Successive retrieval from permanent storage*

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Two separate, spontaneous retrievals without prior presentation of items from each of two categories in three sequences (AABB, ABAB, or ABBA) demonstrated item-specific facilitation of second retrieval that was the same irrespective of sequence. Twice as many new items were gained, mostly at the end of second retrieval, as were lost from first retrieval. About 85% of infrequent, as well as more frequent, items from throughout first retrieval were recalled again in second retrieval. These items were recalled mostly at the beginning of second retrieval, when retrieval rate was increased.

The importance of long-term memory in learning and remembering presented material has long been recognized and has recently received renewed attention (Schiffman & Atkinson, 1969), but relatively little direct information about retrieval from permanent storage has been available because of methodological limitations. The major purpose of this paper is to present some basic data about retrieval from permanent storage obtained by a potentially fruitful method that involves repeated retrieval of items from a category without prior presentation of material. The use of repeated spontaneous retrieval for investigation of permanent storage represents an extension of the single retrieval used by Bousfield & Sedgewick (1944) derived from the technique of successive recall to evaluate retention following original learning (Brown, 1923; Lazar, 1969; Hogan & Kintsch, 1971).

Because spontaneous retrieval from permanent storage is variable, and incomplete (Battig & Montague, 1969), repeated retrieval should be

analyzed in terms of specific items retrieved in both first retrieval (PI) and second retrieval (PII), new items gained in PII, and items lost from PI. This analysis is of interest because recall of specific items presented for learning in particular lists may also involve retrieval from permanent storage, and spontaneous retrieval from permanent storage allows investigation of retrieval processes relatively free of encoding and storage effects.

To determine whether any increase in second retrieval is due to item-specific or category-specific facilitation by previous retrieval, and to exclude interference or fatigue as determinants of the negatively accelerated retrieval function, each S attempted two separate complete retrievals of two different categories in counterbalanced order. The number of items retrieved by each S was also compared with the number of different items retrieved by all Ss, to evaluate accessibility and availability (Tulving & Pearlstone, 1966) in permanent storage and exclude exhaustion of available items as a significant determinant of the decreasing rate of output during retrieval.

METHOD

Each S participated in one of the following three sequences of retrieval: AABB, ABAB, or ABBA. A and B represent the two categories to be retrieved in the sequence given. Four categories (animals, birds, sports, and trees) were used in a counterbalanced design so that each S retrieved items from two of the categories and each category was searched equally often in each sequence. Each sequence was used by 24 Ss, and each category was searched by 36 Ss.

The Ss were instructed to list all the different items they could from a given category and to avoid repetition without looking over their previous responses. For the second retrieval

from a previously retrieved category, Ss were told to recall all items from their first retrieval as well as all the new items they could.

The temporal course of retrieval was obtained by instructing Ss to draw a line under their last response every minute. Five minutes were allowed for each of the four retrieval phases in each sequence, with a 1-min interval between phases.

The Ss were 72 college undergraduates, who participated in small groups.

RESULTS AND DISCUSSION

Table 1 shows the mean number of items retrieved in the first retrieval phase of a category (PI), in the second retrieval phase (PII), in both retrieval phases (PI and PII), and those retrieved only in PI (lost items) or only in PII (gained items). Retrieval of items in both PI and PII is also expressed as a percentage of items retrieved in PI (percentage retained). Table 1 also gives the total number of different items retrieved by each S individually in PI and PII together, the total number of different items retrieved by all Ss as a group, and the percentage of the group total of available items retrieved by individual Ss. Data analysis was done after exclusion of any rare repetitions within any single retrieval. The mean number of repeated items within a single retrieval was only .08 in PI and .40 in PII.

Regardless of sequence, more items were retrieved in PII than in PI and the number of new items gained in PII was about twice as great as the number of items lost from PI. For overall retrieval in PI and PII, three-way analysis of variance (Sequence by First or Second Category by PI or PII) showed that only the increased second retrieval in PII was significant [$F(1,276) = 15.15$, $p < .01$]. The other comparisons showed no significant differences. For items retrieved only in PI (lost items) and items retrieved only in PII (gained items), three-way analysis of variance (Sequence by First or Second Category by Lost or Gained Items) showed only that more items were gained than lost [$F(1,276) = 63.16$, $p < .01$]. The other comparisons showed no significant differences. These analyses indicate that first retrieval in PI, increased retrieval in PII, and relative losses and gains were not affected by sequence order, delay, interference by retrieval of other categories, or nonspecific factors such as warm-up or fatigue. Table 1 also shows that the number of items retrieved in both PI and PII, as well as the percentage of PI retrieval of such items, was not affected by those factors.

Figure 1 shows the time course of retrieval in both PI and PII for each of

*This investigation was supported by USPHS Grants MH-17733 to H.B. from NIMH, NB-03356 from NIMS, and HD-01799-07 from NICHD; it was done while Gerald Lazar was on sabbatical leave in the Saul R. Korey Department of Neurology and the Rose F. Kennedy Center for Research in Mental Retardation and Human Development at Albert Einstein College of Medicine. We thank Gerald Dezinno for assistance in testing Ss and data analysis, Nicholas Gutfield, Director of Scientific Computing at AECOM, and Bob Curci for computer programming and analysis of data. The paper was presented in part at the meeting of the Eastern Psychological Association, Boston, 1972. Requests for reprints should be sent to Herman Buschke, Department of Neurology, Albert Einstein College of Medicine, Bronx, N.Y. 10461.

Table 1
Mean Numbers and Percentages of Items Retrieved from Two Categories in Each Sequence

Sequence		Phase I	Phase II	Both I and II	Percent Both/I	I Only (Loss)	II Only (Gain)	Total I or II	Group Total	Percent Group Total
AABB	A	24.4	28.5	20.1	87.5	3.4	7.4	31.8	142.5	22.3
	B	26.8	28.2	22.2	84.4	4.5	5.8	32.6	155.5	21.0
ABAB	A	22.8	27.2	19.1	85.1	3.6	8.0	31.0	150.0	20.6
	B	22.2	26.8	18.5	84.5	3.8	8.4	30.6	142.0	21.5
ABBA	A	23.7	29.2	20.6	87.9	3.2	8.4	32.1	152.5	21.0
	B	22.9	26.0	18.8	84.1	4.0	7.1	29.8	150.5	19.8
Mean		23.8	27.6	19.8	85.6	3.8	7.5	31.3	148.8	21.0
SD		1.66	1.18	1.38	1.68	0.46	0.99	1.04	5.46	0.84

Fig. 1. First and second retrievals of items from two categories (A and B) for each sequence as a function of time.

the sequences. These retrieval curves are negatively accelerated and rapidly approach asymptote in an apparently exponential function. It is apparent that the temporal production of items was not differentially affected by sequence or order of categories and that more items were recalled in the first minute of the second retrieval from the same category. These curves also show that the facilitation of second retrieval was not due to warm-up but was category-specific because it required previous retrieval of items from the *same* category. The rapid decrease of retrieval also was not due to fatigue, since retrieval rate increased markedly from asymptote when a new retrieval was initiated. It also apparently was not due to exhaustion of the pool of available items, since each S retrieved only about 21% of all the different items in each category retrieved by all Ss together; even though this estimate

may be too low, the low frequency of retrieval of most items (Battig & Montague, 1969) indicates that more items probably were available in permanent storage than were retrieved.

Figure 2 shows the number of items lost (PI only), items gained (PII only), and items retrieved in *both* PI and PII in each consecutive minute. The curves for the mean number of items retrieved in *both* PI and PII are

negatively accelerated. Retrieval of these items was substantially greater in the first minute of PII, but decreased more rapidly to approach a lower asymptote in PII than in PI. The number of items lost (PI only) and new items gained (PII only) both remained relatively constant, and the number of gained items was about twice the number of lost items.

To examine these components of

Fig. 2. Components of first and second retrievals as a function of time: lost items (PI only), gained items (PII only), and items retrieved in both PI and PII.

Fig. 3. Vincentized components of first and second retrievals as a function of sequential retrieval: lost items (PI only), gained items (PII only), and items retrieved in both PI and PII.

repeated retrieval without distortions introduced by averaging across Ss (who showed substantial variability in retrieval over time) and across retrieval from different categories (which differ in total number of items available), each S's retrieval was Vincentized before averaging. Figure 3 shows the relative sequential distribution of items lost from PI, gained in PII, or retrieved in both PI and PII for consecutive fifths of retrieval. More new items were gained at the end of the second retrieval. The number of items lost from consecutive parts of the first retrieval was relatively constant, with only slightly greater losses from the end of PI. While previously retrieved items (both-II) were recalled early in PII, they were not just the more frequent items retrieved early in PI but had been retrieved fairly equally throughout PI

(both-I). About 85% of all previously retrieved items (PI) were retrieved again in PII, relatively independent of either their relative order of output or initial retrieval frequency in PI.

The facilitation of a second retrieval of categorized items from permanent storage by a previous retrieval is restricted to that category. This facilitation is clearly *item-specific*, because a very high proportion of particular items from throughout the first retrieval are retrieved again more rapidly at the beginning of the second retrieval, relatively independent of their initial probability of retrieval. Although the finding that more items were gained than lost suggests *category-specific* facilitation of retrieval by increasing the accessibility of items not previously retrieved, this might be due to effectively increased time for retrieval because previously retrieved items were recalled more rapidly.

The exponential decrease of retrieval over time does not appear to be due to exhaustion of the pool of available items or to nonspecific factors such as fatigue. Shiffrin (1970) has pointed out that, although this negatively accelerated exponential retrieval function is predicted by a simple model assuming random sampling with replacement, the items involved in such retrieval from long-term storage are not equal in strength, since particular items will usually be retrieved earlier than others. Reder & Shiffrin (1971) have shown that an unequal trace strength model, which assumes that the probability of being drawn is proportional to an item's strength, does predict an appropriate cumulative output function. However, the clustering of obviously related items in such retrieval noted by Bousfield (1953)

suggests that cognitively directed search for related items may also contribute to such retrieval. Organization of retrieval from a category by the use of strategies that allow more complete retrieval of items from subcategories might also account for facilitation of successive retrieval.

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