 105	-0.49	0.30
Verbal IQ (WISC)	84.22	11.58	61 - 115	0.25	-0.41
Performance IQ (WISC)	82.68	13.14	62 - 127	0.89	0.69
Reading (WORD)	82.58	11.15	55 - 112	-0.34	0.35
Language (WOLD)	89.26	10.24	71 - 117	0.20	-0.46

Table 2

Correlations between composite scores for cognitive measures and reading and language skills

Measures	1	2	3	4	5	6	7	8
1. Verbal short-term memory	--	.26	.60	.15	.19	.01		
2. Verbal complex memory	.25	--	.15	.03	.35	.03		
3. Sentence recall	.60	.22	--	.01	.23	.04		
4. Expressive vocabulary	-.10	.27	.11	--	.05	.27		
5. WORD	.20	.41	.26	.18	--	.38		
6. WOLD	.02	.31	.14	.54	.44	--		
7. Verbal IQ	.02	.42	.17	.59	.23	.64	--	
8. Performance IQ	.05	.37	.14	.28	.17	.39	.49	--

Note: Zero-order correlation coefficients shown in lower triangle; correlation coefficients with verbal and performance IQ (measures 4 and 5) partialed out shown in upper triangle. For coefficients in excess of .23, $p < .05$; for coefficients greater than .30, $p < .01$.

Table 3

Hierarchical multiple regression analyses predicting reading and language skills

	Reading				Language			
	R^2	R^2 change	*F* change	p value	R^2	R^2 change	*F* change	p value
Step 1								
Age, IQ	.10	.10	2.46	.07	.55	.55	27.82	.00
Step 2								
Expressive vocabulary	.10	.001	.10	.75	.58	.03	4.91	.03
Step 3								
VSTM*	.14	.04	3.17	.08	.59	.002	.24	.62
Step 4								
VCM*	.24	.10	8.09	.01	.59	.002	.29	.60
Step 5								
Sentence recall	.30	.06	5.73	.02	.62	.03	5.44	.02
Step 3								
Sentence recall	.20	.10	8.15	.006	.61	.03	4.91	.03
Step 4								
VSTM	.20	.00	.00	.99	.62	.007	1.25	.27
Step 5								
VCM	.30	.10	8.91	.004	.62	.002	.27	.61
Step 3								
Sentence recall	.20	.10	8.15	.006	.61	.03	4.91	.03
Step 4								
VCM	.30	.09	8.56	.005	.61	.003	.55	.46
Step 5								
VSTM	.30	.005	.41	.52	.62	.006	.10	.33

*VSTM=Verbal short-term memory; VCM=Verbal complex memory