In: Advances in Psychology Research, Volume 51
Editor: Alexandra M. Columbus, pp. 133-148
ISBN: 978-1-60021-660-2

Chapter 4

PART-SET CUING AND ORDER RETENTION

Matthew R. Kelley* and Joanna C. Bovee
Department of Psychology, Lake Forest College, Lake Forest, IL 60045

Abstract

Nearly a dozen distinct models of serial order memory have been proposed over the past two decades. Although the underlying processes and mechanisms are often quite different, each model has successfully accounted for a wide variety of serial order accuracy and error data. The challenge for researchers, then, is to evaluate these models by testing their predictions against new empirical data. The current study provided critical new data as it explored how part-set cuing affects immediate order retention. Using reconstruction of order and serial recall measures, two experiments examined the influences of cue type (consistent, inconsistent, control), cue location (before, after, surround), and list length (8, 16). In addition, the serial recall data permitted fine-grained analyses error patterns (i.e., transpositions, omissions, within-list intrusion, out-of-experiment intrusions). Results suggest that participants can use interitem associative information to facilitate order performance, which poses problems for purely position-based models of order memory.

Over the past two decades, researchers have proposed nearly a dozen distinct models of serial order memory (see Neath & Surprenant, 2003 for a review). Designed to account for benchmark serial order phenomena such as serial position effects and positional uncertainty gradients, these models are often categorized according to the process or mechanism that drives order retention. For instance, the TODAM model (Lewandowsky & Murdock, 1989) is considered an interitem associative model because it assumes that order is retained by forming associations between list items. In the realm of order models, TODAM is unique in its use of interitem associations. Indeed, most current models are classified as positional theories which assume that order retention relies on associations between a to-be-remembered item and its position or time of occurrence (e.g., Henson, 1999). *Absolute* positional models, such as the ACT-R partial matching model (Anderson & Matessa, 1997) and Estes' (1997) perturbation theory, associate items with their absolute ordinal positions, whereas *relative*

* E-mail address: kelley@lakeforest.edu, Phone: 847-735-5262

positional models, such as the primacy model (Page & Norris, 1998), the brain state in a box model (Lewandowsky, 1999), and the start-end model (Henson, 1998), associate items relative to the strengths of positional gradients. Alternatively, *temporal/contextual* positional models, such as the OSCAR model (Brown, Preece, and Hulme, 2000) and the phonological loop model (Burgess & Hitch, 1999), define order relative to a context/timing signal.

Although the underlying processes and mechanisms are often quite different, each model has been shown to successfully account for a wide variety of serial order accuracy and error data (Neath & Surprenant, 2003). The challenge for researchers, then, is to evaluate these models by testing their predictions against new empirical data to determine the limits of these models. For instance, Surprenant, Kelley, Farley, & Neath (2005) examined patterns of microscopic memory errors, known as fill-ins and infills, and established that these models were unable to predict the appropriate patterns of human performance. Accordingly, the current study was designed to provide new data to further evaluate the strengths and shortcomings of these models, particularly in regard to basic assumptions about how order information is retained. To this end, the current study examined the effects of part-set cuing on order retention.

Traditionally, the influence of part-set cuing on retention has been assessed using tests of *item* information, such as free and cued recall (see Nickerson, 1984 for a review). In a typical part-set cuing experiment, participants are asked to remember a long list of words for subsequent memory test. Control participants are instructed simply to free recall as many items as possible, whereas experimental participants are given a subset of the to-be-remembered items as cues and are asked to remember the remaining items. Slamecka (1968) was among the first to describe the counterintuitive effect of part-set cuing in free recall—namely, that part-set cuing inhibited recall performance relative to the control condition. Although the effects of part-set cuing on item retention have been extensively studied over the past 35 years, only recently has the influence of part-set cuing on *order* retention been considered (i.e., Basden, Basden, & Stepehens, 2002; Serra & Nairne, 2000).

Serra and Nairne (2000) were the first to explore part-set cuing using a reconstruction of order task. In one experiment, participants viewed a series of 8-item lists, each followed by a 15 second filled distractor task and a free reconstruction test. On the cued trials, a random half the list items were placed in their original serial positions, the remaining items were given in a new random order, and participants were asked to place the remaining items back into their original positions. Uncued trials employed the same procedure except that plus signs (+) appeared in place of the original list items. Contrary to the standard part-set cuing inhibition reported in item tasks, Serra & Nairne reported that part-set cuing *facilitated* order retention.

In a follow-up experiment, Serra and Nairne (2000) showed that the influence of part-set cuing on order retention depends on the congruence of item/position cues. Again, using 8-item lists and a 15 second distractor task, participants attempted to reconstruct the order of the items using either consistently-configured (cues placed in accurate positions), inconsistently-configured (cues placed in inaccurate positions), or control cues (plus signs). Serra and Nairne reported that consistent cues yielded the highest order accuracy, followed by control cues, and then inconsistent cues, which inhibited order retention. Building upon this work, Basden, Basden, and Stephens (2002) explored how part-set cuing affects order retention using a serial recall task. Following an 8-item list and a 30 second filled interval, participants received serial recall tests with either consistent cues, inconsistent cues, control cues (X's), or no cues whatsoever. Serial recall accuracy showed a pattern of performance similar to Serra and Nairne's (2000) reconstruction results [consistent > (control = no cue) > inconsistent].

Serra and Nairne (2000) argued that their original results support the idea that people are able to utilize interitem associative information as they attempt to remember the order of the lists. Whether these interitem associations act to facilitate or inhibit performance depends on the congruence of the item/position cue; consistent cues tend to enhance performance while inconsistent cues inhibit performance. Furthermore, Serra and Nairne used these findings to argue against purely positional models of serial order. Since participants possessed equivalent positional knowledge on cued and uncued trials, order accuracy should have been comparable. These findings are potentially quite problematic given that nearly all of the current models of order memory are positional in nature (Henson, 1999; Neath & Surprenant, 2003).

The current experiments were designed to provide new insights into how part-set cuing affects *immediate* order memory by examining the influences of cue type (consistent, inconsistent, control), cue location (cue before, cue after, cue surrounded), and list length (8, 16) on order performance. Moreover, these experiments permitted fine-grained analyses of the patterns of various types of errors made in serial recall (e.g., transpositions, omissions, within-list intrusion, out-of-experiment intrusions), as well as analyses of the direct effects of cuing (conditional data). The results of these experiments provide important new data critical for the evaluation and revision of current models of serial order.

Experiment 1

The first experiment was designed to extend the work of Serra & Nairne (2000) by examining the influence of cue type (consistent, inconsistent, or control) on an immediate free reconstruction of order task for span-length lists (8 items) and supraspan-length lists (16 items). Using a blocked, counterbalanced, within-subjects design, participants viewed 18 span-length and 18 supraspan-length lists of items. Each list was immediately followed by a reconstruction of order task on which a random half of the list positions contained either consistent (list item in original position), inconsistent (list item in incongruent position), or control cues (an X in original position). The remaining list items were represented in a new random order and participants were asked to simply place the remaining items back into their original serial positions.

Method

Participants & Apparatus

Fifty-four Lake Forest College students earned extra credit in their introductory psychology course for participation in this experiment. Participants were tested in groups of four or fewer, with each person sitting in a separate cubicle that contained a personal computer (IBM-compatible). Each experimental session lasted approximately 45 minutes.

Design and Materials

The experiment employed a 2 (List Length: 8 vs. 16) x 3 (Cue Type: Consistent, Inconsistent, Control) within-subjects design. Four hundred and thirty-two nouns were selected from Francis & Kucera (1982) norms. These nouns were high in frequency (M = 157.06; SD = 107.77; R = 70–787) and contained between four and nine letters (M = 5.87; SD = 1.55). These words were randomly arranged into two blocks: 18 lists of eight items and 18 lists of 16 items. For each list, half of the serial positions were randomly selected to serve as cues during the free reconstruction of order tests. Within each block of 18 trials, participants received 6 trials with each of the three cue types—consistent, inconsistent, or control. To better illustrate each cue type, imagine that participants viewed an 8-item list (*term, knife, view, sign, election, universe, attention, pattern)* and the following four serial positions were selected to serve as cues (2, 4, 7, & 8). On a consistent test trial, *knife, sign, attention, and pattern* would appear in the same positions that they occupied during study (2, 4, 7, & 8, respectively), whereas on an inconsistent trial, these words would no longer appear in their original positions (e.g., *knife* in position 4, *sign* in position 8, etc.) Alternately, on a control trial, instead of displaying the list items themselves, an "X" occupied each of the cued positions. Participants received the same lists in the same order. Within each block, participants received the same lists in the same order. Cue type was counterbalanced across participants, so that each list served equally often on consistent, inconsistent, and control trials. Additionally, list length was counterbalanced such that half of the participants received the block of 8-item lists first, and half of the participants received the block of 16-items first.

During the study phase, items were individually displayed in black, size 18, Arial font in the center of the screen at a rate of 2 sec each. Following presentation, the test screen appeared on which participants attempted to reconstruct the order of the list. For an 8-item list, the right side of the screen displayed a column of eight boxes numbered 1–8 that contained the four cued items (consistent, inconsistent, or control) in four of the positions and blanks in the other four positions. The non-cued items were shown, in a new random order, in a column on the left side of the screen. The display was similar following a 16-item list, except that two columns of 8 boxes appeared on the right (numbered 1–16; 8 cues; 8 blanks) and a column of the 8 randomly reordered, non-cued items appeared on the left.

Procedure

The experiment began with participants reading instructions on the computer for the first block of lists. Following the instructions, participants clicked the "next" button in order to complete a practice trial, which was similar to a consistent trial, and the participants did not receive feedback on their performance. Participants were encouraged to ask questions during the practice trial if they did not understand the task or if they had problems using the computer. To initiate each experimental trial, participants clicked the 'next' button. Each trial began with the presentation of a list of words at a rate of 2 sec per item. Following presentation of the final list item, participants were asked to complete the free reconstruction of order test in which they clicked on an item on the left and dragged it to a box on the right that was not already occupied by a consistent, inconsistent or control cue item. Noncue items could not be used more than once, and participants could not proceed to the next trial until all cues had been placed in a box. Following the final list of the first block of trials, participants read a fresh set of instructions and completed another practice trial before starting the second block of trials. At the completion of the second block, participants were debriefed and dismissed from the experiment.

Results

The top panel of Table 1 displays the *overall* mean reconstruction accuracy for each list length and cue type, collapsed across serial position. A 2 (List Length: 8, 16) x 3 (Cue Type: consistent, control, inconsistent) repeated-measures analysis of variance (ANOVA) revealed significant main effects of list length, $F(1, 53) = 274.647$, $MSE = .035$, $p < .001$, and cue type, $F(2, 106) = 63.381$, $MSE = .018$, $p < .001$. A series of Newman-Keuls post-hoc tests showed that these main effects were due to higher reconstruction accuracy following 8-item lists and poor reconstruction performance following inconsistent cues [inconsistent < (consistent = control)]. The List Length x Cue Type interaction only approached significance, $F(2, 106) = 2.257$, $MSE = .017$, $p < .109$, however, post-hoc tests revealed two distinct patterns of performance. For 8-item lists, inconsistent cues yielded significantly lower accuracy than consistent and control cues [.604 < (.803 = .791)], whereas with 16-item lists, inconsistent cues produced the poorest performance, with control cues faring better, and consistent cues faring the best [.284 < .401 < .473].

Table 1. Overall Reconstruction Accuracy (Top Panel) and Conditional Reconstruction Accuracy (Bottom Panel) as a Function of List Length and Cue Type, Collapsed Across Serial Position

	Consistent	Control	Inconsistent
Overall Accuracy			
8-Item List	.803	.791	.604
16-Item List	.473	.401	.284
Conditional Accuracy			
8-Item List	.687	.714	.517
16-Item List	.425	.358	.274

In an attempt to more closely examine the *direct* influence of cuing on order retention, the data were reanalyzed so that data inclusion was *conditional* on the presence of at least one cue in an adjacent serial position (i.e., cue before, cue after, or cue surrounded). The bottom panel of Table 1 displays the conditional mean reconstruction accuracy, collapsed across serial position and cue location, for each list length and cue type. A separate 2 (List Length) x

3 (Cue Type) repeated-measures ANOVA revealed reliable main effects of list length, $F(1, 53) = 96.306$, $MSE = .069$, $p < .001$, and cue type, $F(2, 106) = 44.907$, $MSE = .018$, $p < .001$, and a significant List Length x Cue Type interaction, $F(2, 106) = 5.768$; $MSE = .017$, $p < .01$. Newman-Keuls post-hoc tests revealed patterns of performance identical to those reported above—list length [8 > 16], cue type [inconsistent < (consistent = control)], and interaction [8-item: inconsistent < (consistent = control); 16-item: inconsistent < control < consistent].

Table 2. Conditional Reconstruction Accuracy as a Function of List Length, Cue Type, and Cue Location, Collapsed Across Serial Position.

	Consistent	Control	Inconsistent
8-Item List			
Before	.776	.803	.558
After	.624	.640	.488
Surrounded	.708	.761	.515
16-Item List			
Before	.434	.376	.289
After	.441	.385	.283
Surrounded	.397	.317	.255

To assess the influence of cue location, a 2 (List Length) x 3 (Cue Type) x 3 (Cue Location: before, after, surrounded) repeated-measures ANOVA was performed on the *conditional* accuracy data (see Table 2). The ANOVA was consistent with the earlier findings in that it revealed reliable main effects of list length, $F(1, 53) = 100.082$, $MSE = .218$, $p < .001$, and cue type, $F(2, 106) = 46.170$, $MSE = .059$, $p < .001$, and a List Length x Cue Type interaction, $F(2, 106) = 7.289$; $MSE = .051$, $p < .001$. Of central interest, the main effect of cue location was significant, $F(2, 106) = 16.908$, $MSE = .020$, $p < .001$, although the Newman-Keuls post-hoc comparisons revealed only marginally significant differences among the three cue locations [before > after ($p < .07$); before > surrounded ($p < .08$)]. In addition, the List Length x Cue Location interaction was statistically significant, $F(2, 106) = 15.924$, $MSE = .028$, $p < .001$. Post-hoc tests revealed for 8-item lists, before and surrounded cues yielded higher accuracy than after cues [(.713 = .662) > .584], whereas for 16-item lists, all cue types produced similar levels of accuracy [.366 = .323 = .370].

Discussion

Experiment 1 demonstrated that part-set cuing can either facilitate or inhibit performance in an immediate free reconstruction of order task, depending on the length of the list and the type of cues provided at test. With an 8-item list, participants were significantly more accurate when they received either consistent or control cues than when they received inconsistent cues. Following a 16-item list, reconstruction accuracy was best with consistent cues, followed by control cues, and then inconsistent cues. The same pattern of results emerged when the data were made conditional on the presence of an adjacent cue. The location of the adjacent cue (before, after, or surrounded) did not seem to affect reconstruction performance for the 16-item lists. However, with an 8-item list, it appears that participants benefit from having a cue before, or both before and after (surrounded), a to-be-reconstructed position.

A number of these findings are consistent with Serra and Nairne's (2000) research using an 8-item list tested after a 15-second retention interval. Serra and Nairne reported that consistent cues yielded higher accuracy than control cues, which in turn were more accurate than inconsistent cues. In the current experiment, consistent cue performance exceeded inconsistent cue performance for both list lengths and the pattern of performance in the 16-item condition matched the pattern reported by Serra and Nairne. The only deviation between the two studies is that we found no difference between consistent and control performance in the 8-item condition.

To account for these disparate patterns, one might consider the different challenges that a participant faces following an 8-item immediate test, an 8-item delayed test, and a 16-item immediate test. Of the three, the 8-item immediate test seems to provide the fewest challenges. With a list length clearly within normal memory span and no distracting activity, the participants may choose simply to recall from memory using any strategy they choose (e.g., maintenance rehearsal, position cuing), fill in the positions, and then check their work against the cues. It seems that participants would be least likely to revise their initial decisions with either control or consistent cues, whereas inconsistent cues should introduce more confusion and impair performance. Furthermore, one could argue that participants face similar challenges on the 8-item delayed and the 16-item immediate tests. Specifically, in both conditions, participants are less able to use a simple rehearsal process to maintain the list items in memory, either because the list length exceeds normal span or because of the 15-second distracting activity. At test, participants in each condition may be more likely to use the available cues to reconstruct the remaining items. In this case, participants will benefit more from a consistent cue than a control cue, and an inconsistent cue should be most disruptive.

Serra and Nairne's (2000) findings, as well as the current results, are consistent with the idea that participants are able to use interitem associative information as they attempt to remember the sequence of events. The cue location analysis seems to suggest that participants are able to use this interitem associative information whether the cue was presented before or after the to-be-reconstructed position. In other words, it appears that the benefits interitem associations are not limited to forward links in a chain, but also to backward links. Of course, in its current form, the cue location analysis is inadequate because participants were given free (unconstrained) reconstruction of order instructions and we did not record the output order of participants' responses. Hence, we cannot know whether other cues contributed to performance (e.g., if given *blank1 blank2 word* and *blank1* is properly reconstructed first, then *blank2* would no longer be considered a cue-after location, but instead a cue-surrounded location).

Experiment 2

The second experiment was designed to extend the work of Basden et al. (2002) by examining the influence of cue type (consistent, inconsistent, or control) on an immediate serial recall task for span-length lists (8 items) and supraspan-length lists (16 items). Experiment 2 employed a similar design and procedure as Experiment 1, with the exception that serial recall was used instead of reconstruction of order. By using serial recall, the present experiment allowed us to examine patterns of fine-grained errors, specifically transposition errors (i.e., the critical item was recalled correctly but the serial position was incorrect); omission errors (i.e., the critical item was not recalled at all), prior-list intrusion errors (i.e., the subject recalled an item from a previous list in the experiment), and out-of-experiment intrusion errors (i.e., the subject recalled an item that did not occur in a previous list nor in the current list).

Methods

Participants & Apparatus

Fifty-four Lake Forest College students earned extra credit in their introductory psychology course for participation in this experiment. Participants were tested in groups of four or fewer, with each person sitting in a separate cubicle that contained a personal computer (IBM-compatible). Each experimental session lasted approximately 45 minutes.

Design and Materials

The design and materials were identical to those used in Experiment 1, with the following exceptions. The same set of 432 nouns was randomly rearranged into 18 new lists of 8 items and 18 new lists of 16 items. Sets of cues were reselected for each list. Instead of reconstruction of order, Experiment 2 assessed order retention using a serial recall task. On each serial recall test, the right side of the screen displayed a column of boxes (one column of 8 or two columns of 8) that contained the cued items (consistent, inconsistent, or control) in 4 or 8 of the positions and blanks in the remaining positions. Participants entered responses by clicking on a blank box and typing the item. Items could be repeated and all boxes did not have to contain a response in order to continue to the next trial.

Procedure

The procedure was identical to that of Experiment 1 with the following exceptions: after the list was presented, participants were asked to remember as many list items as they could, and to type these items into the boxes that corresponded to their original serial positions.

Results

Table 3 displays the *overall* mean serial recall accuracy for each list length and cue type, collapsed across serial position (top panel). A 2 (List Length: 8, 16) x 3 (Cue Type: consistent, control, inconsistent) repeated-measures ANOVA revealed significant main effects of list length, $F(1, 53) = 176.229$, $MSE = .031$, $p < .001$, and cue type, $F(2, 106) = 25.518$, $MSE = .008$, $p < .001$. The List Length x Cue Type interaction was also statistically significant, $F(2, 106) = 5.591$, $MSE = .010$, $p < .01$. A series of Newman-Keuls post-hoc tests showed that the main effects arose because of higher serial recall accuracy following 8-item lists and poor reconstruction performance following inconsistent cues [inconsistent < (consistent = control)]. The reliable interaction signals different patterns of performance across the two list lengths. With an 8-item list, inconsistent cues yielded significantly lower accuracy than consistent and control cues [.333 < (.456 = .429)], whereas with a 16-item list, inconsistent and control cues produced equally poor performance near the floor, with consistent cues performance being superior to both [(.125 = .145) < .173].

Table 3. Overall Serial Recall Accuracy (Top Panel) and Conditional Serial Recall Accuracy (Bottom Panel) as a Function of List Length and Cue Type, Collapsed Across Serial Position

	Consistent	Control	Inconsistent
Overall Accuracy			
8-Item List	.456	.429	.333
16-Item List	.173	.145	.125
Conditional Accuracy			
8-Item List	.459	.391	.319
16-Item List	.180	.137	.106

The bottom panel of Table 3 shows the *conditional* mean serial recall accuracy, collapsed across serial position, for each list length and cue type. A separate 2 (List Length) x 3 (Cue Type) repeated-measures ANOVA revealed reliable main effects of list length, $F(1, 53) = 173.525$, $MSE = .029$, $p < .001$, cue type, $F(2, 106) = 33.903$, $MSE = .009$, $p < .001$, and a significant List Length x Cue Type interaction, $F(2, 106) = 3.995$; $MSE = .007$, $p < .05$. Newman-Keuls post-hoc tests revealed slightly different patterns of performance in the conditional analysis than those reported in the overall analysis. Specifically, the main effect of cue type reflects that inconsistent cue accuracy was significantly lower than control cue accuracy, which in turn was lower than consistent cue accuracy. This exact pattern was found in the 8-item condition [.319 < .391 < .459], and nearly was found in the 16-item condition [.106 < (.137 = .180); the difference between control and consistent was marginally significant $p < .06$].

Table 4. Overall Free Recall Scoring Accuracy (Top Panel) and Conditional Free Recall Scoring Accuracy (Bottom Panel) as a Function of List Length and Cue Type, Collapsed Across Serial Position

	Consistent	Control	Inconsistent
Overall Accuracy			
8-Item List	.540	.669	.562
16-Item List	.324	.290	.251
Conditional Accuracy			
8-Item List	.540	.645	.564
16-Item List	.246	.365	.249

In addition to scoring the data using traditional serial recall criteria (i.e., must have proper item in correct position), the data were also scored using free recall criteria in which an item was scored as correct if it appeared anywhere in the appropriate list. Separate 2 (List Length) x 3 (Cue Type) repeated-measures ANOVAs were performed on the recall scoring accuracy for the *overall* and *conditional* data, respectively (see Table 4). The analyses revealed reliable main effects of list length, $F(1, 53) = 212.416$, $MSE = .035$, $p < .001$ and $F(1, 53) = 231.717$, $MSE = .031$, $p < .001$, which reflect that participants free recall accuracy was higher following 8-item lists. The main effects of cue type were also statistically significant, $F(2, 106) = 13.802$, $MSE = .011$, $p < .001$ and $F(2, 106) = 32.794$, $MSE = .013$, $p < .001$. Post-hoc analyses revealed classic part-set cuing *inhibition* when data were scored using free recall criteria. That is, participants recalled significantly fewer items when they received list items as cues (consistent = inconsistent) than when they received control cues (X's). The List Length x Cue Type interaction was reliable only for the overall data, $F(2, 106) = 14.191$; $MSE = .013$, $p < .001$. Whereas the conditional data showed the same pattern of performance [(consistent = inconsistent) < control] across list lengths, the overall data only showed that pattern with 8-item lists. In the 16-item condition, consistent and control free recall performance did not differ, but both significantly surpassed inconsistent cue performance.

To assess the influence of cue location, a 2 (List Length) x 3 (Cue Type) x 3 (Cue Location: before, after, surrounded) repeated-measures ANOVA was performed on the *conditional* accuracy data. The ANOVA was consistent with the earlier findings in that it revealed reliable main effects of list length, $F(1, 53) = 142.352$, $MSE = .099$, $p < .001$, and cue type, $F(2, 106) = 24.735$, $MSE = .041$, $p < .001$. Of central interest, the main effect of cue location was significant, $F(2, 106) = 17.042$, $MSE = .027$, $p < .001$, although the Newman-Keuls post-hoc comparisons revealed no reliable differences among these locations. Thus, it appears that cue location did not substantially influence serial recall accuracy. None of the remaining interactions reached statistical significance.

Analysis of Error Patterns

In serial recall, errors can be classified into five primary categories: transpositions (item recalled correctly but placed in inappropriate position), omissions (item not recalled in any serial position), intrusions from prior lists, intrusions from out of the experiment, and repetitions. Table 5 displays the *overall* proportions of each of the first four types of errors, broken down by list length and cue type; repetitions were extremely rare and, therefore, were not included in the analysis. A 4 (Error Type) x 2 (List Length) x 3 (Cue Type) repeated-measures ANOVA revealed significant main effects of error type, $F(3, 159) = 153.749$, $MSE = .063$, $p < .001$, list length, $F(1, 53) = 168.981$, $MSE = .007$, $p < .001$, and cue type, $F(2, 106) = 14.143$, $MSE = .003$, $p < .001$. A series of Newman-Keuls post-hoc tests showed that omission errors were most prevalent, followed by transpositions, and intrusion errors were least frequent (prior lists = out of experiment). Participants made fewer errors following 8-item lists and with consistent cues.

Table 5. Overall Proportions of Transpositions, Omissions, Intrusions from Prior Lists, and Intrusions from Out of the Experiment, as a Function of List Length and Cue Type, Collapsed Across Serial Position

	Consistent	Control	Inconsistent
Transposition Errors			
8-Item List	.085	.240	.230
16-Item List	.151	.144	.126
Omission Errors			
8-Item List	.370	.235	.361
16-Item List	.506	.540	.551
Intrusion Errors from Prior Lists			
8-Item List	.033	.041	.028
16-Item List	.036	.023	.024
Intrusion Errors from Out of Experiment			
8-Item List	.050	.062	.042
16-Item List	.144	.140	.156

The Error Type x List Length interaction, $F(3, 159) = 16.306$, $MSE = .065$, $p < .001$, showed that participants made significantly more omission errors in the 16-item condition than the 8-item condition, whereas the proportion of transpositions and intrusions of both types did not differ across list lengths. The Error Type x Cue Type interaction, $F(6, 318) = 9.672$, $MSE = .009$, $p < .001$, revealed different patterns of errors for transpositions and omissions. Significantly fewer transposition errors occurred with consistent cues [consistent < (control = inconsistent)] and omissions were reliably reduced with control cues [control < (consistent = inconsistent)]. The proportions of prior-list and out-of-experiment intrusion errors did not differ as a function of cue type.

The three-way Error Type x List Length x Cue Type interaction, F (6, 318) = 14.757, $MSE = .009$, $p < .001$, showed a number of differing patterns of performance. While consistent cues produced the fewest number of transposition errors for 8-item lists [consistent < (control = inconsistent)], similar proportions of transposition errors were produced following each cue type in the 16-item lists. With 8-item lists, control cues produced the fewest omission errors [control < (consistent = inconsistent)], but again no differences were found across cue types in the 16-item condition. The proportions of prior-list intrusion errors did not differ across all cue types and list-lengths. Finally, although all cue types produces similar levels of out-of-experiment intrusions, significantly more intrusions were recorded following 16-item lists than 8-item lists.

In an effort to examine the direct effects of cuing on patterns of errors, a separate 4 (Error Type) x 2 (List Length) x 3 (Cue Type) repeated-measures ANOVA was performed on the *conditional* data. As in the previous ANOVA, the main effects of error type, $F(3, 159) = 146.559$, $MSE = .067$, $p < .001$, list length, $F(1, 53) = 163.846$, $MSE = .007$, $p < .001$, and cue type, $F(2, 106) = 36.690$, $MSE = .003$, $p < .001$, and the Error Type x List Length interaction, $F(3, 159) = 14.172$, $MSE = .070$, $p < .001$, were statistically significant. Post-hoc tests showed identical patterns of performance as those reported in the *overall* analysis. The Error Type x Cue Type interaction was also reliable, $F(6, 318) = 45.362$, $MSE = .009$, $p < .001$, but the patterns of performance differed slightly than those seen in the *overall* analysis. Specifically, consistent cues produced significantly fewer transposition errors than inconsistent cues which, in turn, produced fewer transpositions than control cues.

In addition, the three-way Error Type x List Length x Cue Type interaction was significant, $F(6, 318) = 2.277$, $MSE = .010$, $p < .05$. The patterns of transposition errors differed for 8-item lists [consistent < (inconsistent = control)] and 16-item lists [consistent < inconsistent < control]. Both 8-item and 16-item lists produced similar patterns of omission errors [control < (consistent = inconsistent)]. Recall that in the *overall* analysis, there appeared to be no differences in the proportion of transpositions or omissions across cue types in the 16-item condition. Finally, the patterns of prior-list and out-of-experiment intrusions were identical to those reported earlier.

Discussion

Using an immediate serial recall task, Experiment 2 showed the specific effects of part-set cuing depend on list length, cue type, and type of scoring. With both 8-item and 16-item lists, consistent part-set cues facilitated serial recall accuracy, whereas inconsistent part-set cues inhibited accuracy. Serial recall performance following control cues was typically superior to inconsistent cues, but inferior to consistent cues, particularly when examining the *conditional* data. Interestingly, when the serial recall data were scored using free recall criteria, the benefits of part-set cuing with consistent cues disappeared. Indeed, participants showed the classic free recall part-set cuing effect because they recalled significantly fewer items on consistent and inconsistent trials than on control trials. Thus, while the presence of list items as cues inhibited net recall of the remaining items, participants were able to benefit from the presence of consistent cues when placing the recalled items in their appropriate serial positions. Also, the present experiment tentatively suggests that the location of the adjacent cue (before, after, surrounded) does not affect serial recall performance, although admittedly the conditions were not ideal for assessing the effect of cue location (i.e., output order of serial recall responses was unconstrained, as in Experiment 1).

The order error analysis revealed distinct patterns of transpositions and omission errors across the three cue types. The *conditional* data, which assessed the direct effects of cuing, showed that consistent cues produced significantly fewer transposition errors than either control or inconsistent cues. Control cues, on the other hand, yielded reliably fewer omissions than consistent and inconsistent cues. In addition, the error analysis suggested that the 16-item lists afforded different challenges than 8-item lists—omissions and out-of-experiment intrusions occurred more often following the longer lists. These error patterns provide further insight as to the origin of the consistent cue part-set cuing facilitation effect (i.e., reduced transpositions), as well as the locus of the free recall advantage for control lists (i.e., reduced omissions).

Table 6. Conditional Proportions of Transpositions, Omissions, Intrusions from Prior Lists, and Intrusions from Out of the Experiment, as a Function of List Length and Cue Type, Collapsed Across Serial Position

	Consistent	Control	Inconsistent
Transposition Errors			
8-Item List	.081	.253	.241
16-Item List	.066	.227	.144
Omission Errors			
8-Item List	.369	.256	.360
16-Item List	.559	.447	.585
Intrusion Errors from Prior Lists			
8-Item List	.034	.045	.032
16-Item List	.027	.028	.027
Intrusion Errors from Out of Experiment			
8-Item List	.051	.053	.040
16-Item List	.151	.133	.158

Generally, the present results are consistent with those reported by Basden, Basden, & Stephens (2002). Using an 8-item list and a 30-second filled retention interval, Basden et al. showed that serial recall accuracy with consistent cues was superior to control accuracy (two types: X's or blanks), and control accuracy exceed inconsistent cue accuracy. Given their use of alternating cues (cued all odd or all even positions), all of the Basden et al. data would be considered *conditional* data in the present study and, accordingly, their results and the present *conditional* results showed nearly identical effects of cue type (inconsistent < control < consistent) on serial recall performance.

On the surface, part-set cuing seems to affect serial recall and reconstruction of order in similar ways—participants' order performance appears to benefit from the presence of consistent part-set cues, while inconsistent cues impair performance. By definition, all errors in a reconstruction of order task are classified as transposition errors because omissions and intrusions are not possible when item information is controlled at test. Thus, consistent cues seem to reduce transposition errors in both reconstruction and serial recall. Interestingly, in serial recall, the advantage afforded by these reduced transposition errors seems to outweigh the cost of reduced item recall with part-set cues.

General Discussion

The present experiments provide important new data concerning how part-set cuing affects immediate order retention and examined the influences of cue type, cue location, list length, and retention measure. Using a free reconstruction of order task, Experiment 1 revealed disparate patterns of accuracy performance for 8-item [(consistent = control) > inconsistent] and 16-item lists [consistent > control > inconsistent], for both the overall and conditional data. These results clearly suggest that participants can use interitem associative information and this information can either facilitate or inhibit reconstruction performance, depending on whether the cue is consistent or inconsistent with original presentation. The fact that consistent and control performance was equivalent following 8-item lists further suggests that, at least for span-length immediate tests, participants need not use interitem associative information when reconstructing the order of events. We reasoned that on a span-length immediate task, participants may simply recall from memory using any means that they see fit (e.g., maintenance rehearsal, position cuing, etc.), record the words, and then check their work against the cues. It seems reasonable that participants would be more error prone following inconsistent cues because the cues would not mesh well with their recall and participants would be more likely to modify their output.

Using a serial recall task, Experiment 2 further supported the assertion that participants can use interitem associative information when immediately recalling the sequence of events. More interestingly, using two separate indices, the experiment showed that part-set cuing can simultaneously inhibit item retention and enhance order retention. Using strict serial recall scoring criteria, the data showed elevated order accuracy following consistent cues as compared to the control and inconsistent cues. When the same data were scored using free recall criteria, participants showed classic part-set cuing inhibition—participants remembered fewer items on cued trials than on control trials. The error analysis shed further light on these findings—more items were omitted on cued trials than on control trials and consistent cues produced the fewest transposition order errors.

The conditional data analyses for Experiments 1 and 2 suggested that cue location (before, after, surround) does not seem to differentially influence order retention. However, given the nature of the testing (free reconstruction of order and unconstrained serial recall) and the fact that we did not record the output or placement order, the experiments were not ideally suited to provide an unequivocal answer on this issue. Depending on the output order of the to-be-remembered information, many of the "before" and "after" cue locations might be better described as "surround" cue locations. Still, even with these shortcomings, the data suggest that the benefits of interitem associations are not limited to simple forward-chained associations.

The primary motivation behind this part-set cuing exploration was to provide new empirical data to help evaluate existing models of order retention. The present results, in concert with those reported by Serra and Nairne (2000) and Basden et al. (2002), provide a strong challenge to any purely position-based account of order retention. With position-based models, cue type should not influence order retention because each cue type would provide identical positional information. Yet, these experiments repeatedly demonstrated that the type of cue will determine whether part-set cuing facilitates or inhibits performance. Of course, a purely interitem associative model of order retention is likely to be incomplete as well as it would have trouble accounting for the intermediate level of accuracy on control trials. A successful model of order memory, presumably, will need to account for the use of both positional and interitem associative information and the data from the present experiments should prove critical as current models are revised and new accounts are introduced.

Acknowledgements

The authors would like to thank Ben Reiss for his programming expertise. Also, special thanks for the funding provided by the Hotchkiss Fellows Program for Junior Faculty and the Grants-in-Aid Program at Lake Forest College.

References

Anderson, J. R, & Matessa, M. (1997). A production system theory of serial memory. *Psychological Review*, **104**(4), 728-748.

Basden, B. H., Basden, D. R., & Stephens, J. P. (2002). Part-set cuing of order information in recall tests. *Journal of Memory and Language*, **47**(4), 517-529.

Brown, G. D. A., Preece, T., & Hulme, C. (2000). Oscillator-based memory for serial order. *Psychological Review*, **107**(1), 127-181.

Estes, W. K. (1997). Processes of memory loss, recovery, and distortion. *Psychological Review*, **104**(1), 148-169.

Francis, W. N., & Kucera, H. (1982). *Frequency Analysis of English Usage: Lexicon and Grammar*. Boston: Houghton-Mifflin.

Henson, R. N. A. (1998). Short-term memory for serial order: The start-end model. *Cognitive Psychology*, **36**(2), 73-137.

Henson, R. N. A. (1999). Coding position in short-term memory. *International Journal of Psychology*, **34**(5/6), 403-409.

Lewandowsky, S. (1999). Redintegration and response suppression in serial recall: A dynamic network model. *International Journal of Psychology*, **34**(5/6), 434-446.

Lewandosky, S., & Murdock , B. B., Jr. (1989). Memory for serial order. *Psychological Review*, **96**(1), 25-57.

Nickerson, R. S. (1984). Retrieval inhibition from part-set cuing: A persisting enigma in memory research. *Memory & Cognition*, **12**(6), 531-552.

Neath, I., & Surprenant, A. M. (2002). *Human Memory: An Introduction to research, data, and theory*. (2nd ed.). Belmont, CA: Wadsworth.

Page, M. P. A., & Norris, D. (1998). The primacy model: A new model of immediate serial recall. *Psychological Review,* **105**(4), 761-781.

Serra, M., & Nairne, J. S. (2000). Part-set cuing of order information: Implication for associative theories of serial order memory. *Memory & Cognition*, **28**(5), 847-855.

Slamecka, N. J. (1968). An examination of trace storage in free recall. *Journal of Experimental Psychology*, **76**(4), 504-513.

Surprenant, A. M., Kelley, M. R., Farley, L. A., & Neath, I. (2005). Fill-in and infill errors in order memory. *Memory*, **13**(3/4), 267-273.