The Journal of Undergraduate Research

Volume 8 *Journal of Undergraduate Research, Volume 8: 2010*

Article 6

2010

Serial and Concurrent Presentations of Stimuli and Their Effects on Items Recalled

Dustin J. Rhoades
South Dakota State University

Jordan Sippel
South Dakota State University

Serial and Concurrent Presentations of Stimuli and Their Effects on Items Recalled

Authors: Dustin J. Rhoades, Jordan Sippel
Faculty Advisor: Dr. Deborah Spear
Department: Psychology

ABSTRACT

The present study examined differences in accuracy of responses to serial and concurrent stimuli in an immediate free recall task for individuals from chemistry and psychology courses. Average accuracy of responses for presentation order, stimulus type, and gender differences were measured. The procedure used Superlab 4.0 and consisted of one practice trial followed by eight recorded trials of serial and concurrent word lists. Counterbalancing was used to try to control learning of one order of presentation over the opposite order. Serial word lists consisted of ten words presented two seconds apart and one at a time. Concurrent lists consisted of ten words presented simultaneously for twenty seconds. No significant main effects of presentation order, stimulus type, or gender were found when calculating a mixed ANOVA. No gender differences in accuracy between the two types of stimuli were expected. There were also no significant effects of the interactions for these variables. However, a medium effect was found for the interaction of presentation order and stimulus type. Increasing the population may lead to a significant effect of the presentation order by stimulus type interaction.

Immediate free recall (IFR) is a common method used to try to determine individual differences in the number of stimuli (usually words) that can be stored in working (short-term) memory (Bhatarah, Ward, Smith & Hayes, 2009; Huang, Tomasini & Nikl, 1977; Seiler & Engelkamp, 2003; Ward & Maylor, 2005). Most often, a recall task involves participants presented with a given number of words in a serial presentation. Presentation of this format is a specific word, followed every one or two seconds by each consecutive word, until the list is complete (Bhatarah et al, 2009; Matlin, 1976). Stimuli presentation is either oral or visual depending on the procedure (Baumeister & Luszcz, 1976; Ozubko & Joordens, 2007). IFR is employed promptly following the final stimulus. According to Laming (2009), the recall task regularly occurs for one minute; and at this time, individuals write down or verbally list as many items as they can remember (Russo & Grammatopoulou, 2003; Smith, Jones & Broadbent, 1981). This provides the measurement of recall as number of items remembered, or accuracy of recall.

According to current theory, working memory consists of a system that briefly stores and processes information from the environment, from long-term memory, as well as maintaining and altering stimuli that are still currently in the system itself (Gazzaniga, Ivry & Mangun, 2009). The phonological loop is one aspect of the working memory system and its main function is the encoding and rehearsal of stimuli such as words. Verbal stimuli, rehearsed or processed by the phonological loop, may stay in the working memory system,

or may be processed and stored in long-term memory. IFR procedures record the number of words processed and subvocally rehearsed in the phonological loop (Campoy, 2008). The words at the beginning of the list tend to be encoded in long-term memory and the most recent words in the list are thought to be present in the short-term store, or working memory.

Accuracy of recall, the number of items correctly recalled, using serial presentation of stimuli, spans most of the literature over the past forty years (Campoy, 2008; Haist, Shimamura & Squire, 1992; Joseph, McKay & Joseph, 1982; Matlin, 1976). Students make up the participants in many of the studies by performing serial presentation recall tasks (Bhatarah et al, 2009; Seiler & Engelkamp, 2003; Ward & Tan, 2004). Serial presentation of IFR is used to test accuracy of individuals' working memory; concurrent presentation, in a similar manner, is useful for the same reason.

Very few recall tests include concurrent presentation of stimuli (Harness, Jacot, Scherf, White & Warnick, 2008; Sneed, Brunts, Mueller, 1977). This method presents all the stimulus words simultaneously to the participants. Once the stimulus exposure period ends, individuals perform the recall task as they would in serial presentation formats. Concurrent presentation recall procedures have been used to compare recall accuracy of schizophrenic populations versus healthy subjects (Brebion, David, Bressan & Pilowsky, 2006). It was found that healthy subjects did have increased accuracy in the free recall task. Concurrent lists, presenting all the words at the same time, may lead to many words being processed into the long-term store, or may allow more words to remain in short-term memory.

Some studies suggest that concurrent presentation is believed to lead to diminished accuracy of items recalled in comparison to serial presentation. (Hoppe, Stojanovic, Karg Foundation Young Researchers Group 2008/09, & Elger, 2009). Sneed, Brunts, and Mueller (1977) found that concurrent lists of more than two words decreased performance in free recall. Theoretically, this is due to less ability to process single words in a concurrent list because the individual will instead process that list as a „chunk,' in which case the entirety of the list can be one single stimulus, as well as a few words, or even just one word. Other research has shown that the availability of more words can also lead to increased recall stemming from the ability to make more chunks from a larger set of words, leading to recalling more words in the list (Chen & Cowan, 2005; Miller, 1956). It is also possible that one chunk can even cue the participant for the next chunk in a list, further increasing the likelihood of recalling more words (2005).

The present study aims to determine if format of presentation alters the number of items remembered for each individual. If there is a difference between the accuracy of responses to each presentation, this may lead to increased understanding of the working memory model. If concurrent presentation of stimuli leads to an increased number of accurate responses, it is possible that the list presenting all the stimuli simultaneously allows individuals to process more words and move them into long-term memory. Participants will recall eight lists of words in concurrent presentation and eight lists in serial presentation. Counterbalancing of each presentation type, by switching around the order of presentation, should help counteract learning of one presentation over the other, if accuracy of recalled items increases temporally. This study does not employ the use of distractors between serial presentation stimuli. This allows for performance of chunking in both presentations. Participants can also covertly rehearse words from the lists. Covert rehearsal is the process of practicing the words without orally reciting them. Chunking and covert rehearsal are two of the main strategies used to

remember words in a recall task (Eagle, 1967). Accuracy will be determined by the number of items recalled that are perfect matches.

Differences in accuracy of items recalled for concurrent compared to serial presentation of stimuli for individuals is the focus of this paper. The effects of stimulus type are expected to alter accuracy. However, it is not clear whether concurrent or serial presentation will lead to increased accuracy. Order of presentation will also be reported. It is expected that as individuals proceed through the serial and concurrent presentation tasks, some learning will occur and items remembered will increase over time for both stimuli presentations for all individuals. As mentioned earlier, counterbalancing will control for learning of the presentation types in a specific order. As a quasi-experimental variable, gender differences in accuracy of items recalled shall be examined. There is expected to be no difference between the accuracy scores of men and women.

METHOD

Participants

Forty-eight undergraduate students at South Dakota State University participated in the free recall task. Psychology majors (2 males, 13 females), Chemistry majors (16 males, 15 females) and other majors (2 males, 0 females) made up the sample. Individuals in some courses were offered extra credit for their participation in the study. Those students in classes where extra credit was offered for participation who did not want to be a part of the study were given alternate opportunities for extra credit by their professors. Recruitment of students took place in psychology, sociology, and chemistry classes. Students taking part in the study also had their name entered into a drawing for a fifty-dollar gift certificate to the SDSU Bookstore. The Institutional Review Board approved the procedure and participants gave implied consent prior to performing the task. Data from students with any of the following criteria was not used: diagnosis of psychiatric or behavioral disorders, those currently under the influence of alcohol, any other illegal substances, anti-anxiety, anti-depressant, anti-histamine, or cold medication, history of epilepsy or seizures, students taking medication for Attention Deficit Disorder, and any student under the age of eighteen. The basis for data use was voluntary consent of each participant.

Materials

This immediate free recall task implemented the use of the English Lexicon Project (ELP) Database for word selection (Balota et al, 2007). Using the database allowed for controlling the word length for each item in the word lists, as well as the frequency of use, in the English language. Words for all the lists were four or five letters long. Hyperspace Analogue to Language (HAL) frequency norms were used to set the parameters of word frequency. The list of words was narrowed down from the 3815 most frequently used four and five letter words to a list of 180 that were randomly selected to 18 trial lists via Microsoft Excel.

Superlab 4.0 (Cedrus Corporation, 2009), a computer program, was used to conduct the recall task on a color-monitor computer. Performance of the recall task occurred in sets of one practice trial followed by eight recorded trials for concurrent stimuli or serial stimuli.

Whichever stimuli were presented for the first nine trials was then followed by a practice trial and eight recorded trials of the other stimulus type. On the computer, serial presentation occurred with a list of words one after the other. The single word appeared in the center of the screen for two seconds and was immediately on the screen as the trial began. The second word in the list, and all proceeding words, replaced the one before it after the two-second time limit. There was no interval between words. At the end of the list of ten words, the screen read "Begin Recall Now" and "Press 1 to End Recall."

For concurrent presentation, the list of ten words appeared on the screen simultaneously. In order to try to reduce chunking as much as possible, the words were presented on separate lines and spread across the page. One word appeared on the first line, and the second word was on the next line but across the page, with at least 14 spaces between them. This process was used for each word, spanning the entire screen. As with the serial presentation, the concurrent presentation appeared for two seconds per word, or for 20 seconds concurrently. After the 20 seconds, the "Begin Recall Now" screen appeared.

Participants used paper and a pencil to write down their responses for each recall task. The paper was cut in half and each half-sheet of paper was stapled together into a packet consisting of 16 half-sheets, eight each for the concurrent and serial lists. A demographic survey at the end of the task obtained age, gender, and class standing for each participant. Recorded answers were also printed using pencil and paper. The experimenters collected data after the procedure period ended.

Procedure

The recall task was conducted in a computer lab, on multiple days, with each session supervised by one experimenter. Participants followed along as the experimenter read the consent form. The final statement from the consent form stated that moving on with the study would imply consent. Prior to the participants' arrival, the computers were set up and ready to run the recall task. Each stimulus presentation consisted of a practice trial and eight trials of recorded recall. The experimenter read the directions for each task prior to running through the practice and recorded trials. Each trial of serial lists contained ten words presented one at a time. The first word appeared immediately after a command was entered by the participant, and stayed on the screen for two seconds. Each word that followed immediately appeared after two seconds. After ten words, the screen presenting "Begin Recall Now" and "Press 1 to End Recall" flashed on the screen. This screen appeared for one minute, unless the participant pressed the "1" key, in which case the screen would go blank.

After eight trials the directions for the concurrent presentation was read. The only difference for the concurrent presentation consisted of all ten words presented simultaneously for 20 seconds instead of one at a time for two seconds each. Again, the "Begin Recall Now" screen prompted the participants to begin writing down the words for each trial. Participants wrote their answers on a sheet of paper and flipped it over for each proceeding list.

Following the recall task, a demographic survey collected the age, gender, and class standing of each participant. This survey, which was recorded using pencil and paper, also had a question asking if consent was given to use the data for our study. Individuals could respond "yes," implying the data could be used, or "no," implying their data could not be used. Debriefing was included as well as informing the participants about the recall task and

what it was intended to accomplish. Before and after the task, individuals were told they did not need to participate.

Results

Figure 1 shows the average (*SD*) number of correct responses to concurrent and serial stimuli as a function of presentation order. For the individuals performing serial followed by concurrent stimuli (Group 1), participants have an increased score on concurrent stimuli (*M* = 46.33, *SD* = 10.18). This is the largest mean for any stimulus type for either presentation order. The average correct responses for concurrent stimuli, by the concurrent followed by serial presentation participants (Group 2) is the lowest average score of accuracy (*M* = 41.17, *SD* = 8.01). Serial stimuli for Group 1 (*M* = 44.04, *SD* = 9.83) and Group 2 (*M* = 43.17, *SD* = 8.10) are both relatively close and fall between the concurrent scores of each group.
As the current study is set to determine any differences in presentation order, stimulus type, and gender, a two-way mixed ANOVA was calculated. The descriptive statistics for gender as a function of presentation order and stimulus type are shown in Table 1. This data shows that Group 1 men have the highest average number of correct responses to concurrent stimuli. Group 1 men also have the largest average number of correct responses to serial stimuli. However, Group 2 men have the lowest average scores to serial as well as concurrent stimuli, when compared to Group 1 men and Group 1 and 2 women.

The two-way mixed ANOVA shows no main effect of the within factor of stimulus type F (1/94) = .027, p = .871. Data for all interactions of significance, and error, for this ANOVA are presented in Table 2, which shows the within-subjects factors, and Table 3, showing the between subjects factors. Gender F (1/47) = .328, p = .57 and presentation order F (1/47) = 2.65, p = .111, the between subjects factors, also show no significant main effect. As Table 3 shows the stimulus type and presentation order interaction shows a significant effect at p = .073, if significance level is at $p < 0.1$.

Discussion

Analyzing the results of the mixed ANOVA showed no significant effect of stimulus type, presentation order, gender, or any of their interactions. However, a medium effect was found for the interaction of stimulus type by presentation order. The results showed that participants in Group 1 and Group 2 both had increased scores as they moved from one presentation type to the other, but not at a significant level. This finding leads to the possibility that presentation of one stimuli followed by the other stimuli could allow for a learning process in a temporal manner. This could allow individuals to have more responses that are accurate in the second stimulus list. With a medium effect size it may be possible that if the number of participants increased, a significant effect may be seen for the presentation order and stimulus type interaction.

Looking at the results of the presentation order by stimulus type interaction, a greater accuracy rate for Group 1 is possibly related to performing the serial presentation followed by the concurrent presentation and learning the procedure. According to Cowan (2001), if participants are allowed to see a list for a longer time, they are going to make larger chunks. Since Group 1 saw the concurrent lists second in the presentation order, they may have learned the procedure by performing the serial lists; and then performed better once doing

the concurrent lists because it makes chunking more likely. Chunking has been found to increase accuracy during recall (Eagle, 1967). Group 2 learned the procedure using the concurrent list first; so they may not have performed as well as Group 1 on the second list, which was serial for Group 2 individuals. If learning is what lead to an increase in the average number of correct responses for both groups on the second set of stimulus lists, then doing the concurrent list second may increase the number of correct responses at a higher rate than performing the serial presentation second.

Bhatarah, Ward, Smith and Hayes (2009) found that faster presentation rates decreased the accuracy of recall. The current study did not find a significant difference between concurrent and serial presentation. However, presentation of the serial list, one word at a time, prior to the concurrent stimuli lists, may allow the participants in Group 1 to have increased accuracy on the concurrent lists. This may be due to learning the procedure and then having a longer exposure to the concurrent list, which could increase the likelihood of chunking (Cowan, 2001). Since both Group 1 and Group 2 had a slight increase in the number of accurate responses on their second presentation, it is possible that learning of the procedure may be likely. Counterbalancing the word lists and not just the presentation order would be a benefit to future research. Then it would be possible to see if the second half of the task had an increased number of words that could be recalled easier, or if learning is why the participants performed better on the second set of presentations.

Gender differences for stimulus type and presentation order did not show any significant effect either. However, men in Group 1 did have increased average accuracy scores on both serial and concurrent lists, compared to men in Group 2, and women in both groups. It was expected to find no significant difference in the average number of accurate responses by men compared to women. Thus, this portion of the hypothesis is correct.

One important aspect to this study is that it found no significant difference between individuals' scores of accuracy for the two stimulus types. This might lead to more use of concurrent stimuli in recall procedures. The lack of a significant difference between average accuracy scores of individuals for each stimulus type does show that the two presentations may use the same method of processing into long-term memory for words rehearsed when the presentation began, and processing of recent words in working memory.

Comparing accuracy scores of concurrent and serial presentation does allow for increased generalizability in the recall literature. There are few studies that have compared the average correct responses to stimuli in a concurrent compared to a serial presentation. Not one study was found that used ten words presented in each type as this one did. It is also possible that a significant effect may have been found if close matches were counted as correct responses along with the correctly spelled matches.

Further work on this procedure could make use of questioning the participants on what strategy they used while the presentation of words occurred. If participants explained that they used chunking or covert rehearsal, the data may explain learning strategies and the differences in accuracy for each type. Chunking has been shown to increase accuracy scores in comparison to rehearsal (Eagle, 1967). Otherwise, giving them directions that do not allow a specific strategy could be implemented. Using articulatory suppression, a process of making the participant repeatedly say a word, or words, during the presentation of stimuli, could be used to control for chunking and rehearsal in both of these presentations (Russo &

Grammatopoulou, 2003). Also, delaying the recall portion of the task may show differences in the accuracy of stimuli presentation. If participants are given time to rehearse the words during a delay, between presentation and recall, it is possible that a difference in the encoding of serial and concurrent stimuli would possibly show a difference in accuracy (Campoy, 2008).

This study had a large population of participants receiving extra credit. It may confound results for the fact that only those people who need or want extra credit will participate. Recruiting in three classes that did not offer extra credit resulted in zero participants. In order to generalize the findings a population of students not receiving extra credit may be necessary. The temperature in the lab where the procedure was performed was also variable. The heat from no air-conditioning could cause changes in responses for the procedure. During the day, the room had an increased temperature, especially on warm days. This may affect the accuracy of responses as well. Further study of IFR and different presentation types is necessary.

REFERENCES

Atkinson, R.C., & Shiffrin, R.M. (1968). Human memory: A proposed system and its control processes. In Spence, K.W., Spence, J.T. (Eds.), *The psychology of learning and motivation: II* (pp. 89-122). Oxford, England: Academic Press.

Balota, D.A., Yap, M.J., Cortese, M.J., Hutchison, K.A., Kessler, B., Loftis, B., … Treiman, R. (2007) The English Lexicon Project. *Behavior Research Methods, 39* (3), 445-459.

Baumeister, A.A., & Luszcz, M. (1976). A Within-subjects analysis of free recall with preschool children. *Child Development,* 47, 729-736.

Bennett, I.J., Golob, E.J., Parker, E.S., & Starr, A. (2006). Memory evaluation in mild cognitive impairment using recall and recognition tests. *Journal of Clinical and Experimental Neuropsychology,* 28, 1408-1422. doi: 10.1080/13803390500409583

Bhatarah, P., Ward, G., Smith, J., & Hayes, L. (2009). Examining the relationship between free recall and immediate serial recall: Similar patterns of rehearsal and similar effects of word length, presentation rate, and articulatory suppression. *Memory & Cognition*, 37, 689-713. doi: 10.3758/MC.37.5.689

Brbion, G., David, A.S., Bressan, R.A., & Pilowsky, L.S. (2006). Processing speed: a strong predictor of verbal memory performance in schizophrenia. *Journal of Clinical and Experimental Neuropsychology,* 28, 370-382. doi: 10.1080/13803390590935390

Campoy, G. (2008). The effect of word length in short-term memory: is rehearsal necessary?. *The Quarterly Journal of Experimental Psychology*, 61, 724-734. doi: 10.1080/17470210701402364

Chen, Z. & Cowan, N. (2005). Chunk limits and length limits in immediate recall: A reconciliation. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 31 (6), 1235-1249. doi: 10.1037/0278-7393.31.6.1235

Eagle, M.N. (1967). The effect of learning strategies on free recall. *The American Journal of Psychology*, 80(3), 421-425. doi: 10.23071420376

Gazzaniga, M.S., Ivry, R.B., & Mangun, G.R. (2009). Learning and memory. In Durbin, J.W. (Ed.) *Cognitive neuroscience: The biology of the mind* (312-363).New York: W.W. Norton & Company, Inc.

Haist, F., Shimamura, A.P., & Squire, L.R. (1992). On the relationship between recall and

recognition memory. *Journal of Experimental Psychology: Learning, Memory and Cognition*, 18(4), 691-702.

Harness, A., Jacot, L., Scherf, S., White, A., & Warnick, J.E. (2008). Sex differences in working memory. *Psychological Reports*, 103(1), 214-218. Abstract retrieved from http://search.ebscohost.com.

Hoppe, C., Stojanovic, J., Karg Foundation Young Researchers Group 2008/09, Elger, C.E. (2009). Enhancing memory for lists by grouped presentation and rehearsal: A pilot study in healthy subjects with unexpected results. *Seizure*, 18, 711-715. doi: 10.1016/j.seizure2009.10.001

Huang, I., Tomasini, J., & Nikl, L. (1977). The primacy and recency effects in successive single-trial immediate free recall. *The Journal of General Psychology*, 97, 157-165.

Jelinek, L., Jacobsen, D., Kellner, M., Larbig, F., Biesold, K.-H., Barre, K., Moritz, S. (2006) Verbal and nonverbal memory functioning in posttraumatic stress disorder (PTSD). *Journal of Clinical and Experimental Neuropsychology*, 28, 940-948. doi: 10.1080/13803390591004347

Joseph, C.A., McKay, T.D., & Joseph, C.R. (1982). Sex effects on free recall of transforming orally and visually presented nouns into printed, picture, or imagery form. *The Journal of General Psychology*, 107, 51-55.

Laming, D. (2009). Failure to recall. *Psychological Review*, 116(1), 157-186. Abstract retrieved from http://apps.isiknowledge.com.

Matlin, M. W. (1976). The relationship between english word length and short-term memory. *The Journal of General Psychology*, 94, 47-57.

McDowell, B.D., Bayless, J.D., Moser, D.J., Meyers, J.E., & Paulsen, J.S. (2004). Concordance between the CVLT and the WMS-iii word lists test. *Archives of Clinical Neuropsychology*, 19, 319-324. doi:10.1016/S0887-6177(03)00023-4

Microsoft Excel® 2007 [Computer Software] (2010) Microsoft Corporation.

Miller, G.A. (1956). The magical number seven, plus or minus two some limits on our capacity for processing information. *Psychological Review*, 101 (2), 343-352.

Ozubko, J.D., & Joordens, S. (2007). The mixed truth about frequency effects on free recall: effects of study list composition. *Psychonomic Bulletin & Review*, 14(5), 871-876.

Russo, R., & Grammatopoulou, N. (2003). Word length and articulatory suppression affect short-term and long-term recall tasks. *Memory & Cognition*, 31(5), 728-737.

Seiler, K.H., & Engelkamp, J. (2003). The role of item-specific information for serial position curve in free recall. J*ournal of Experimental Psychology: Learning, Memory & Cognition*, 29, 954-964. doi: 10.1037/0278-7393.29.5.954

Smith, A.P., Jones, D.M., & Broadbent, D.E. (1981). The effects of noise on recall of categorized lists. *British Journal of Psychology*, 72, 299-316.

Sneed, P.R., Brunts, D.C., & Mueller, J.H. (1977). Instructions and grouped presentation in free recall. *American Journal of Psychology*, 90(2), 263-268.

SuperLab (Version 4.0) [Computer Software] (2009) San Pedro, CA; Cedrus Corporation

Ward, G., & Maylor, E.A. (2005). Age-related deficits in free recall: the role of rehearsal. *The Quarterly Journal of Experimental Psychology*, 58A, 98-119. doi: 10.1080/02724980443000223

Ward, G., & Tan, L. (2004). The effect of the length of to-be-remembered lists and

intervening lists on free recall: a reexamination using overt rehearsal. *Journal of Experimental Psychology: Learning, Memory and Cognition*, 30, 1196-1210. doi: 10.1037/0278-7393.30.6.1196

Table 1: *Average (SD) Number of Correct Responses to Serial and Concurrent Stimuli as a Function of Gender and Presentation Order*

	Men			Women		
Stimulus Type	**Serial Then Concurrent**	**Concurrent Then Serial**	**Total**	**Serial Then Concurrent**	**Concurrent Then Serial**	**Total**
Serial	47.86 (8.36)	42.23 (8.36)	44.20 (8.73)	42.47 (10.18)	44.27 (7.72)	43.18 (9.18)
Concurrent	50.29 (11.57)	39.69 (8.38)	43.40 (17.73)	44.71 (9.43)	42.91 (7.57)	44.00 (8.65)

Table 2: *ANOVA Tests of Within-Subjects Factors and Effect Size*

Source	**Sum of Squares**	**Mean df**	**Square**	**F**	**Sig.**	**Partial Eta Squared**
Stimulus Type	.785	1	.785	.027	.871	.001
Stimulus Type by Order	99.287	1	99.287	3.370	.073	.071
Stimulus Type by Gender	1.304	1	1.304	.044	.834	.001
Stimulus Type by Order by Gender	2.533	1	2.533	.086	.771	.002
Error (Stimulus Type)	1296.275	44	29.461			

Table 3: *ANOVA Tests of Between-Subjects Factors and Effect Size*

Source	**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**	**Partial Eta Squared**
Order	355.749	1	355.749	2.650	.111	.057
Gender	44.081	1	44.081	.328	.570	.007
Order by Gender	356.219	1	356.219	2.654	.110	.057
Error	5905.944	44	134.226			

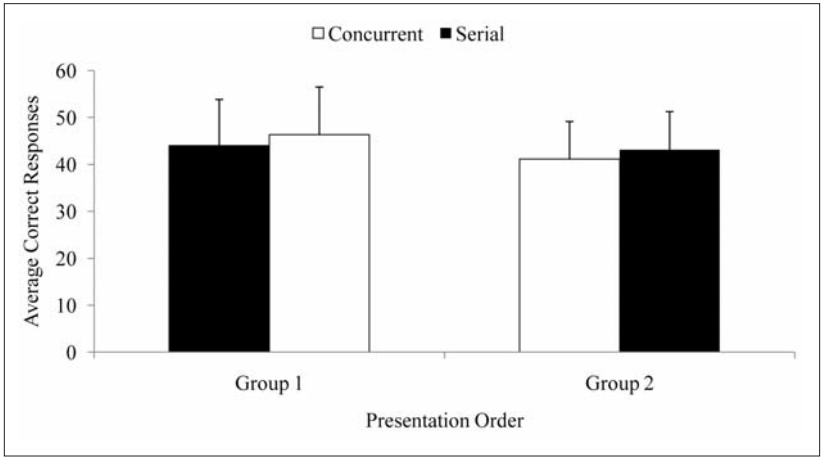

Figure 1. Average accurate responses to serial and concurrent stimuli as a function of presentation order. Error bars represent standard deviation.