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Ascending blocks enhance two-digit number recall

Gregory Christopher Savage
San Jose State University

ASCENDING BLOCKS ENHANCE TWO-DIGIT NUMBER RECALL

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Gregory Christopher Savage

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APPROVED FOR THE DEPARTMENT OF PSYCHOLOGY

Dr. Mark G. Van Selst

Dr. Kevin P. Jordan

Dr. Laree A. Huntsman

APPROVED FOR THE UNIVERSITY

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ABSTRACT

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Blocking the presentation of items by category can be demonstrated to yield superior recall over random presentations when the stimuli representations are not high in detail. Two experiments demonstrated this phenomenon for two-digit number recall. Experiment 1 demonstrated superior recall for ascending (i.e., blocked) than for random presentation orders but only for the "category" that included the most exemplars (i.e., included four of the ten possible decile items). The better performance for ascending (i.e., blocked) than for random presentations was also present in decile clustering. The second experiment demonstrated that the better recall performance is not due to a difference in participants' awareness of set size and that the higher clustering is not due to attempted serial recall. These experiments suggest that people are better able to organize two-digit numbers into decile units during encoding of ascending (i.e., blocked) presentations, which facilitates cueing during retrieval.

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Table of Contents

List of Tables

List of Figures

Introduction

The ability to encode, store, and retrieve information from memory is important in many contexts. For example, when a person receives a call while driving home from work and is requested to buy several items from the grocery store, he or she likely does not have a pen and paper available and ought not to write while driving. Also, while in school, people often need to memorize long lists of names, such as a person in an anatomy course who must memorize all of the muscles and bones in the human body.

Due to the importance of effectively recalling information, some psychologists have proposed strategies for improving memory performance. Strategies proposed by Morris and Fritz (2006) include integrating new information with previously learned information, elaborating on information, using imagery, and attending to the organization of information. One approach to studying the effectiveness of processing the organization of information in enhancing the recall of information is to sequentially present participants with lists of items (i.e., pieces of information; e.g., numbers, words, phrases) that vary in the degree to which they are organized (e.g., Birnbaum, 1975; Houston, 1976; Puff, 1973). This approach is useful because it allows a researcher to precisely control the structure and amount of organization in a set of information before it is encoded and then observe the relationship between organization and recall.

One specific type of organization that has been found to improve memory performance in many experiments is the blocking of items within lists by category (Cofer, Bruce, & Reicher, 1966; D'Agostino, 1969; Dallet, 1964; Engelkamp & Zimmer, 2002; Gollin & Sharps, 1988; Lewis, 1971; Luek, Mclaughlin, & Cicala, 1971; Matthews

& Hoggart, 1970; Puff, 1973; Sharps, 1997; Sharps, Day, Nunes, Neff, & Woo, 2004; Sharps, Martin, Nunes, & Merrill, 1999; Sharps & Pollitt, 1998; Sharps & Tindall, 1992; Sharps, Wilson-Leff, & Price, 1995; Stones, 1973; Toglia, Hinman, Dayton, & Catalano, 1997). In blocked presentations, items from the same category are presented contiguously and there are distinct boundaries between categories (Puff, 1974). Items from categorically blocked presentations, in which items from the same category are presented contiguously, are better recalled than items from presentations in which items from the same category are separated (i.e., random or unblocked presentations). This pattern of data is variously referred to as either the blocked-random effect (D'Agostino, 1969; Stones, 1973; Toglia et al., 1997) or the category superiority effect (Sharps, 1997; Sharps et al., 1999; Sharps & Pollitt, 1998; Sharps et al., 1995). Experiments investigating this effect have demonstrated higher categorical *clustering* in free recall following blocked presentations than in free recall following random presentations (Cofer, et al., 1966; Dallet, 1964; Engelkamp & Zimmer, 2002; Gollin & Sharps, 1988; Puff, 1973; Sharps et al., 2004; Sharps et al., 1999; Sharps & Tindall, 1992; Toglia et al., 1997). Clustering during free recall involves the blocking of items by category during recall or, in other words, recalling items from the same category contiguously (Bousfield, 1953). The degree to which a participant clusters his or her responses during recall is often measured with the adjusted ratio of clustering (ARC), developed by Roenker, Thompson, and Brown (1971), which is a measure of clustering during free recall that is adjusted for the degree of clustering expected by chance, based on the number of items recalled from each category and the total number of items recalled.

At least three distinct explanations have been provided for the blocked-random effect. These explanations propose that the higher recall of blocked presentations is due to stronger priming of mediators (Puff, 1966), a guided retrieval strategy (Slamecka, 1968), or more efficient organization of items into categorical units in memory (D'Agostino, 1969). The explanation involving the efficiency of organizing items into categorical units has historically received the most support (Puff, 1974). These categorical units are based on the relationships among items within categories and the relationship between each item and the concept of its category (Cofer et al., 1966). These categorical units enable recalled items (Bousfield & Cohen, 1953; Cofer et al., 1966; Houston, 1976) or presented items (Lewis, 1971; Luek et al., 1971; Sowder, 1977; Wood, 1969) to cue the recall of other items from the category.

Puff (1966) proposed that blocked presentations are better recalled than random presentations because they prime *mediators* (i.e., non-presented concepts related to a category) at a cumulatively higher level. The reasoning behind this explanation was that if each item from a category automatically primes the same mediators during presentation, but then this priming decreases over time, the summation of priming should be highest when items from each category are presented closely together in time (Puff, 1966). After the recall of one item from a category, the mediators are activated and are able to cue the recall of other items from the category (Puff, 1966). The ability of mediators to cue the recall of presented items is greater after blocked than after random presentations because the mediators are more strongly primed (Puff, 1966). This stronger cueing after blocked presentations results in higher levels of recall and clustering (Puff, 1966). This explanation suggests that recall should decrease with slower presentation rates because, with slower presentation rates, items from each category are more greatly separated in time and the summation of priming cannot reach as high a level. However, recall of blocked and random presentations increases with slower presentation rates (Cofer et al., 1966; Stones, 1973). Therefore, the blocked-random effect is probably not due to stronger priming of mediators in the blocked condition. Puff (1966) noted that his explanation could not explain the fact that random presentations are better recalled with slower presentation rates, but he did not abandon it in his review of the blocked-random effect (Puff, 1974). The following two explanations do not emphasize the degree to which mediators are primed but instead emphasize the degree to which categorical relationships among presented items are used during encoding or retrieval.

Slamecka (1968) proposed an explanation for the blocked-random effect based on his suggestion that items are stored independently in memory. Slamecka (1968) suggested that items are stored independently (i.e., not organized into categorical units) after finding that individual items presented as cues do not increase the recall of random categorized presentations of words. Slamecka (1968) also observed clustering during recall of these presentations, which led him to suggest that recall is optimal when participants are aware of the categorical structures of their presentations and can engage in a guided strategy of searching for items one category at a time. Slamecka (1968) did not consider that items from blocked presentations might be organized into categorical units but instead suggested that blocked presentation is one of the many factors that facilitate the detection of list structure and encourage guided retrieval strategies.

D'Agostino (1969) refuted Slamecka's explanation by demonstrating the blocked-random effect despite pre-cueing half of the participants to the to-be presented categories. Pre-cueing did not influence the magnitude of the blocked-random effect (D'Agostino, 1969). Also, research has provided evidence against Slamecka's claim that items are stored independently in memory (D'Agostino, 1969; Luek et al., 1971). Several researchers have provided evidence that items are organized into categorical units during blocked presentations by showing that individual item cues do increase recall of blocked presentations (Lewis, 1971; Luek et al., 1971; Sowder, 1977; Wood, 1969). Also, Hunt and Einstein (1981) demonstrated higher recall and clustering for random presentations of words from strong categories than for random presentations of words from weak categories, which they interpreted as suggesting that random presentations are organized into categorical units when categorical relationships are more easily detected.

D'Agostino (1969) proposed an explanation for the blocked-random effect consistent with the formation of categorical units in memory. D'Agostino (1969) proposed that the process of organizing items into categorical units is more efficient during blocked presentations because, while each item is presented, less time is needed to retrieve previously presented items from the category and more time is available to organize the item into a categorical unit with items presented earlier. D'Agostino (1969) noted that his explanation accounts for the finding that recall of random presentations increases when items are presented at a slower rate and more time is available to organize items. D'Agostino's explanation implies that items from blocked presentations are more highly organized into categorical units in memory than items from random presentations.

Therefore, it is likely that after one item is recalled from any category, more items are cued during recall of blocked presentations than during recall of random presentations (Cofer et al., 1966). The greater number of items cued during recall of blocked presentations, both directly through connections between individual items and indirectly through connections between items and category labels, results in higher recall and clustering (Cofer et al., 1966). As noted by D'Agostino (1969), this explanation is supported by the finding that blocked presentation does not increase the number of categories from which at least one item is recalled (i.e., *number of categories recalled*) but does increase the number of items recalled from each category from which at least one item is recalled (i.e., *within-category recall*; D'Agostino, 1969; Lewis, 1971; Sowder, 1977).

The blocked-random effect has been demonstrated with various types of stimuli. For example, it has been demonstrated in many experiments studying free and cued recall of word presentations (Cofer et al., 1966; D'Agostino, 1969; Dallet, 1964; Gollin & Sharps, 1988; Lewis, 1971; Luek et al., 1971; Matthews & Hoggart, 1970; Puff, 1973; Sharps, 1997; Sharps et al., 2004; Sharps et al., 1999; Sharps & Pollitt, 1998; Sharps & Tindall, 1992; Sharps et al., 1995; Stones, 1973; Toglia et al., 1997). Also, Sharps and Pollitt (1998) demonstrated the effect with auditory stimuli (e.g., sounds from musical instruments, animals, or tools). Further, recent research has demonstrated that action phrases are better recalled when blocked into scripts than when presented randomly (Engelkamp & Zimmer, 2002) but that categorically blocking action phrases by the objects of the actions does not affect recall (Engelkamp, Seiler, & Zimmer, 2004). The discrepancy between these two studies suggests that to facilitate recall, blocked presentations must be organized in a manner that people would normally use to organize the items (Dabady, Bell, & Kihlstrom, 1999).

Studies examining free recall of pictures have only demonstrated the blocked-random effect in certain conditions. According to Sharps et al. (1995), it is useful to consider Hunt and Einstein's proposed distinction between relational information (i.e., relationships or similarities between items) and item-specific information (i.e., details specific to individual items; Hunt & Einstein, 1981). D'Agostino (1969) indicated that more time is available to process relationships between items during blocked presentations than during random presentations. Sharps et al. (1995) proposed that the blocked-random effect depends upon the processing of relational information because people depend on relational information to recall stimuli low in item-specific information, such as words, and the blocked-random effect is found with these stimuli unless they are presented at a fast rate (Sharps et al., 1995). People can typically rely on item-specific information to recall pictures, which contain high levels of item-specific information, and are therefore not likely to produce blocked-random effects (Sharps et al., 1995). Consistent with this proposal, the blocked-random effect in picture recall is only found in conditions when item-specific information is more difficult to process and people must depend on relational information (Sharps, 1997; Sharps et al., 2004; Sharps et al., 1999; Sharps et al., 1995). The only exception to this pattern of findings was a study by Sharps et al. (2004), which found a blocked-random effect with picture lists containing large numbers of categories. Sharps et al. (2004) suggested that although participants had no difficulty in processing item-specific information in this study, the large number of presented categories encouraged participants to process relational information. However, other studies have failed to produce this outcome (Sharps & Tindall, 1992; Sharps et al., 1995). The greater reliability of the blocked-random effect with stimuli low in item-specific information suggests that numbers might be useful stimuli for demonstrating the blocked-random effect.

A separate line of research has demonstrated higher recall of ascending than random two-digit number presentations (Birnbaum, 1975; Houston, 1976). Houston (1976) proposed two compatible explanations for this effect. One explanation is that people represent ascending presentations in ascending order in memory, which is an organized sequence in which larger numbers occupy later list positions (Houston, 1976). Houston (1976) also suggested that the blocked presentation of *deciles* (e.g., 70s, 80s, 90s) during ascending presentations might facilitate the formation of decile units in memory, which would enable the first recalled number from each decile to begin a process of cueing other numbers from the same decile. This explanation could account for the findings of Birnbaum (1975) and Houston (1976) because they constructed their presentations by randomly selecting 12 two-digit numbers between 21 and 55 while limiting the selection of consecutive numbers. Therefore, multiple numbers were likely presented from every decile and participants would have been able to organize these numbers into decile units.

Two studies converge with those of Birnbaum (1975) and Houston (1976) on the conclusion that people form decile units in memory during two-digit number presentations (Ganor-Stern, Tzelgov, & Ellenbogen, 2007; Gordon & Horowitz, 1968). A study by Gordon and Horowitz (1968) showed that initial digits are better recall cues than terminal digits for randomly presented two-digit numbers. Gordon and Horowitz (1968) therefore concluded that initial digits are more meaningful than terminal digits. Initial digits are more meaningful than terminal digits because they are better indicators of a two-digit number's magnitude (Ganor-Stern et al., 2007). Therefore, it makes sense to propose that people organize two-digit numbers into units defined by the more meaningful digit, within which fall the digits providing additional detail about magnitude. The greater importance of initial digits was demonstrated in a study that required participants to view a pair of two-digit numbers, in which the larger number was presented in smaller font, and decide which number is physically larger (Ganor-Stern et al., 2007). Ganor-Stern et al. (2007) found that this task was more difficult when the pairs contained different initial digits (e.g., 21, 51) than when they contained different terminal digits (e.g., 21, 29). This finding suggests that when the more meaningful digit differs within a pair of two-digit numbers, and the numbers differ more greatly in magnitude, more interference occurs in a physical-size judgment task (Ganor-Stern et al., 2007).

Experiment 1

In Experiment 1, we presented two-digit number lists with deciles that differ in their set sizes to examine Houston's suggestion regarding the formation of decile units in memory. Our reasoning was that if we presented lists of two-digit numbers containing some unique numbers (e.g., 11, 27, 62, 85) and some sets of numbers drawn from the same decile (e.g., 41, 44, 45, 49) in ascending order, the decile sets would be presented as ascending blocks, but the unique numbers would be scattered throughout the presentation in the same manner as in a random presentation. Therefore, recall of the decile sets would benefit from blocked presentation in the ascending condition but recall of the unique numbers would not. In an experiment of this type, Tulving and Patterson (1968) demonstrated that a list consisting of four words from one category and other unrelated words is better recalled when the related words are blocked during presentation, which they suggested facilitates the formation of a categorical unit in memory. Therefore, in this experiment, higher recall of ascending than random presentations should be found for the decile sets but not the unique numbers. Also, the higher recall of ascending than random presentations should be larger for one large decile set of four numbers than two small decile sets of two numbers because the latter requires more deciles to be accessed and the first recalled number from each of these deciles will lead to the cueing of fewer other numbers. However, if decile units are not formed in memory and ascending presentations are better recalled only because people represent them in ascending order in memory (Houston, 1976), the effect of presentation order should be equal across the unique numbers and decile sets.

Method

Participants

The participants included 108 undergraduate students taking General Psychology at San Jose State University who received course credit for their participation. Age data was available for 100 participants. These participants' ages ranged from 18 to 47, and the mean age was 19.40. Gender data was available for 103 participants. These participants included 28 (27.20%) men and 75 (72.80%) women.

Apparatus and Materials

A total of 18 two-digit number lists were used in this experiment, each of which was presented in both ascending order and a modified random order. The random orders were modified to ensure that numbers from the same decile would not be presented contiguously. The number lists used in this experiment were presented in Power Point slide shows, which were timed at a rate of 2 seconds per slide. Each slide contained one two-digit number located in the center of the screen in Times New Roman and 80-point font. Each list contained four single numbers from different deciles (e.g., 23, 47, 54, 78), which were called *singles*, four numbers from two pairs each drawn from the same decile (e.g., 23, 27, 45, 49), which were called *doubles*, and four numbers from one set of numbers all drawn from the same decile (e.g., 72, 75, 77, 79), which were called *quadruples*. In the quadruples, the number of pairs of consecutive numbers (e.g., 23, 24) was either one or zero.

The process of creating the number lists began with the use of the sequence "ABCDEFGHI" to stand for the decile set sizes "121014102." In this pattern, 0s represent empty deciles containing no numbers, 1s represent deciles containing one number, 2s represent deciles containing two numbers, and 4s represent deciles containing four numbers. Next, the digits 1-9 (representing deciles) were placed above a Latin square that contained different orders of the "ABCDEFGHI" sequence. The first line of the Latin square contained the sequence "AIBHCGDFE," which stood for "122011041." This Latin square was used to determine the allocation of set sizes to each decile of the first nine number lists. In order to balance the first Latin square, a reversal of the first Latin square was created to determine the allocation of set sizes to each decile of the final nine number lists. This second Latin square was also placed under the digits 1-9, which represented the deciles to which set sizes were allocated.

At this point, the initial digits of the number lists had been determined and the terminal digits needed to be added. Therefore, separately for each decile, the digits 1-8 were inserted as terminal digits for the singles, doubles, and quadruples. This procedure finished the creation of the number lists. This procedure also ensured that each two-digit number would be equally represented across the singles, doubles, and quadruples. The sequence in which the terminal digits were inserted into the singles, doubles, and quadruples, for each decile, was "14683257." The use of this specific random sequence prevented more than one pair of consecutive numbers (e.g., 23, 24) from appearing in the quadruples of any list. After the number lists had been created, the next step was to determine the random order of each list.

In order to organize each number list into its modified random order, the sequence "124124124124" was used to represent the serial positions of each list. Then, for each list, the singles were randomly assigned to the "1" positions, the doubles were randomly assigned to the "2" positions, and the quadruples were randomly assigned to the "4" positions. Therefore, two numbers intervened between each of the singles, each of the doubles, and each of the quadruples.

Procedure

The entire experiment lasted approximately 4 minutes for each participant. Each participant was tested individually. After entering the laboratory, each participant signed a consent form and was told that he or she would be viewing a slide show containing 12 slides, with a number on each slide. They were told that after the slide show was finished, the screen would turn blank, and they were to then verbally recall as many numbers as possible, in any order. Next, they were seated in the chair in front of the computer and were asked to close their eyes so that the researcher could start the slide show. The participants were then asked to open their eyes just before the slide show began. The slide shows were presented at a rate of 2 seconds per slide. Once the slide shows were finished, most participants needed verbal prompting to begin recalling the numbers. The researcher wrote down each recalled number. Participants were allowed to continue recalling numbers until they were confident that they could not recall any more. Each participant's recall session consisted of only one trial. If participants did not self-terminate their recall sessions, approximately 8-10 seconds after their last response, they were asked if they were finished recalling numbers. Most, if not all, of these participants were confident that they could not recall any more numbers at this point. If a participant produced fewer than three responses, he or she was asked to guess the number of additional responses needed for his or her recall protocol to contain four responses. This procedure was used to prevent participants from being excessively cautious during recall. If a participant decided that any of his or her responses were incorrect, those responses were deleted. Finally, participants were informed of the presentation rate only when they asked for this information.

Results

Recall

A 2 (presentation order: ascending, random) X 3 (set size: singles, doubles, quadruples) mixed-subjects analysis of variance was conducted on recall (i.e., number of numbers recalled) with presentation order as a between-subjects variable and set size as a within-subjects variable. The main effect of presentation order was significant, $F(1,106) = 10.79$, $MSE = 1.00$, $p = .001$, partial $\eta^2 = .09$. As shown in Table 1 and Figure 1, participants in the ascending condition recalled significantly more numbers ($M = 2.01$, $SD = 0.60$) than participants in the random condition ($M = 1.65$, $SD = 0.55$). The main effect of set size was not significant, $F(2,212) = 1.15$, $MSE = 1.11$, $p = .32$, nor was the presentation order by set size interaction, $F(2,212) = 1.48$, $MSE = 1.11$, $p = .23$. The main effect of presentation order was principally driven by the observed difference across presentation order for the quadruples, $F(1,106) = 9.15$, $MSE = 1.24$, $p = .003$, partial $\eta^2 = .08$. As shown in Table 1 and Figure 1, the quadruples were significantly better recalled when presented in ascending order ($M = 2.28$, $SD = 1.17$) than when presented in random order ($M = 1.63$, $SD = 1.05$). As shown in Table 1, no other pairwise comparisons across presentation order were significant.

Two additional analyses were conducted to determine whether the significant difference across presentation order for the quadruples was due to more participants recalling zero numbers from the quadruples in the random condition than in the ascending condition. The effect of presentation order was examined on whether or not participants recalled at least one number from the quadruples. The effect of presentation order was also examined on the number of numbers correctly recalled from the quadruples by participants who recalled at least one number from the quadruples. As shown in Table 2 and Figure 2, participants were not more likely to recall zero numbers from the quadruples in the random condition than in the ascending condition, $\chi^2(1, N = 108) = 1.50$, $p = .22$. As shown in Table 3 and Figure 3, participants who recalled at least one number from the quadruples recalled significantly more quadruples in the ascending condition ($M = 2.46$, $SD = 1.01$) than in the random condition ($M = 1.91$, $SD = 0.86$), $F(1,94) = 8.01$, $MSE = 0.89$, $p = .006$, partial $\eta^2 = .08$.

Table 1.

Recall as a Function of Presentation Order and Set Size

Set Size	Mean	Standard Deviation	Sample Size	*F*	*MSE*	η^2	*p*
Overall**							
Ascending	2.01	0.60	54	10.79	1.00	.09	.001
Random	1.65	0.55	54				
Singles							
Ascending	1.87	0.97	54	1.58	0.99	.02	.21
Random	1.63	1.01	54				
Doubles							
Ascending	1.89	1.11	54	1.13	0.99	.01	.29
Random	1.69	0.86	54				
Quadruples**							
Ascending	2.28	1.17	54	9.15	1.24	.08	.003
Random	1.63	1.05	54				

** $p < .01$.

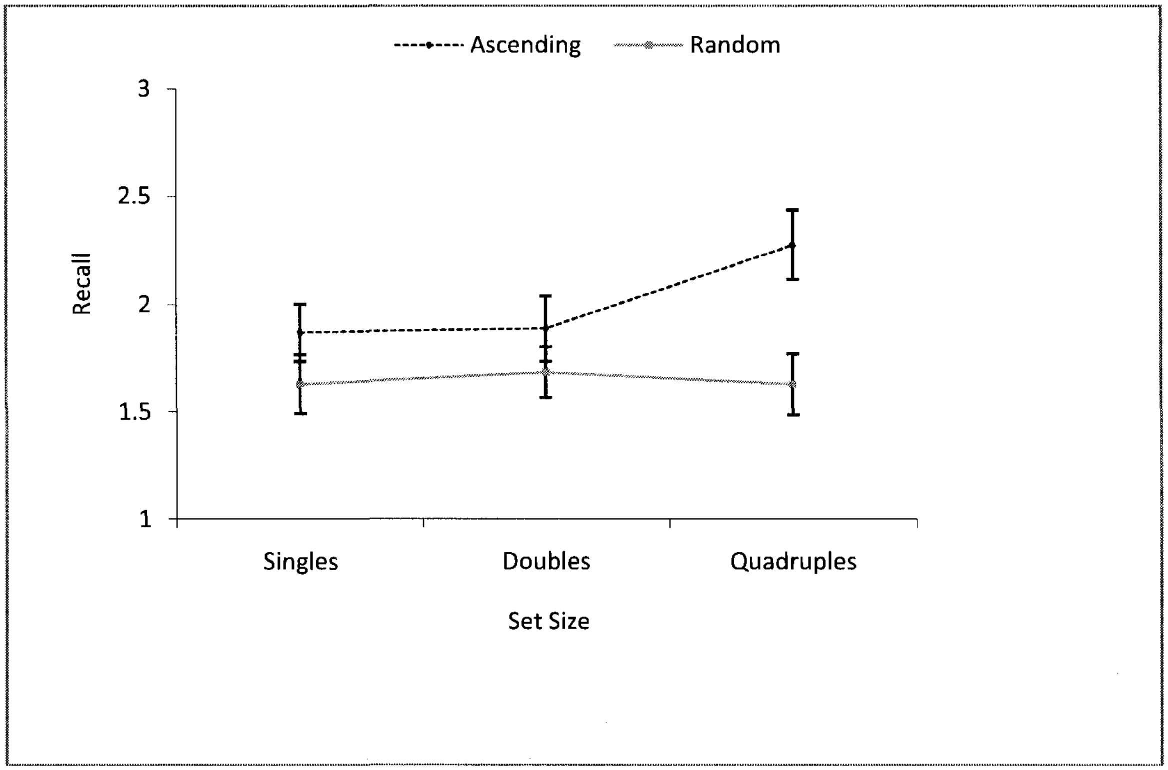

Figure 1. Recall as a function of presentation order and set size. Error bars show +/- 1 standard error of the mean.

Table 2.

Number of Participants who Recalled Zero or at Least One Quadruple as a Function of Presentation Order

	No Recall	Recall of One or More	χ^2	*p*
Presentation Order				
Ascending				
n	4	50	1.50	.22
%	3.70%	46.30%		
Random				
n	8	46		
%	7.41%	42.59%		

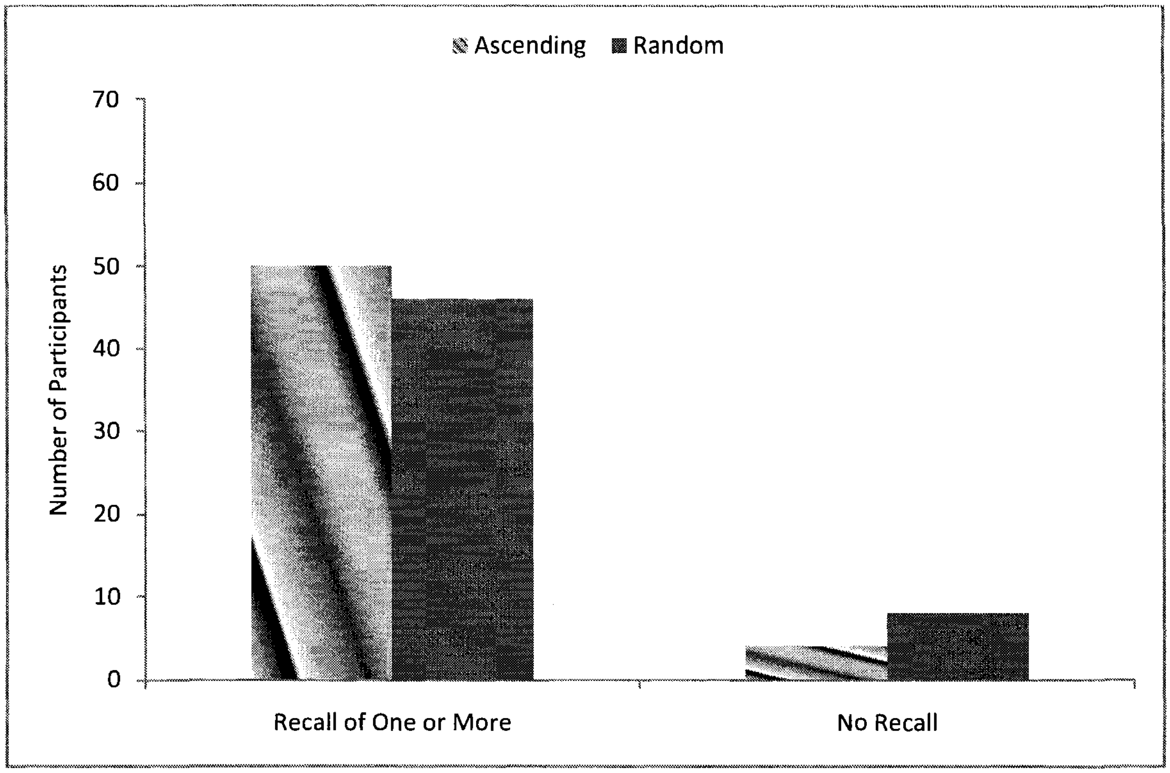

Figure 2. Number of participants who recalled zero or at least one quadruple as a function of presentation order.

Table 3.

Recall for Quadruples as a Function of Presentation Order (Restricted to Participants who Recalled at Least One Quadruple)

	Mean	Standard Deviation	Sample Size	*F*	*MSE*	η^2	*p*
Set Size							
Quadruples**							
Ascending	2.46	1.01	50	8.01	0.89	.08	.006
Random	1.91	0.86	46				

** $p < .01$.

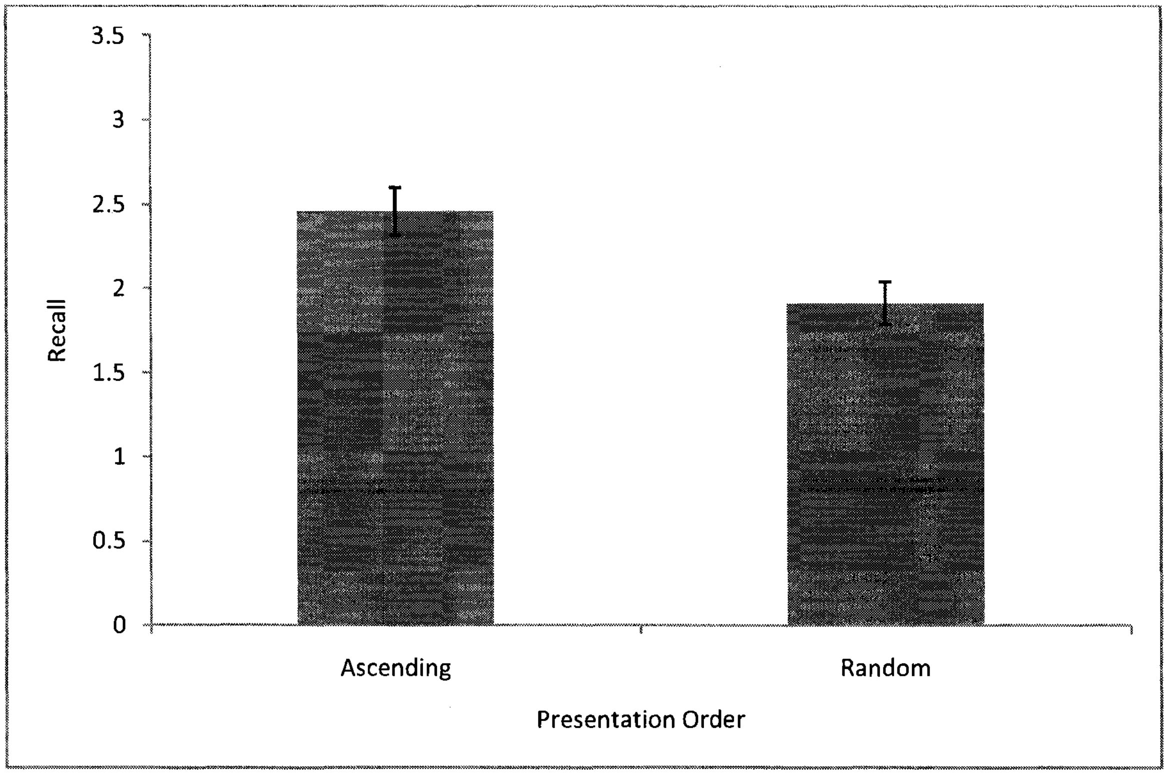

Figure 3. Recall for quadruples as a function of presentation order (restricted to participants who recalled at least one quadruple). Error bars show +/- 1 standard error of the mean.

Intrusions

The effect of presentation order was examined on each participant's four intrusion scores. Intrusions were defined as numbers recalled by participants that were not part of their number lists. Each participant received four intrusion scores: one score representing the number of intrusions from the deciles containing the singles, one score representing the number of intrusions from the deciles containing the doubles, one score representing the number of intrusions from the decile containing the quadruples, and one score representing the number of intrusions from the deciles not included in his or her presentation. As shown in Table 4 and Figure 4, there were few intrusions produced by the participants. As shown in Table 4, presentation order did not have a significant effect on any intrusion score, Fs < 1.00.

Table 4.

Intrusions as a Function of Presentation Order (Experiment 1)

Set Size of Decile	Mean	Standard Deviation	Sample Size	F	MSE	η^2	p
Singles							
Ascending	0.70	0.88	54	0.77	0.98	.01	.38
Random	0.87	1.08	54				
Doubles							
Ascending	0.50	0.77	54	0.07	0.52	.00	.79
Random	0.46	0.66	54				
Quadruples							
Ascending	0.24	0.51	54	0.15	0.25	.00	.70
Random	0.28	0.49	54				
Other							
Ascending	0.11	0.37	54	0.87	0.10	.01	.35
Random	0.06	0.23	54				

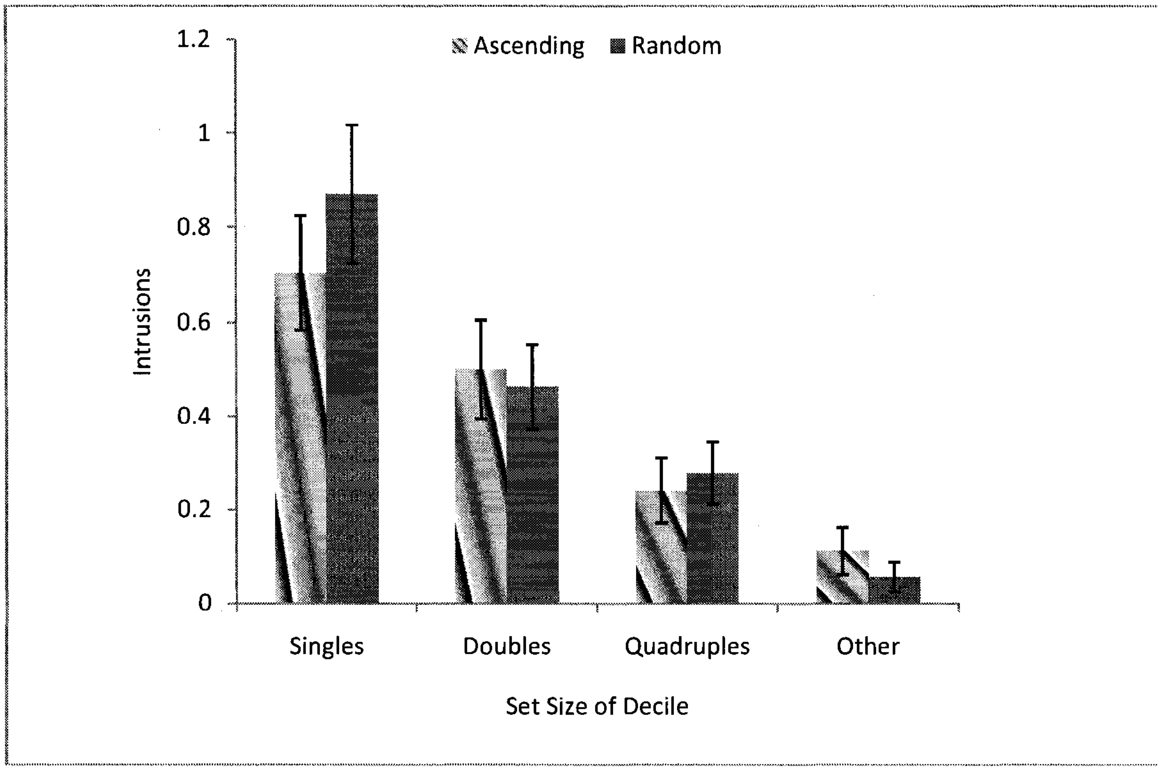

Figure 4. Intrusions as a function of presentation order (Experiment 1). Error bars show +/- 1 standard error of the mean.

Clustering

A 2 (presentation order: ascending, random) X 3 (quadruple recall: 2-4) between-subjects analysis of variance was conducted each participant's number of cluster pairs. Quadruple recall was defined as the number of quadruples correctly recalled by participants. Clustering was defined as the number of within-decile cluster pairs (e.g., 25, 23; Puff, 1966) in each participant's correctly recalled numbers from the quadruples. A cluster pair was defined as the contiguous recall of two valid numbers from a participant's quadruple set. This analysis of cluster pairs was restricted to participants who recalled at least two numbers from the quadruples. The main effect of presentation order was significant, $F(1,62) = 14.78$, $MSE = 0.22$, $p < .001$, partial $\eta^2 = .19$. As shown in Table 5 and Figure 5, participants in the ascending condition produced significantly more cluster pairs during recall of quadruples ($M = 1.58$, $SD = 0.90$) than participants in the random condition ($M = 0.61$, $SD = 0.69$). The main effect of quadruple recall was significant, $F(2,62) = 40.45$, $MSE = 0.22$, $p < .001$, partial $\eta^2 = .57$. As shown in Table and 5 and Figure 5, the number of cluster pairs increased as a function of increasing quadruple recall. The presentation order by quadruple recall interaction was not significant, $F(2,62) = 0.16$, $MSE = 0.22$, $p = .85$. Pairwise comparisons at each level of quadruple recall are presented in Table 5.

Table 5.

Cluster Pairs as a Function of Presentation Order and Quadruple Recall

Quadruple Recall	Mean	Standard Deviation	Sample Size	F	MSE	η^2	p
2-4***							
Ascending	1.58	0.90	40	14.78	0.22	0.19	< .001
Random	0.61	0.69	28				
2***							
Ascending	0.81	0.40	16	17.41	0.17	0.38	< .001
Random	0.20	0.41	15				
3**							
Ascending	1.60	0.51	15	7.90	0.30	0.24	.009
Random	1.00	0.60	12				
4*							
Ascending	2.89	0.33	9	6.40	0.11	0.44	.04
Random	2.00	-	1				

* $p < .05$. ** $p < .01$. *** $p < .001$.

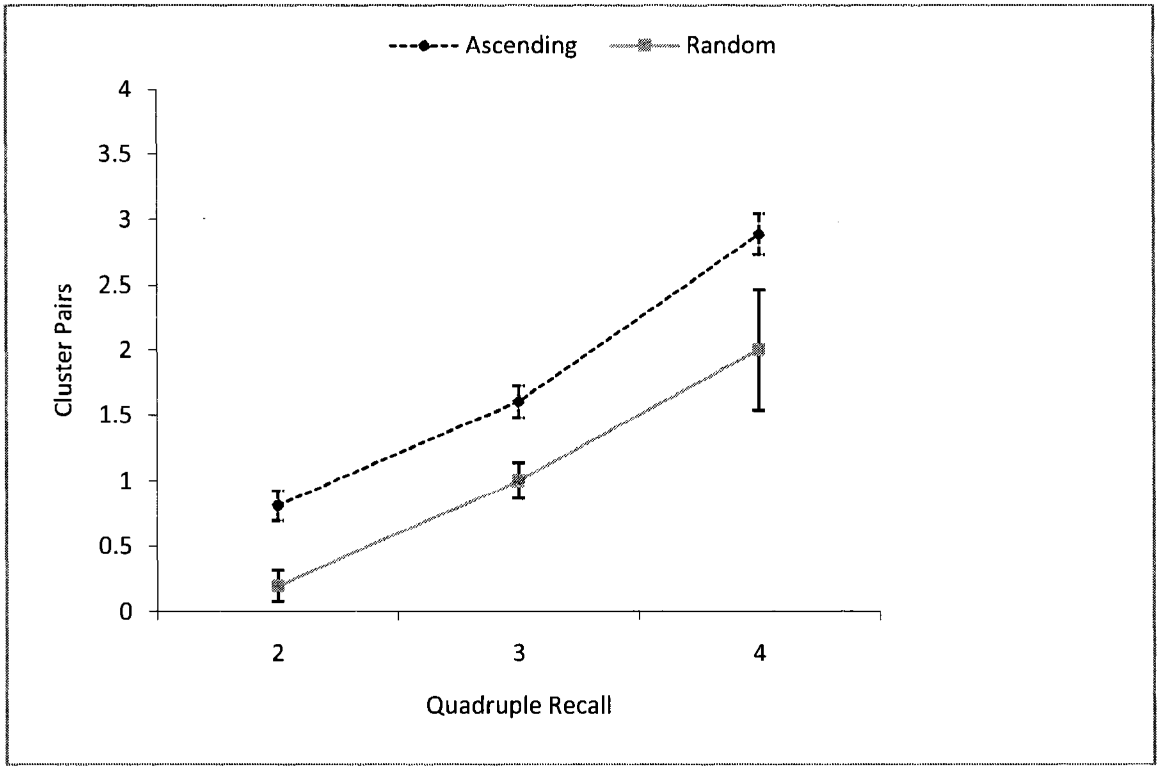

Figure 5. Cluster pairs as a function of presentation order and quadruple recall. Error bars show +/- 1 standard error of the mean. Random (4) reflects data from a single participant.

Discussion

The pattern of results was consistent with Houston's suggestion that people form decile units in memory, from which recalled numbers can cue the recall of other numbers (Houston, 1976). The effect of presentation order on recall was found for the quadruples, which are sets of numbers that can be organized into decile units, but not for the singles, which cannot be organized into decile units. Therefore, the higher recall of ascending two-digit numbers cannot be explained by participants in the ascending condition representing their presentations in ascending order (Houston, 1976), although the ascending presentation order might benefit the organization of numbers within decile units. The organization of numbers into decile units is further supported by the fact that participants produced few intrusions from non-presented deciles, which suggests that participants were aware of which deciles were included in their presentations. Also, the presentation order effect for recall of quadruples was not altered when restricted to participants who recalled at least one quadruple. This finding is consistent with the finding that blocked presentation of words selectively increases within-category recall (D'Agostino, 1969; Lewis, 1971; Sowder, 1977) and suggests that participants in the ascending condition were not more likely to remember that the decile of quadruples was presented (Tulving & Pearlstone, 1966) or more willing to attempt recall within this decile. Instead, this finding suggests that the higher recall of quadruples in the ascending condition was due to a tendency for participants to be better able to organize numbers into decile units in the ascending condition (Houston, 1976) because the organization process was more efficient than in the random condition (D'Agostino, 1969). The stronger organization of quadruples in the ascending condition enabled more numbers to be cued from the quadruples during recall, given the recall of at least one number from this decile (Houston, 1976). The stronger organization in memory, due to higher relational information processing, also explains the higher clustering in the ascending condition (Hunt & Einstein, 1981) because clustering is likely due to organization in memory and recalled items cueing the recall of related items (Bousfield & Cohen, 1953). The failure to find a presentation order effect for the doubles was not expected. However, since this outcome was mostly due to lower recall of doubles than quadruples in the ascending condition, it reflects the fact that with a larger number of smaller decile sets, more deciles must be accessed and recalled numbers cannot cue as many numbers. This outcome is consistent with a study that failed to find a blocked-random effect with categorical word pairs (Basden, 1971).

Alternative explanations could be proposed for the higher recall and clustering of ascending than random quadruples that do not require the assumption of decile units and cueing during recall. It is possible that the difference in recall for quadruples was due to participants accurately determining the set size of quadruples in the ascending condition but underestimating the set size of quadruples in the random condition. Most participants in the ascending condition were probably able to easily determine the set size of the quadruples because the quadruples were blocked during presentation. However, participants in the random condition might have frequently experienced difficulty in determining the set size of the quadruples and assumed by default that it was about the average of set size of each presentation (i.e., 1-2 items). Therefore, it could be proposed that the difference in recall for quadruples was due to participants in the ascending condition guessing additional numbers to meet the requirement of recalling four quadruples. However, this explanation suggests that the number of intrusions from the decile containing quadruples should have been higher in the ascending condition than in the random condition. Another possible explanation is that recall of ascending quadruples was high because knowing how many numbers to retrieve from this decile facilitated retrieval, but recall of random quadruples was impaired because participants who underestimated the set size prematurely stopped attempting to recall quadruples. Finally, an alternative explanation for the higher clustering of ascending than random quadruples is that participants in both conditions attempted to follow their presentation orders during recall (Puff, 1966).

Experiment 2

The first purpose of Experiment 2 was to demonstrate higher recall of ascending than random presentations of two-digit numbers while controlling for differential awareness of set size between conditions. Each number list in Experiment 2 consisted of three quadruple sets, presented in either ascending order or a modified random order. We asked participants to estimate the set size after their recall sessions and then we examined the effect of presentation order on recall at different levels of set size awareness. Due to the consistent presentation of four numbers from each decile, we expected many of the individuals from both the ascending and random conditions to be aware of the set size. These "aware" participants allowed us to selectively examine the effect of presentation order on recall at each level of set size awareness.

The second purpose of Experiment 2 was to provide evidence that the higher clustering in the ascending than in random condition reflects more than serial recall in the ascending and random conditions. The method we used for this purpose was to examine the relationship between clustering and recall while adjusting for the amount of clustering expected by chance.

Method

Participants

The participants included 108 undergraduate students taking General Psychology at San Jose State University who received course credit for their participation. Their ages ranged from 18 to 30, and the mean age was 18.94. The participants included 34 (31.5%) men and 74 (68.5%) women.

Apparatus and Materials

A total of 54 two-digit number lists were used in this experiment, each of which was presented in both ascending order and a modified random order. The random orders were modified to ensure that numbers from the same decile would not be presented contiguously. The number lists used in this experiment were presented in Power Point slide shows, which were timed at a rate of 2 seconds per slide. Each slide contained one two-digit number located in the center of the screen in Times New Roman and 80-point font. Each number list contained 12 two-digit numbers: four of which were from one decile (e.g., 11, 13, 14, 17), four of which were from a different decile (e.g., 61, 65, 66, 68), and four of which were from one other decile (e.g., 82, 84, 87, 89). The number lists were created in sets of three, in which the nine possible initial digits were equally divided amongst the three lists in any given set. The random number generator by Daniels (2001-2003) was used throughout the process of creating the number lists.

The process of creating the first number list of any set began with the selection of deciles. The deciles were selected by dividing the nine possible initial digits (1-9) into groups of three, which included (1, 2, 3), (4, 5, 6), and (7, 8, 9). Next, the random number generator (Daniels, 2001-2003) was asked three times to provide one pseudo-random integer between 1 and 3, with no repeats. The three digits generated were used to select one digit from each of the three groups, based on the positions of digits inside each of the three groups. The process of creating the second number list of any set began with the division of the six remaining initial digits into three groups of two, such as (1, 3), (4, 5), and (7, 9). Next, the random number generator (Daniels, 2001-2003) was used to select a digit from each of the three groups. Finally, the process of creating the third number list of any set began with the selection of the three remaining deciles.

After the three deciles of a number list were selected, the next step was to select the terminal digits of the number list. The terminal digits were selected and assigned to positions inside the list with the random number generator (Daniels, 2001-2003). The restrictions were that no blocks based on terminal digits (e.g., 25, 35), no adjacent quadruples containing more than two common terminal digits (e.g., 21, 23, 25, 29, 41, 43, 45, 48), and no quadruples containing more than one pair of consecutive numbers (e.g., 21, 22, 27, 28) were included. The first two rules were meant to prevent participants from organizing numbers by their terminal digits, and the third rule was meant to prevent the results of this experiment from being limited to blocked presentations of consecutive numbers. After a number list was created, its random order needed to be determined. The process of arranging a number list into its random order began with the use of the random number generator (Daniels, 2001-2003) to arrange the initial digits of the list into a random pattern that did not contain any adjacent identical initial digits or any alternating patterns of initial digits. For example, sequences like (4-, 2-, 8-, 8-, 4-, 2-) or (2-, 4-, 8-, 2-, 4-, 8-) were not acceptable. These restrictions were meant to prevent participants from recognizing blocks or units of numbers during random presentations. After the initial digits had been arranged, the next step in creating a random list was to use the random number generator (Daniels, 2001-2003) to randomly assign the terminal digits into list positions. The restrictions at this stage of the process were that no blocks based on terminal digits (e.g., 21, 81, 41) and no alternating sequences of terminal digits (e.g., 21, 84, 47, 81, 44, 27) were included. These restrictions were also meant to prevent participants from recognizing blocks or units of numbers during random presentations.

Procedure

The instructions and procedure were the largely the same as in Experiment 1. During the recall phase, approximately 10 seconds after their last response, participants were asked if they were finished recalling numbers. The small number of participants who attempted to continue recall ($n = 3$) were again asked if they were finished approximately 10 seconds after their last response. No participants attempted to continue recall after being asked a second time. After each participant had completed the recall task, he or she was told, "There were different sets of numbers in the presentation you received – for example 30s and 50s." The two example deciles for each participant were taken from his or her number presentation. Each participant was then asked, "How many sets were there?" and further, "How many numbers were in each set?"

Results

Recall

A 2 (presentation order: ascending, random) X 3 (set size awareness: aware, somewhat aware, not aware) between-subjects analysis of variance was conducted on recall. Set size awareness was defined as participants' levels of awareness that four numbers were presented from each decile. Participants were considered to have been aware of the set size if they confidently stated that four numbers were presented from each decile. Participants were considered to have been somewhat aware of the set size if they provided estimates that were not completely correct but included the correct set size (e.g., “three or four”) or provided correct estimates pertaining to only one or two deciles (e.g., “four in the 20s”). Participants were considered to have been not aware of the set size if they provided estimates that did not include the correct set size or claimed to not know the set size. The main effect of presentation order was significant, $F(1,102) = 23.90$, $MSE = 2.52$, $p < .001$, partial $\eta^2 = .19$. As shown in Table 6 and Figure 6, participants in the ascending condition recalled significantly more numbers ($M = 6.94$, $SD = 1.73$) than participants in the random condition ($M = 5.28$, $SD = 1.43$). The main effect of set size awareness was not significant, $F(2,102) = 2.10$, $MSE = 2.52$, $p = .13$, nor was the presentation order by set size awareness interaction, $F(2,102) = 0.08$, $MSE = 2.52$, $p = .93$. Pairwise comparisons at each level of set size awareness are presented in Table 6.

Table 6.

Recall as a Function of Presentation Order and Set Size Awareness

	Mean	Standard Deviation	Sample Size	F	MSE	η^2	p
Set Size Awareness							
Overall***							
Ascending	6.94	1.73	54	23.90	2.52	.19	< .001
Random	5.28	1.43	54				
Aware*							
Ascending	7.13	1.87	23	6.52	3.23	.16	.02
Random	5.54	1.66	13				
Somewhat Aware**							
Ascending	7.50	1.20	8	8.95	1.80	.35	.008
Random	5.64	1.43	11				
Not Aware**							
Ascending	6.57	1.73	23	13.36	2.29	.21	.001
Random	5.03	1.33	30				

* $p < .05$. ** $p < .01$. *** $p < .001$.

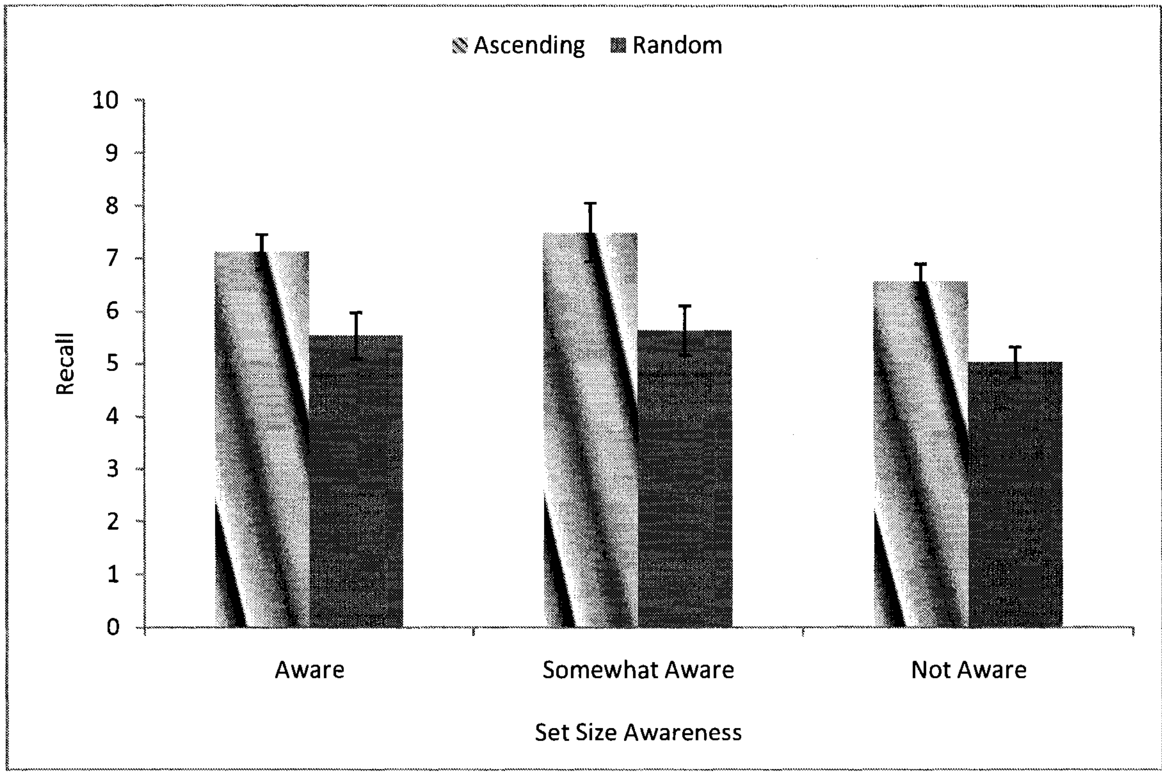

Figure 6. Recall as a function of presentation order and set size awareness. Error bars show +/- 1 standard error of the mean.

Intrusions

The effect of presentation order on each participant's total number of intrusions was significant, $F(1,106) = 4.68$, $MSE = 2.56$, $p = .03$, partial $\eta^2 = .04$. As shown in Table 7 and Figure 7, participants in the ascending condition produced significantly more intrusions ($M = 2.06$, $SD = 1.89$) than participants in the random condition ($M = 1.39$, $SD = 1.25$). As shown in Table 7 and Figure 7, this overall effect was principally driven by participants producing significantly more intrusions from non-presented deciles in the ascending condition ($M = 0.96$, $SD = 1.72$) than in the random condition ($M = 0.19$, $SD = 0.48$), $F(1,106) = 10.30$, $MSE = 1.59$, $p = .002$, partial $\eta^2 = .09$. However, the effect of presentation order on each participant's number of intrusions from presented deciles was not significant, $F(106) = 0.25$, $MSE = 1.31$, $p = .62$.

Table 7.

Intrusions as a Function of Presentation Order (Experiment 2)

	Mean	Standard Deviation	Sample Size	F	MSE	η^2	p
Deciles of Intrusions							
Total*							
Ascending	2.06	1.89	54	4.68	2.56	.04	.03
Random	1.39	1.25	54				
Presented Deciles							
Ascending	1.09	1.07	54	0.25	1.31	.00	.62
Random	1.20	1.22	54				
Non-presented Deciles**							
Ascending	0.96	1.72	54	10.30	1.59	.09	.002
Random	0.19	0.48	54				

* $p < .05$. ** $p < .01$.

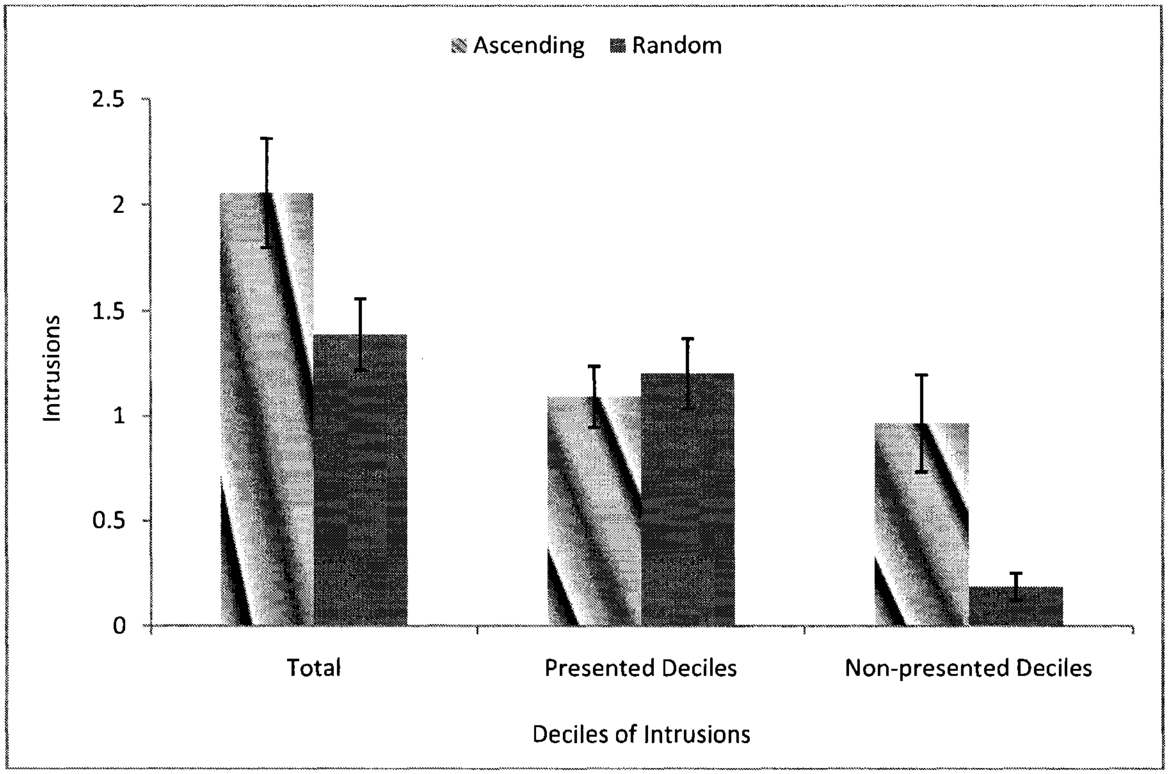

Figure 7. Intrusions as a function of presentation order (Experiment 2). Error bars show +/- 1 standard error of the mean.

Clustering

Two measures of clustering were used in this experiment. The first measure was the number of cluster pairs. In this experiment, a cluster pair was defined as the contiguous recall of two valid numbers from a participant's entire number list. The second measure was the adjusted ratio of clustering (ARC), which measures clustering during free recall while adjusting for clustering expected by chance, based on the number of items recalled from each category and the total number of items recalled (Roenker et al., 1971). ARC scores are calculated with this formula: ARC = $[R - E(R)] / [\max R - E(R)]$, in which R is the number of repetitions (i.e., cluster pairs) observed, $E(R)$ is the number of repetitions expected by chance, and max$R$ is the maximum number of possible repetitions (Roenker et al., 1971). The formula for the number of repetitions expected by chance is $E(R) = [(\Sigma n^2) / N] - 1$, in which n is the number of items recalled from each category and N is the total number of recalled items (Roenker et al., 1971). The formula for the maximum number of possible repetitions is $\max R = N - k$, in which k is number of categories from which at least one item is recalled (Roenker et al., 1971).

Cluster pairs. A 2 (presentation order: ascending, random) X 6 (recall: 4-9) between-subjects analysis of variance was conducted on each participant's number of cluster pairs. This analysis of cluster pairs was restricted to participants who recalled 4-9 numbers to ensure data for both the ascending and random conditions. This analysis was also restricted to participants who recalled at least two numbers from any one decile. The main effect of presentation order was significant, $F(1,88) = 11.52$, $MSE = 1.00$, $p = .001$, partial $\eta^2 = .12$. As shown in Table 8 and Figure 8, participants in the ascending condition produced significantly more cluster pairs ($M = 3.49$, $SD = 1.54$) than participants in the random condition ($M = 1.31$, $SD = 1.39$). The main effect of recall was significant, $F(5,88) = 19.52$, $MSE = 1.00$, $p < .001$, partial $\eta^2 = .53$. As shown in Table 8 and Figure 8, the number of cluster pairs increased as a function of increasing recall. The presentation order by recall interaction was not significant, $F(5,88) = 1.88$, $MSE = 1.00$, $p = .11$. Pairwise comparisons at each level of recall are presented in Table 8.

Table 8.

Cluster Pairs as a Function of Presentation Order and Recall

	Mean	Standard Deviation	Sample Size	*F*	*MSE*	η^2	*p*
Recall							
4-9**							
Ascending	3.49	1.54	51	11.52	1.00	.12	.001
Random	1.31	1.39	49				
4							
Ascending	0.75	0.96	4	0.48	0.53	.03	.50
Random	0.46	0.66	13				
5							
Ascending	1.67	0.58	3	0.68	1.20	.05	.42
Random	1.08	1.16	12				
6***							
Ascending	3.06	0.77	16	55.15	0.55	.67	< .001
Random	1.00	0.71	13				
7*							
Ascending	3.80	0.79	10	5.19	0.94	.25	.04
Random	2.75	1.16	8				
8							
Ascending	3.78	1.48	9	0.80	3.34	.08	.39
Random	2.50	3.54	2				
9							
Ascending	5.44	0.73	9	0.34	0.53	.04	.58
Random	5.00	-	1				

* $p < .05$. ** $p < .01$. *** $p < .001$.

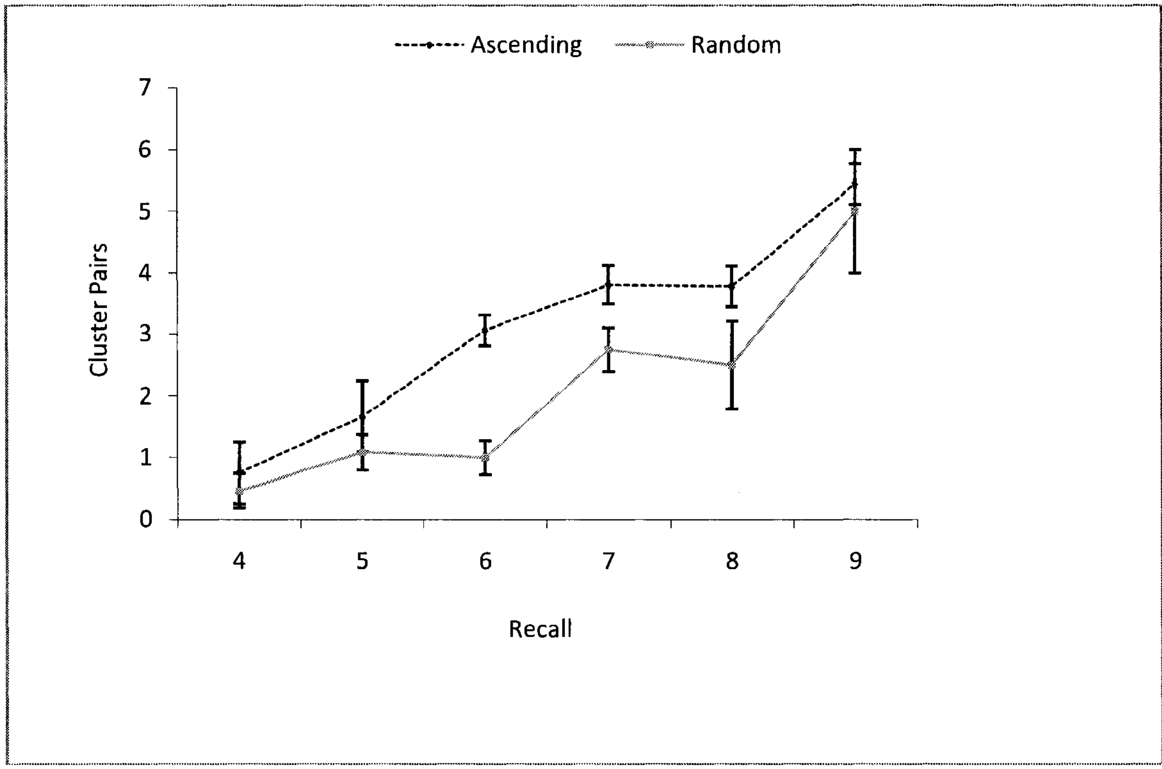

Figure 8. Cluster pairs as a function of presentation order and recall. Error bars show +/- 1 standard error of the mean. Random (9) reflects data from a single participant.

ARC scores. A 2 (presentation order: ascending, random) X 6 (recall: 4-9) between-subjects analysis of variance was conducted on participants' ARC scores. This analysis was restricted to participants who recalled 4-9 numbers to ensure data for both the ascending and random conditions. This analysis was also restricted to participants who recalled at least two numbers from any one decile. Intrusions were not included in the ARC equations. The main effect of presentation order was significant, $F(1,88) = 6.84$, $MSE = 0.35$, $p = .01$, partial $\eta^2 = .07$. As shown in Table 9 and Figure 9, participants in the ascending condition had significantly higher ARC scores ($M = 0.70$, $SD = 0.48$) than participants in the random condition ($M = -0.07$, $SD = 0.75$). The main effect of recall was significant, $F(5,88) = 3.41$, $MSE = 0.35$, $p = .007$, partial $\eta^2 = .16$. As shown in Table 9 and Figure 9, ARC scores increased as a function of increasing recall. The presentation order by recall interaction was not significant, $F(5,88) = 1.45$, $MSE = 0.35$, $p = .21$. Pairwise comparisons at each level of recall are presented in Table 9.

Table 9.

Adjusted Ratio of Clustering (ARC) Scores as a Function of Presentation Order and Recall

	Mean	Standard Deviation	Sample Size	*F*	*MSE*	η^2	*p*
Recall							
4-9*							
Ascending	0.70	0.48	51	6.84	0.35	.07	.01
Random	-0.07	0.75	49				
4							
Ascending	0.00	1.15	4	0.29	0.99	.02	.60
Random	-0.31	0.95	13				
5							
Ascending	0.25	0.07	3	0.60	0.39	.05	.42
Random	-0.09	0.67	12				
6***							
Ascending	0.83	0.32	16	40.29	0.21	.60	< .001
Random	-0.25	0.58	13				
7*							
Ascending	0.83	0.22	10	5.31	0.13	.25	.04
Random	0.43	0.49	8				
8							
Ascending	0.61	0.48	9	0.70	0.34	.07	.42
Random	0.23	1.09	2				
9							
Ascending	0.86	0.19	9	0.30	0.03	.04	.60
Random	0.75	-	1				

* $p < .05$. *** $p < .001$.

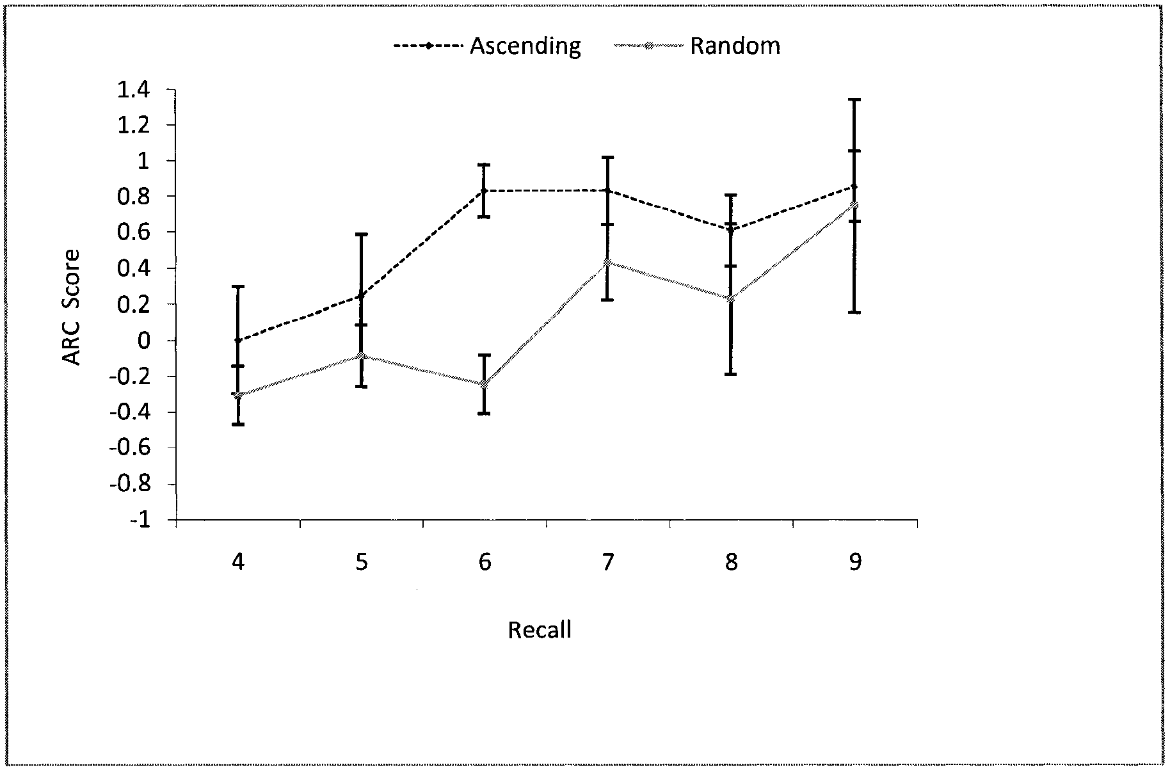

Figure 9. Adjusted ratio of clustering (ARC) scores as a function of presentation order and recall. Error bars show +/- 1 standard error of the mean. Random (9) reflects data from a single participant.

Serial Order Pairs

A 2 (presentation order: ascending, random) X 7 (recall: 3-9) between-subjects analysis of variance was conducted on each participant's number of serial order pairs. Serial order pairs were defined as pairs of contiguously recalled numbers that were contiguously presented in the same order as they were recalled (Puff, 1966). This analysis was restricted to participants who recalled 3-9 numbers to ensure data for both the ascending and random conditions. The main effect of presentation order was significant, $F(1,92) = 34.81$, $MSE = 0.79$, $p < .001$, partial $\eta^2 = .28$. As shown in Table 10 and Figure 10, participants in the ascending condition produced significantly more serial order pairs ($M = 2.67$, $SD = 1.53$) than participants in the random condition ($M = 0.37$, $SD = 0.56$). The main effect of recall was significant, $F(6,92) = 6.85$, $MSE = 0.79$, $p < .001$, partial $\eta^2 = .31$. As shown in Table 10 and Figure 10, the number of serial order pairs increased as a function of increasing recall. The presentation order by recall interaction was significant, $F(6,92) = 4.26$, $MSE = 0.79$, $p = .001$, partial $\eta^2 = .22$. As shown in Table 10 and Figure 10, the number of serial order pairs increased as a function of increasing recall only in the ascending condition. Pairwise comparisons at each level of recall are presented in Table 10.

Table 10.

Serial Order Pairs as a Function of Presentation Order and Recall

	Mean	Standard Deviation	Sample Size	*F*	*MSE*	η^2	*p*
Recall							
3-9***							
Ascending	2.67	1.53	52	34.81	0.79	.28	< .001
Random	0.37	0.56	54				
3							
Ascending	0.00	-	1	0.44	0.30	.10	.54
Random	0.40	0.55	5				
4							
Ascending	0.50	0.58	4	0.29	0.39	.02	.60
Random	0.31	0.63	13				
5							
Ascending	0.67	0.58	3	1.80	0.33	.12	.20
Random	0.17	0.58	12				
6***							
Ascending	2.63	0.96	16	53.38	0.63	.66	< .001
Random	0.46	0.52	13				
7***							
Ascending	2.60	0.84	10	37.33	0.53	.70	< .001
Random	0.50	0.53	8				
8*							
Ascending	3.22	1.56	9	5.44	2.23	.38	.045
Random	0.50	0.71	2				
9^							
Ascending	4.22	1.39	9	4.81	1.94	.38	.06
Random	1.00	-	1				

^ $p < .10$. * $p < .05$. *** $p < .001$.

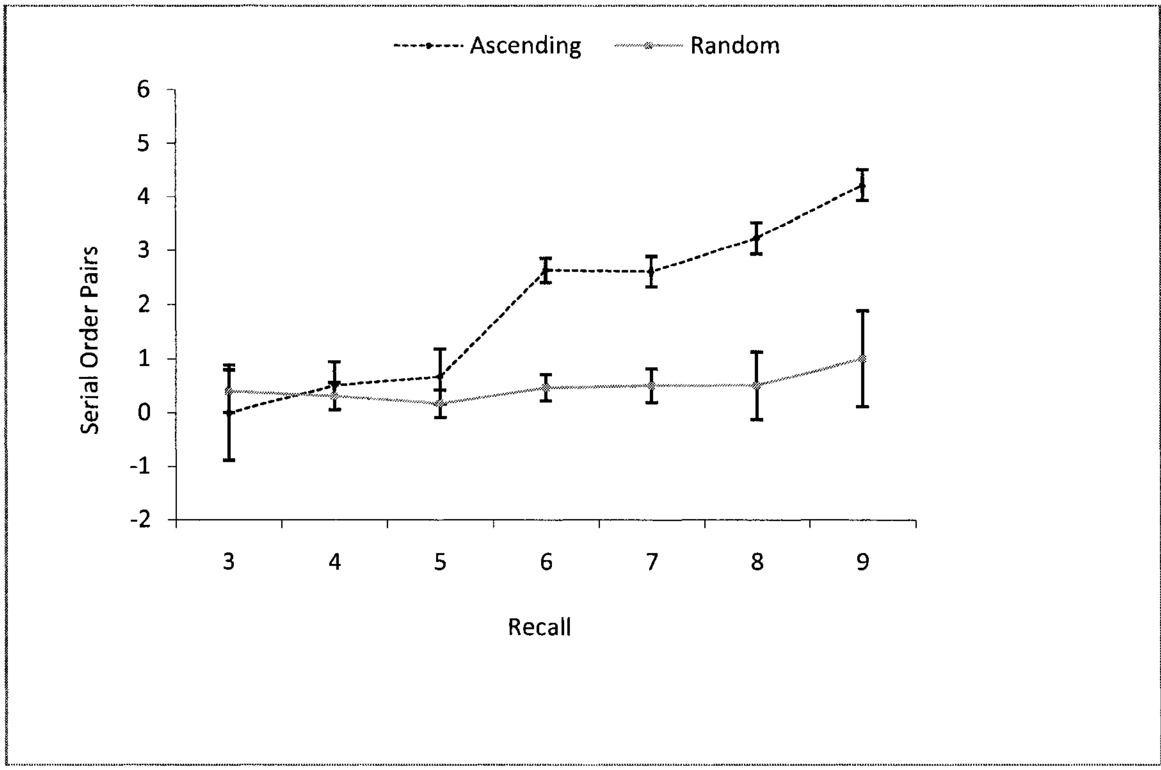

Figure 10. Serial order pairs as a function of presentation order and recall. Error bars show +/- 1 standard error of the mean. Ascending (3) and Random (9) each reflect data from a single participant.

Discussion

The results of Experiment 2 are not consistent with the proposed explanation for the higher recall of ascending than random quadruples based on participants more frequently knowing the set size in the ascending condition. The failure to find a significant effect of set size awareness on recall suggests that set size awareness does not facilitate recall and that unawareness of set size does not impair recall. Also, the effect of presentation order was significant for participants who correctly estimated the set size. A potential limitation of this outcome is that some participants might have been able to accurately estimate the set size without having been aware of the set size during recall.

However, the set size awareness explanation cannot account for the significant effect of presentation order for participants who were not aware of the set size. Therefore, it appears that the higher recall of ascending than random two-digit numbers is more likely due to stronger organization of ascending than random two-digit numbers into decile units, which enables more numbers to be cued after the first number from any decile is recalled (Houston, 1976). The lack of a significant difference in the number of intrusions from presented deciles supports the conclusion that the higher recall in the ascending condition was not due to more frequent guessing in this condition.

The current findings suggest that the higher clustering of ascending than random quadruples is more likely due to stronger organization of numbers into decile units in the ascending condition (Hunt & Einstein, 1981), which results in stronger cueing during recall (Cofer et al., 1966), than a serial recall strategy in either condition. The tendency for participants in the ascending condition to recall numbers in ascending order might suggest that the higher clustering in the ascending condition was due to participants in the ascending condition adopting an ascending output strategy. However, significant positive relationships between recall and ARC scores were found in both the ascending and random conditions. If the higher clustering in the ascending condition was due to an ascending output strategy, participants' ARC scores should have been high at each level of recall in the ascending condition. For example, a participant who recalls four numbers in ascending order (e.g., 21, 24, 42, 45) would receive the same ARC score as a participant who recalls eight numbers in ascending order (e.g., 21, 24, 42, 45, 49, 91, 95, 98). Similarly, an ascending output strategy in the random condition cannot explain the positive relationship between recall and ARC scores in the random condition. One might argue that these positive relationships between recall and ARC scores were due to participants who adopted an ascending output strategy recalling more numbers than participants who did not adopt this strategy (Houston, 1976). However, Houston (1976) found no difference in recall between participants who were instructed to recall numbers in ascending order and participants who were not instructed to use this strategy. Therefore, it appears that participants within each condition differed in their levels of decile organization in memory, and the participants with the strongest decile organization recalled the most numbers.

There is evidence to suggest that participants in the random condition of Experiment 2 might have more frequently organized quadruples into decile units than participants in the random condition of Experiment 1. First, because their presentations did not include singles, participants in the random condition of Experiment 2 might have been more likely to perceive that their presentations contained decile sets that needed to be organized than participants in the random condition of Experiment 1. Also, participants in the random condition of Experiment 2 were likely often aware of which three deciles were presented (e.g., 20s, 40s, 70s), due to the small number of presented deciles and the large number of numbers presented from each decile (Stones, 1973). This awareness of the labels of presented deciles likely facilitated participants' organization of numbers into three decile units (Gollin & Sharps, 1988). This claim is supported by the finding that participants who are informed of the categories that will be included in their presentations show higher recall and clustering than uninformed participants (Gollin &

Sharps, 1988). Finally, the positive relationship between recall and ARC scores in the random condition of Experiment 2 suggests that certain participants in this condition were able to effectively organize numbers into decile units. The method we used to investigate this possibility was a comparison of the presentation order effect in quadruple recall across the two experiments.

Comparison of Experiments 1 and 2

The effect of presentation order on quadruple recall (as defined in Experiment 1 but with averaged scores for Experiment 2) was compared across the two experiments in order to determine if this effect was reduced in Experiment 2. We predicted that participants would organize random quadruples by decile more frequently in Experiment 2 than in Experiment 1 and recall of random quadruples would therefore be higher in Experiment 2 than in Experiment 1. However, due to the fact that ascending quadruples were blocked during presentation and easy to organize in both experiments, we did not predict a difference in recall of ascending quadruples across the two experiments.

Results

In order to compare quadruple recall across experiments, participants' recall scores for each quadruple set in Experiment 2 were averaged so that all participants' scores would be on a 1-4 scale. Next, a 2 (presentation order: ascending, random) X 2 (experiment: experiment 1, experiment 2) between-subjects analysis of variance was conducted on quadruple recall. The main effect of presentation order was significant, $F(1,212) = 25.49$, $MSE = 0.76$, $p < .001$, partial $\eta^2 = .11$. As shown in Table 11 and Figure 11, quadruple recall was significantly higher in the ascending condition ($M = 2.30$, $SD = 0.92$) than in the random condition ($M = 1.70$, $SD = 0.81$). The main effect of experiment was not significant, $F(1,212) = 0.53$, $MSE = 0.76$, $p = .47$, nor was the presentation order by experiment interaction, $F(1,212) = 0.17$, $MSE = 0.76$, $p = .68$. Pairwise comparisons at each level of experiment are presented in Table 11.

Table 11.

Comparison of Quadruple Recall across Experiments

Experiment	Mean	Standard Deviation	Sample Size	*F*	*MSE*	η^2	*p*
Overall***							
Ascending	2.30	0.92	54	25.49	0.76	.11	< .001
Random	1.70	0.81	54				
Experiment 1**							
Ascending	2.28	1.17	54	9.15	1.24	.08	.003
Random	1.63	1.05	54				
Experiment 2***							
Ascending	2.31	0.58	54	29.22	0.28	.22	< .001
Random	1.77	0.47	54				

** $p < .01$. *** $p < .001$.

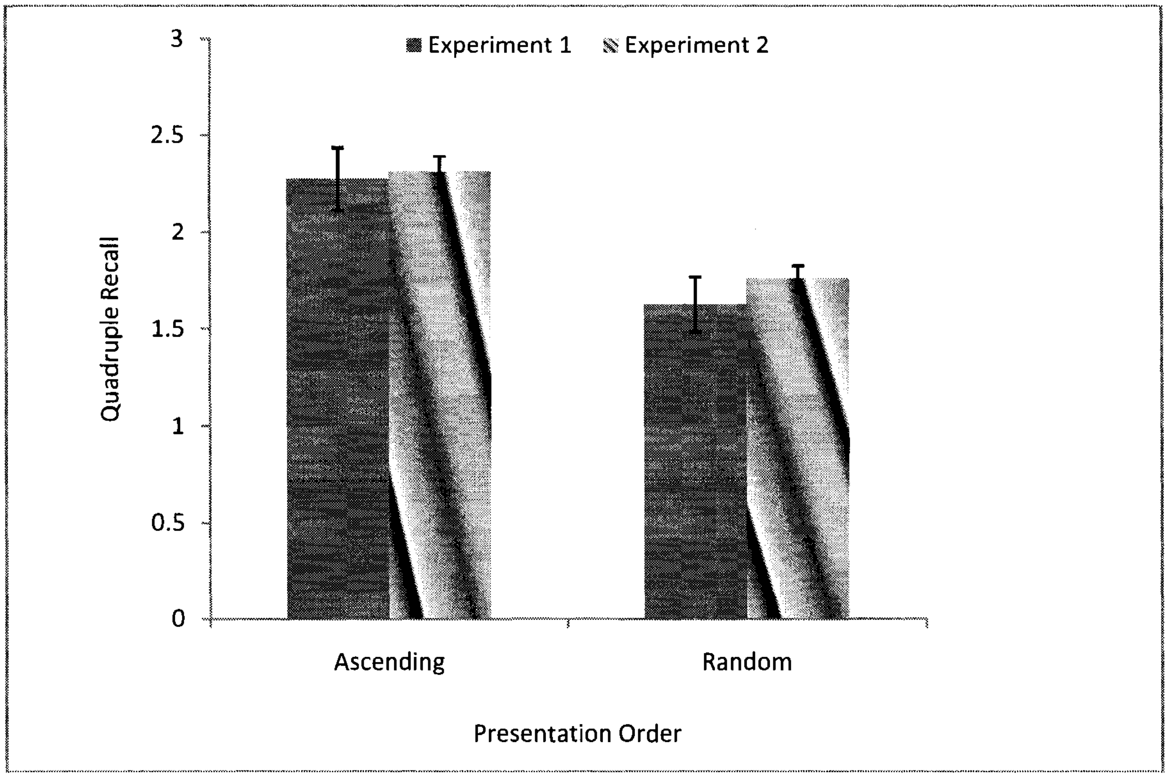

Figure 11. Comparison of quadruple recall across experiments. Error bars show +/- 1 standard error of the mean.

Discussion

The comparison across the two experiments demonstrated that recall of random quadruples was not increased in Experiment 2 by participants more frequently organizing random quadruples into decile units. Recall of random quadruples was only slightly higher in Experiment 2 than in Experiment 1. Therefore, it appears that the number of participants who were able to effectively organize numbers into decile units was probably about equal across the two random conditions.

General Discussion

The current series of experiments demonstrated that the higher recall of ascending than random two-digit numbers is due to the presentation of numbers from sufficiently populated deciles (e.g., quadruples) as ascending blocks during ascending but not random presentations. In both experiments, numbers from these deciles were better recalled and more highly clustered when presented as ascending blocks than when scattered throughout random number presentations. A likely explanation for these findings is that participants can better organize two-digit numbers into decile units when they are presented as ascending blocks than when they are presented in a random order (Houston, 1976). The stronger organization of numbers from ascending presentations into decile units enables more numbers to be cued from these units during recall, given the recall of at least one number from each unit (Houston, 1976). Future researchers could provide stronger evidence for this explanation by conducting an experiment including conditions in which certain two-digit numbers are provided as recall cues (e.g., Lewis, 1971; Luek et al., 1971; Sowder, 1977; Wood, 1969). If cues activate the recall of previously inaccessible numbers from the same decile (Tulving & Pearlstone, 1966), thereby enhancing recall (Lewis, 1971; Luek et al., 1971; Sowder, 1977; Wood, 1969), the explanation for the higher recall of ascending than random two-digit numbers based on decile organization would be further supported.

These experiments leave certain issues unresolved. One unresolved issue is the extent to which these findings generalize to different types of two-digit number presentations, such as those containing larger decile sets (e.g., sets of six numbers) or only small decile sets (e.g., singles or doubles). Although our findings suggest that presentation order would not affect recall of two-digit number presentations containing only small decile sets, this claim must be tested by future research. Also, the fact that participants did not always cluster numbers in ascending order raises the issue of whether two-digit numbers must be presented in ascending order or simply blocked by decile (e.g., 31, 35, 32, 39, 75, 73, 77, 78, 42, 49, 47, 44) to facilitate the organization of numbers into decile units and enhance recall. Finally, an additional alternative explanation could be proposed for the higher recall of ascending than random quadruples, which is that participants organized quadruples into units because they were presented in close proximity on the number line (e.g., the Gestalt principle of proximity; Postman, 1972) but not because they were from the same decile. This issue is difficult to resolve because numbers that are in close proximity on the number line are also likely to be from the same decile. However, it would be possible to replicate Experiment 1 with ascending two-digit number presentations containing sets of doubles that have the same proximity level as quadruples (e.g., 27, 29, 32, 34). If these sets of doubles were recalled at the same level as the ascending doubles in Experiment 1, evidence would be provided for the formation of decile units. However, if they were recalled at the same level as the ascending quadruples in Experiment 1, the conclusion would be that people group numbers that are in close proximity on the number line, regardless of whether they are from the same decile.

The current series of experiments provides evidence that blocked presentation facilitates the recall of two-digit numbers and words through a common mechanism.

This mechanism is the greater ability of people to organize items into categorical units (D'Agostino, 1969), which increases the likelihood that recalled items will cue the recall of other items from the same category (Bousfield & Cohen, 1953; Cofer et al., 1966; Houston, 1976). People likely categorize words and two-digit numbers into categorical units because they are low in detail and difficult to recall purely on the basis of item-specific information (Sharps et al., 1995).

Cofer et al. (1966) proposed that the organization of items into categorical units in memory is based on the relationships among items within categories and the relationship between each item and the concept of its category. Therefore, since numbers are ordinal but are typically not semantically meaningful, the relationships between two-digit numbers within deciles are likely based on their relative magnitudes (e.g., 82 is lower than 85, which is lower than 88). Also, the relationship of a two-digit number to its category label involves its initial digit that identifies it as belonging to a certain decile. These relationships likely enable people to organize two-digit numbers into categorical units, which facilitates their recall (Houston, 1976). However, during ascending presentations, in which numbers from the same decile are blocked, more time is available to organize two-digit numbers into categorical units on the basis of these relationships (D'Agostino, 1969). The organization of stimuli is directly related to the strength of its organization in memory, which is directly related to its likelihood of being recalled (Postman, 1972).

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Appendix A

Analysis of Variance Source Tables

Table 1A.

Analysis of Variance for Recall (Experiment 1)

Source	*df*	*F*	η^2	*p*
	Recall			
Presentation Order (PO)	1	10.79**	.09	.001
Error- PO	106	(1.00)		
Set Size (SS)	2	1.15	.01	.32
PO X SS	2	1.48	.01	.23
Error- SS	212	(1.11)		
	Singles			
Presentation Order	1	1.58	.02	.21
Error	106	(0.99)		
	Doubles			
Presentation Order	1	1.13	.01	.29
Error	106	(0.99)		
	Quadruples			
Presentation Order	1	9.15**	.08	.003
Error	106	(1.24)		
	Quadruples (Restricted Analysis)			
Presentation Order	1	8.01**	.08	.006
Error	94	(0.89)		

Note. Values enclosed in parentheses represent mean square errors.
** $p < .01$.

Table 2A.

Analysis of Variance for Intrusions (Experiment 1)

Source	*df*	*F*	η^2	*p*
	Singles			
Presentation Order	1	0.77	.01	.38
Error	106	(0.98)		
	Doubles			
Presentation Order	1	0.07	.00	.79
Error	106	(0.52)		
	Quadruples			
Presentation Order	1	0.15	.00	.70
Error	106	(0.25)		
	Other			
Presentation Order	1	0.87	.01	.35
Error	106	(0.10)		

Note. Values enclosed in parentheses represent mean square errors.

Table 3A.

Analysis of Variance for Cluster Pairs (Experiment 1)

Source	*df*	*F*	η^2	*p*
	Cluster Pairs			
Presentation Order (PO)	1	14.78***	.19	< .001
Quadruple Recall (QR)	2	40.45***	.57	< .001
PO X QR	2	0.16	.01	.85
Error	62	(0.22)		
	Quadruple Recall = 2			
Presentation Order	1	17.41***	.38	< .001
Error	29	(0.17)		
	Quadruple Recall = 3			
Presentation Order	1	7.90**	.24	.009
Error	25	(0.30)		
	Quadruple Recall = 4			
Presentation Order	1	6.40*	.44	.04
Error	8	(0.11)		

Note. Values enclosed in parentheses represent mean square errors.
* $p < .05$. ** $p < .01$. *** $p < .001$.

Table 4A.

Analysis of Variance for Recall (Experiment 2)

Source	*df*	*F*	η^2	*p*
	Recall			
Presentation Order (PO)	1	23.90***	.19	< .001
Set Size Awareness (SSA)	2	2.10	.04	.13
PO x SSA	2	0.08	.00	.93
Error	102	(2.52)		
	Aware			
Presentation Order	1	6.52*	.16	.02
Error	34	(3.23)		
	Somewhat Aware			
Presentation Order	1	8.95**	.35	.008
Error	17	(1.80)		
	Not Aware			
Presentation Order	1	13.36**	.21	.001
Error	51	(2.29)		

Note. Values enclosed in parentheses represent mean square errors.
* $p < .05$. ** $p < .01$. *** $p < .001$.

Table 5A.

Analysis of Variance for Intrusions (Experiment 2)

Source	*df*	*F*	η^2	*p*
	Intrusions- Total			
Presentation Order	1	4.68*	.04	.03
Error	106	(2.56)		
	Intrusions- Presented deciles			
Presentation Order	1	0.25	.00	.62
Error	106	(1.31)		
	Intrusions- Non-presented deciles			
Presentation Order	1	10.30**	.09	.002
Error	106	(1.59)		

Note. Values enclosed in parentheses represent mean square errors.
* $p < .05$. ** $p < .01$.

Table 6A.

Analysis of Variance for Cluster Pairs (Experiment 2)

Source	*df*	*F*	η^2	*p*
	Cluster Pairs			
Presentation Order (PO)	1	11.52**	.12	.001
Recall (R)	5	19.52***	.53	< .001
PO X R	5	1.88	.10	.11
Error	88	(1.00)		
	Recall = 4			
Presentation Order	1	0.48	.03	.50
Error	15	(0.53)		
	Recall = 5			
Presentation Order	1	0.68	.05	.42
Error	13	(1.20)		
	Recall = 6			
Presentation Order	1	55.15***	.67	< .001
Error	27	(0.55)		
	Recall = 7			
Presentation Order	1	5.19*	.25	.04
Error	16	(0.94)		
	Recall = 8			
Presentation Order	1	0.80	.08	.39
Error	9	(3.34)		
	Recall = 9			
Presentation Order	1	0.34	.04	.58
Error	8	(0.53)		

Note. Values enclosed in parentheses represent mean square errors.
* $p < .05$. ** $p < .01$. *** $p < .001$.

Table 7A.

Analysis of Variance for ARC Scores

Source	*df*	*F*	η^2	*p*
	ARC Scores			
Presentation Order (PO)	1	6.84*	.07	.01
Recall (R)	5	3.41**	.16	.007
PO X R	5	1.45	.08	.21
Error	88	(0.35)		
	Recall = 4			
Presentation Order	1	0.29	.02	.60
Error	15	(0.99)		
	Recall = 5			
Presentation Order	1	0.69	.05	.42
Error	13	(0.39)		
	Recall = 6			
Presentation Order	1	40.29***	.60	< .001
Error	27	(0.21)		
	Recall = 7			
Presentation Order	1	5.31*	.25	.04
Error	16	(0.13)		
	Recall = 8			
Presentation Order	1	0.70	.07	.42
Error	9	(0.34)		
	Recall = 9			
Presentation Order	1	0.30	.04	.60
Error	8	(0.03)		

Note. Values enclosed in parentheses represent mean square errors.
* $p < .05$. ** $p < .01$. *** $p < .001$.

Table 8A.

Analysis of Variance for Serial Order Pairs

Source	*df*	*F*	η^2	*p*
	Serial Order Pairs			
Presentation Order (PO)	1	34.81***	.28	< .001
Recall (R)	6	6.85***	.31	< .001
PO X R	6	4.26**	.22	.001
Error	92	(0.79)		
	Recall = 3			
Presentation Order	1	0.44	.10	.54
Error	4	(0.30)		
	Recall = 4			
Presentation Order	1	0.29	.02	.60
Error	15	(0.39)		
	Recall = 5			
Presentation Order	1	1.80	.12	.20
Error	13	(0.33)		
	Recall = 6			
Presentation Order	1	53.38***	.66	< .001
Error	27	(0.63)		
	Recall = 7			
Presentation Order	1	37.33***	.70	< .001
Error	16	(0.53)		
	Recall = 8			
Presentation Order	1	5.44*	.38	.045
Error	9	(2.23)		
	Recall = 9			
Presentation Order	1	4.81^	.38	.06
Error	8	(1.94)		

Note. Values enclosed in parentheses represent mean square errors.
^ $p < .10$. * $p < .05$. ** $p < .01$. *** $p < .001$.

Table 9A.

Analysis of Variance for Quadruple Recall

Source	*df*	*F*	η^2	*p*
	Quadruple Recall			
Presentation Order (PO)	1	25.49***	.11	< .001
Experiment (E)	1	0.53	.00	.47
PO x E	1	0.17	.00	.68
Error	212	(0.76)		
	Experiment 1			
Presentation Order	1	9.15**	.08	.003
Error	106	(1.24)		
	Experiment 2			
Presentation Order	1	29.22***	.22	< .001
Error	106	(0.28)		
	Ascending			
Experiment	1	0.04	.00	.84
Error	106	(0.85)		
	Random			
Experiment	1	0.75	.01	.39
Error	106	(0.67)		

Note. Values enclosed in parentheses represent mean square errors.
** $p < .01$. *** $p < .001$.

Appendix B

Recall Data for Experiment 1

List	Order	Singles	Doubles	Quadruples
1	A	3.00	1.00	1.00
1	R	1.00	1.00	0.00
2	A	3.00	3.00	3.00
2	R	0.00	1.00	1.00
3	A	4.00	2.00	1.00
3	R	2.00	2.00	1.00
4	A	0.00	3.00	0.00
4	R	3.00	1.00	3.00
5	A	2.00	2.00	2.00
5	R	3.00	1.00	0.00
6	A	2.00	2.00	4.00
6	R	2.00	1.00	1.00
7	A	1.00	3.00	3.00
7	R	3.00	2.00	2.00
8	A	2.00	3.00	4.00
8	R	2.00	1.00	1.00
9	A	3.00	3.00	2.00
9	R	2.00	1.00	2.00
10	A	3.00	2.00	3.00
10	R	2.00	2.00	1.00
11	A	1.00	0.00	4.00
11	R	2.00	2.00	4.00
12	A	3.00	0.00	2.00
12	R	4.00	2.00	2.00
13	A	2.00	3.00	2.00
13	R	1.00	4.00	1.00
14	A	1.00	2.00	3.00
14	R	2.00	1.00	1.00
15	A	2.00	2.00	3.00
15	R	1.00	1.00	0.00
16	A	3.00	1.00	2.00
16	R	1.00	1.00	3.00
17	A	2.00	1.00	3.00
17	R	1.00	1.00	2.00
18	A	4.00	1.00	1.00
18	R	1.00	1.00	2.00

1	A	2.00	2.00	1.00
1	R	1.00	2.00	3.00
2	A	2.00	2.00	1.00
2	R	1.00	2.00	2.00
3	A	2.00	3.00	2.00
3	R	1.00	3.00	3.00
4	A	2.00	3.00	3.00
4	R	2.00	2.00	1.00
5	A	1.00	0.00	2.00
5	R	3.00	1.00	2.00
6	A	2.00	2.00	4.00
6	R	1.00	3.00	2.00
7	A	1.00	2.00	2.00
7	R	3.00	2.00	1.00
8	A	1.00	3.00	1.00
8	R	2.00	1.00	0.00
9	A	3.00	3.00	0.00
9	R	2.00	2.00	1.00
10	A	3.00	2.00	4.00
10	R	1.00	2.00	3.00
11	A	2.00	3.00	4.00
11	R	2.00	1.00	0.00
12	A	2.00	0.00	3.00
12	R	4.00	1.00	0.00
13	A	3.00	0.00	2.00
13	R	2.00	3.00	2.00
14	A	2.00	2.00	0.00
14	R	1.00	3.00	1.00
15	A	1.00	0.00	3.00
15	R	4.00	2.00	3.00
16	A	0.00	4.00	2.00
16	R	0.00	2.00	1.00
17	A	1.00	0.00	2.00
17	R	2.00	1.00	0.00
18	A	1.00	1.00	1.00
18	R	0.00	2.00	2.00

1	A	3.00	1.00	3.00
1	R	2.00	1.00	3.00
2	A	2.00	4.00	3.00
2	R	1.00	2.00	0.00
3	A	2.00	3.00	3.00
3	R	2.00	2.00	2.00
4	A	2.00	2.00	0.00
4	R	0.00	2.00	2.00
5	A	3.00	2.00	4.00
5	R	1.00	2.00	2.00
6	A	0.00	1.00	4.00
6	R	1.00	4.00	1.00
7	A	1.00	1.00	2.00
7	R	3.00	1.00	3.00
8	A	1.00	2.00	3.00
8	R	1.00	1.00	3.00
9	A	2.00	2.00	1.00
9	R	0.00	1.00	2.00
10	A	2.00	1.00	3.00
10	R	2.00	2.00	1.00
11	A	2.00	3.00	4.00
11	R	1.00	3.00	3.00
12	A	3.00	1.00	3.00
12	R	1.00	2.00	1.00
13	A	0.00	2.00	2.00
13	R	2.00	0.00	1.00
14	A	2.00	2.00	2.00
14	R	1.00	1.00	1.00
15	A	1.00	4.00	1.00
15	R	2.00	3.00	1.00
16	A	1.00	1.00	2.00
16	R	2.00	1.00	3.00
17	A	1.00	1.00	2.00
17	R	1.00	2.00	3.00
18	A	1.00	3.00	1.00
18	R	0.00	0.00	2.00

Order: A = Ascending. R = Random.

Appendix C

Intrusion Data for Experiment 1

List	Order	Singles	Doubles	Quadruples	Other
1	A	0.00	0.00	2.00	0.00
1	R	1.00	1.00	0.00	0.00
2	A	2.00	0.00	0.00	0.00
2	R	4.00	1.00	0.00	0.00
3	A	0.00	0.00	1.00	0.00
3	R	2.00	0.00	0.00	0.00
4	A	3.00	0.00	0.00	0.00
4	R	3.00	0.00	0.00	0.00
5	A	1.00	1.00	0.00	0.00
5	R	1.00	0.00	1.00	0.00
6	A	0.00	0.00	0.00	0.00
6	R	0.00	0.00	0.00	0.00
7	A	2.00	0.00	0.00	0.00
7	R	0.00	0.00	0.00	0.00
8	A	1.00	0.00	1.00	0.00
8	R	0.00	2.00	0.00	0.00
9	A	0.00	0.00	0.00	0.00
9	R	1.00	0.00	0.00	0.00
10	A	1.00	0.00	0.00	0.00
10	R	0.00	0.00	0.00	0.00
11	A	0.00	0.00	0.00	0.00
11	R	2.00	0.00	0.00	1.00
12	A	0.00	3.00	0.00	0.00
12	R	1.00	1.00	1.00	0.00
13	A	0.00	0.00	0.00	0.00
13	R	0.00	0.00	1.00	0.00
14	A	0.00	1.00	0.00	0.00
14	R	1.00	1.00	0.00	0.00
15	A	1.00	2.00	0.00	0.00
15	R	0.00	1.00	1.00	0.00
16	A	2.00	1.00	0.00	0.00
16	R	0.00	1.00	1.00	0.00
17	A	2.00	0.00	0.00	0.00
17	R	0.00	1.00	0.00	0.00
18	A	0.00	2.00	1.00	0.00
18	R	2.00	0.00	1.00	0.00

1	A	0.00	0.00	1.00	1.00
1	R	0.00	1.00	0.00	0.00
2	A	0.00	0.00	0.00	0.00
2	R	1.00	1.00	0.00	0.00
3	A	0.00	0.00	0.00	0.00
3	R	1.00	0.00	0.00	0.00
4	A	0.00	1.00	0.00	0.00
4	R	0.00	0.00	0.00	0.00
5	A	1.00	0.00	0.00	0.00
5	R	0.00	0.00	0.00	1.00
6	A	0.00	0.00	0.00	0.00
6	R	0.00	2.00	0.00	0.00
7	A	0.00	0.00	0.00	1.00
7	R	0.00	0.00	0.00	0.00
8	A	1.00	1.00	1.00	0.00
8	R	0.00	0.00	1.00	0.00
9	A	0.00	1.00	0.00	0.00
9	R	0.00	0.00	0.00	0.00
10	A	1.00	0.00	0.00	0.00
10	R	0.00	0.00	0.00	0.00
11	A	1.00	0.00	0.00	0.00
11	R	1.00	1.00	0.00	0.00
12	A	0.00	1.00	0.00	0.00
12	R	1.00	0.00	0.00	1.00
13	A	2.00	0.00	1.00	2.00
13	R	0.00	0.00	0.00	0.00
14	A	3.00	1.00	0.00	0.00
14	R	0.00	2.00	0.00	0.00
15	A	2.00	1.00	1.00	0.00
15	R	0.00	2.00	1.00	0.00
16	A	0.00	0.00	0.00	0.00
16	R	2.00	0.00	0.00	0.00
17	A	0.00	1.00	1.00	0.00
17	R	0.00	1.00	1.00	0.00
18	A	0.00	3.00	0.00	0.00
18	R	1.00	1.00	0.00	0.00

1	A	0.00	0.00	0.00	0.00
1	R	0.00	0.00	0.00	0.00
2	A	0.00	0.00	0.00	0.00
2	R	1.00	0.00	2.00	0.00
3	A	0.00	1.00	0.00	0.00
3	R	0.00	0.00	0.00	0.00
4	A	2.00	0.00	0.00	0.00
4	R	3.00	0.00	0.00	0.00
5	A	2.00	0.00	0.00	0.00
5	R	1.00	1.00	0.00	0.00
6	A	1.00	1.00	0.00	0.00
6	R	0.00	0.00	0.00	0.00
7	A	1.00	0.00	2.00	1.00
7	R	1.00	0.00	0.00	0.00
8	A	0.00	0.00	0.00	0.00
8	R	0.00	0.00	0.00	0.00
9	A	1.00	1.00	0.00	1.00
9	R	0.00	2.00	0.00	0.00
10	A	0.00	0.00	0.00	0.00
10	R	2.00	0.00	0.00	0.00
11	A	0.00	0.00	0.00	0.00
11	R	0.00	0.00	0.00	0.00
12	A	0.00	2.00	1.00	0.00
12	R	4.00	1.00	0.00	0.00
13	A	1.00	0.00	0.00	0.00
13	R	1.00	0.00	1.00	0.00
14	A	0.00	0.00	0.00	0.00
14	R	1.00	0.00	1.00	0.00
15	A	1.00	1.00	0.00	0.00
15	R	0.00	0.00	0.00	0.00
16	A	2.00	1.00	0.00	0.00
16	R	1.00	2.00	1.00	0.00
17	A	1.00	0.00	0.00	0.00
17	R	2.00	0.00	0.00	0.00
18	A	0.00	0.00	0.00	0.00
18	R	3.00	1.00	1.00	0.00

Order: A = Ascending. R = Random.

Appendix D

Clustering Data for Experiment 1

List	Order	Quadruples	Cluster Pairs
2	A	3.00	2.00
4	R	3.00	1.00
5	A	2.00	0.00
6	A	4.00	3.00
7	A	3.00	2.00
7	R	2.00	0.00
8	A	4.00	2.00
9	A	2.00	1.00
9	R	2.00	0.00
10	A	3.00	2.00
11	A	4.00	3.00
11	R	4.00	2.00
12	A	2.00	1.00
12	R	2.00	0.00
13	A	2.00	1.00
14	A	3.00	2.00
15	A	3.00	2.00
16	A	2.00	0.00
16	R	3.00	1.00
17	A	3.00	1.00
17	R	2.00	1.00
18	R	2.00	0.00
1	R	3.00	2.00
2	R	2.00	0.00
3	A	2.00	1.00
3	R	3.00	1.00
4	A	3.00	1.00
5	A	2.00	1.00
5	R	2.00	1.00
6	A	4.00	3.00
6	R	2.00	0.00
7	A	2.00	1.00
10	A	4.00	3.00
10	R	3.00	0.00

11	A	4.00	3.00
12	A	3.00	1.00
13	A	2.00	1.00
13	R	2.00	0.00
15	A	3.00	1.00
15	R	3.00	1.00
16	A	2.00	0.00
17	A	2.00	1.00
18	R	2.00	1.00
1	A	3.00	2.00
1	R	3.00	1.00
2	A	3.00	2.00
3	A	3.00	2.00
3	R	2.00	0.00
4	R	2.00	0.00
5	A	4.00	3.00
5	R	2.00	0.00
6	A	4.00	3.00
7	A	2.00	1.00
7	R	3.00	1.00
8	A	3.00	2.00
8	R	3.00	2.00
9	R	2.00	0.00
10	A	3.00	1.00
11	A	4.00	3.00
11	R	3.00	1.00
12	A	3.00	1.00
13	A	2.00	1.00
14	A	2.00	1.00
16	A	2.00	1.00
16	R	3.00	1.00
17	A	2.00	1.00
17	R	3.00	0.00
18	R	2.00	0.00

Order: A = Ascending. R = Random.

Appendix E

Recall and Serial Order Pair Data for Experiment 2

List	Order	Set Size Awareness	Recall	Quadruples	Serial Order Pairs
1	A	2.00	8.00	2.67	4.00
1	R	2.00	6.00	2.00	1.00
2	A	1.00	9.00	3.00	4.00
2	R	1.00	7.00	2.33	1.00
3	A	3.00	5.00	1.67	1.00
3	R	3.00	5.00	1.67	0.00
4	A	1.00	6.00	2.00	3.00
4	R	1.00	3.00	1.00	0.00
5	A	1.00	6.00	2.00	4.00
5	R	3.00	4.00	1.33	0.00
6	A	3.00	6.00	2.00	4.00
6	R	2.00	5.00	1.67	0.00
7	A	3.00	6.00	2.00	2.00
7	R	3.00	6.00	2.00	1.00
8	A	2.00	9.00	3.00	4.00
8	R	3.00	7.00	2.33	1.00
9	A	3.00	6.00	2.00	3.00
9	R	2.00	8.00	2.67	1.00
10	A	3.00	8.00	2.67	1.00
10	R	3.00	5.00	1.67	0.00
11	A	3.00	6.00	2.00	3.00
11	R	3.00	4.00	1.33	1.00
12	A	1.00	9.00	3.00	2.00
12	R	3.00	6.00	2.00	1.00
13	A	3.00	8.00	2.67	1.00
13	R	3.00	7.00	2.33	1.00
14	A	2.00	7.00	2.33	3.00
14	R	2.00	5.00	1.67	0.00
15	A	3.00	5.00	1.67	0.00
15	R	1.00	4.00	1.33	0.00
16	A	1.00	6.00	2.00	3.00
16	R	3.00	5.00	1.67	0.00
17	A	3.00	9.00	3.00	3.00
17	R	3.00	3.00	1.00	0.00
18	A	2.00	6.00	2.00	3.00
18	R	1.00	6.00	2.00	0.00

19	A	3.00	6.00	2.00	3.00
19	R	3.00	7.00	2.33	1.00
20	A	1.00	8.00	2.67	5.00
20	R	3.00	5.00	1.67	0.00
21	A	1.00	3.00	1.00	0.00
21	R	3.00	5.00	1.67	0.00
22	A	1.00	7.00	2.33	2.00
22	R	3.00	4.00	1.33	0.00
23	A	3.00	8.00	2.67	3.00
23	R	3.00	3.00	1.00	0.00
24	A	3.00	10.00	3.33	7.00
24	R	1.00	7.00	2.33	0.00
25	A	1.00	9.00	3.00	6.00
25	R	1.00	4.00	1.33	0.00
26	A	1.00	7.00	2.33	2.00
26	R	3.00	6.00	2.00	0.00
27	A	3.00	6.00	2.00	2.00
27	R	3.00	4.00	1.33	2.00
28	A	3.00	7.00	2.33	4.00
28	R	3.00	3.00	1.00	1.00
29	A	3.00	7.00	2.33	3.00
29	R	1.00	9.00	3.00	1.00
30	A	1.00	7.00	2.33	3.00
30	R	1.00	5.00	1.67	2.00
31	A	3.00	9.00	3.00	5.00
31	R	1.00	4.00	1.33	0.00
32	A	3.00	7.00	2.33	1.00
32	R	1.00	5.00	1.67	0.00
33	A	3.00	5.00	1.67	1.00
33	R	2.00	4.00	1.33	1.00
34	A	2.00	8.00	2.67	4.00
34	R	2.00	6.00	2.00	0.00
35	A	2.00	9.00	3.00	5.00
35	R	3.00	3.00	1.00	1.00
36	A	2.00	7.00	2.33	3.00
36	R	2.00	4.00	1.33	0.00

37	A	3.00	9.00	3.00	3.00
37	R	2.00	8.00	2.67	0.00
38	A	1.00	6.00	2.00	2.00
38	R	3.00	6.00	2.00	0.00
39	A	1.00	8.00	2.67	4.00
39	R	1.00	7.00	2.33	0.00
40	A	1.00	4.00	1.33	0.00
40	R	3.00	7.00	2.33	0.00
41	A	1.00	9.00	3.00	6.00
41	R	2.00	5.00	1.67	0.00
42	A	1.00	8.00	2.67	2.00
42	R	2.00	6.00	2.00	1.00
43	A	3.00	6.00	2.00	3.00
43	R	3.00	6.00	2.00	1.00
44	A	1.00	7.00	2.33	3.00
44	R	3.00	4.00	1.33	0.00
45	A	2.00	6.00	2.00	2.00
45	R	3.00	6.00	2.00	0.00
46	A	3.00	4.00	1.33	1.00
46	R	1.00	5.00	1.67	0.00
47	A	1.00	6.00	2.00	3.00
47	R	3.00	7.00	2.33	0.00
48	A	1.00	8.00	2.67	5.00
48	R	3.00	5.00	1.67	0.00
49	A	1.00	7.00	2.33	2.00
49	R	3.00	6.00	2.00	1.00
50	A	1.00	12.00	3.00	11.00
50	R	3.00	4.00	1.33	0.00
51	A	3.00	4.00	1.33	1.00
51	R	1.00	6.00	2.00	0.00
52	A	3.00	4.00	1.33	0.00
52	R	2.00	6.00	2.00	0.00
53	A	1.00	6.00	2.00	0.00
53	R	3.00	4.00	1.33	0.00
54	A	1.00	6.00	2.00	2.00
54	R	3.00	4.00	1.33	0.00

Order: A = Ascending. R = Random.
Set Size Awareness: 1 = Aware. 2 = Somewhat Aware. 3 = Not Aware.

Appendix F

Intrusion Data for Experiment 2

List	Order	Presented Deciles	Non-presented Deciles	Total
1	A	1.00	0.00	1.00
1	R	1.00	0.00	1.00
2	A	0.00	0.00	0.00
2	R	1.00	0.00	1.00
3	A	3.00	0.00	3.00
3	R	0.00	1.00	1.00
4	A	1.00	5.00	6.00
4	R	2.00	0.00	2.00
5	A	0.00	0.00	0.00
5	R	0.00	0.00	0.00
6	A	0.00	5.00	5.00
6	R	2.00	0.00	2.00
7	A	0.00	1.00	1.00
7	R	0.00	1.00	1.00
8	A	1.00	0.00	1.00
8	R	1.00	1.00	2.00
9	A	1.00	1.00	2.00
9	R	0.00	0.00	0.00
10	A	1.00	0.00	1.00
10	R	0.00	0.00	0.00
11	A	1.00	2.00	3.00
11	R	0.00	1.00	1.00
12	A	0.00	1.00	1.00
12	R	0.00	0.00	0.00
13	A	2.00	0.00	2.00
13	R	2.00	0.00	2.00
14	A	3.00	0.00	3.00
14	R	3.00	0.00	3.00
15	A	3.00	0.00	3.00
15	R	0.00	0.00	0.00
16	A	1.00	2.00	3.00
16	R	0.00	0.00	0.00
17	A	0.00	0.00	0.00
17	R	2.00	0.00	2.00
18	A	2.00	0.00	2.00
18	R	1.00	0.00	1.00

19	A	1.00	1.00	2.00
19	R	0.00	0.00	0.00
20	A	1.00	0.00	1.00
20	R	1.00	0.00	1.00
21	A	3.00	0.00	3.00
21	R	0.00	0.00	0.00
22	A	0.00	1.00	1.00
22	R	0.00	0.00	0.00
23	A	2.00	2.00	4.00
23	R	3.00	0.00	3.00
24	A	1.00	0.00	1.00
24	R	2.00	0.00	2.00
25	A	1.00	0.00	1.00
25	R	1.00	0.00	1.00
26	A	2.00	0.00	2.00
26	R	1.00	0.00	1.00
27	A	0.00	0.00	0.00
27	R	1.00	0.00	1.00
28	A	1.00	0.00	1.00
28	R	1.00	0.00	1.00
29	A	1.00	0.00	1.00
29	R	1.00	0.00	1.00
30	A	0.00	0.00	0.00
30	R	0.00	0.00	0.00
31	A	2.00	2.00	4.00
31	R	1.00	0.00	1.00
32	A	1.00	2.00	3.00
32	R	2.00	0.00	2.00
33	A	0.00	6.00	6.00
33	R	1.00	0.00	1.00
34	A	0.00	1.00	1.00
34	R	2.00	0.00	2.00
35	A	0.00	0.00	0.00
35	R	2.00	0.00	2.00
36	A	1.00	1.00	2.00
36	R	3.00	0.00	3.00

37	A	0.00	1.00	1.00
37	R	1.00	0.00	1.00
38	A	1.00	1.00	2.00
38	R	2.00	0.00	2.00
39	A	4.00	0.00	4.00
39	R	0.00	0.00	0.00
40	A	1.00	0.00	1.00
40	R	0.00	0.00	0.00
41	A	3.00	0.00	3.00
41	R	1.00	0.00	1.00
42	A	1.00	0.00	1.00
42	R	0.00	0.00	0.00
43	A	1.00	0.00	1.00
43	R	3.00	1.00	4.00
44	A	1.00	0.00	1.00
44	R	0.00	0.00	0.00
45	A	1.00	0.00	1.00
45	R	4.00	0.00	4.00
46	A	0.00	1.00	1.00
46	R	4.00	0.00	4.00
47	A	1.00	7.00	8.00
47	R	4.00	0.00	4.00
48	A	0.00	0.00	0.00
48	R	1.00	2.00	3.00
49	A	1.00	0.00	1.00
49	R	1.00	2.00	3.00
50	A	0.00	0.00	0.00
50	R	0.00	1.00	1.00
51	A	4.00	0.00	4.00
51	R	4.00	0.00	4.00
52	A	1.00	5.00	6.00
52	R	0.00	0.00	0.00
53	A	2.00	4.00	6.00
53	R	1.00	0.00	1.00
54	A	0.00	0.00	0.00
54	R	2.00	0.00	2.00

Order: A = Ascending. R = Random.

Appendix G

Clustering Data for Experiment 2

List	Order	ARC Scores	Cluster Pairs
1	A	0.69	4.00
1	R	-0.80	0.00
2	A	1.00	6.00
2	R	1.00	4.00
3	A	0.29	2.00
3	R	-0.67	0.00
4	A	1.00	3.00
4	R	-2.03	0.00
5	A	1.00	3.00
5	R	1.00	1.00
6	A	1.00	4.00
6	R	0.29	2.00
7	A	1.00	4.00
7	R	-0.50	0.00
8	A	0.74	5.00
8	R	0.17	3.00
9	A	1.00	3.00
9	R	-0.54	0.00
10	A	-0.33	1.00
10	R	-0.25	1.00
11	A	0.40	3.00
11	R	0.00	1.00
12	A	0.50	4.00
12	R	-0.20	1.00
13	A	0.08	2.00
13	R	-0.17	1.00
14	A	0.50	3.00
14	R	-1.00	0.00
15	A	0.17	1.00
15	R	1.00	1.00
16	A	1.00	4.00
16	R	0.17	1.00
17	A	1.00	6.00
17	R	1.00	1.00
18	A	1.00	3.00
18	R	-0.20	1.00

19	A	1.00	3.00
19	R	-0.31	1.00
20	A	1.00	5.00
20	R	1.00	3.00
21	R	-0.67	0.00
22	A	1.00	5.00
22	R	-1.00	0.00
23	A	1.00	5.00
23	R	-2.03	0.00
24	A	1.00	7.00
24	R	0.61	3.00
25	A	0.74	5.00
25	R	-1.00	0.00
26	A	1.00	4.00
26	R	0.40	2.00
27	A	1.00	4.00
27	R	-1.00	0.00
28	A	1.00	4.00
29	A	1.00	4.00
29	R	0.75	5.00
30	A	1.00	4.00
30	R	-0.67	0.00
31	A	0.74	5.00
31	R	-1.00	0.00
32	A	1.00	5.00
32	R	-0.67	0.00
33	A	0.29	2.00
33	R	-1.00	0.00
34	A	1.00	5.00
34	R	0.40	2.00
35	A	1.00	6.00
36	A	0.61	3.00
36	R	1.00	2.00

37	A	1.00	6.00
37	R	1.00	5.00
38	A	0.40	2.00
38	R	0.40	1.00
39	A	0.67	4.00
39	R	1.00	4.00
40	A	-1.00	0.00
40	R	0.61	3.00
41	A	1.00	6.00
41	R	0.29	2.00
42	A	0.38	3.00
42	R	-0.20	1.00
43	A	1.00	3.00
43	R	-1.40	0.00
44	A	0.61	3.00
44	R	1.00	1.00
45	A	1.00	3.00
45	R	-0.50	1.00
46	A	1.00	2.00
46	R	1.00	3.00
47	A	0.50	3.00
47	R	0.56	3.00
48	A	1.00	5.00
48	R	0.17	1.00
49	A	0.61	3.00
49	R	-1.00	1.00
50	A	1.00	9.00
50	R	-1.00	0.00
51	A	1.00	1.00
51	R	0.40	2.00
52	A	-1.00	0.00
52	R	0.00	1.00
53	A	0.00	1.00
53	R	-1.00	0.00
54	A	1.00	3.00
54	R	-1.00	0.00

Order: A = Ascending. R = Random.

Appendix H

Number Lists Presented in Experiment 1

List	Order	Number List
1	A	11 26 28 32 33 54 68 81 84 86 87 91
1	R	81 33 91 84 28 68 87 32 11 86 26 54
2	A	11 14 26 33 45 47 72 87 91 94 96 98
2	R	91 45 72 98 11 33 96 47 26 94 14 87
3	A	14 22 23 45 56 63 68 71 72 75 77 94
3	R	71 68 94 75 23 56 77 22 45 72 63 14
4	A	28 32 41 44 53 54 56 58 63 75 81 87
4	R	56 87 28 58 81 75 54 44 32 53 41 63
5	A	16 32 33 35 37 47 58 62 65 81 91 94
5	R	35 62 16 32 65 58 37 91 81 33 94 47
6	A	11 14 16 18 23 35 62 72 75 84 86 96
6	R	11 75 23 14 72 62 18 86 35 16 84 96
7	A	18 22 23 26 28 41 54 56 77 84 96 98
7	R	28 98 18 22 54 84 26 56 77 23 96 41
8	A	22 35 37 41 44 45 47 53 65 71 77 98
8	R	44 71 53 41 37 98 47 35 22 45 77 65
9	A	16 18 37 44 53 58 62 63 65 68 71 86
9	R	62 53 71 65 16 44 63 18 86 68 58 37
10	A	13 21 24 25 27 46 52 74 76 83 88 93
10	R	25 76 46 24 88 13 21 83 93 27 74 52
11	A	12 13 15 17 25 31 61 67 74 88 92 93
11	R	13 93 31 12 67 88 17 92 74 15 61 25
12	A	12 31 34 36 38 46 48 55 67 82 85 92
12	R	34 46 55 38 85 12 31 82 92 36 48 67
13	A	25 27 34 48 51 52 55 57 64 66 76 83
13	R	51 64 34 55 66 76 52 25 48 57 27 83
14	A	12 13 27 42 43 57 61 73 74 76 78 95
14	R	74 13 27 76 12 95 73 42 61 78 43 57
15	A	15 21 24 31 34 43 78 82 92 93 95 97
15	R	97 31 78 93 24 82 92 21 15 95 34 43
16	A	15 17 21 36 52 55 64 82 83 85 88 97
16	R	83 17 36 85 52 64 82 55 21 88 15 97
17	A	17 36 38 42 51 61 64 66 67 73 78 85
17	R	61 38 17 66 73 51 64 78 42 67 36 85
18	A	24 38 42 43 46 48 51 57 66 73 95 97
18	R	48 51 66 42 57 24 46 95 73 43 97 38

Order: A = Ascending. R = Random.

Appendix I

Number Lists Presented in Experiment 2

List	Order	Number List
1	A	13 15 17 18 41 45 46 48 82 84 85 87
1	R	48 13 85 17 46 87 41 15 82 45 84 18
2	A	32 35 37 38 61 64 65 68 72 75 77 78
2	R	37 68 72 38 77 61 75 32 65 78 64 35
3	A	21 23 25 28 52 54 56 57 91 95 96 98
3	R	21 95 56 98 25 57 91 52 28 54 23 96
4	A	22 24 26 28 61 64 67 68 82 83 85 88
4	R	28 83 64 22 68 82 67 24 88 61 85 26
5	A	33 34 36 38 52 54 55 58 92 93 96 98
5	R	96 55 34 92 38 54 36 98 52 33 58 93
6	A	11 14 17 18 41 43 45 48 72 75 76 78
6	R	41 18 72 14 48 75 11 78 45 76 17 43
7	A	31 32 34 38 51 53 55 58 72 74 76 78
7	R	53 38 76 55 78 34 72 58 31 74 32 51
8	A	12 13 15 18 41 44 46 48 82 84 87 88
8	R	82 15 44 88 41 13 48 84 12 46 18 87
9	A	23 25 27 28 31 33 36 38 91 92 95 97
9	R	95 23 38 91 36 27 33 97 28 31 25 92
10	A	21 23 26 28 52 55 56 58 71 72 74 77
10	R	23 74 58 21 52 77 55 28 72 56 71 26
11	A	11 14 15 18 42 43 45 48 91 93 95 96
11	R	15 43 91 45 14 95 48 96 11 93 42 18
12	A	32 34 35 37 63 65 66 68 81 84 85 87
12	R	85 68 34 81 35 63 32 87 66 37 65 84
13	A	22 24 25 28 42 44 46 47 71 72 75 77
13	R	75 46 28 47 72 25 44 22 71 24 42 77
14	A	12 13 15 18 63 64 66 68 82 84 85 87
14	R	82 63 12 87 13 64 18 84 66 15 68 85
15	A	32 33 36 38 52 54 55 57 93 95 97 98
15	R	36 97 55 33 54 95 52 38 93 57 98 32
16	A	21 23 25 26 61 62 64 66 92 94 95 98
16	R	25 61 95 26 94 66 92 23 64 98 62 21
17	A	12 15 17 18 41 44 46 48 71 73 75 76
17	R	46 73 12 41 15 76 17 44 71 18 75 48
18	A	31 33 34 37 53 55 57 58 81 82 84 87
18	R	34 82 53 31 57 81 58 33 87 55 84 37

19	A	12	15	17	18	61	64	66	67	71	72	76	78
19	R	18	61	78	15	71	66	72	17	64	76	67	12
20	A	21	23	24	26	42	44	46	47	81	82	85	88
20	R	82	24	42	81	46	21	47	88	26	44	23	85
21	A	31	32	34	36	53	54	56	58	61	62	65	67
21	R	56	34	62	31	58	61	36	65	54	67	32	53
22	A	21	24	26	27	61	63	67	68	91	93	95	96
22	R	61	95	27	63	24	96	21	68	93	26	91	67
23	A	31	32	35	37	52	54	56	57	71	73	77	78
23	R	31	57	78	52	37	71	54	77	32	73	56	35
24	A	13	15	17	18	41	44	46	47	83	85	86	88
24	R	88	41	18	86	13	47	15	83	46	17	44	85
25	A	12	15	17	18	51	54	56	57	71	72	75	77
25	R	77	51	18	75	17	56	15	71	54	12	57	72
26	A	23	24	26	28	61	62	64	66	92	94	95	98
26	R	66	95	23	62	24	98	26	64	92	28	94	61
27	A	32	34	37	38	42	43	46	48	81	83	85	87
27	R	48	85	37	43	32	83	38	46	81	34	87	42
28	A	31	34	35	38	61	62	65	67	91	94	95	98
28	R	94	67	35	61	98	34	65	38	95	31	62	91
29	A	11	14	16	17	42	44	45	47	71	72	74	78
29	R	78	44	16	71	14	47	11	72	45	17	42	74
30	A	21	22	25	27	51	53	57	58	81	84	85	88
30	R	88	25	57	22	81	58	27	51	84	53	21	85
31	A	11	13	14	17	61	65	67	68	93	94	96	98
31	R	93	61	14	67	96	11	65	17	98	13	68	94
32	A	33	35	36	38	42	44	45	48	71	74	77	78
32	R	78	44	38	77	36	48	35	71	42	33	45	74
33	A	21	24	25	27	51	53	56	58	81	83	84	87
33	R	21	84	56	24	51	87	53	25	81	58	83	27
34	A	31	32	34	37	43	44	46	48	81	83	87	88
34	R	31	88	43	34	46	81	48	32	87	44	83	37
35	A	22	24	25	27	63	65	66	68	72	74	75	78
35	R	24	63	72	27	75	66	78	25	68	74	65	22
36	A	11	14	15	18	53	55	57	58	91	92	95	97
36	R	11	58	92	15	91	57	95	18	53	97	55	14

37	A	31	33	34	38	51	53	56	57	81	82	84	86
37	R	51	86	34	57	38	84	31	56	82	33	81	53
38	A	13	15	16	18	61	64	65	68	92	94	95	97
38	R	64	13	92	65	94	15	97	61	18	95	16	68
39	A	21	22	24	26	41	45	46	48	72	74	75	78
39	R	21	75	41	22	45	78	46	24	72	48	74	26
40	A	22	24	25	28	61	63	65	68	92	94	96	97
40	R	96	68	22	65	94	28	63	25	97	24	61	92
41	A	32	33	35	37	41	44	47	48	82	83	85	88
41	R	48	83	32	85	47	35	88	37	41	33	82	44
42	A	11	13	14	16	51	52	55	58	71	73	75	77
42	R	16	58	71	13	77	55	73	14	51	75	52	11
43	A	31	33	35	38	61	64	66	68	92	93	96	98
43	R	68	96	33	61	38	93	35	66	98	31	92	64
44	A	21	24	26	28	42	44	45	48	71	72	74	76
44	R	26	71	45	21	48	74	42	24	76	44	72	28
45	A	12	14	16	17	52	53	56	58	81	83	84	88
45	R	81	58	16	83	17	52	14	88	53	12	56	84
46	A	13	14	16	18	51	53	55	57	72	75	76	78
46	R	57	18	72	13	55	78	16	75	53	76	14	51
47	A	31	35	37	38	42	43	46	48	81	83	85	88
47	R	35	43	88	46	31	85	48	81	37	83	42	38
48	A	21	23	25	28	61	63	64	66	91	94	97	98
48	R	91	63	28	61	94	21	64	23	98	25	66	97
49	A	11	14	15	18	63	65	67	68	71	73	76	78
49	R	67	18	76	14	68	73	15	71	63	78	11	65
50	A	22	23	25	28	41	43	45	46	81	83	84	88
50	R	28	43	84	45	23	88	41	83	25	81	46	22
51	A	31	33	37	38	53	54	56	58	92	94	95	98
51	R	54	37	95	56	98	31	92	58	33	94	38	53
52	A	12	13	15	18	42	44	45	47	92	94	96	98
52	R	98	45	13	44	92	18	47	12	96	15	42	94
53	A	21	23	25	28	61	63	66	67	83	85	87	88
53	R	21	66	85	67	28	83	61	87	23	88	63	25
54	A	32	34	35	38	51	52	56	58	71	73	76	77
54	R	32	71	56	35	52	77	51	38	76	58	73	34

Order: A = Ascending. R = Random.

Appendix J

Letter of Approval from Human Subjects Institutional Review Board

San José State
UNIVERSITY

Office of the Provost
Associate Vice President
Graduate Studies & Research

One Washington Square
San José, CA 95192-0025
Voice: 408-924-2427
Fax: 408-924-2477

E-mail: gradstudies@sjsu.edu
http://www.sjsu.edu

To: Gregory Christopher Savage

From: Pamela Stacks, Ph.D.
Associate Vice President
Graduate Studies and Research

Date: April 12, 2007

The Human Subjects-Institutional Review Board has approved your request for an extension to the use of human subjects in the study entitled:

"The effects of presentation order and category size on recall of two-digit numbers"

This approval is contingent upon the subjects participating in your research project being appropriately protected from risk. This includes the protection of the anonymity of the subjects' identity when they participate in your research project, and with regard to all data that may be collected from the subjects. The approval includes continued monitoring of your research by the Board to assure that the subjects are being adequately and properly protected from such risks. If at any time a subject becomes injured or complains of injury, you must notify Dr. Pamela Stacks, Ph.D. immediately. Injury includes but is not limited to bodily harm, psychological trauma, and release of potentially damaging personal information. This approval for the human subject's portion of your project is in effect for one year, and data collection beyond April 12, 2008 requires an extension request.

Please also be advised that all subjects need to be fully informed and aware that their participation in your research project is voluntary, and that he or she may withdraw from the project at any time. Further, a subject's participation, refusal to participate, or withdrawal will not affect any services that the subject is receiving or will receive at the institution in which the research is being conducted.

If you have any questions, please contact me at (408) 924-2480.

Mark Van Selst, 0120