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The Experiential Basis of Serial Position Effects

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Subjects studied eight lists in preparation for single-trial, free recall tests, but were tested only on four lists. They later received a recognition test over all lists and judged items as "old" or "new" and, when old, judged whether they actually remembered the occurrence of the word or knew that it occurred on some other basis. The chief findings were that (1) recall benefited later recognition of items at the end of the list; (b) recall increased "remember" responses; (c) serial position effects occurred in later recognition for both tested and non-tested lists; and (d) serial position effects were reflected in "remember" responses. Interpreted within Tulving's (1983; 1985) framework, primacy and recency effects in final recognition are episodic memory phenomena.

INTRODUCTION

Tulving (1985) proposed there are two means of accessing the past: remembering and knowing. Remembering refers to the phenomenological experience of mentally travelling back in time and recounting to ourselves the original event. We remember when the event occurred, where it occurred and myriad details involved in the event—those external to us as well as our internal reactions. On the other hand, knowing about our past seems more impersonal. We may know that we experienced some event, but we cannot remember the details surrounding it. For example, one might remember quite vividly the most recent aeroplane trip one has taken, but if queried about another trip taken 10 or 15 years ago, one

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might know that the trip occurred, yet be unable to remember anything about the experience.

Within Tulving's (1983) theory, remembering is a product of the episodic memory system. Interestingly, Tulving (1985) proposed that standard episodic or explicit memory tests such as free recall, cued recall and recognition do not purely measure episodic memory, because performance on all these tests involves some mixture of remembering and knowing. Intuitively, free recall provides a relatively purer measure of episodic memory than does cued recall or recognition because the only cues guiding free recall are internally produced cues (Tulving, 1974). The cues in recognition tests and in other tests that provide powerful retrieval aids may themselves provoke responses from subjects about events that may not be well remembered. However, responding—even on a memory test—may not index remembering. Some method is needed to distinguish different bases of responding on memory tests.

Tulving (1985) developed a method to differentiate two states of awareness about the past that he called "remembering" and "knowing". The technique involves giving subjects a list of items and then testing their memories for recall or recognition. After subjects recall an item or recognise it as old, they are asked to perform "remember"/"know" judgements, with detailed instructions being given as to how to accomplish this task. The general instruction is for subjects to judge items as "remembered" if they can (in some sense) re-experience the event and recall details of its presentation, whereas items are judged to be "known" if subjects are confident that the response corresponds to a studied list word but they cannot recollect the event of the word's appearance in the list (see Gardiner, 1988; Rajaram, 1993; Tulving, 1985). In his original paper, Tulving (1985) showed that free recall is predominantly composed of remember responses (with subjects rarely saying that they know but do not remember a word), whereas with increasing power of retrieval cues (i.e. cued recall and recognition) subjects are increasingly likely to say that they know a word occurred but cannot remember its presentation in the list.

Although remembering is attributed to episodic memory, the interpretation of know responses is more an open question. Tulving (1985) originally proposed know responses to be products of semantic memory. Semantic memory is atemporal and is thought to be our general knowledge about the world. Yet some information about ourselves may also have this impersonal character. To take an extreme example, we may know in what city we were born but have no recollection of when we first learned about it from our parents. Similarly, as noted previously, we may know we flew in an aeroplane from one city to another without being able to remember anything about the trip. Thus, we may know about our own past in the same general way we know that Charlemagne was King of the Franks or that Paris is a city in France (and in Texas).

A second interpretation of know responses is that they are driven by perceptual fluency, or the same factors that create priming on data-driven implicit memory tasks and in some types of recognition decisions. Mandler (1980) and Jacoby and Dallas (1981) argued that there are two bases of recognition memory, one of which is familiarity or perceptual fluency. This basis of recognition memory involves an item seeming familiar because it is easily perceived. Gardiner (1988) first proposed that the experience of knowing arises from the same processes responsible for familiarity in recognition memory. Indeed, considerable evidence can be marshalled in support of this proposition (e.g. Rajaram, 1993; see Gardiner & Java, 1993, for a review), but there are also problems with this idea (Rajaram & Roediger, in press).

With respect to experiments that have employed remember and know judgements, most manipulations that affect recognition hit rates affect remember judgements in the same manner. Know judgements tend to be less dramatically affected or not affected at all by these same manipulations. For example, low-frequency words are better recognised and receive more remember responses than do high-frequency words, but no difference occurs for know responses as a function of word frequency (Gardiner & Java, 1990). The generation effect (Gardiner, 1988), the picture superiority effect (Rajaram, 1993), levels-of-processing effects (Gardiner, 1988) and the effect of divided attention (Gardiner & Parkin, 1990) are all reflected in remember responses. Know responses, on the other hand, are relatively unaffected by these manipulations.

Although remember and know judgements could potentially be based solely on confidence, the evidence has not supported this possibility (Gardiner & Java, 1990; Rajaram, 1993). Despite subjects' confidence that remembered items did occur on the study list (Tulving, 1985), confidence judgements are not invariably correlated with remember and know judgements (e.g. Gardiner & Java, 1990; Rajaram, 1993).

The primary purpose of the present experiment was to determine how serial position effects are related to remembering or knowing. To our knowledge, this issue has not been examined and is of interest in light of the great amount of attention devoted to serial position effects. We ask if primacy and recency are reflected by enhanced remembering or knowing of the initial and terminal items, relative to middle position items.

Secondly, we sought to determine if the act of recall boosts recognition and affects remembering or knowing differentially. This question assumed interest because prior recall is known to have a large positive effect on later recall (e.g. Hogan & Kintsch, 1971; Wheeler & Roediger, 1992), but some studies have shown little or no benefit of recall on later recognition (Darley & Murdock, 1971; Hogan & Kintsch, 1971).

Lockhart (1975) provided a persuasive analysis of this situation by noting that, in the recall and then later recognition of unrelated lists of words, most items recalled would be encoded well enough to be recognised (prior to recall, to exist in a state of RG, where R = able to be recalled and G = able to be recognised). Therefore, recall would be unlikely to benefit later recognition. He noted that the one exception to this generalisation should occur for items that are, prior to recall, in a state of being able to be recalled but not recognised ($R\bar{G}$). Recall of items in a state of $R\bar{G}$ should then help one to recognise these items later. Since terminal list items are often recalled on an immediate test yet expected to show negative recency in long-term recall or recognition (e.g. Cohen, 1970), they are probably the most likely items to be in a state of $R\bar{G}$. Therefore, Lockhart (1975) predicted that an immediate test should aid recognition of items from terminal list positions, and his results strongly supported this prediction. We sought to replicate Lockhart's (1975) finding and to determine if the benefit of recall on later recognition of terminal items would be reflected in remember or know responses.

In our experiment, subjects studied eight lists of 16 words but were tested by immediate free recall after only four of the lists. Later, subjects received a recognition test over all lists and made remember/know responses after identifying items as old.[1] Our interest was centred on three questions: (1) Would prior recall of lists increase their recognition? (2) If so, would this increase be reflected in increased remember or know responses (or both)? And (3), assuming that serial position effects were found in delayed recognition, would these effects be the result of remember or know responses (or both)?

METHOD

Subjects

Sixty-three Rice University undergraduates and one graduate student participated in the study for course credit or as a volunteer. The subjects were tested individually or in groups of 2–4. All of them spoke English fluently.

[1]Throughout the paper, we refer to lists as "tested" or "non-tested". We use these terms with respect to the immediate free recall test only; both list types (tested and non-tested) were always tested for recognition.

Materials and Equipment

A total of 256 low-frequency words (0–10 per million; Kučera & Francis, 1967), all 7–10 letters in length, were randomly assigned to one of 16 lists, each composed of 16 words. Four Micro Express 386-SX computers with 2A+ SuperSync monitors were used to run a program based on Micro Experimental Laboratory (MEL; Schneider, 1988) software. Eight sheets of two-digit multiplication problems, eight blank sheets of paper and a pencil were placed on the desk of each computer station.

Design and Procedure

The subjects were told that eight 16-word lists would be presented, and that following each list they would be cued by a row of symbols either to recall the most recent list (&&&&&&&&) or to work on maths problems (********). The subjects were told that they might be cued to recall any number of the eight lists or none at all. Actually, four lists were tested by free recall and four were not. The tested lists and non-tested lists were always alternated, and the order of alternation was balanced across subjects. Additionally, each list was tested by free recall equally often in each of the eight possible study list positions. Finally, each item in each list served in each serial position an equal number of times according to a Latin square design, resulting in 16 variations of each of the 16 lists.

Free recall instructions required the subjects to recall the words from the end of a list first, then recall the words from the beginning and middle parts of the list. These instructions were given to prevent the subjects from adopting different recall strategies across lists. To begin the presentation of each list, the subjects simply pressed the "Enter" key. The stimuli were presented visually on a computer monitor at a rate of 2 sec per word with an inter-stimulus interval of 100 msec. Following the display of the 16th word of each list, a row of symbols (&&&&&&&& or ********) signalled the subjects to recall the list or to work on arithmetic problems for 2 min. After 2 min, the subjects were signalled to stop their work and to prepare for the next list.

After the test period for the eighth list, the subjects received a 5-min maths recognition task as an interpolated task before the final recognition test. The maths recognition task presented approximately half the two-digit problems the subjects had worked on between study lists and an equal number of similar items that were new. The subjects responded to each problem by indicating whether the problem was "old" (one which had been solved) or "new" (one which had not been solved) by pressing "O" for "old" and "N" for "new". (This information was presented on the screen for each item.) The maths recognition data were not of interest and were not analysed.

A final word recognition test was then administered for all 256 words (half old, half new) with remember/know judgements made for "old" identifications. The order of stimuli in the recognition test was constant for all subjects. This order was composed of 16 blocks of 16 words; one word from each list was randomly assigned to each block. Thus, for every block, half the words were old and half were new.

Before the final recognition test, the experimenter explained to the subjects the yes/no recognition and remember/know judgement procedures. Similar to the maths recognition test, the subjects pressed "O" to identify "old" words and "N" to identify "new" words. However, immediately after identifying a word as "old", the subjects classified the accompanying subjective experience as a remember or know judgement. The instructions concerning remember/know judgements closely followed those used by Rajaram (1993). The subjects were told that if they recollected some aspect of a study word—the particular position in the list, a particular association, thought or image at the time the word was initially presented—they should report "remember" by pressing the appropriate key ("7"). If they were unable to recollect anything about the initial presentation of a word, but believed on some other basis that the word was "old", they should report "know" by pressing the "9" key. Information on which key subjects should press ("7 = remember, 9 = know") was presented on the monitor without the stimulus after an "old" recognition judgement had been made.

The recognition test took 15–20 min to complete. The subjects were then debriefed. The entire experimental session lasted 50–55 min.

RESULTS

Free Recall

Figure 1 displays the mean proportion of items recalled from the four lists tested by immediate free recall as a function of serial position, with the data smoothed by averaging three adjacent positions except for the first and last. Figures 2 and 3 were treated similarly. A standard serial position effect for single-trial free recall, with a primacy effect extending over the first 2–3 positions and a recency effect occurring over the last 4 positions, is apparent and replicates prior work (e.g. Deese & Kaufman, 1957). One-way analysis of variance yielded a significant effect of position: $F(15,945) = 29.07$, $MSe = 0.07$ (throughout this paper, an alpha level of 0.05 was used to test statistical significance). The proportion of words recalled was 0.48 overall, or 7.7 words out of 16 words per list.

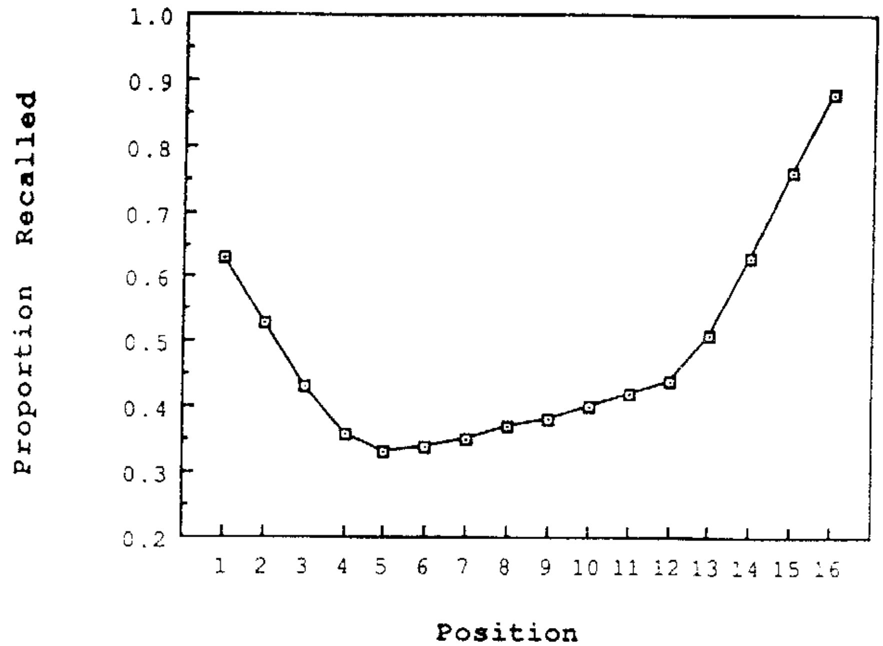

FIG. 1. Proportion recalled by serial position for the four lists tested by free recall.

Recognition

The recognition data are presented in Table 1 for tested and non-tested lists. The hit rate was slightly greater for lists that were previously recalled. When the hits were decomposed into remember and know judgements, two facts were revealed: (1) remember responses were greater than know responses for both types of list, and (2) the advantage in hits for tested lists was reflected in increased remember responses. Prior recall of words enhanced the hit rate by 3% but also caused more remember judgements at the expense of know judgements, relative to the case for non-tested lists. (Statistical justification for these conclusions will be provided later; also, we show that the beneficial effect of recall on recognition only

TABLE 1
Proportion Identified as "Old" for Tested and Non-tested Lists and Lures, Decomposed into Remember and Know Judgements

	Tested Lists	*Non-tested Lists*	*Lures*
Recognition	0.82	0.79	0.16
Remember	0.55	0.44	0.02
Know	0.27	0.35	0.14

occurred for the last few items in the list, as predicted by Lockhart, 1975). The false alarm rate for the recognition test was 0.16, with 0.02 judged as remember responses and 0.14 judged as know responses. This corroborates previous research where the greatest proportion of false alarms are deemed to be known rather than remembered (e.g. Gardiner, 1988). This makes sense, as under normal circumstances it would be unusual to remember something that never happened (Roediger & McDermott, in press, report an exception to this claim, however).

The data of primary interest are the serial position curves from the recognition test, decomposed into remember and know responses. Figure 2 presents serial position curves for the tested lists, with proportion correct the dependent measure. The top function represents the proportion of hits by serial position. The two lower curves represent probability of a remember or know judgement at each position (i.e. decomposing the top curve —the hit rate—into the two separate components). As in the free recall results in Fig. 1, there was a primacy effect extending across the first three positions and a slight recency effect across the final three positions. The bottom two curves demonstrate that the serial position effect on the recognition test was attributable to enhanced remember responses at the beginning and end of the lists. The know responses were relatively unaffected by serial position, ranging between 0.25 and 0.30.

The results in Fig. 1 showed strong primacy and recency effects in recall, and, coupled with the fact that testing lists seems to have enhanced remember responses (see Table 1), it could be that the recall test led to the primacy and recency effects on the final recognition test. We examined this supposition by considering the results for the lists that were not tested.

The serial position results for the non-tested lists are shown in Fig. 3. A primacy effect was still observed, indicating that the primacy effect observed for tested lists in Fig. 2 was not due to prior recall of the items. However, no recency effect appeared in the recognition results; indeed, a hint of negative recency appears in Fig. 3, confirming Lockhart's (1975) results.

As in the results shown in Fig. 2 for tested lists, the pattern in the hit rate for non-tested lists seems to be reflected in remember responses and not know responses. Both the primacy effect and the negative recency effect occurred in remember responses.

We now provide statistical analyses for the conclusions drawn above from the visual presentation of the data. Because the interest of this experiment focused on recognition, remember and know judgements for the three portions of the serial position curve (primacy, recency and the flat middle portion), the data from the recognition test were consolidated across serial position. Based on the recall and recognition data, serial positions 1–3, 4–12 and 13–16 were averaged, yielding data points which

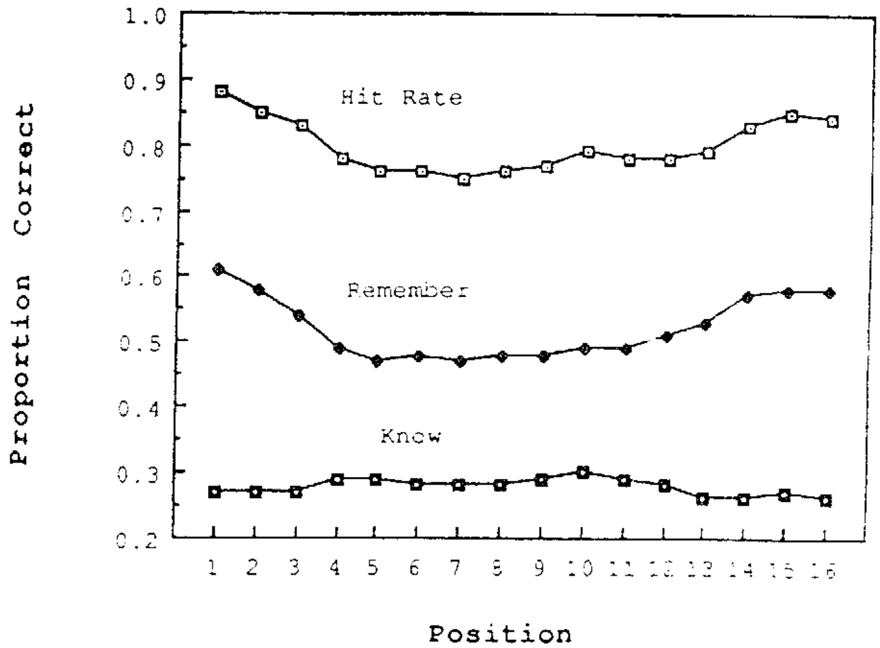

FIG. 2. Proportion correct for tested lists for the hit rate (top function), decomposed into remember and know judgements (bottom functions), by serial position.

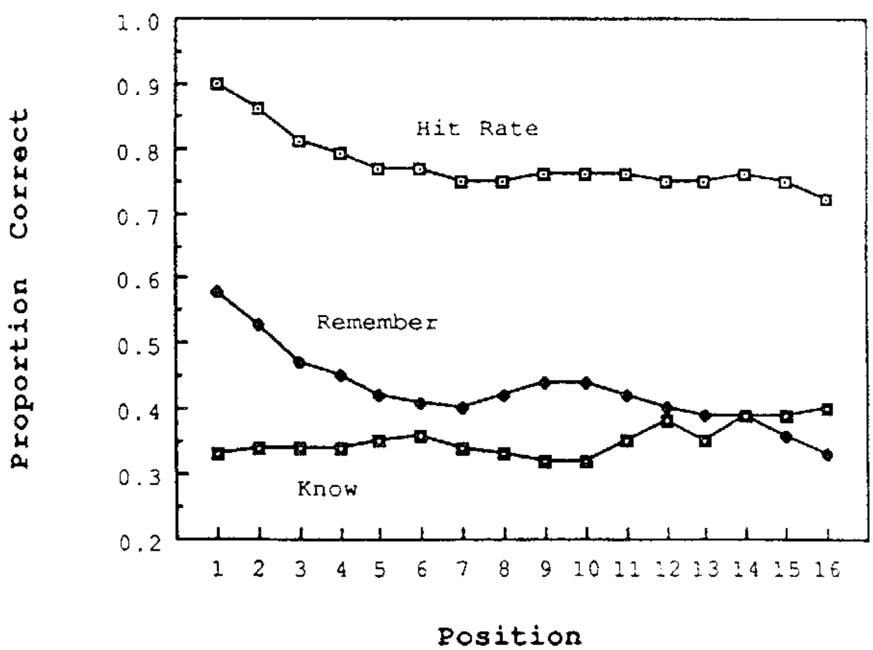

FIG. 3. Proportion correct for non-tested lists for the hit rate (top function), decomposed into remember and know judgements (bottom functions), by serial position.

TABLE 2
Proportion of Hits with Remember and Know Judgements by Type of List and Position

	Tested Lists			*Non-tested Lists*		
	P	*M*	*R*	*P*	*M*	*R*
Recognition	0.85	0.77	0.83	0.86	0.76	0.75
Remember	0.58	0.49	0.58	0.53	0.42	0.37
Know	0.27	0.28	0.26	0.33	0.34	0.39

Note: P. Primacy items; M. middle items; R. recency items.

represented the primacy, middle and recency areas of the serial position curve for each type of list (tested or non-tested). Analyses were then conducted using these aggregate data, which are shown in Table 2. The results bear out observations made from Figs 1 and 2: primacy effects were largely reflected in a change for remember responses; recency effects, positive for tested lists but negative for non-tested lists, were also related to a change in remember responses.

First, a 2 (list type: tested *vs* non-tested) × 3 (position: primacy, middle or recency) factorial ANOVA on the recognition hit data revealed main effects of list type [$F(1,63) = 5.71$, MSe = 0.01] and position [$F(2,126) = 26.63$, MSe = 0.01], as well as a significant interaction [$F(2,126) = 10.84$, MSe = 0.01]. The main effect of list type confirmed the slight advantage of prior testing of lists (relative to not testing lists). The source of the effect of position (revealed by a Tukey test, crit. diff. = 0.04) centred on the fact that primary items were better recognised than middle and recency items. However, the interaction qualified the main effects of position and list type. A Tukey test using Cicchetti's (1972) adjustment for a *post-hoc* interaction matrix (crit. diff. = 0.04) showed that only recency items of the tested lists were recognised significantly better than recency items of the non-tested lists. In the case of tested lists, both primacy and recency items were better recognised than middle items. For non-tested lists, primacy items were recognised better than both middle and recency items.

A 2 (list type) × 3 (position) factorial ANOVA on the remember responses revealed a strikingly similar pattern to those of the recognition hits. The ANOVA produced significant effects of list type [$F(1,63) = 49.23$, MSe = 0.02], position [$F(2,126) = 19.57$, MSe = 0.02] and their interaction [$F(1,126) = 20.04$, MSe = 0.01]. First, more remember judgements were given for tested list items than for non-tested list items. Second, similar to the recognition hit data, a Tukey test (crit. diff. = 0.05) showed that more remember judgements were given for primacy items than middle and recency items. Finally, a Tukey test with the Cicchetti (1972) adjustment for the interaction matrix (crit. diff. = 0.05) demonstrated that the differences in remember judgements between the tested lists and non-tested lists at the middle and recency positions were significant. For the tested lists, the primacy and recency items received more remember responses than the middle items. The non-tested lists showed more remember judgements for the primacy positions than the middle positions, which in turn showed more remember judgements than the recency positions.

A 2 (list type) × 3 (position) ANOVA on the know responses yielded a significant effect of list type [$F(1,63) = 40.71$, MSe = 0.02], with more know responses being given to non-tested list items. More importantly, though, there was no effect of position [$F(2,126) = 0.92$, MSe = 0.02]. A significant list × position interaction [$F(2,126) = 3.48$, MSe = 0.02] was followed up using Cicchetti's (1972) adjustment of the Tukey test (crit. diff. = 0.06). This test revealed that more know judgements were given to the non-tested lists than the tested lists at the primacy and recency positions.[2]

DISCUSSION

The present experiment led to several new findings. First, recognition was enhanced by prior recall of lists for the terminal positions only, and this enhancement was attributable to subjects' increased remember responses, not know responses. Second, the primacy effect existed in recognition for both tested and non-tested lists; because the effect existed for both types of list, it could not be attributed to prior recall of primacy items. Third, the primacy effect was reflected in enhanced remember responses; there was no primacy effect in know responses. Fourth, recency effects also appeared, albeit fairly small ones, for both tested and non-tested lists. However, the picture here is a bit more complicated than for primacy. For lists that had been recalled, positive recency occurred in the final recognition test. For lists that had not been recalled, there was a tendency for negative recency to occur in the final recognition test. In both cases—for positive and negative recency—the trend seemed attributable to differences in remember responses, not know responses. (There was a hint of positive recency in know responses for non-tested lists, which was the only serial position effect for know responses that appeared in the experiment.) These results will be discussed in turn.

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[2]The difference between tested and non-tested lists for middle items appears significant only because the percentages have been rounded.

The significant beneficial effect of recall on later recognition in our experiment was rather slight overall (3%), and the effect was carried by the last few items of the lists. These results replicate Lockhart's (1975) findings and support his analysis of when recall will aid later recognition: items in a state of R$\bar{G}$, which are predominantly terminal items, are the items that should benefit from the recall test. The data from Darley and Murdock's (1971) figure 1 also show such an advantage, although they did not find an overall enhancement of recognition by recall.

Examination of Table 2 shows clearly the accuracy of Lockhart's (1975) prediction: recognition hit rates for items in primacy and middle list positions averaged 0.81 for both tested and non-tested lists, whereas the hit rate for recency items was 0.08 greater for tested than non-tested lists. However, it is also apparent in Table 2 that a prior recall test increases remember responses throughout the list (although especially so at the end). The act of recall may essentially give subjects a second presentation —or a second opportunity to remember an item—prior to the recognition test. The instructions for making remember/know judgements specifically direct subjects to the study episode, so that a remember judgement should reflect their recollection of an item's occurrence during study of the list. However, during the recognition test, subjects may remember events surrounding the (earlier) recall of an item and misattribute them to the study episode. Roediger and McDermott (in press) have also shown that a recall test increases remember responses on a later recognition test.

We also examined the data for tested lists in one other way. We divided items recalled into those items retrieved from primary or from secondary memory using Tulving and Colotla's (1970) measure,[3] then examined their fate on the later recognition test. Overall, items recalled from secondary memory were recognised almost perfectly (0.97 hit rate, with 0.83 remember and 0.14 know responses), and items recalled from primary memory were recognised nearly as well (0.92 hit rate, with 0.69 remember and 0.23 know responses). While the overall hit rate was not much different between items recalled from primary and secondary memory, note that the proportion of remember responses was considerably lower for primary memory items.

Although items recalled from primary memory were "remembered" more poorly than those recalled from secondary memory, the proportion of remember responses for primary memory items was well above the

[3]Using this method, each studied item and each recalled item assumes a particular input or output position. The number of items intervening a given study item and its recall determines whether the item is a primary memory item (seven or fewer intervening items) or a secondary memory item (greater than seven intervening items).

overall level for items in non-tested lists (0.69 *vs* 0.44). Considering just the recency positions, the benefit of recalling an assumed R$\bar{G}$ item from primary memory on the later recognition test was clearly exhibited in the remember responses (0.69 *vs* 0.37).[4]

Finally, we examined the fate of items presented at the end of the list but recalled from *secondary* memory. Assuming that recall from secondary memory indicates the items that are well encoded (state RG), one might expect that these items should appear similar to other items retrieved from secondary memory. Although the data are relatively sparse—86 items in the last 4 positions were recalled from secondary memory over all subjects—the probability of recognition (0.97), of remembering (0.84) and of knowing (0.13) are almost exactly the same as that of the aggregate data for items recalled from secondary memory (given above; based on 1313 observations over subjects).

The final recognition results in the present experiment revealed a primacy effect for both tested and non-tested lists. Somewhat surprisingly, the effect was of the same magnitude for both types of lists; indeed, for the first two positions, the non-tested lists actually showed a slight advantage over the tested lists. Therefore, the primacy effect in recognition clearly did not depend on prior recall. In addition, when responding was decomposed into remember and know responses, the primacy effect in both cases was related to enhanced remembering. Although tested lists showed a slight advantage over non-tested lists in remember responses for the primacy positions, this advantage was not statistically significant. If remember responses reflect episodic memory, as Tulving (1985) argued, then clearly the primacy effect is a phenomenon of episodic memory (however, see Roediger & Crowder, 1976, for a primacy effect in a semantic memory test).

Our findings also bear on a more recent proposal made by Tulving (1993), although it is not yet published. Briefly, Tulving proposed that primacy effects are the product of semantic memory. He argued (a) that the nervous system has a proclivity for registering the first items in a sequence better than later events and (b) that the ubiquitous primacy effect is a product of semantic memory, a form of memory shared by other species (which therefore also show the proclivity for primacy; e.g. Wright et al., 1985). Episodic memory, characterised by remembering, is thought to be phylogenetically much more recent and perhaps to occur only in humans.

Tulving (1993) has mustered a considerable amount of general support for this idea, but we have provided a more direct test to determine if the

[4]Of course, item selection factors may play a role here.

processes underlying primacy effects involve remembering or knowing the initial events. If know responses reflect semantic memory, and if primacy effects are due to semantic memory, then it follows that any primacy effects on the recognition test ought to be reflected by a relative increase in know responses. Of course, our results show the opposite: primacy effects reflect remembering, not knowing, contrary to Tulving's (1993) proposal.

The situation with regard to recency effects is more complicated. The very strong recency effect in free recall (Fig. 1) produced only a relatively small advantage of tested to non-tested lists on the later recognition test (see Table 2). Once again, this advantage was carried by the remember responses. For the non-tested lists, there was no overall recency effect in recognition, but decomposing the responses into remember and know categories revealed a negative recency effect for remember responses and a touch of positive recency in the know responses. While free recall did not affect primacy effects via the remember judgements, it did influence whether a recency effect was obtained. A prior test led to a positive recency effect, whereas without a prior test a negative recency effect occurred for remember responses. Thus, the influence of free recall on remember responses appears most strongly on the latter part of a list. Further work will be required to see if this effect holds over various conditions and to determine the reliability of the slight positive recency effect observed for know responses.

In general, serial position effects—especially primacy—were reflected in remember responses, whereas know responses were little affected by serial position (with the minor exception just noted). Brooks (1994) has recently reported serial position effects in an explicit test (cued recall with word-stem cues) but not on an implicit test with the same stimuli (word-stem completion). Relating our results to those of Brooks (1994), we see another parallel between performance on explicit and implicit tests on the one hand, and remember and know judgements on the other. explicit tests and remember judgements show serial position effects, whereas implicit tests and know judgements do not (but see Gershberg & Shimamura, in press).

The main conclusion from this experiment is that serial position effects in the recognition of lists arise from episodic memory, in terms of Tulving's (1983; 1985) theory. Primacy and (to a lesser extent) recency effects reflect the experience of remembering.

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REFERENCES

Brooks, B.M. (1994). A comparison of serial position effects in implicit and explicit word-stem completion. *Psychonomic Bulletin and Review, 1*, 264–268.

Cicchetti, D.V. (1971). Extension of multiple-range tests to interaction tables in the analysis of variance: A rapid approximate solution. *Psychological Science, 77*, 405–408.

Cohen, R.L. (1970). Recency effects in long-term recall and recognition. *Journal of Verbal Learning and Verbal Behavior, 9*, 672–678.

Darley, C.F., & Murdock, B.B. (1971). Effects of prior free recall testing on final recall and recognition. *Journal of Experimental Psychology, 91*, 66–73.

Deese, J., & Kaufman, R.A. (1957). Serial effects in recall of unorganized and sequentially organized verbal material. *Journal of Experimental Psychology, 54*, 180–187.

Gardiner, J. (1988). Functional aspects of recollective experience. *Memory and Cognition, 16*, 309–313.

Gardiner, J., & Java, R. (1990). Recollective experience in word and nonword recognition. *Memory and Cognition, 18*, 23–30.

Gardiner, J., & Java, R. (1993) Recognizing and remembering. In A. Collins, S. Gathercole, & P. Morris (Eds), *Theories of memory*, pp. 168–188. Hillsdale, NJ: Lawrence Erlbaum Associates Inc.

Gardiner, J., & Parkin, A. (1990). Attention and recollective experience in recognition memory. *Memory and Cognition, 18*, 579–583.

Gershberg, F.B., & Shimamura, A.P. (in press). Serial position effects in implicit and explicit tests of memory. *Journal of Experimental Psychology: Learning, Memory and Cognition*.

Hogan, R.M., & Kintsch, W. (1971). Differential effects of study and test trials on long-term recognition and recall. *Journal of Verbal Learning and Verbal Behavior, 10*, 562–567.

Jacoby, L., & Dallas, M. (1981). On the relationship between autobiographical memory and perceptual learning. *Journal of Experimental Psychology: General, 110*, 306–340.

Kučera, H., & Francis, W.N. (1967). *Computational analysis of present-day American English*. Providence, RI: Brown University Press.

Lockhart, R.S. (1975). The facilitation of recognition by recall. *Journal of Verbal Learning and Verbal Behavior, 14*, 253–258.

Mandler, G. (1980). Recognizing: The judgment of previous occurrence. *Psychological Review, 87*, 252–271.

Rajaram, S. (1993). Remembering and knowing: Two means of access to the personal past. *Memory and Cognition, 21*, 89–102.

Rajaram, S., & Roediger, H.L. (in press). Remembering and knowing as states of consciousness during retrieval. In J.D. Cohen & J.W. Schooler (Eds), *Scientific approaches to the question of consciousness*. Hillsdale, NJ: Lawrence Erlbaum Associates Inc.

Roediger, H.L., & Crowder, R. (1976). A serial position effect in the recall of United States Presidents. *Bulletin of the Psychonomic Society, 8*, 275–278.

Roediger, H.L., & McDermott, K.B. (in press). Creating false memories: Recall of words not presented in lists. *Journal of Experimental Psychology: Learning, Memory and Cognition*.

Schneider, W. (1988). Micro Experimental Laboratory: An integrated system for IBM-PC compatibles. *Behavior Research Methods, Instrumentation and Computers, 20*, 206–217.

Tulving, E. (1974). Cue-dependent forgetting. *American Scientist, 62*, 74–82.

Tulving, E. (1983). *Elements of episodic memory*. Oxford: Clarendon Press.

Tulving, E. (1985). Memory and consciousness. *Canadian Psychologist, 26*, 1–12.

Tulving, E. (1993). *The brain's proclivity for primacy*. Colloquium presented at Rice University, Houston, TX, April.

Tulving, E., & Colotla, V.A. (1970). Free recall of trilingual lists. *Cognitive Psychology, 1*. 86–98.

Wheeler, M., & Roediger, H.L. (1992). Disparate effects of repeated testing: Reconciling Ballard's (1913) and Bartlett's (1932) results. *Psychological Science, 3*. 240–245.

Wright, A.A., Santiago, H.C., Sands, S.F., Kendrick, D.F., & Cook, R.G. (1985). Memory processing of serial lists by pigeons, monkeys, and people. *Science, 229*, 287–289.