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The serial position curve in immediate serial recall

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Two different kinds of serial position curves are produced by immediate serial recall of supraspan lists. One is the regular bow-shaped curve, generally regarded as the standard shape. The other is a curve in which recall decreases from the first to about the third serial position, levels off at the fourth position, and then decreases more sharply at the fifth serial position. In many studies, this marked pattern suggests a discontinuity in the serial position curve. This article reviews studies producing each kind of curve, presents some analyses suggesting that a chunking process is involved in the production of the second kind of curve, and discusses the significance of the problem for studies of serial recall and order information.

The purpose of this article is to point out and discuss a peculiar characteristic of the serial position curve of immediate serial recall. This characteristic is readily apparent in many published reports of serial recall experiments, most of which deal with the stimulus suffix effect (Morton, Crowder, & Prussin, 1971). This article will describe and document the effect, discuss its origin and significance, and present some analyses of digit-span data that bear on an interpretation of it.

TWO KINDS OF SERIAL POSITION CURVES

When a list of digits, letters, or words of 7-10 items is presented at a rate of 1 item/sec or faster, forward serial recall of the list produces a marked serial position curve. In general, the curve shows that the probability of recall of an item in its correct position is greatest for the first (input) serial position and decreases from that point to around the last or next-to-last serial position. The curve rises from that point, the rise being relatively small for visual presentation and much larger for auditory presentation.

An idealized form of the curve is shown on the left panel of Figure 1. Such curves are common enough in the literature, although they may vary in the steepness of the first half of the curve and in the presence or absence of an inflection point there. Examples of this kind of curve (referred to in this article as the Type I curve) can be found in the following sources: Ayres, Jonides, Reitman, Egan, and Howard, 1979, Experiment 2; Crowder, 1971, Experiment 1; Jensen, 1971; Madigan, 1971. This form of the serial position curve is widely regarded as the standard form for short-term forward serial recall (Craik & Levy, 1976, p. 150; Morton, 1970, p. 220), and models of short-term memory for order have been devised to account for it (Murdock, 1974). The Type I curve is, of course, very similar to the classic bow-shaped curve of serial learning (McGeoch, 1942, pp. 104-106).

However, the literature on immediate serial recall indicates that another kind of curve is also commonly found. An idealized version of the Type II curve appears in the right panel of Figure 1. (The vertical placement of the curves is arbitrary.) The feature that distinguishes the Type II from the Type I curve is that it does not show a uniform decrease in recall of the list from the start. Instead, the curve levels off just before the middle of the list and resumes the decrease at that point. The representation of the Type II curve shown in Figure 1 is a reasonable summary of the actual serial position effect found in a large number of studies (Hinrichs, 1968; Jahnke, 1963; Morton et al., 1971; Salter, 1975; Salter & Colley, 1977; Salter & Osler, 1978; Spoehr & Corin, 1978; Watkins & Todres, 1979). The single best reference for this effect is Morton et al. (1971). In that paper there are graphs of 34

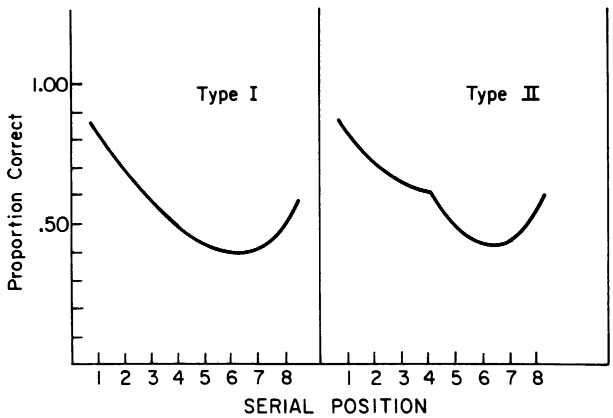

Figure 1. Idealized representations of Type I and Type II serial position curves in immediate serial recall.

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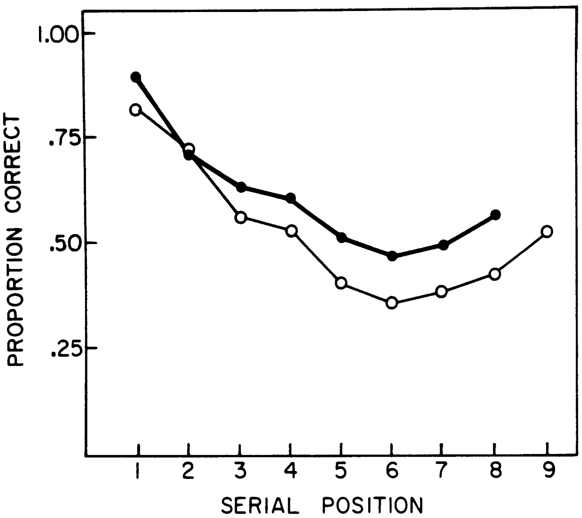

Figure 2. Serial position curves for immediate recall of 8- and 9-digit lists. Each data point is based on 352 observations.

serial position curves for 8- and 9-digit lists, representing a variety of experimental conditions. The Type II curve is shown in 32 of the graphs.

Two actual examples of the Type II are shown in Figure 2. These data were obtained in a series of ongoing studies of individual differences in memory span. The 88 subjects (college students) were given four trials on lists of from five to nine digits with auditory presentation at a 1-sec rate. A redundant spoken suffix followed the last digit in all tests. Recall was written under strict forward-order instructions. The dipper-shaped Type II curve is apparent at both list lengths.

In general, serial position results such as these indicate that one smooth curve would not adequately describe the data. In a number of cases the Type II pattern is strong enough to suggest a discontinuity in the serial position curve. While some studies show a Type II curve because of a smaller decrease in recall from Positions 3 to 4 than from Positions 4 to 5, others in fact show complete flattening of the curve or an actual rise between Positions 3 and 4 (Salter & Colley, 1977, Experiment 2; Spoehr & Corin, 1978, Experiment 1). Though we have not attempted an exhaustive count of the relative frequencies of Type I and Type II curves in the literature, inspection of relevant studies suggests that the Type II pattern is the more common one, even if doubtful cases involving generally irregular serial position curves or weak Type II patterns (e.g., Murdock, 1968, Experiment 6) are counted as Type I outcomes and if the criterion for classification as a Type II curve is the flattening between Serial Positions 3 and 4 only.

WHEN DO TYPE I AND TYPE II CURVES OCCUR?

With a large number of studies available and with the relatively simple experimental procedures involved, it might seem possible to identify design or procedural differences among studies that are correlated with the occurrence of Type I or Type II curves. However, a review of the literature failed to identify any such differences, apart from suggesting that the Type II pattern seems less likely to occur with lists of fewer than eight items. Among the factors that do not seem involved in the production of one kind of curve rather than the other are stimulus modality (auditory, visual), kind of material (digits, words, letters), prefix or suffix conditions, and, barring floor and ceiling effects, overall performance levels. The Type I and Type II curves have often occurred in the same study (e.g., Conrad & Hull, 1968; Elmes, 1974; Jensen, 1971; Morton, 1976, Experiment 3; Morton & Chambers, 1976; Penney, 1979; Routh, 1976; Routh & Frosdick, 1978, Experiment 2).

Type I and Type II curves both appear to be unique to forward serial recall with a whole-report procedure. Neither kind of serial position effect is typically found with probe (partial-report) tests (Murdock, 1967, 1968); this kind of test usually produces, at best, only a small primacy effect. This does not necessarily implicate processes during recall as sources of either Type I or Type II curves, since it cannot be assumed that encoding or rehearsal processes are equivalent in the two procedures.

AN ANALYSIS OF TYPE II CURVES

While comparison of the serial position curves obtained under different experimental conditions provides few clues to the reasons for the occurrence of Type I and Type II results, some additional understanding of the problem may be gained from analyses of serial recall data beyond simple serial position effects. The analyses follow from what may be an obvious interpretation of the Type II curve: The flattening or scalloping of the serial position curve after three or four items is the result of a chunking process. Such an interpretation seems especially applicable to the Type II curve, in light of Wickelgren's (1967) identification of rehearsal of grouping sets of about three items as the optimal chunk size for serial recall and in view of the scalloping within a serial position curve that can occur with experimenter-imposed grouping or demarcation of items (Murdock & Carey, 1972).

One method of investigating chunking or organizational processes is an analysis of transition probabilities in recall. When some organizational or perceptual chunking pattern is independently imposed on a serial list, transitional error probabilities (TEPs) have been found to be relatively low within chunks and higher between chunk boundaries (Bower & Winzenz, 1969; Johnson, 1970; Penney, 1978). Since this analysis requires treatment of individual subject-item events, it cannot be performed on any of the

Table 1
Probability of Recall of Item n Conditionalized on Recall of Item n – 1 for the Data Shown in Figure 1

List Length	Serial Position n							
	2	3	4	5	6	7	8	9
Eight Digits	.755	.800	.785	.700	.697	.747	.809	
Nine Digits	.826	.679	.752	.617	.629	.663	.755	.834

data of the experiments cited. Instead, we will report an analysis for the data shown in Figure 2.

The transitional probabilities of recall are presented in Table 1. To keep the same format as that of the serial position data, these are shown as probabilities of recall of item n given correct recall of item n – 1, rather than as transitional error probabilities. The data show the usual kind of positive dependency in recall of adjacent items, the conditional probabilities being consistently greater than the unconditional (Figure 1). They also show a pattern that is consistent with the chunking hypothesis: The conditional probability of recall of the fifth item is lower than the conditional probability of recall of the fourth item, with the difference being not merely a continuation of a steady decrease from the start of the sequence. The difference between the transition probabilities at the fourth and fifth positions is also the largest pairwise difference at each list length. The flattening of the curve at Serial Position 4 may represent recall of the last element of a chunk, and the drop at Position 5 may represent transition to a new chunk. This interpretation probably cannot be extended on the basis of the data presented, since an after-the-fact specification of chunks leads to circularity of inference and since it is difficult to determine the reliability of differences in these probabilities. In any event, differences in the transitional probabilities in these data for Serial Positions 4 and 5 are not nearly as large as those found for experimentally defined chunks (Penney, 1978). Also, before it can be claimed that type of serial position curve and chunking are even correlated, it is necessary to show that data producing the Type I curve do not also display discontinuities in transition probabilities of the kind described here. It is possible, in a statistical sense at least, for such patterns to occur in data that produce a smooth bow-shaped curve for unconditionalized recall.

SUMMARY AND CONCLUSIONS

The main purpose of this article has been to point out the existence of a serial position effect in immediate serial recall that does not follow the classic description of a simple bow-shaped or U-shaped curve. There is no doubt that a more complicated serial position curve–in its extreme form, one consisting of two parts–is commonly found, although its existence is not generally acknowledged.

Which is the real serial position effect of immediate serial recall? In light of the fact that both kinds of serial position curves occur, this question should probably be cast in terms of the variables that produce one form or the other. At this point, however, the variables remain unidentified. Some evidence has been presented that indicates that Type II curves involve a within-list chunking process and that the two components that define the Type II curve are a reflection of recall from two (or more) subjective units or groupings. Explanation of the Type II curve in terms of chunking seems to imply that those studies yielding Type I curves must somehow involve conditions less conducive to chunking and within-list organization or are based on different distributions of digit-span ability of rehearsal patterns. This interpretation also seems to suggest that the serial position curve for fast rates of presentation should be the Type I variety, to the extent that the increased presentation rate greatly reduces the possibility of recoding or chunking (Lyons, 1977).

Finally, what is the importance of this whole question? What is interesting about possible irregularities in the serial position curve? Two answers can be given here. One is that there are fundamental empirical questions that remain unanswered about performance in a type of short-term memory test that has been studied for some 100 years. The second is that the questions about the form of serial position curves are important for theories of serial order and the processing and representation of order information. For example, Murdock's nesting-and-unpacking theory is tailored to account for a smooth bow-shaped serial position function (Murdock, 1974, pp. 296-297). The fact that such a curve is not descriptive of the results of many studies must be considered in this, or any other, theory of serial recall.

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