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An Unremembered Principal Serial-Position Feature

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ABSTRACT

Because it has been virtually ignored by contemporary researchers, the late W. J. Brogden's long-term research program on various topics related to serial learning is reviewed and evaluated in terms of its relevance to current and possible future research activities. The review includes five major parts covering Brogden's research on (1) Effects of number of response alternatives, (2) Effects of patterns and subpattern sequential properties, (3) Learning of multiple serial lists varying in item and temporal relationships, (4) Effects of ordinal position variations on serial learning, and (5) Part vs. whole learning and intralist grouping of verbal and numerical items. Some subsequent unpublished research is also described briefly, as is a potentially significant theoretical contribution emerging from this strictly empirical research program.

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Researchers who claim discovery of a significant new behavioral phenomenon, theoretical interpretation, or methodological development, often find subsequently that someone else had reported essentially the same thing many years previously. Such "rediscoveries" most typically reflect the antiquity of the original report, its publication in a different language, and/or its appearance in a journal representing a topical area apparently disassociated from the present new report.

With the recent explosion in magnitude and variety of published research and of different publication outlets, this phenomenon of "repeated new discoveries" is increasingly encompassing also more recent if not currently ongoing research programs and reports. The present paper is specifically concerned with one such notable instance within the general area of "serial learning" (currently relabelled as "seriation" or "order information"). This becomes of particular current interest because the alleged "cognitive information-processing revolution" appears to have inspired a strong current research focus upon the importance of serial patterns and/or organization of subsequences (e.g., Greeno & Simon, 1974; Jones, 1976; Martin, 1974; Restle, 1976; Simon, 1972).

The foregoing and other researchers currently interested in serial patterning and/or organization appear totally oblivious to a long-term systematic research program extending over two decades that has been primarily concerned with these topics. Despite being reported in numerous articles in an appropriate topflight journal, this particular research program has nonetheless been almost totally ignored, as documented below.

Between 1954 and 1973, the Journal of Experimental Psychology had devoted to this research program well over 100 pages in 15 articles reporting 19 major experiments involving over 2500 individual subjects. Further attesting to the high quality of this research is its support by grants from the National Science Foundation throughout its last 15 years. Moreover, it was carried out by the late W. J. Brogden, an especially influential and respected experimental psychologist who played a central role in the founding of the Psychonomic Society (see Grant, 1975, 1976; R. Thompson & Voss, 1972). Included among the 13 graduate-student coauthors in this series of papers have been a recent recipient of the APA Distinguished Scientific Contribution award (Richard F. Thompson), and such other prolific contributors to the current research literature as James F. Voss and Douglas L. Nelson.

Despite these impressive credentials, however, none of this research has ever been cited in the Annual Review of Psychology, or in any contemporary textbook or other published review of serial learning other than Harcum (1975). Even those reviews authored by Brogden's own colleagues or students (e.g., Battig, 1969; Bewley, 1972; Ebenholtz, 1972) have totally ignored this research. Not even the recent "Festschrift" volume written by Brogden's students (R. Thompson & Voss, 1972) contains more than one passing reference to this research. Only Harcum's (1975) recent encyclopedic review of the serial-learning literature contains any substantive discussion of this research, although even this is limited to a single page covering less than half (seven) of these articles. The primary indication of any significant impact of

Brogden's research was the early usage of certain findings from the earliest of these experiments (Brogden & Schmidt, 1954a; 1954b; R. Thompson, 1958) as evidence for theoretical interpretations proposed by G. A. Miller (1956) and Simon (1957), both of whom subsequently received the APA Distinguished Scientific Contribution award. It is doubtful that a more extreme case exists anywhere in the psychological literature where so much systematic research has been so completely ignored by so many!

Although one of the few Brogden students who had never become involved in any way with this particular research program, the present writer nonetheless undertook the formidable task of reading through in detail this entire series of articles. This proved sufficiently informative to lead to the present attempt at an evaluative summary of the mass of results emanating from this lengthy research program, with the purpose of making this information more accessible and usable for present and future researchers concerned with similar problems. Brogden's untimely death of course prevented him from undertaking any such project himself, nor would it have been his style to try to do so. Moreover, all of the students who had worked directly with Brogden on this research subsequently shifted to quite different areas. In fact, only two of these made any subsequent published contributions directly relevant to their earlier research with Brogden. In addition to his Ph.D. dissertation (Thompson, 1966), C. P. Thompson reported three later experiments (Thompson, 1965; Heine, Pivik, & Thompson, 1966). These reports, along with one by Voss (Voss & Ziegler, 1960) and Ernst's (1967) Master's thesis, will be covered herein only insofar as they relate directly to major issues addressed directly by Brogden. Also discussed briefly will be a final experiment not completed until after Brogden's death, and consequently never published.[1]

Contrasting sharply with the atheoretical nature of Brogden's research in this and other areas (see Brogden, 1951) is a concluding statement in the last (and posthumous) publication in this series (Fingeret & Brogden, 1973), which offers a potentially significant theoretical contribution in the form of a different way of conceptualizing the "serial position curve" and the effect of other variables thereupon. That any research implications of the latter must necessarily depend entirely upon other researchers totally unfamiliar with Brogden's work would seem to provide a particularly compelling reason for the present review thereof.

General Procedural Characteristics and Changes

Although Grant (1976) separates this research into two distinct programs concerned with the "verbal maze" (1954-1960) and "verbal learning" (1962-1973), for present purposes these can better be understood as parts of a single continuous research program. Moreover, the initial intention to develop and investigate a human analogue to spatial maze learning failed to survive even the first experiment, despite the presentation (as part of the initial instructions) of "tinker toy" models illustrating the spatial choices, and asking subjects to "assume presence at a given point with the intention of proceeding in a forward direction, as rapidly as possible, to some other point" with E saying "forward" to designate a correct response (e.g., left, right, up, down) and "stop" when the end of the maze was reached (Brogden & Schmidt, 1954a, p. 236). The first paragraph of the introduction to this initial paper, however, states that "the task becomes one of nonspatial verbal maze learning," (p. 235) because a post-experimental questionnaire showed that subjects predominantly failed to achieve the attitude of spatial movement, only 18% replying positively to the question "Were you able to visualize the correct maze pathway as you were learning the maze?" (p. 238).

Thus the spatial maze analogue is deemphasized from the beginning, although traces of these maze-learning origins can be detected throughout this series of experiments, and the problems investigated as well as the methodologies employed can best be understood in the context of their verbal-maze derivation. In the initial experiments primarily concerned with the effects of variations in number of response alternatives, a typical maze "correction" procedure was employed whereby blindfolded subjects continued to select directional response alternatives for each choice point until they were correct, with correctness indicated by the experimenter saying "Forward." Responding was self-paced, and trials were continued to a criterion of one errorless trial, with number of trials and errors to criterion being recorded along with time as the basic dependent variable measures.

Changes from the spatial maze analogue began to accumulate immediately following the initial two experiments in this series (Brogden & Schmidt, 1954a, 1954b). Subjects' blindfolds and Tinker-toy models were discarded, and visual presentation of stimuli via memory drums, projectors, etc., replaced aural presentation with experimenter-provided oral feedback, although the "forward" signal following a correct response extended through Namikas and Brogden (1960), thus characterizing the first 11 experiments in this series.

The more significant shifts away from the maze-learning methodology, however, involved systematic experimental manipulations and/or comparisons, including modifications of the original correction method, and usage of numbers (and occasionally unrelated words) rather than directional responses. Thus R.

Thompson (1958) directly compared this correction with a "modified correction" procedure whereby subjects make only one response and immediately thereafter are shown the correct response, finding similar effects of number of response alternatives under these two procedures (with one important exception as described in the next section). Generally comparable results emerged also from R. Thompson and Brogden's (1958) Experiment II which included both correction and modified correction procedures, although here this result was obscured somewhat by significant differences between two experimenters localized primarily within the correction procedure.[2] Nonetheless, this latter procedure continued to be used through the remainder of the first 11 experiments, terminating (along with the "forward" signal) after Namikas and Brogden (1960). Further evidence of the shift away from the verbal maze derives from the subsequent replacement of the "modified correction" label by its "anticipation" equivalent traditionally used in serial verbal learning research (Ernst, C. Thompson, & Brogden, 1962, who also found somewhat greater sensitivity to localized serial position effects under the anticipation than the correction procedure). This adoption of the "anticipation" label coincided with the Ernst et al. (1962) replacement of the previous subject-paced trials by a fixed 2-sec. presentation rate, which was maintained throughout all subsequent experiments.

The directional responses characterizing the initial experiments soon were changed to two-digit numbers (10, 20, 30, 40) by R. Thompson, Voss, & Brogden (1957), possibly reflecting the confusing complexities inherent in describing the directional "maze" patterns as particularly evidenced in R. Thompson's 1953 Master's thesis (Thompson, 1958). R. Thompson and Brogden (1958) subsequently demonstrated closely comparable effects of numbers of response alternatives to those of Brogden and Schmidt (1954b), using these two-digit numbers (and written instead of spoken responses). Use of a limited pool of response alternatives, with the same response being correct more than once, was continued through the first 12 experiments, until two partially overlapping lists with each number appearing no more than once in a given list were introduced by Nelson, Simpson, and Brogden (1966). Lists of nonrepeated two-digit numbers (avoiding repeated digits and numbers ending in zero, but ignoring available association-value ratings, e.g., Battig & Spera, 1962) were used throughout all subsequent experiments. While closely comparable results to those for the more typical CVC nouns were demonstrated, the numbers did show less positive transfer with unrelated lists (Bewley, Nelson, & Brogden, 1968, Exp. I). Thus CVC nouns subsequently were used only in two subsequent experiments investigating multiple lists constructed from two different classes of materials (Fingeret & Brogden, 1970, 1972). After the first four verbal-maze papers, at least two different lists were always used in each condition, representing different items or different orderings thereof (or sometimes both).

Probably the most important methodological change characterizing this series of experiments, however, is one which stemmed directly from and represented a maintenance of the spatial maze influence. Certain kinds of regularities and/or irregularities in the sequence of correct responses, which produced corresponding departures from the classical serial position curve, were acknowledged as important in the very first article (Brogden & Schmidt, 1954a, p. 240). Thus careful attention to avoidance of repetitions and pattern regularities in construction of sequential patterns can be seen particularly in R. Thompson (1958). More importantly, the third published article (R. Thompson, et al., 1957) began a long series of direct experimental comparisons of the effects of various localized and/or list-wide pattern regularities, all of which gave the subjects minimal or no advance instructions about these pattern characteristics. In fact, a direct concern with this factor, which subsequently was extended to multiple related lists and sublists learned either successively or simultaneously, represented the main thread of communality characterizing all of the subsequent experiments in this series.

No effort will be made herein to provide even a complete summary of the vast and often highly complex set(s) of results emerging from this series of experiments, which required 152 separate figures including 340 different serial-position curves along with 13 data tables (plus four additional tables of methodological or analytic information). Instead, the following sections will be limited to the principal findings of each of these experiments, with special emphasis upon those findings (often of a secondary nature) which appear particularly germane to present and possible future topics of research interest (some of which, incidentally, were of little or no concern at the time of this research, which may help account for its lack of impact). Consistent with the preceding summary of methodological characteristics and major problem interests, the following selective summary of results will be divided into five sections concerning (1) Effects of number of response alternatives, (2) Effects of pattern and subpattern sequential properties, (3) Learning of multiple serial lists varying in item and temporal relationships, (4) Effects of ordinal position variations on serial learning, and (5) Part vs. whole learning and intralist grouping of verbal and numerical items.

Effects of Number of Response Alternatives

The initial "verbal maze" experiments on the functional relationship between performance and number of response alternatives, which alone are responsible for any impact of this program upon other researchers (e.g., Miller, 1956; Simon, 1957), constitute four early publications (Brogden & Schmidt, 1954a, 1954b; R. Thompson, 1958; R. Thompson & Brogden, 1958). This concern with number of response alternatives reflects at least in part the relevance of this variable to a long forgotten distinction between "discovery" of which of several alternative responses is correct and actual "performance" of this response, attributed to Melton (1950). The major result of interest characterizing all of these experiments was a systematic linear increase with increased response alternatives in total time and errors required to reach a criterion of one perfect trial, but no consistent increase in number of trials to criterion or number of "first errors" (errors on the first response at each choice point).

These experiments establish the linear increase in time and errors measures with increased response alternatives as an impressively general relationship up to at least 12 alternatives, holding over a variety of changes in procedure, materials, and/or specific patterns. The slope of this function, however, is shown to decline with shorter mazes, and with the "modified correction" procedure (see above) where the "discovery" component is substantially reduced. Although number of alternatives might thus appear to influence primarily the difficulty of the initial discovery phase, the linear relationship of number of alternatives to time and errors is accounted for instead by a combination of this (which operates primarily on early trials) with decreased interference from repetitions of the same response for patterns based on more response alternatives (localized primarily in later trials).

Further explicating the latter is Ernst's 1958 Master's thesis (Ernst, 1967) suggesting the importance throughout learning of increased "response uncertainty" with more response alternatives. Examining intermaze transfer and retroaction with orthogonal variations in response alternatives (2, 4, or 8) for two successive mazes, Ernst found first-maze relearning to be inhibited only with 4 or 8 alternatives on both mazes, and particularly when these alternatives were identical for both. In addition to this evidence for maximal interference with maximal response uncertainty, however, Ernst also found consistent facilitation of second-maze learning irrespective of number of alternatives, which is attributed to learning of general "subsidiary responses" that counteract this uncertainty.

Contrasting with Miller's (1956) emphasis upon the importance of the finding that trials to criterion is unaffected by number of response alternatives is the authors' contention merely that "trials on mazes with different numbers of alternate choices are not comparable" (Brogden & Schmidt, 1954b, p. 337), there is "questionable validity of trials in comparing mazes" (R. Thompson & Brogden, 1958, p. 505), and "trials is apparently unreliable and insensitive to the number of choices" (Ernst, 1967, p. 476). Moreover, the Thompson-Brogden (1958) finding under the correction (but not the modified correction) procedure of a significant nonlinear effect of number of response alternatives on trials and first-error measures (both being least with 2 and 8 alternatives) is relegated to the "indeterminate category," on the grounds that this relationship differs from the slight linear relationship found by R. Thompson (1958), and "the lack of any reasonable hypothesis" to account for such results (R. Thompson & Brogden, 1958, p. 505).

Effects of Patterns and Subpattern Sequential Properties

Before the aforementioned work on number of response alternatives had been completed, the Thompson et al. (1957) article began a series of five publications representing seven experiments which covered virtually all possible types of simple subpatterns (doublets, split-doublets, triplicates, and quadruplicates, as well as cyclic response patterns) that are possible with the 16-unit maze with four response alternatives (10, 20, 30, 40) used throughout this series of experiments. Except for the Namikas-Brogden (1960) investigation of recurrent cyclic patterns characterizing the entire list, these experiments all investigated the effects of a single subpattern as a function of its serial position(s) within the list.

The initial R. Thompson et al. (1957) demonstration of a "negative recency" increment in errors for the second repeated element of a doublet was inextricably confounded with frequency and locus of "split doublets" (occurrence of the same item twice, but separated only by one intervening different item). Thus Ernst, Hoffeld, Seidenstein, & Brogden (1960) performed two separate experiments using respectively either a doublet or split doublet localized at varying serial positions within the list. Although neither doublets nor split doublets produced any overall performance effects (as found also by R. Thompson et al., 1957), the "negative recency" finding of increased errors on the repeated element was found both within the doublet and split-doublet subpatterns. These doublet and split doublet effects, however, extended also to other serial positions in the list, which may be at least partially attributable to correlated variations elsewhere in the pattern resulting from each of the four alternatives being correct exactly four times within all doublet, split-doublet, and control patterns. Another secondary finding of some interest emerged from analyses of subjects' avoidance of repeating the same response as a possible explanation for the decrement on the repeated element of these doublet patterns. These showed a greater likelihood of repeating the number 10 (the first element in the sequence of response alternatives) than the other three elements (20, 30, and 40).

Comparisons between the doublet and split-doublet effects, however, revealed enough differences between them to be described as "independent of each other" (Ernst et al., 1960, p. 102). In agreement with R. Thompson et al. (1957), the increased error for the second item of a doublet was found to reflect primarily avoidance of guessing repetitions during the initial discovery phase. Unlike the previous study, however, Ernst et al. (1960) found during later stages of learning a decrease in errors on the second member of the doublet of much smaller magnitude than the initial increase, while C. Thompson (1966) later showed a similar decrease during delayed relearning. Except for some minor variations, these doublet effects appeared relatively consistent across five different serial locations within the list. Subsequent studies by C. Thompson, however, showed substantial changes in magnitude of doublet effects across serial locations, which varied with such other factors as interval between successive numbers (Thompson, 1965; Heine et al., 1966).

In contrast with the doublet effect, the increased error on the second repeated element of a split doublet was found only when located at the middle or end of the list, and appeared not to change systematically over stages of learning nor to depend on subjects' guessing habits. It is these differences between doublet and split-doublet effects that led them to be characterized as independent rather than representing the same general phenomenon or process.

Still more impressive differences were reported by Namikas, C. Thompson, & Brogden (1960) for single triplets and quadruplicates, representing respectively three and four repeated occurrences of the same correct response. Although neither produced any overall facilitation of performance, triplets showed a significant increase in total errors primarily on the third member thereof, with a concomitant decrease for the first triplet member.

Quadruplicates showed instead a general facilitation for the first three members with little or no effect on errors in the final position. Although both triplet and quadruplicate effects were somewhat reduced when located in early serial positions and/or on later trials, neither showed the reversed direction of these effects over trials that Ernst et al. (1960) had reported for doublets. As with doublets and split doublets, significant effects at serial positions other than those of the triplet and quadruplicate were acknowledged, but not directly accounted for.

Both triplicates and quadruplicates showed a very different pattern of results for errors made on the first response at each choice point (first errors), as contrasted with the foregoing results based on total errors. Ernst et al. (1960) had also reported such differences for doublets (but not split doublets), finding no consistent increase in first errors for the second doublet member like that shown for total errors. Even larger and more consistent discrepancies for the first errors measure were found by Namikas et al. (1960) particularly for triplicates, which showed a general reduction in first errors that was maximal for the middle position of the triplicate. Such a general reduction also occurred for first errors on quadruplicates located in beginning and middle (but not end) positions, although first errors differed only inconsistently from total errors in relative performance across positions within the quadruplicate.

Because of these substantive differences between results for total-error and first-error measures, combined with previous evidence that the first-error measures corresponded closely to those for a modified-correction or anticipation method where subjects make only one response at each position (R. Thompson, 1958), the results of the preceding five experiments appeared likely to hold only for the correction maze procedure used therein. Thus Ernst et al. (1962) replicated the doublet, split-doublet, triplicate, and quadruplicate patterns using instead a standard serial-anticipation procedure, with three (early, middle, and late) locations of each subpattern within the list.

In addition to localized serial-position effects which generally were consistent with those for the first-errors measure in the preceding experiments, Ernst et al. (1962) report generally faster overall acquisition especially for the triplet and quadruplicate "pleonasms" as compared with the control list. Doublets were consistently but insignificantly superior to the control across all three loci. Split doublets, however, were significantly superior to the control only when located in an early position, becoming insignificantly worse than the control for middle and late positions. As found also both with total and first errors in the 1960 Ernst et al. experiment, the split-doublet pattern showed significant interference on the repeated item thereof. None of the other three pleonasms, however, showed any decrements whatever, with serial-position curves similar in shape to those for first errors in the previous studies but with much larger facilitation on all repeated elements within doublets, triplets, and quadruplicates. All of these localized serial-position effects were larger during early stages of learning and when the pleonasm was in the middle of the list, with the early locus showing minimal serial-position effects for both triplets and quadruplicates. Both doublet types, however, showed minimal effects at the late locus, with the split-doublet alone showing major changes in shape of the serial-position curve over the three loci.

That such patterning regularities could produce marked facilitation of learning also under the maze correction method had been shown previously by Namikas and Brogden (1960) in the only experiment of this series where a given subpattern appeared repeatedly throughout the list instead of only once. Three types of sequential patterns were employed, one involving successive quadruplicates in series (four 10s, followed respectively by four 20s, 30s, and 40s), a second involving four successive repetitions of the same 10-20-30-40 cycle, and the third involving two repeated cycles of the doublet sequence (10-10-20-20-30-30-40-40). Each pattern type was counterbalanced so that each number began the pattern equally often, although the same ascending sequential characteristics were maintained (e.g., 20-30-40-10).

All three cyclic patterns produced marked overall facilitation relative to the control group which was four times larger than that found by Ernst et al. (1962) for triplets and quadruplicates under serial anticipation. For the errors measure only, the doublet cycle pattern produced significantly worse performance than the quadruplicate and single cyclic pattern which were closely comparable. This reflected a consistent increase in errors for the second over the first member of each doublet within the doublet cycle pattern, although this "sawtooth" pattern was attributable almost entirely to the specific subpattern beginning with 10 (as represented above). Both for quadruplicate and single cycle patterns, performance showed some decrement as the beginning number of the pattern increased from 10 to 40, and both the single and doublet cycle patterns showed consistent increases in errors as number values increased from 10 to 40. Errors also tended to be larger at transition points between successive cycles. These effects, plus the virtual elimination of the bowed serial-position curve for all patterns, led to the conclusion that within these sequential patterns, "the distribution of errors is a function of relations between items rather than the position of the items in the sequence" (Namikas & Brogden, 1960, p. 55).

The preceding quotation, along with the detailed evidence throughout these experiments demonstrating the heavy dependence particularly of localized serial position effects as well as overall serial learning difficulty upon various types of repetitive or cyclic subpatterns, clearly preceded and still appears highly relevant to more recent information-processing analyses of serial patterns (e.g., Greeno & Simon, 1974; Jones, 1976; Restle, 1976; Simon, 1972). Yet these and all other current serial-patterning researchers known to the present author, including Harcum's (1975) comprehensive review, have in common their failure to make any reference whatever to any of the publications described in this section.

<u>Learning of Multiple Serial Lists Varying in Item and Temporal Relationships</u>

The next series of three experiments incorporated a major shift to the investigation of the learning of two or three separate serial lists varying in the number and locus of items common to both lists, and in the temporal sequence of presentation of these lists.

The initial experiment (Nelson et al., 1966) included two 8-item lists of two-digit numbers presented on alternate trials, with 0, 2, 4, and 6 items in common (and in the same serial positions) across these two lists. With 2, 4, and 6 common items, these were located for different groups in early, middle, and late serial positions. For comparison purposes, control groups learning a single 8-item list and a single 16-item list were also included. The results showed no consistent differences between the two lists within any condition, but a consistent improvement in performance as number of common items increased from 0 to 6, except for little difference between 2 and 4 common items. Serial-position analyses indicated this facilitation to be localized primarily in the common items, except for the group with 6 common items where facilitation was relatively greater on the two different items if the latter represented the first or last two items in the list. Also the peak error tended to shift toward the end of the list with more common items, as contrasted with the classical bowed serial-position curves for each list with no common items.

The subsequent two experiments (Bewley, Nelson, & Brogden, 1968) both included also alternately presented lists varying in number of common items and their locus within these lists, but under changed conditions and with additional successive and simultaneous learning conditions added for purposes of comparison. The first experiment used two 12-item lists of CVC nouns with 0, 4, or 8 common items always appearing in the middle positions, which were presented either on alternate trials (continuing until both lists were learned to one errorless trial), or successively with one list learned alone to this criterion before the second list was ever presented and learned. Although the results were somewhat complicated by the non-equivalence in learning difficulty of the two lists, alternation of two lists produced significantly slower learning with 0 than with 4 and 8 common items (with 8 producing more errors than 4 common items). No significant overall effects of number of common items were found under successive conditions, although adjustments for first-list differences indicated greater second-list facilitation with 8 than 0 or 4 common items. However, the second successive list always showed a marked improvement over the first list, with the latter insignificantly inferior to the alternating lists, while its successor was markedly superior thereto (as was overall performance on both successive lists combined). Unlike Nelson et al. (1966), the present serial-position curves showed small and inconsistent differences as a function of number of common items, except for a relative facilitation on the 4 common items in the second successive list.

Because of the list differences and lack of serial-position effects with CVC nouns, the second Bewley et al. (1968) experiment returned to the lists of eight 2-digit numbers used by Nelson et al. (1966). In addition to the previous successive and alternating presentation of two lists each with different numbers, this experiment included also both alternating and successive learning of three nonoverlapping 8-item lists. Two other groups learned these same numbers as single 16- and 24-item lists respectively.

The results under these nonoverlapping conditions showed a marked overall superiority for successive over alternating (and combined-list) conditions, thus replicating previous findings with two lists and extending these also to three lists. Unlike the previous experiment, however, there was no improvement after the first list under successive conditions. As compared with learning the component lists as a single list, the initial sublist thereof was learned more easily than under alternating conditions, whereas the subsequent sublist(s) were significantly more difficult than alternation. Comparisons between differing numbers of sublists revealed consistent increases in difficulty as lists increased from one to three, based either on single sublist units or combined performance thereupon. The serial-position curves were closely comparable across sublists (as had been found also for the no-common-item conditions in the previous two experiments), as well as for alternating and successive conditions (possibly reflecting the use throughout of single digit or letter designations preceding each sublist). The only other finding of interest in these serial-position analyses was the marked relative flattening of the serial-position curves across all but the first 5-6 and the last two serial positions for the 16- and 24-item combined lists, which was not mentioned by the authors.

Another largely ignored result of interest from Nelson et al. (1966), which regrettably could not be evaluated in the subsequent experiments, was the facilitation with 6 common items localized primarily in the two different items, provided that the latter were adjacent in either the first or last two serial positions. It is worth noting, however, that their concluding sentence (p. 721) suggesting that "this may reflect an effect of the two items that are different rather than of the six identical items" comes very close to an independent discovery that performance is facilitated on any type of item which represents a small and "isolated" minority within a mixed list, which has been credited to the present author (Battig, 1966).

Even more surprisingly ignored in these articles is the obvious relevance, especially of the Nelson et al. (1966) results for two lists with overlapping items, to what at that time was still a very active research controversy about the nature of the "functional stimulus" in serial learning (e.g., Bewley, 1972). Unlike the preceding instance, however, the present author was not remiss in failing to acknowledge this contribution in the Battig-Young (1969) attempt (which was largely unsuccessful) to resolve this issue by requiring subjects to learn two overlapping lists under a serial recall procedure (as contrasted with the present serial anticipation). The following section describes an even more extreme instance of Brogden's unwillingness to deal with the controversial issue of the functional stimulus (or what is learned) in serial learning, which Bewley (personal communication) reports Brogden to have described as "a can of worms" which he preferred to stay away from. Certainly this contributed to the lack of impact of this research on other researchers in the same general area.

Effects of Ordinal Position Variations on Serial Learning

Although only one experiment was done on this topic (Bewley, Nelson & Brogden, 1969), it included 11 groups representing a variety of conditions differing primarily in presence or absence of intertrial intervals, starting point within the list, and/or intertrial consistency in list length. Also run were four added control groups with varying list lengths. Although the literature contains many other closely related experiments using similar techniques to assess the importance of sequential vs. ordinal position cues as the functional stimuli in serial learning (resulting in over twice as many cited outside references in this as in any of the other 14 articles in this series), this particular issue is not even mentioned. Instead, the purpose is described merely as "to compare the effects of elimination of the intertrial interval and variation of the starting position of each trial on the speed of acquisition of serial anticipation learning and on the form of the serial position error curve" (Bewley et al., 1969, p. 446).

Because neither the 11 experimental conditions, relative performance thereupon, nor methods of analysis or comparison, fit readily into any simple factorial or other basis of organization, each of these conditions is described in a separate numbered paragraph below. Each paragraph includes both a description of the experimental condition and of the other conditions from which its performance differed significantly. Ordering of the 11 experimental conditions learning 8-item lists proceeds from best to worst performance in terms of total errors to the criterion of one errorless sequence (these numbers appearing in parentheses following the group numbers). In this (and all subsequent) experiments, all serial-position curves are based solely on percentages of total errors made at each serial position, although serial-position analyses based upon absolute errors were also performed.

1. (32.4) The standard control condition learned an 8-item list of two-digit numbers using a standard serial-anticipation procedure with a 10-sec intertrial interval and a visual "start" anticipation cue at the beginning of each trial. This group was significantly superior to all other groups except for _2_ below, and produced a typical bow-shaped serial-position curve.

2. (47.7) This added control condition differed from _1_ above only in that the "start" signal prior to each trial was an added presentation of the last item in the list, which produced only insignificantly fewer errors than _1_ and also an apparent flattening of the middle of the serial-position curve which is reported as nonsignificant.

3. (71.8) This third control condition differed from _1_ only in its elimination of the 10-sec intertrial interval, with only a 2-sec presentation of "start" intervening between successive trials. This produced significantly more errors than _1_, and insignificantly more than _2_, but significantly fewer than all of the remaining eight groups except _4_. Other than an insignificant decrement on the first item, the serial-

position curve was virtually identical in shape to that for 1.

4. (84.4) After an initial presentation of the 8-item list, this group was presented (in an unsystematic order) on successive trials sequences of all other lengths from 4 to 12, with a 10 sec intertrial interval and the last item from the preceding sequence being re-presented as the start signal. Although significantly worse than 1 and 2 but not 3, this condition was significantly superior to all other conditions except for 5 and 6, with a somewhat flattened although still bow-shaped serial-position curve that showed slightly better performance on the last two than the first two positions.

5. (106.5) This group received exactly 13 items per trial (with the first five being repeated as the last five), and each successive trial began with the last item of the preceding trial as a start signal. It was significantly worse than all preceding groups except 4, and significantly superior only to Groups 9-11, with a virtually flat serial-position curve except for a peak decrement on the third item.

6. (112.6) This group received no intertrial interval whatever, and only one "start" signal presented vocally to coincide with the first item following the initial display trial. Its performance was significantly worse than Groups 1-3, and significantly superior only to Groups 9-11. The serial-position curve, however, was virtually identical in shape to that for 3 as described above.

7. (113.7) This group, much like 5 above except that only 11 items were presented on each trial with the first three repeated as the last three items, was only slightly inferior to (and differed significantly from the same other groups) as 6 above. It showed, however, virtually

idential performance across all serial positions.

8. (125.7) Differing from 5 and 7 only in that 15 items were presented on each trial (with all but the 8th presented item repeated at the end of the list), this group made significantly more errors than Groups 1-4, and was significantly superior only to 11 below. Like 7 above, it showed a virtually flat serial-position curve.

9. (143.6) This group was exactly like 6 above in having no intertrial interval, differing only in that its single "start" signal coincided with the last item on the initial list presentation. Its performance, however, was significantly inferior to Groups 1-7 (including 6), and superior only to 11 below. Its serial-position curve was similar in shape to 3 and 6, except for a larger decrement at the first position.

10. (148.3) This group differed from 5, 7, and 8 above only in that 9 items were presented on each trial with the first being repeated at the end of the list. Only slightly inferior to 9, it too was significantly worse than Groups 1-7, but significantly superior to 11 below. Its serial-position curve, however, had a shape similar to those for the first three control groups, except for relatively poorer performance at the first two positions.

11. (193.4) Significantly worse than all of the preceding ten groups, this group also had no intertrial interval, like 6 and 9 above. It was unique, however, in that the single vocal "start" signal coincided with the third item after the initial list presentation rather than the first or last items. Its serial position curve was relatively flat, but with a slight decrement for the last three as compared with the first five serial positions.

Results for the additional four control groups, which learned lists of 9, 11, 13, or 15 different items, were not presented in a form permitting comparisons directly with the preceding groups, with their error means and serial-position curves being totally omitted. Their usage herein involved only direct individual comparisons of each with the corresponding experimental groups given respectively 9, 11, 13 and 15 total items with the initial eight items being repeated as necessary at the end of the list (Groups 10, 7, 5, and 8 as described above), but based on error measures for all items rather than just the initial eight items. These individual group comparisons showed a shift from significant interference relative to the control group with one repeated item (Group 10), to no effect with three repeated items (Group 7), and significant facilitation with five or seven repeated items (Groups 5 and 8).

Several conclusions of potential interest can be drawn from these results. To begin with, although elimination of the intertrial interval tended to increase learning difficulty, the serial-position curve showed little change unless the intralist starting position was also changed. Type and frequency of starting signals across trials, however, had in themselves little or no deleterious effect. When the intertrial interval elimination was combined with designation of an item other than the first presented item as a starting point, marked performance decrements resulted especially when a middle (third) item was so designated. Contrary to previous research (e.g., Lippman & Denny, 1964), however, there was little evidence herein for idiosyncratic selection by individual subjects of one specific item as a starting point for a bow-shaped serial-position curve under conditions where the beginning of the list was not clearly designated.

When the starting position was changed after every trial by repeating initial items later in the list, performance was degraded more if this trial-to-trial variation was large in magnitude (Groups 5 and 7 above) than if it involved shifts of only a single item especially if this was in a forward (10) rather than backward direction (8). Particularly noteworthy was the relatively good performance by the only group (4) which had totally unpredictable trial-to-trial shifts in starting position, probably because this group was unique in that only 4-7 of the 8 items were presented on half of its trials (which always represented four of the first five trials of each block).

Unfortunately the serial-position curve comparisons yield little useful information, being described as providing "no specific clues as to the identification of the relevant variables" responsible for group differences in serial-position effects, which correspond only partially to differences in learning difficulty (Bewley et al., 1969, p. 451). This dearth of serial-position information can be attributed at least partially to the failure herein to use the trend analyses characterizing serial-position comparisons in many previous studies in this series. Instead, Fisher LSD tests alone are used to compare percentage-error data for all possible pairs of serial positions within each individual group, as well as each individual serial position for pairs of groups (or in many cases pooled subsets of groups). As a consequence, these serial-position data become unnecessarily difficult to comprehend, and prohibit a direct evaluation of group differences in serial-position curve shape and/or departures from the standard bow-shaped curve.

Considering the massive evidence from this experiment indicating marked decrements in serial learning if ordinal-position information is changed or eliminated (which impresses this writer as providing at least as strong evidence for ordinal position as a key "functional stimulus" in serial learning as exists anywhere), it is difficult to understand how this evidence could have been so completely overlooked even by those advocating a positional interpretation of serial learning (e.g., Ebenholtz, 1972). This obviously reflects, of course, the failure of Bewley et al., (1969) to say anything about this beyond the initial sentence of the discussion (p. 449) that "All treatments designed to reduce ordinal-position effects on serial anticipation learning significantly increased the difficulty in acquisition of eight two-digit numbers relative to acquisition by the standard control." In any event, not even Bewley's (1972) otherwise very balanced and complete review of this literature makes any reference to this experiment.

Brogden's atheoretical approach to what others regarded as a critical theoretical issue may well represent something much more important than merely an extreme example of otherwise competent research being ignored because its author(s) chose not to relate it to current theorizing. From today's perspective, the theoretical controversy over "what is learned in serial learning" can be seen as greatly oversimplified, with the consequence that the various "crucial" experiments not only failed to settle this controversy, but became of little lasting value once the highly complex multipleprocess nature of serial learning was finally acknowledged (e.g., Bewley, 1972; Harcum, 1975). When and if the current aversion is overcome to the many complex issues involved in developing a comprehensive understanding of serial learning, and this once again becomes a major area of research, the Bewley et al. (1969) experiment may well contribute more useful information than any of the experiments directly spawned by this theoretical controversy. If so, persuasive support would be provided for Brogden's views that "A theory of learning may impede advancement seriously. It may fail to consider existing experimental evidence that does not support it; it may encourage research to proceed in non-productive channels; or it may define problems verbally that cannot be attacked experimentally," and that "The answer to any given problem will come when someone is ingenious enough to take the problem into the laboratory and solve it by means of experimentation. A theory can be a satisfier, but it is no substitute for knowing by means of experiment" (Brogden, 1951, p. 224 & 229). In the present-day climate where empirically based experimentation is subservient to prior theorizing, the present analysis suggests Brogden's atheoretical viewpoint to merit reconsideration.

Part vs. Whole Learning and Intralist Grouping of Verbal and Numerical Items

The final series of three experiments, all by Fingeret and Brogden (1970, 1972, 1973), began as a direct followup of the earlier research indicating a marked facilitation of serial learning if the entire list was divided into sublists learned individually in succession (Bewley et al., 1968). This apparent superiority of part over whole learning was more directly evaluated in the first (1970) experiment, by adding thereto subsequent learning of the parts combined into a single whole (which had not been required in the previous experiments). Also introduced into this experiment was the use of part lists of two different types of material (two-digit numbers and CVC nouns), the intralist arrangements of which became a primary focus of the final two experiments.

The 1970 experiment involved learning of two 8-item sublists both consisting of either two-digit numbers or CVC nouns, or with one sublist each of numbers and nouns. For each of these three types of material, the two sublists were learned either separately on alternate trials, successively with the first sublist learned to criterion before the second was presented for learning, or simultaneously as a single whole 16-item list. These alternating, successive, and whole-learning procedures correspond closely to Bewley et al. (1968), except that the two part-learning procedures were followed by additional trials to a criterion of one errorless trial on the two sublists combined into the single 16-item list used under whole-learning conditions. For all groups, this final 16-item list consisted of the two sublists as its first and second halves. This provided that the mixed number and word conditions always involved totally different types of material in the first and second halves of the final 16-item list. To evaluate the effects of this separation of number and word materials, a single 16-item list with 8 words and 8 numbers randomly intermixed throughout was learned by still another group.

As had been shown previously, both alternating and successive procedures produced significantly fewer errors to criterion on the 16-item list than did whole learning thereof. Also replicated was the significant superiority of successive over alternating conditions when both sublists were either numbers or words. With one sublist of each type of material, however, alternation became significantly superior to the successive procedure. Moreover, although the words were markedly superior to the number lists and sublists, the mixed word and number sublists were nonetheless superior to exclusively word sublists (significantly so under alternating and whole but not successive conditions). Also significant was the superiority of all conditions where mixed words and numbers were separated as the first and second halves of the combined list, over random intermixing of these two types of material (although the latter was significantly superior to unmixed lists of words as well as of numbers). Serial-position curves (which again were compared across groups only by Fisher LSD tests at each individual position) appeared bimodal with a marked facilitation around the transition point between the two sublists particularly under alternating and successive conditions, and to a lesser extent under whole conditions where the two halves contained different number and word materials.

Further analyses indicated that successive differed from alternating conditions in showing (a) marked relative facilitation for the second as compared with the first sublist localized primarily in the sublist learning phase, (b) greater localization of errors in the combined relative to the sublist phase (combined actually being significantly more frequent than sublist errors with lists of numbers only), and (c) a reduction in errors during the combined phase around the middle transition point between sublists if these were both words or numbers as contrasted with a marked relative increase on the transition (ninth) item when one sublist was numbers and the other words.

The next (1972) experiment involved further investigation of the facilitation of part relative to whole serial learning under conditions where the parts represented different classes of materials, introducing a new kind of organization of these sublists similar to doublet and quadruplicate subpattern variations studied previously (e.g., Namikas & Brogden, 1960; Ernst et al., 1962). More specifically, after alternating or successive learning of one sublist of nouns and another of numbers exactly as in the previous experiment, these were combined into a single 16-item list wherein each successive item pair or quadruple was interleaved with the corresponding 2- or 4-item subset from the other sublist. Also included were whole-learning conditions with the same 16-item combined lists as used for the above double and quadruple alternation conditions, along with four nonspecific transfer control groups learning these same combined lists after previous alternating or successive learning of two 8-item lists of words and numbers different from those constituting the combined list.

Even under these double and quadruple alternation conditions, both alternating and successive sublist learning produced consistently fewer total errors than whole learning (significantly so except for quadruple alternation following alternating sublist learning). When only combined-list performance was considered, whole learning produced over four times as many errors as did any of the part-learning conditions, as well as being significantly superior for quadruple over double alternation (although this latter difference was nonsignificant for alternating and successive sublist learning). Although significantly inferior to alternating and successive groups, the nonspecific transfer control groups made consistently fewer combined-phase errors than the corresponding whole-learning groups. These latter differences were all significant except for quadruple alternation with successive sublist learning. Serial-position analyses (again only by Fisher LSD comparisons) showed essentially no group differences in early serial positions, and sometimes reduced effects also in later positions. Especially in middle positions, however, double alternation led to more errors on the first than second member of each "doublet," with this saw-tooth effect more pronounced for alternating and successive than whole conditions. Quadruple serial position effects were much less consistent, showing some cyclic variations which differed considerably across alternating and successive conditions as well as across middle and terminal serial positions.

The final (1973) experiment was limited to whole-list learning conditions, ingeniously eliminating the previous complications induced by differences between word and number classes of material (and responses) by using instead both verbal and numerical forms of two-digit numbers (e.g., forty-two and 42) as the two classes of material to be learned. These verbal and numerical items were interleaved not only in doubles and quadruples (as in the 1972 experiment), but also single alternation of individual verbal with numerical items. Octuple alternation conditions presented all 8 verbal (or numerical) items prior to any of the 8 items of the other type. In addition to these single, double, quadruple, and octuple alternation groups, there were two control groups in which all 16 items were verbal and numerical, respectively. A third control group had 8 verbal and 8 numerical items which were randomly intermixed throughout the list.

Although analyses including all seven groups showed only insignificant group differences, pooling of the three control groups (despite a near significant superiority of numerical over verbal control conditions) did produce significant overall group differences. These reflected the inferiority of the single-alternation to the closely comparable double, quadruple, and octuple alternation groups, None of these groups, however, differed significantly from the pooled control groups which were superior only to single-alternation performance.

Serial-position curves were similar in shape for single- and double-alternation groups, showing a sawtoothed increment on odd- relative to even-numbered items except for the first six positions (quite similar in shape although less pronounced in magnitude when compared with the whole double-alternation condition in the 1972 experiment). Quadruple- and octuple-alternation conditions both showed a different bimodal serial-position effect, with errors maximized at the 7th and 13th serial positions, and relative facilitation across the intervening middle positions especially for the octuple-alternating group. Thus even with lists of two-digit numbers differing only as to verbal and numerical form, both overall group differences and serial-position effects exhibit similar (although much smaller) effects to those observed in the previous two experiments using mixed lists.

The results of these experiments provide substantial generality to the superiority of part over whole learning conditions in serial learning, which is shown to be enhanced especially under alternating part presentation conditions when the parts consist of different types of learning material. Considerable evidence is also provided for facilitative effects of intra-list grouping into subsets of two or more items of the same type of material. Especially significant is the substantial evidence of organizational effects with two distinct types of items in a single list, shown most convincingly by the 1970 finding that lists composed of more difficult 2-digit numbers combined with easier CVC words were significantly easier to learn than lists constituted entirely from the easier words. Nonetheless, in common with previous articles in this series, little is said about these results that is theoretical or even speculative in nature, although the 1972 article does suggest that the effects therein of double- and quadruple-alternation patterns were "probably due to the transfer of associative learning between items of the doublets and quadruplicates in the part phase to the combination phase" (Fingeret & Brogden, 1972, p. 255).

Epilogue

Although the foregoing summary has omitted much of the detailed information provided by the various modes of presentation and analysis of this mass of data, there can be no question about the wealth of empirical information therein which present or future researchers with interests related to any of the above five topical areas can ill afford to ignore. This is particularly true of current research activity in serial pattern learning, organization or grouping of subsequences, and/or whole vs. part learning.

Brogden's own subsequent research plans focussed primarily on further investigations of the organizational and whole-part aspects deriving from the Fingeret-Brogden (1970, 1972, 1973) research described in the preceding section. A brief progress report, dated only a month before Brogden's death, makes reference to three subsequent experiments. The first of these evaluated organization in terms of variations in quantitative progression in numerical magnitude of 2-digit numbers constituting a serial list, but was not considered to "justify publication." Also judged as not worth publishing was a comparison of standard serial-anticipation learning with a procedure whereby each trial terminated upon occurrence of the first error, wherein the latter "progressive part" procedure required insignificantly less time to achieve one errorless trial on the entire list than the standard whole-list procedure.

Still being analyzed at the time of Brogden's death were the data from a more extensive progressive-part experiment, which included also learning thereafter of a second unrelated whole list as well as subsequent recall of the first list. Four progressive-part groups differed only in the order in which the four quarters of the list were introduced, all learning 4 items to one errorless trial, with successive addition of three other sets of 4 items to produce lists of 8, 12, and 16 items, each of which was also learned to one errorless trial. Designating the four quarters of the final 16-item list in order as A, B, C, and D, these four groups differed only in the sequence of addition thereof as the list increased from 4 to 16 items, with all part lists consistent with the final list order. These groups represented respectively forward (A-B-C-D), backward (D-C-B-A), middle-first (C-B-D-A) and ends-first (A-D-B-C) progressive-part conditions. Also included were appropriate control groups learning corresponding whole lists of 8, 12, and 16 items. Unfortunately, it is not possible to get access to the complete data and analyses from this final experiment, although these reportedly were completed after Brogden's death. From the very limited information available, however, any superiority of these progressive-part conditions over whole-list controls appears rather small, with relative performance across the progressive part groups also differing slightly and ordered from best to worst in the listing above.

Despite the lack of concern with theoretical issues pervading this entire series of experiments, and the likelihood that Brogden would have preferred that these research findings be evaluated solely on the basis of their experimental soundness and empirical contributions, the final paragraph of his last published article nonetheless presents an idea which can appropriately be presented also as the last word for purposes of the present article. This idea seems to offer a promising perspective applicable to much of the puzzling mass of unexplained data concerning the serial-position curve as affected (or unaffected) by other variables, that still characterizes the serial-learning literature. In Brogden's own words, this final legacy is reproduced below (Fingeret & Brogden, 1973; p. 343).

"These results suggest that the effects of pattern are due in part to positive transfer from prior learning. Any pattern or principle that might be used for organization of a serial list to be learned by adult Ss would have a substantial history of prior practice. Thus, the prior learning of a pattern or principle would always be confounded with the current effect such a variable would have upon the ease of acquisition of a serial list. Any conditions that contribute to increasing the magnitude of such positive transfer effects should contribute also to the effect of organization upon the difficulty of serial learning. Thus, when patterns or principles of organization are manipulated as variables, the prior learning and its positive transfer and the effect of pattern upon ease of serial learning are intermingled. The effects of primacy and recency may also be considered in the same manner. Positive transfer effects from prior serial learning are the basis for primacy and recency effects and these effects are prominent and large for serial learning. When there is an addition of some pattern or principle of organization to a serial list demonstration of the effects of pattern are necessarily limited to the middle serial positions. Primacy and recency effects will interfere with and markedly reduce any pattern effects at the beginning and terminal ordinal positions. Even without the imposition of a specific pattern every serial list has a minimum pattern that is dependent upon positive transfer effects from previous serial learning that involves primacy and recency effects due to the initial and terminal ordinal positions. The acquisition of items in the middle of the list will occur at a slower rate than will those at the beginning and end of the list and will depend upon cues that are inherent in the items or upon cues that are idiosyncratic with each learner."

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Footnotes

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[2]This experiment represented also an early instance where experimenter differences were explicitly analyzed and acknowledged, although it should be noted that none of the several subsequent experiments, wherein experimenter differences could have been evaluated, involve any mention of such analyses.