SECONDARY MEMORY AND THE ACQUISITION OF READING IN YOUNG CHILDREN

G. Brian Thompson
Psychological Service, Department of Education, Napier.

Evidence for several memory retrieval processes was found in single-trial free recall by six-year-old children, by determining through subsequent second recall the fate of items retrieved on initial recall. Items recalled by primary memory (PM) retrieval at initial recall had a much lower probability of subsequent recall than items recalled by secondary memory (SM) retrieval. Individual differences in probability of PM recall and total initial recall were uncorrelated. SM recall was correlated with both verbal intelligence and progress in learning to read. PM recall was not.

INTRODUCTION

There has been some recent interest in the relationship between individual differences in aural "memory span" and individual differences in progress in acquiring the skill of reading. Clay (1971), using immediate memory of digits and immediate memory of randomly selected words, found low relationships with reading progress among five and six year olds. Dornbush and Basow (1970), using a digit span task, found no relationship with reading progress of children aged six to fourteen years. Intelligence level of the children was held constant in the experimental design of this study.

In these studies there was an implicit assumption that individual differences in performance on a particular aural memory task have a meaningful unitary interpretation. This may not be the case. The purpose of the present study is, first, to examine the nature of individual differences in the single-trial free-verbal-recall task and, second, to examine concomitant relationships with progress in learning to read.

In a free-verbal-recall task with meaningful items, the items are already registered and retained in memory. The task requires not that items but that retrieval cues for items be registered and retained. The following theoretical outline derives in part from Tulving (1968). Several potentially available retrieval processes are postulated:

1. Primary memory (PM) retrieval cues, which are effective only for a brief duration (under 30 seconds) between presentation and recall. The acoustic features of the items commonly serve as cues for PM retrieval.
2. Serial position retrieval cues, which are effective for a similar brief duration between presentation and recall. Position within the presentation or input sequence serves as a retrieval cue.
3. Secondary memory (SM) retrieval cues which are effective over long durations (at least several minutes). Semantic codes and verbal

associations commonly provide the retrieval cues for this type of retrieval process.

It is postulated that each item recalled by the individual is recalled by means of one and only one of these retrieval processes. The individual may recall different items by different processes. It is assumed that the three types of retrieval processes are potentially available to all individuals but that the extent of use of a retrieval process varies from individual to individual. Individual differences in the use of retrieval processes may not represent individual differences in structural characteristics of memory but simply individual differences in ways of using the same structures common to all individuals.

Tulving and Colotla (1970) have provided, for immediate-free-recall data, a method of experimentally distinguishing items recalled by PM retrieval from those recalled by SM retrieval. If more than *i* other items, either presentation or recall, intervened between presentation and recall of an item, then that item was classified as having been recalled by SM retrieval. All other items correctly recalled were classified as having been recalled by PM retrieval. However, the decision on the value of *i* was rather arbitrary. In the present investigation the probability of *subsequent* recall of items retrieved in immediate recall is employed to distinguish items retrieved by PM cues from those retrieved by SM cues, and to determine the value of *i*. As it is postulated that PM retrieval cues are effective for only a brief duration (under 30 seconds), it would be expected that items recalled by PM retrieval in immediate recall would show zero probability of subsequent recall after a duration of several minutes, while items recalled by SM retrieval would have a relatively high probability of subsequent recall.

METHOD

The subjects were children aged 6:0 to 6:3. Sample A consisted of 62 children who were all the children of this age range attending four state schools in Hawkes Bay. Sample B consisted of 51 children who were all the children of this age range attending a further three state schools in Hawkes Bay. None of the subjects had previous experience with the free-recall task, nor with any other experimental tasks. The testing session for each child comprised presentation of one form of the free-recall task, administration of a test of reading attainment, presentation of the other form of the recall task and then administration of a measure of verbal intelligence, the Crichton Vocabulary Scale (Raven, 1961).

The test of reading comprised oral reading of unrelated sentences. The items used for the single-trial free-verbal-recall task were 72 one- and two-syllable nouns drawn from those listed as the 500 most frequent in the Edwards and Gibbon (1964) list of words used by six

year olds in their free-expression writing. The 72 words were randomly divided into 12 lists of 6 words each. Six lists comprised one form and the remaining six the other form. The lists were presented vocally by the experimenter at a rate of one item every two seconds. Following the presentation of each list the subject attempted immediate free recall by spoken response. Fifteen seconds were allowed for immediate recall, after which duration the next list was presented. After immediate recall of the sixth list, the subject was asked to attempt recall of the words of all six lists. Seventy seconds were allowed for this subsequent recall. Note that subjects were not given any clue which would lead them to suspect that a subsequent recall would take place. The procedure was the same for the presentation of both forms of the free-recall task. The presentation orders of the two forms were counterbalanced.

RESULTS

Except for those given in Table 4, the results are from the first 5 lists of the form of the recall task presented first. Four of the 113 subjects recalled no items on these first 5 lists and thus the results were tabulated for 109 subjects.

A preliminary analysis of the results was made to determine conditional probabilities of subsequent recall of an item, given that it was recalled in immediate recall. These conditional probabilities were estimated for each cell in the matrix of serial position of recall response for each serial position of presentation. Relative to the estimated values for other cells of this matrix, the following cells had low conditional probabilities of subsequent recall: Presentation serial position 5: recall response position 1, Presentation serial position 6: recall response positions 1 and 2. This criterion is equivalent to $i = 1$ in the Tulving and Colotla (1970) method of distinguishing items recalled by PM and SM retrieval. This value for i is much smaller than that employed by Tulving and Colotla but their subjects were adults, not six year olds.

On the basis of this criterion for distinguishing PM and SM retrieval, Table 1 shows values of .21 and .23 for the conditional probabilities of subsequent recall of an item, given that the item was recalled by SM retrieval in immediate recall. The equivalent conditional probabilities of subsequent recall for items recalled by PM retrieval in immediate recall were .09 and .08. As there was a duration of more than 30 seconds between presentation of any of the items of the first 5 lists and the subsequent final recall, zero conditional probability would be predicted by the postulated characteristics of PM retrieval. However, the recall of an item in immediate recall may well act as another presentation of the item and if this is so, it might be expected that the conditional probability of *any* item being recalled in both immediate recall and subsequent recall (S_2+P_2). $P_2 : P_1$ is in fact approximately equal to $S_2 + P_2$ in Table 1.

TABLE 1

RECALL PROBABILITIES FOR ITEMS AT IMMEDIATE AND SUBSEQUENT RECALLS

	A	B
Immediate Recall		
Probability of SM Retrieval (S_1)	.36	.38
Probability of PM retrieval (P_1)	.08	.08
Subsequent Recall		
Conditional probability of subsequent recall of an item, given that the item was recalled by SM retrieval in immediate recall ($S_2 : S_1$)	.21	.23
Conditional probability of subsequent recall of an item, given that the item was recalled by PM retrieval in immediate recall ($P_2 : P_1$)	.09	.08
Unconditional probability of recall of item both in immediate and subsequent recalls ($S_2 + P_2$)	.08	.09
Unconditional probability of item reminiscence, i.e. recall of item in subsequent recall (R_2)	.02	.02

Differences betwen individuals in the extent of their use of the three retrieval processes were examined. All but one of the 109 subjects making any recall responses used SM retrieval in immediate recall. There were wide differences in the extent of use of PM retrieval in immediate recall, some subjects not using it at all. Table 4 shows that there was a zero linear correlation between total immediate recall and amount of PM retrieval. The total recall column of Table 2 indicates that the probability of subsequent recall of items was independent of the extent to which items were recalled by PM retrieval in immediate recall. Tables 2 and 3 give the results by subjects classified into three groups according to the amount of PM retrieval in their immediate recall. Subjects with no items recalled by PM retrieval in the first 5 lists formed GP_0 (26 subjects), those with 1 to 3 items recalled by PM retrieval formed GP_1 (48 subjects) and those with 4 or more items so recalled formed GP_4 (35 subjects).

Subjects not using PM retrieval in immediate recall did not show the serial position recency effect shown by other subjects (see Table 2). The recency effect was not apparent in the subsequent recall for subjects at all levels of use of PM retrieval.

TABLE 2

RECALL PROBABILITIES FOR SERIAL POSITIONS OF PRESENTATION AS A FUNCTION OF INDIVIDUAL DIFFERENCES IN AMOUNT OF PM RETRIEVAL

(Samples A and B Combined)

		Serial position of presentation						
		1	2	3	4	5	6	Total
Total	GP_0	.65	.40	.32	.33	.42	.42	.42
Immediate	GP_1	.42	.30	.34	.43	.57	.75	.47
Recall	GP_4	.29	.18	.27	.41	.66	.86	.45
Total	GP_0	.12	.05	.09	.11	.11	.07	.09
Subsequent	GP_1	.13	.11	.13	.15	.10	.08	.11
Recall	GP_4	.11	.09	.10	.14	.14	.08	.11

Subjects not using PM retrieval showed a marked serial position primacy effect. The primacy effect appeared to decrease as the amount of PM retrieval increased (see Table 2). Thus there was a tendency for subjects showing a high recency effect not to be the same subjects showing a high primacy effect. The primacy effect in the immediate recall data may represent attempts by subjects to use the retrieval cue of serial position. Of significance for this interpretation are the results of Table 3 which clearly shows that the subjects with the greatest primacy effect (GP_0) almost always recalled the first item of the list in their first recall response and not in later recall responses. This was not the case for subjects with a lesser primacy effect. The identification of items recalled by the retrieval cue of serial position has not been attempted and in so far as serial position retrieval has occurred it is confounded with the measure of amount of SM retrieval. Individual difference variables have been derived only for SM and PM retrieval in the immediate recall.

TABLE 3

CONDITIONAL PROBABILITIES OF SERIAL POSITION OF IMMEDIATE RECALL RESPONSE, GIVEN RECALL OF ITEM OF EACH SERIAL POSITION OF PRESENTATION

(Samples A and B Combined)

Group	Serial position of recall response	Serial position of presentation		
		1	2-4	5-6
GP_0	1	.93	.22	.00
	2-6	.07	.78	1.00
GP_1	1	.77	.27	.23
	2-6	.23	.73	.77
GP_4	1	.57	.15	.45
	2-6	.43	.85	.55

The concomitant relationships between individual differences on the immediate recall variables, and individual differences in verbal intelligence and in acquisition of the reading skill, were examined by computation of linear correlations. The recall data were from all 12 lists of both forms of the recall task. Split-half reliability coefficients, corrected by the Spearman-Brown formula, exceeded .90 for all variables except P_1, for which the coefficient was .79. Examination of Table 4 shows that there was a statistically significant negative linear correlation between the amount of immediate recall by SM retrieval (S_1) and the amount of immediate recall by PM retrieval (P_1). Such a negative relationship is to be expected when only *one* immediate recall response for any item is required. The fact that an item has been recalled by PM retrieval excludes the item from being recalled again by SM retrieval, thus reducing the maximum number of items available for SM retrieval. There was a zero linear correlation between total immediate recall (T_1) and the amount of recall by PM retrieval (P_1).

TABLE 4

PRODUCT-MOMENT LINEAR CORRELATIONS BETWEEN IMMEDIATE RECALL VARIABLES, VERBAL INTELLIGENCE (V) AND READING PROGRESS (RP)

	Samples A and B combined (N = 112)		
	RP	V	P_1
T_1	.32*	.50*	.05
S_1	.33*	.46*	—.33*
P_1	—.08	.03	
V	.40*		

$T_1 = S_1 + P_1$
*Correlation significantly different from zero ($p<.01$).

It was postulated that PM retrieval depends on acoustic features of items, whereas SM retrieval depends on semantic codes and verbal associations. In so far as the measure of individual differences is the facility for using semantic codes and verbal associations, a positive correlation between immediate recall by SM retrieval (S_1) and verbal intelligence would be expected. Results in Table 4 show that this was the case, and also that there was a zero correlation between verbal intelligence and immediate recall by PM retrieval (P_1).

There was a zero linear correlation between immediate recall by PM retrieval and progress in acquiring the reading skill (RP). There was a significant positive linear relationship between recall by SM retrieval and reading progress, but computation of partial correlation coefficients indicated that the relationship could be accounted for by the common influence of verbal ability in both SM retrieval and reading progress. The partial correlation between RP and S_1, with V partialled out was .18, which was not significantly different from zero ($p>.01$). It also may be noted that the partial correlation between RP and V, with S_1 partialled out, was .30 which was significant ($p<.01$).

CONCLUSIONS

Individual differences in single-trial free verbal recall were not unitary. The data were consistent with the theoretical description of free recall according to three retrieval processes, distinguished as SM, PM, and serial position retrieval cues. SM retrieval was used by almost all the six-year-old subjects. There were wide individual differences in the extent of use of PM retrieval, some subjects not using it at all. The extent of use of PM retrieval was independent of total recall performance. Thus, two children may have had the same total recall score

but one child could have recalled the items using only SM retrieval while the other could have recalled a proportion of the items by PM retrieval and the remainder by SM retrieval.

Examination was made of the concomitant relationships of individual differences in the PM and SM components with progress in acquisition of the reading skill. Individual differences in the extent of use of PM retrieval were not correlated with reading progress. Individual differences in the extent of use of SM retrieval were positively correlated with progress in learning to read, but the correlation could be accounted for by the common influence of verbal intelligence.

REFERENCES

Clay, M. M. Visual perception, ethnic difference, and early school progress. Paper presented to ANZAAS Conference, Brisbane, 1971.

Dornbush, R. L. and Basow, S. The relationship between auditory and visual short-term memory and reading achievement. *Child Development*, 1970, 41, 1033-1044.

Edwards, R. P. A., and Gibbon, V. *Words Your Children Use.* London: Burke (1964).

Raven, J. C. *Guide to Using the Crichton Vocabularly Scale.* London: H. K. Lewis (1961).

Tulving, E. Theoretical issues in free recall. In T. R. Dixon and D. L. Horton (Eds.), *Verbal Behaviour and General Behaviour Theory.* Englewood Cliffs, N. J.: Prentice-Hall (1968).

Tulving, E. and Colotla, V. Free recall of trilingual lists, *Cognitive Psychology*, 1970, 1, 86-98.