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Sub-Categorical Properties of Stimuli Determine the Category-Order Effect

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Abstract

The category-order effect (COE) is observed when the categorical properties of items within the first half of a given list affect recall performance in a mixed-list serial-recall task. The present study examines whether the advantage is due to other sub-categorical properties (e.g., orthographic similarity and word frequency) rather than an artifact of stimuli used in previous studies (e.g., numbers vs. nouns). Participants were presented with numeric stimuli and nouns from a variety of semantic categories while their orthography and word frequency were systematically manipulated. The results suggest that a large portion of the COE can be attributed to the sub-categorical properties of the items.

Keywords: memory, category-order effect, recall

Introduction

In serial recall tasks, item information activates both short-term (e.g., order) and long-term (e.g., semantic) memory components (e.g., Healy, 1974; Lashley, 1951; Nairne & Kelley, 2004). These components affect the extent to which participants can rehearse and retrieve to-be-recalled items. In the present study, we examined the contribution of long-term memory representations by varying stimulus properties associated with category membership (e.g., semantic similarity) as well as those that are associated with individual stimuli (e.g., word frequency).

The Category-Order Effect

Brooks and Watkins (1990) referred to the dependency of recall performance on the order in which items from a particular category are presented in a list as the *category-order effect* (or COE). Category-order effects have been established across several word categories, including when higher-frequency words precede lower-frequency words (Watkins & Watkins, 1977), semantically-related words precede semantically-unrelated words, rhyming words precede non-rhyming words (Brooks & Watkins, 1990), and when numeric digits precede words (Greene & Lasek, 1994; Brooks & Watkins, 1990). Greene and Lasek concluded that the COE arises when a relatively smaller, homogenous category is presented before a relatively larger, heterogeneous category. Given that category set-size has proven to determine recall accuracy and response times, this appears to be a reasonable set of assumptions.

There is evidence that the category effect can be mediated by other factors such as rehearsal strategy. For instance, the COE can be eliminated by decreasing the presentation rate of the stimuli or by using articulatory suppression (Greene & Lasek, 1994). Greene and Lasek (1994) further explored whether the order of recall of the stimuli (i.e. input or output position) was a factor in the category-order effect. To test their hypothesis, participants were asked to either recall items in forward or backward order. In the backward condition, items were to be recalled in reverse order that they were presented in. Although recall order did affect overall accuracy and memory span, both forward and backward recall exhibited a significant input position COE, with improved full-list recall when the more readily categorized items were presented in the first half of the list.

In a series of experiments directed toward examining the subcategorical properties of the COE, Schoenherr and Thomson (2008) also found the effect using both successive and simultaneous split-list presentation. In their study, lists consisted of four non-repeating letters and four non-repeating numbers. Letters were from one of four categories: 1) four letter words, 2) four letter pseudowords (CVCVs), 3) four rhyming letter nonwords, or 4) four random letter sets. Their results indicated that a COE was exhibited when stimuli with more sub-categorical properties (i.e., letters making up words or pseudowords) were presented before stimuli that had fewer subcategorical properties (i.e., random letters, rhyming letters, and numbers).

Most interestingly, Schoenherr and Thomson conducted a serial-order analysis comparing within-category accuracy based on input position, and found evidence that only the accuracy for the category presented first improved rather than both presented categories, and only for the word and pseudoword categories. Further support for the contributions of subcategorical properties to the COE was evidenced in results from an oscillator-based connectionist model (Schoenherr & Thomson, 2009) wherein the manipulation of a distinctiveness parameter produced COE-like effects. Thus, while categorical information no doubt contributes to recall, a COE-like effect can be obtained by means of the manipulation of subcategorical information.

Semantic Similarity and Recall

Semantic similarity could help explain the COE as evidenced in the literature on immediate recall. For instance, Crowder (1979) presented participants with 10 item lists consisting of similar or dissimilar words. He observed enhanced recall for similar words relative to dissimilar ones (see also Saint-Aubin, Ouellette, & Poirier, 2005). Moreover, research has also found that the probability of correctly recalling an item is inversely proportional to the number of associates for that item in a given list (for a review, see Nelson, 1989). A straightforward explanation of these findings is that once a word is presented, it activates both its representation and similar stimuli (with overlapping semantic or contextual information) in long-term memory. As activation increases, semantically related units also become active thereby becoming candidates for recall, creating proportionally higher interference for items with a greater category size or items seen in more contexts than items with a smaller category size; known as the fan effect (Anderson & Reder, 1999; West, Pyke, Rutledge-Taylor, & Lang, 2011).

Earlier evidence of the fan effect was observed by Crannell and Parrish (1957). They examined the effect of set sizes and semantic categories on immediate serial recall. More specifically, participants were asked to remember sets consisting of digits (1-9; set size = 9), letters (from the full set of letters), letters (from a limited set of letters ‘a’ to ‘i’), three-letter words (from a set comprised of 286 members), and three-letter words (from a set comprised of 9 members). Overall, Crannell and Parrish found that digits led to the highest recall and that letters were recalled more accurately than words. Thus, it appears that the category set size explains only part of the advantage for digits relative to letters and words in general and that another stimulus property stored in long-term memory contributes to the recall advantage.

Sub-Categorical Properties and Recall

Despite the evidence for recall facilitation resulting from the availability information stored within long-term memory, it is not necessarily the case that this information need be categorical (West et al., 2011). Sub-categorical information can be used as the basis for grouping exemplars. As Howes and Solomon (1951) first observed, the frequency of words in a language corpus is negatively correlated with their response threshold. McGinnies, Comer, and Lacey (1952) later demonstrated that word length affects performance independently of word frequency (see also Postman & Adis-Castro, 1957). This finding is of considerable importance for COE experiments considering that word stimuli used in those studies (e.g., goose, dog, sheep, ox) have more characters than digit stimuli (e.g., 1, 6, 9) which has previously been shown to affect recall (Cowan et al., 1992). This could explain Schoenherr and Thomson’s (2008/9) results whereby letters forming words or pseudowords exhibited relatively higher recall rates when compared against numeric digits.

Moreover, studies have also found that orthographic properties affect recall performance. For example, it has been found that lowercase words are reported more accurately than uppercase words (e.g., Perri et al., 1996; Jordan, Redwood, & Patching, 2003; cf. Smith et al., 1969). Given that words are reported in lowercase type set and numbers are presented as Indian-Arabic numerals, this difference might enhance recall performance resulting in an additional release from proactive interference solely from orthographic properties.

Present Study

Previous studies of the category-order effect and related phenomena have frequently used number-word lists as stimuli (Brooks & Watkins, 1990; Greene & Lasek, 1994; Young & Supa, 1941). Although this paradigm has been viewed as contrasting a small, homogeneous set of items (i.e., numbers) against a larger, heterogeneous set of items (i.e., animals), several properties of the stimuli prohibit such a direct interpretation. First, number stimuli have been presented as digits resulting in a decreased load during visual encoding of a single item (e.g., 4) relative to an equivalent word (e.g., four). Second, number stimuli have a higher frequency than the word stimuli used in the recall lists. Examining these values reveals that within the Brysbaert and New Corpus[1] there is a greater occurrence for the number words (WF_{BN} = 4.10) than animal words (WF_{BN} = 3.12) used in previous studies. Given this potential methodological confound, the present experiments use an immediate serial recall task to assess the effect of item (e.g., word frequency; orthography) and order (e.g., number-word vs. word-number) information on recall performance.

Experiment 1A

In Experiment 1A, we sought to replicate the Category-Order Effect with the materials used by Brooks and Watkins (1990) while also examining the effects of orthographic properties (i.e., letter case; numeric digits vs. words) on encoding.

Method

Participants

Twenty-three Carleton University students participated in the experiment receiving 1% toward their final grade in an introductory psychology class.

Materials

Stimuli consisted of monosyllabic numbers and animal names (nouns) used in previous studies of the COE (Brooks & Watkins, 1990; Greene & Lasek, 1994; Young & Supa, 1941). These include the related animal words *dog, horse, goose, cow, cat, ox, hen, pig and sheep*, in addition to the numeric digits 0-9 excluding the number 7 and their word equivalents (e.g., *zero, one*). Words were presented in both lowercase and uppercase formats.

Procedure

Similar to the procedure of Schoenherr and Thomson (2008), participants were told that an eight-item sequence of four letters and four numbers would be presented on the computer monitor. Each item was presented for 1s and was

[1] Word counts retrieved November, 20, 2011. WF_{BN} is given by adding one and taking the log10 of the SUBTLx word count.

immediately replaced with the subsequent item in the list. After all items were presented, the screen was cleared and a response cue of either FORWARD or BACKWARD was presented following a 250 ms inter-stimulus interval. If the cue indicated FORWARD, participants were instructed to write the items down in the order that they were perceived. Alternatively, if the cue indicated BACKWARD then participants were required to respond with the order of the categories reversed while preserving the order of the items within the category (see Figure 1). This was similar to the procedure used by Greene and Lasek (1994) to preserve within-category integrity between study and recall.

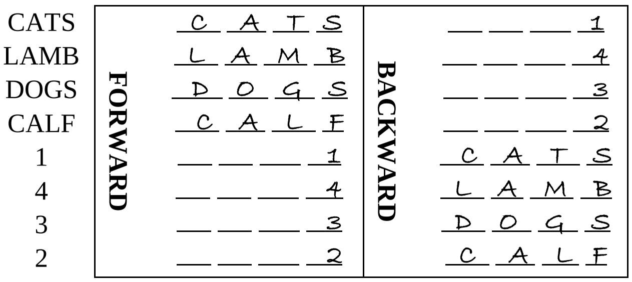

Figure 1. Sample of FORWARD and BACKWARD response for stimuli from Experiment 1.

Instructions emphasized both speed and accuracy. Participants completed 20 training trials and 48 experimental trials. No feedback was provided after training.

Results

A mixed ANOVA with 2 Category-Order (number-word vs. word-number) x 2 Number Format (digits vs. nouns) repeated-measures factors were conducted on the proportion of items recalled, with 2 Recall Order (forward vs. backward) x 2 Letter Case (uppercase vs lowercase) as between-subjects factors. There was no main effect of Letter Case on accuracy, nor was it present in any higher interaction. As such, the Letter Case factor was collapsed.

Replicating the findings of earlier studies, we obtained what has traditionally been the explanation of the COE, $F(1, 21) = 5.704$, $MSE = .013$, $p = .026$. Participants recalled more items in Number-Word lists ($M = .6812$, SD = .1806) than in Word-Number lists ($M = .6403$, $SD = .1706$). Importantly, we also observed a significant effect of Number Format, $F(1, 21) = 18.783$, $MSE = .006$, $p < .001$. Supporting our hypothesis that encoding fluency affected recall, we found that participants recalled more items in number lists written as digits ($M = .6863$) than number lists written as words ($M = .6352$). This suggests that the COE is influenced by sub-categorical properties of the stimuli such as orthography rather than solely categorical information.

Discussion

While we were able to replicate the category-order effect seen in prior literature (Brooks & Watkins, 1990; Greene & Lasek, 1994), we also identified a significant influence of sub-categorical properties (namely the orthography of numerical digits vs words) on recall performance. That said, the lack of a significant interaction between Category-Order and Number Format implies that the effect of sub-categorical properties on the COE might be limited.

Experiment 1B

Experiment 1B further examined the influence of word frequency on the COE. Experiment 1A found that number format influenced recall accuracy, however this only had a limited influence on the COE. However, number stimuli are represented at a higher frequency than word stimuli. If the COE was due to sub-categorical properties such as word frequency (rather than categorical properties such as categorical similarity) then one would predict that the COE might be largely attenuated or completely eliminated by controlling for word frequency. As such, lists of high- and low-frequency words were created from two categories based on word norms and these were paired with high- (e.g., *one* and *two*) and low-frequency (e.g., *twenty* and *thirty*) numbers printed as words.

Method

Participants

Twenty-two Carleton University students participated in the experiment receiving 1% toward their final grade in an introductory psychology class.

Materials

Two sets of high- and low-frequency words were created to exclude the possibility that one semantic category was more salient than another. One high frequency set consisted of terms pertaining to familial relatives (*son, mom, father, aunt, uncle, sister, brother*) whereas the other consisted of terms pertaining to units of time (*second, minute, hour, day week, month, year*). One low frequency set consisted of colour terms (*maroon, aqua, violet, tan, grey, purple, orange*) whereas the other consisted of items used in carpentry (*nail, wrench, wood, ruler, hammer, drill, screw*). This resulted in high- (M = 4.10) and low-frequency (M = 2.62) word sets.

Two sets of numbers were also created, high-frequency (M = 4.10; *two, three, four, five, six, eight, nine*) and low-frequency (M = 2.64; *twenty, thirty, forty, fifty, sixty, eighty, ninety*). The number one and ten were removed from the list to balance number-word frequency with category-word frequency. An important feature of the present study is that by constraining the items in the word list, the total set-size of the items available for participants to recall is reduced while category set-size increases for numbers relative to Experiment 1A. Sets were matched for mean word length.

Procedure

Experiment 1B replicated the procedure of Experiment 1A.

Results

Data from one participant was removed prior to analysis for failing to conform to task demands. A repeated-measures 2 Category-Order (number-word vs. word-number) x 2 Word Frequency (high-frequency vs low-frequency) x 2 Number

Frequency (high-frequency vs low-frequency) ANOVA was conducted on the proportion of items recalled with Recall Order (forward vs. backward) included as a between-subjects measure.

The most revealing effect of this study was the lack of an effect of Category-Order alone, $F(1,17) = 1.007$, $MSE = .009$, $p = .33$, nor was Category-Order significant in any interactions. This suggests that the COE might in fact be a result of sub-categorical properties that were not controlled in previous studies, such as the aforementioned set-size and word frequency. Supporting this interpretation, we obtained a significant main effect of Number Frequency, $F(1,17) = 27.63$, $MSE = .016$, $p < .001$. More items were recalled in lists containing high-frequency numbers ($M = .707$) relative to low-frequency numbers ($M = .598$).

In addition, we obtained a significant interaction between word frequency and recall order, $F(1,17) = 5.135$, $MSE = .003$, $p = .037$. Table 1 demonstrates that recall performance was highest (and significantly different, only) for forward recall. This suggests that items that have numerous traces stored in long-term memory benefit from relatively early activation as a result of presentation (i.e., input) order.

Table 1. Mean proportion recalled and standard error in forward and backward orders for high and low word frequency conditions.

Recall Order	Word Frequency	Proportion Recall
Forward	High	.695 (.053)
	Low	.662 (.052)
Backward	High	.623 (.062)
	Low	.630 (.061)

Interestingly, one effect that was not found in contrasts was that when high-frequency items were in the first input positions (e.g., high-frequency numbers followed by low-frequency words, or high-frequency words followed by low-frequency numbers) there was still no equivalent to a category-order effect ($M = .663$ for High-Low vs $M = .658$ for Low-High).

Discussion

Experiment 1B also provides evidence for an explanation of the category-order based on subcategorical properties. One reason for this lack of effect might be that only number words were used rather than digits, which, as we observed in Experiment 1A, provided the strongest COE. The increased performance for higher frequency words (regardless of whether they represented categories such as numbers, tools, or units of time) is consistent with the view that category-order effects were not necessarily due to category set-size or other categorical properties (e.g., similarity), but instead were driven in part by sub-categorical properties (orthography and word frequency). However, by allowing word length to vary, Experiment 1B might have eliminated another important orthographic feature associated with the expression of the COE.

Experiment 2

To better understand what categorical properties might underlie the COE, in the present study we control for category-relatedness and set-size, in addition to using numeric digits and number words as in Experiment 1A to replicate previous COE studies. One aspect of previous studies examining the category-order effect for numbers and words is that the categories used for comparison were very large and very small (animals vs numbers, respectively). In the present study, we identified natural categories used in the categorization literature (e.g., birds, tools) and used latent-semantic analysis (Dumais, 2004) to determine which words within these categories were highly (and equivalently, when possible) related.

Moreover, the fact that multiple lists were used from different categories should ensure long-term memory activation does not change considerably for any given list. To avoid the influence of the word-length effect, we only used four letter words. This procedure allowed us to create more principled categories and stimulus sets. Words were then divided into exemplar lists (e.g., *owls, hawk*) from the same category and related words (e.g., *wing, claw, beak*).

If category size facilitates performance in the initial positions of a list, both number words and number digits should produce highest recall performance when in the initial list positions. Similarly, if frequency of exposure to the stimuli facilitates performance in the initial positions of a list, then number stimuli regardless of format should produce highest recall performance.

Method

Participants

Thirty-two Carleton University students participated in the experiment receiving 1% toward their final grade in an introductory psychology class.

Materials

Stimuli sets were created by selecting six sets of words of similar frequencies ($M = 2.5$) using the same calculation as Experiment 1B, and inter-category relatedness ($M = .45$) using LSA co-occurrence compared to category label (*birds*, *fish*, *clothing*, *tools*, *trees*, and *vehicles*). For instance, from the set *bird* (features) was *peck, sing, flew, claw*; while *bird* (examples) was *jays, hawk, duck, kiwi*. The same number stimuli were used as in Experiment 1A.

Procedure

Experiment 2 replicated the procedure of Experiment 1A with the following differences. Participants completes both backwards and forwards recall conditions in separate blocks.

Results

Data from one participant was removed prior to analysis for failing to conform to task demands. A repeated-measures 2 Category-Order (number-word vs. word-number) x 2 Number Format (number digit vs word) x 2 Recall Order (forward vs. backward) was performed.

Unlike Experiment 1A but similar to Experiment 1B there was no main effect of Category-Order, $F(1, 30) = .034$, $MSE = .034$, $p = .855$, but similar to Experiment 1A there was a main effect of Number Type, $F(1, 30) = 39.07$, $MSE = .019$, $p = .001$. Again, lists containing numeric digits were recalled with higher accuracy than lists containing number-words ($M = .634$ vs $M = .557$). As seen in Figure 2, the interaction of Category-Order and Number Format was significant $F(1, 30) = 5.438$, $MSE = .018$, $p = .027$. While not significant, it was interesting that there was higher overall accuracy for the Word-Number condition with numeric digits (i.e., *1*), but the effect reversed when numbers were presented at words (i.e., *one*) which was the opposite pattern to Experiment 1A.

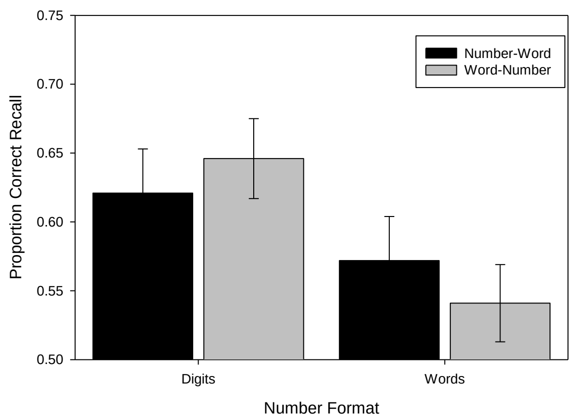

Figure 2. The effect of Number Format on the Category-Order Effect. Encoding fluency influences the nature of the effect rather than being due to numbers preceding words. Errors bars represent 1 SE.

The interaction of Category-Order and Recall Order was also found to be significant, $F(1,30) = 14.767$, $MSE = .02$, $p = .001$. As seen in Figure 3, recall was relatively higher for Word-Number lists over Number-Word lists when recalled in forward recall order compared to backward recall order.

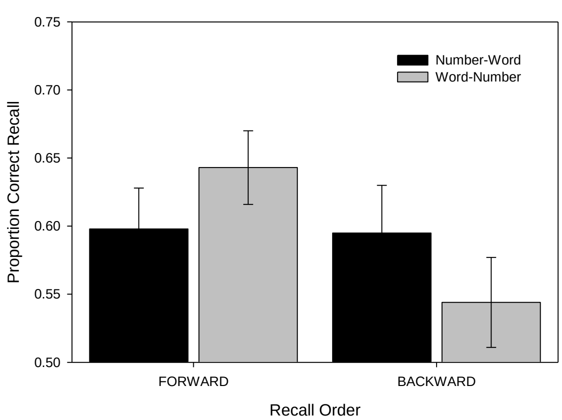

Figure 3. The effect of Recall Order on the Category-Order Effect. When words are recalled first (i.e., in the forward Word-Number or the backward Number-Word condition) recall performance is highest. Errors bars represent 1 SE.

Discussion

The present experiment did not replicate the main category-order effect from Experiment 1A, however, a pattern of improved overall recall was still present for numeric digits over numbers represented as words. Additionally, unlike prior studies, the effect of recall order did not show a category-order effect based on input position, but instead indicated that words exhibited relatively higher recall when recalled first, that is, for forward recall with the Word-Number category order and for backward recall with the Number-Word category order. The main difference in word stimuli in this study is that words were controlled for length, category-relatedness, and were from smaller category-sets than the stimuli from Brooks and Watson (1990).

One possible explanation for these findings is that, in the short-term, the lexical and phonotactic properties of the stimuli facilitate recall but when more time is allowed to pass, the activation of associated items in long-term memory creates competition during retrieval and decreases recall accuracy. If recall can proceed immediately, related words can be recalled with little interference. If participants are required to recall these items last, as more time passes a greater number of alternative candidates could be activated in long-term memory creating greater interference (Anderson, 1974).

General Discussion

Brooks and Watkins (1990) and Greene and Lasek (1994) both proposed the existence of a category-order effect whereby full-list recall is improved when numbers precede words in a mixed-list design. The original interpretation of the COE attributed this finding to the categorical properties of the number and word stimuli: number stimuli were drawn from a smaller, more homogenous category than word stimuli.

The results of two experiments revealed the conditions in which item and order information interact to increase recall performance in serial recall tasks in which the items belong to two different categories. In Experiment 1A, we replicated the findings of previous experiments. More items were recalled from lists which presented number items prior to words (Brooks & Watkins, 1990; Greene & Lasek, 1994; Young & Supa, 1941). Experiments 1A, however, extended these results. It was also observed that number format (digit vs word) and orthographic properties of list halves also contribute to the COE. In general, the greater the orthographic differences there were between the lists halves, the greater the increase in recall performance.

Experiment 1B further extended these results by eliminating the COE once word-frequency was controlled. Experiment 2 also eliminated the main effect of COE once category set-size, word length, and within category similarity was controlled. In fact, the trend evidenced a contrasting pattern of results: once the categorical and sub-categorical properties of the word stimuli was more comparable to those of the number stimuli, the trend was for more items recalled when words preceded numbers. The fact that a COE-like effect was observed in Experiments 1A and 2 wherein word length was allowed to vary might suggest that orthographic properties reduce proactive interference giving rise to previous results interpreted as COE.

The relative gain for recall performance of digit-word lists relative to word-digit lists is only one demonstration of a category-order effect. This does, however, illustrate that what previous authors have construed as categorical properties might in fact be partly due to sub-categorical properties shared by the stimuli. For instance, the robust finding that high-frequency words are better recalled than low-frequency words in no way implies that high-frequency and low-frequency words are represented as contrasting categories in an individual's memory. Instead, categories would seem to require additional inter-item associations such as physical similarity of exemplars (e.g., whales and fish or whales and mammals), as seen in Experiment 2.

Traditionally, the COE was assumed to arise from an interaction between categorical properties of stimuli (numbers rather than words) and the order in which they were presented (numbers before words). When participants are presented with stimuli, a trace is created in short-term memory. Information associated with those stimuli is activated in long-term memory. When items share category membership, the associations between items in a list generally enhance recall performance (Saint-Aubin et al., 2005). However, when categories are large, the resultant spread of activation to other category members creates interference (Nelson et al., 1989).

The results of our experiments lead us to question previous assumptions about the COE. Namely, although order and item information do contribute to recall performance, and that categorical properties of the stimuli likely affect recall performance, the initial detection threshold of the stimuli appears to account for more recall performance once it has been controlled. This finding also has implications for studies in that perceptual effects appear to contribute more to recall performance than knowledge effects.

References

Anderson, J. R. (1974). Retrieval of propositional information from long-term memory. *Cognitive Psychology*, 5, 451-474.

Anderson, J. R. & Reder, L. M. (1999). The fan effect: New results and new theories. *Journal of Experimental Psychology: General*, 128, 186-197.

Brooks, J. O., & Watkins, M. J. (1990). Further evidence of the intricacy of memory span. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 16, 1143-1141.

Cowan, N., Day, L., Saults, J. S., Keller, T. A., Johnson, T., & Flores, L. (1992). The role of verbal output time in the effects of word length on immediate memory. *Journal of Memory and Language, 31*, 1-17.

Crannel, C. W., & Parrish, J. M. (1957). A comparison of immediate memory span for digits, letters, and words. *Journal of Psychology*, *44*, 319-327.

Crowder, R.G. (1979). Similarity and order in memory. In G. Bower (Ed.), *The psychology of learning and motivation* (Vol. 13, pp. 319-353). New York: Academic Press.

Dumais, S. T. (2004). Latent semantic analysis. *Annual review of information science and technology*, *38*(1), 188-230.

Greene, R. L., & Lasek, R. (1994). Category-order effects in memory span. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *20*, 1391-1395.

Healy, A. F. (1974). Separating item from order information in short-term memory. *Journal of Verbal Learning & Verbal* Behavior, 13, 644-655.

Howes, D. H., & Solomon, R. L. (1951). Visual duration threshold as a function of word-probability. *Journal of Experimental Psychology, 41*, 401-410.

Jordan, T. R., Redwood, M., & Patching, G. R. (2003). Effects of form familiarity on perception of words, pseudowords and nonwords in the two cerebral hemispheres. *Journal of Cognitive Neuroscience, 15*, 537-548.

Lashley, K.S. (1951). The problem of serial order in behaviour. In L. A. Jefress (Ed.), *Cerebral Mechanisms in Behaviour: the Hixon Symposium*. Wiley.

McGinnies, E., Comer, P. B., & Lacey, O. L. (1952). Visual-recognition thresholds as a function of word length and word frequency. *Journal of Experimental Psychology*, *44*, 65-69.

Nairne, J. S., & Kelley, M. R. (2004). Separating item and order information through process dissociation. *Journal of Memory and Language*, *50*, 113-133.

Nelson, D. L., Keelean, P. D., & Negrao, M. (1989). Word-fragment cuing: The lexical search hypothesis. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 15*, 388-397.

Perri, R., Bartolomeo, P., & Silveri, M. C. (1996). Letter dyslexia in a letter-by-letter reader. *Brain and Language*, *53*, 390-407.

Postman, L., & Adis-Castro, G. (1957). Psychophysical methods in the study of word recognition. *Science, 125*, 193-4.

Schoenherr, J. R. & Thomson, R. (2009). Modeling the Category-Order Effect with an Oscillator-Based Connectionist Network. *Proceedings of the 31st Annual Meeting of the Cognitive Science Society*, Amsterdam, ND.

Schoenherr, J. R. & Thomson, R. (2008). Category Properties and the Category-Order Effect. *Proceedings of the 30th Annual Meeting of the Cognitive Science Society*, Washington, USA.

Smith, F., Lott, D., & Cronnell, B. (1969). The effect of type size and case alternation on word identification. *The American Journal of Psychology*, *82*, 248-253.

Saint-Aubin, J., Ouellette, D., & Poirier, M. (2005). Semantic similarity and immediate serial recall: Is there an effect on all trials? *Psychonomic Bulletin & Review*, *12*(1), 171-177.

Watkins, M. J. (1977). The intricacy of memory span. *Memory & Cognition*, *5*, 529-534.

West, R. L., Pyke, A. A., Rutledge-Taylor, M. F., & Lang, H. (2010). Interference and ACT-R: New evidence from the fan effect. In D. D. Salvucci & G. Gunzelmann (Eds.), *Proceedings of the 10th International Conference on Cognitive Modeling* (pp. 277-281). Philadelphia, PA: Drexel University.

Young, C. W., & Supa, M. (1941). Mnemonic inhibition as a factor in the limitation of the memory span. *The American Journal of Psychology*, *54*, 546-552.