A Category-Order Effect?: Sub-Categorical Properties of Stimuli Determine a Categorical 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 an immediate serial-recall task. The present study examines whether this recall advantage is a consequence of categorical properties (e.g., semantic-relatedness and category set-size) or whether the advantage is due to sub-categorical properties (e.g., orthographic similarity and word frequency). Participants were presented with numeric stimuli and nouns from a variety of semantic categories while their orthography (Experiment 1) and frequency (Experiment 2) were systematically manipulated. The results suggest that a large portion of the COE can be attributed to a reduction of the detection threshold associated with the sub-categorical properties of the items.

In serial recall tasks, item information activates both long-term (i.e., item information) and short-term (i.e., order information; Healy, 1974; Lashley, 1951; Nairne & Kelley, 2004; Schoenherr & Thomson, 2008) memory components. 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 the long-term memory by varying stimulus properties associated with category membership (e.g., semantic category) as well as those that are associated with individual stimuli (e.g., word frequency).

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). Both Brooks and Watkins (1990) and Greene and Lasek (1994) observed that list recall was enhanced when numbers are presented in a list prior to words (Young & Supa, 1941) and when related words precede unrelated words. Greene and Lasek thus concluded that the COE effect arises when a small, homogenous category is presented before a large, heterogeneous category because items in the initial positions of a list are likely to be more strongly activated in long-term memory.

The full-list immediate recall literature suggests that semantic similarity could help explain the COE. For instance, Crowder (1979) presented participants with 10 item lists consisting of similar or dissimilar words. He observed enhance 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 finding 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. This phenomenon is known as the fan effect (Anderson, 1974; Anderson & Reder, 1999). 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 (West, Pyke, Rutledge-Taylor, & Lang, 2011). Some earlier evidence of the fan effect is presented in the work of 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 (categorical or sub-categorical) stored in long-term memory that contributes to the recall advantage.

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. One of the most robust findings in the literature on immediate serial recall is that the frequency of words in a language corpus is negatively correlated with their response threshold (Howes & Solomon, 1951). For instance, McGinnies, Comer, and Lacey (1952) showed 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 (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). 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 may 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 experiment (e.g., Young & Supa, 1941).Given the potential methodological confounds of previous studies, the present experiment uses an immediate serial recall task to assess the effect of item and order information on recall performance. Lists of high-

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

and low-frequency words were created from four 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. These manipulations allow us to directly test the effect of a sub-categorical property (e.g., word frequency) and a categorical property (e.g., category nouns and numbers).

In Experiment 1, 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 on encoding. Experiment 2 examined the role of word frequency. If the COE is a product of the activation of information in LTM, then orthographic dissimilarity and differences in word frequency between list halves should increase recall performance due to sub-categorical rather than categorical properties of the stimuli.

Experiment 1

Method

Twenty-three Carleton University students participated in the study for course credit. Format congruency between noun and number stimuli was manipulated. 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). In the incongruent condition, we partially replicated the conditions used in previous studies by using word lists with number stimuli presented as digits and nouns (e.g., dog, ox) presented in lowercase letters as well as presenting digits with uppercase letters. In the congruent condition, both nouns and numbers were presented as words written in either uppercase or lowercase letters. As in previous studies, participants were either required to recall items in forward or backward order.

Participants were told that an eight-item sequence of four letters and four numbers would be presented on the computer monitor. Each participant was provided with an answer sheet and instructed to write down the memory stimuli after a response cue indicating the direction of recall, either “FORWARD" or “BACKWARD”. The response cue followed a 250 ms inter-stimulus interval that occurred after the stimuli were presented. If the cue indicated forward, participants would write down the stimulus in the order it was presented in. Alternatively, if the cue indicated backward, participants would be required to respond with the order of the categories reversed while preserving the order of the items within the category. Instructions emphasized both speed and accuracy. There were 20 training trials and 48 experimental trials.

Results and Discussion

A repeated-measures ANOVA was conducted on proportion correct examining the within-subjects variable of category-order (number-word vs. word-number) and recall order (forward vs. backward) as a between-subjects measures. In an additional analysis, we restructured the data to examine the effect of format congruency (i.e., list halves with same or different formats).

Replicating the findings of earlier studies, we obtained a 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 ($M = .6403$, $SD = .1706$). This result suggests that both item and order information contribute to the successful recall of stimuli. 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 ($M = .6863$) lists than number lists written as words ($M = .6352$).

This suggests that the COE might be influenced by sub-categorical properties of the stimuli such as orthography rather than solely categorical information.

We additionally wanted to determine whether orthographically similar (e.g., all uppercase or lowercase words v. nouns and number digits) items of the stimuli affected recall. Restructuring the data to examine the effect of stimuli congruency within a list, we found that list half dissimilarity affected recall, $F(1, 21) = 18.783$, $MSE = .003$, $p < .001$. We observed that when two lists halves were presented in different format, ($M = .686$) greater recall was observed then for those in the same format ($M = .634$).

Experiment 2

Method

Twenty-two Carleton University students participated in the study for course credit. Experiment 2 replicated the procedure of Experiment 1. For Experiment 2, stimuli sets were created by selected to create two sets of high- and low-frequency words to exclude the possibility that one semantic category was more salient than another. One high frequency set consisted of terms pertaining to relatives (e.g., son, mom, father) whereas the other consisted of terms pertaining to units of time (e.g., day, month, second). One low frequency set consisted of colour terms (e.g., tan, aqua, orange) whereas the other consisted of carpenter's tools (e.g., nail, wrench, pliers). This resulted in high- ($M = 4.10$) and low-frequency ($M= 2.62$) words and High- ($M = 4.10$) and low-frequency ($M= 2.64$) numbers were used as stimuli. All sets were matched for mean word length. Participants were randomly assigned to the category set conditions.

Results and Discussion

Data from one participants were removed prior to analysis for failing to conform to task demands. A repeated-measures ANOVA was conducted on the proportion of items recalled with category-order (word-number vs. number-word), recall order (forward vs. backward), word frequency (high vs. low), and number frequency (high vs. low) without analyzing stimulus set.

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)

An examination of the effect of category-order alone did not reveal any significant results, $F(1,17) = 1.007$, $MSE = .009$, $p = .33$. This could suggest that the category-order effect might in fact be a result of sub-categorical properties that were not controlled for in previous studies. Supporting this hypothesis, 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 for forward recall with this effect increasing for lists of high frequency words. This suggests that items that have numerous traces stored in long-term memory benefit from early activation as a result of presentation order.

Further evidence for the effect of sub-categorical properties was also observed in the main effect of number frequency, $F(1,17) = 5.135$, $MSE = .003$, $p = .037$. More items were recalled in lists containing high-frequency numbers ($M = .707$) relative to low-frequency numbers ($M = .598$) again suggesting that the number of memory traces is a primary determinant of recall performance in this task.

General Discussion

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 1, 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). 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. Experiment 1, however, extended these results. It was alsoobserved that number format (digit and 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.

Having identified the importance of orthographic properties to encoding during the task, Experiment 2 examined the effect of another sub-categorical property: stimulus frequency. When both word and number frequency were controlled, we failed to observe a COE. This result is not surprising given that the earliest evidence provided for the COE by Brooks and Watkins (1990) were the results of Watkins' (1977) study of list halves that varied in word frequency. Although it might not be the case that all COEs are the result of stimulus frequency, those associated with numeric stimuli used in the present study and similar studies do appear to be a result of frequency effects reducing the detection thresholds for the stimulus. Whereas it could be argued that the repeated exposure of stimuli could be construed as a categorical property due to continuous association of items within memory, it seems more reasonable to classify these memory traces properties as sub-categorical properties of the stimuli.

Conclusions

The present study replicated the COE of Brooks and Watkins (1990) and Greene and Lasek (1994). It is assumed to arise from an interaction between categorical properties of stimuli and the order in which they were presented. 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, 1989). Thus, the COE was thought to arise when items from a smaller, relatively homogenous category preceded a larger, relatively heterogeneous category. The results of our experiments, however, lead us to question this characterization of 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.

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