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Effects of massed repetition with level of processing on implicit and explicit memory tests

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The reported experiments examined the effects of massed repetition with level of processing on implicit (word fragment completion) and explicit (word fragment cued recall, recognition) memory tests. Subjects saw words presented once or massed-repeated 4 or 16 times, in graphemic or semantic study conditions. Word fragment completion benefited from repetition in graphemic but not semantic conditions, whereas explicit tests benefited from repetition in both study conditions. The findings are explained by a processing view of repetition effects on implicit and explicit memory tests.

Key words: implicit memory, priming, explicit memory, repetition, level of processing.

Repetition of stimuli is a basic variable in the experimental study of learning and memory. The general finding is that repetition increases retention of experience on virtually all tests, so that exceptions to the rule are of particular interest (e. g., Crowder, 1976).

One notable exception to the rule was reported by Challis and Sidhu (1993). They showed that many massed repetitions of a studied word in a list (up to 16 consecutive presentations) did not increase priming in word fragment completion beyond that obtained from a single presentation. In comparison, massed repetition benefited performance on other direct (free recall, recognition, word fragment cued recall) and indirect tests (general knowledge test).

Challis and Sidhu's (1993) interpretation of their massed repetition findings encompassed several contemporary ideas: First, repetition of a word does not necessarily mean a repetition of all cognitive processes. Rather, memory for a prior presentation may attenuate or eliminate certain processing on repeated presentations of the word (e. g., Challis, 1993; Jacoby & Dallas, 1981). Second, memory tests benefit to the extent that type of processing promoted at study overlaps with the type of processing required for performance on the test; that is, the idea of transfer appropriate processing (Morris, Bransford, & Franks, 1977). Third, primed word fragment completion depends primarily on perceptually-based or data-driven processes, whereas performance on explicit tests of recall and recognition rely on conceptually-driven or semantic processes for their completion (e. g., Roediger, Weldon, & Challis, 1989; Roediger & McDermott, 1993).

Challis and Sidhu (1993) noted that massed repetition improved performance on various conceptually-driven tests (e.g., free recall, recognition, word fragment cued recall) but did not benefit word fragment completion, a data-driven test. They assumed that massed repetition under the study conditions (counting the number of times a word was presented) promoted meaningful processing but did not invoke the kind of data-driven processing on repeated presentations that supports priming in word fragment completion.

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The experiments in this article were motivated by Challis and Sidhu's (1993) processing account of massed repetition effects on implicit and explicit memory tests. The experiments examined the effects of massed repetition with level of processing on word fragment completion and explicit tests of word fragment cued recall and recognition. A graphemic letter-search task was used to promote data-driven processing whereas a semantic task was used to promote meaning-based processing on presented words.

On one hand, the graphemic task was expected to promote data-driven processing on repeated presentation such that massed repetition would benefit word fragment completion. On the other hand, the semantic study task was expected to promote meaningful processing to the benefit of conceptually-driven tests; the semantic task would not promote data-driven processing on repeated presentations so that repetition would not benefit word fragment completion (cf. Challis & Sidhu, 1993; Roediger & Challis, 1992.

Research shows that word fragment cued recall and recognition behave rather differently than word fragment completion, in line with the view that conceptually-driven processes contribute to explicit tests (e. g., Challis et al., 1993; Challis et al., 1996). Challis and Sidhu (1993) concluded that massed repetition in graphemic and semantic study conditions promotes conceptually-driven processing, so we expected that massed repetition in both study conditions would benefit explicit tests.

Experiment 1

In Experiment 1, subjects saw words presented once or repeated 4 or 16 times in a massed fashion. In a graphemic study condition, subjects performed a letter search task on each presentation of a word. In a semantic study condition, subjects answered a meaning-based question about each presentation of a word. The tests were word fragment completion and word fragment cued recall.

Method

Subjects. Thirty-six University of Toronto students participated for an experimental credit in an undergraduate course.

Design, materials and procedure. The experiment was a 2 x 2 x 2 mixed factorial design, with number of presentations (1, 4, 16) and encoding condition (graphemic, semantic) as within-subject factors, and test type (word fragment completion, word fragment cued recall) as a between-subject factor. An equal number of subjects were assigned to the two tests.

The materials were the same as those used by Challis and Sidhu (1993; Experiment 3). Briefly, a set of 108 target words (e. g., cheetah) with a corresponding word fragment (-h--t-h) were drawn from a set of materials used by Blaxton (1989). Eighteen words were collected to serve as buffer items in the study lists. The 108 target words were randomly separated into 9 sets of 12 items. One set of items was assigned to each of the six presentation conditions (number of presentations x encoding condition), which accounted for 72 target items. One list containing 36 target words was presented in a graphemic encoding condition. A second list containing 36 target words was presented in a semantic encoding condition. Each list contained 261 words, which represented the three presentation conditions and the buffer words. Thirty-six target items were assigned to a nonstudied baseline condition. Across subjects, target items were counterbalanced across studied and nonstudied conditions. The order of study condition (graphemic then semantic, or vice versa) was varied across subjects. In the graphemic condition, questions asked whether a certain letter of the alphabet was in the word (e. g., h?; p?). For the semantic condition, we constructed 82 questions related to the meaning of words (e. g., It is bigger than a truck?; Can you cook it?). In both study conditions, questions and responses varied across repeated presentations of a word.

The study procedure was the same as that used by Challis and Sidhu (1993; Experiment 3). Subjects were told that a list of words would be presented on the computer screen, and that they would be asked a question about each word. In the graphemic condition, subjects were told to focus on the letters of each word, and to provide a "yes" or "no" response to the question that followed each word. In the semantic question condition, subjects were told to focus on the meaning of the presented words, and to provide a "yes" or "no" response to the question that followed each word. In the graphemic and semantic conditions, questions were selected from the set of questions in a pseudorandom fashion so that questions varied across repeated presentations of the same word, and so that half of the questions required a "yes" response and half required a "no" response. For once-presented words, half of the questions required a "yes" response and half required a "no" response. In the graphemic and semantic conditions, each word was presented for 1 s and followed by the 1-s presentation of a question. Subjects were instructed to answer each question aloud with "yes" or "no". Subjects completed several practice items. No mention was made of a subsequent memory test.

After the study phase, subjects completed a 5-min distracter task (played video games) and then received a test of word fragment completion or word fragment cued recall. The test procedure was the same as that used by Challis and Sidhu (1993). For the two tests, the 108 fragments corresponding to the target words were presented on a computer monitor. Of the 108 fragments, 72 corresponded to studied words and 36 corresponded to nonstudied words. Most of the fragments had a unique solution, although some had more than one solution. In both tests, a fragment was presented for 2 s on the computer screen and subjects were given 5 s to respond. Subjects in the fragment completion group were told to complete each fragment by saying the first English word that fit the fragment. No mention was made of the relation between study and test. Subjects in the fragment cued recall group were told they were receiving a memory test and they should use the word fragment cue to help them remember and recall a studied word.

Results and Discussion

The proportions of target words produced in word fragment completion and word fragment cued recall are presented in Table 1. In the tables, the standard error of the mean (SE) is presented in parentheses. The reported statistical analyses were performed on the proportion of target words produced, with a significance level of .05.

Priming in word fragment completion benefited from massed repetition in the graphemic but not the semantic condition. A 3 (number of presentations) x 2 (encoding condition) analysis of variance (ANOVA) yielded a significant interaction between the two factors, $F(2,34)=3.94$, MSe = .01. Separate

Table 1 Proportions of Targets Produced in Word Fragment Completion and Word Fragment Cued Recall (SE in parentheses), in Experiment 1

Test	Encoding condition	Number of presentations: 1	4	16
Word fragment completion	Graphemic	.23(.03)	.32(.03)	.38(.04)
	Semantic	.29(.03)	.32(.04)	.31(.03)
Word fragment cued recall	Graphemic	.24(.04)	.31(.03)	.44(.04)
	Semantic	.31(.04)	.39(.04)	.48(.04)

Note. The baseline completion rate was .09 in word fragment completion and .04 in word fragment cued recall.

one-way ANOVAs on the two encoding conditions revealed a significant repetition effect in the graphemic condition but not the semantic condition: $F(2,34)=9.70$, MSe = .01; and $F(2,34)<1$; respectively. Planned comparisons indicated significant priming in all study conditions: Fs > 20.31, MSes = .01. For once-presented items, there was trend for more priming in the semantic than graphemic condition ($p=.07$).

Word fragment cued recall improved with massed repetition in the semantic and the graphemic condition, with better overall performance in the semantic than graphemic condition. A 3 (number of presentations) x 2 (encoding condition) ANOVA yielded main effects of repetition and encoding condition, but no interaction between the two factors: $F(1,17)=6.19$, MSe = .02 ; $F(1,17)=14.77$, MSe = .02; and $F(2,34)<1$; respectively.

In sum, word fragment completion benefited from massed repetition in the graphemic condition but not the semantic study condition, whereas word fragment cued recall benefited from massed repetition in both study conditions. A 2 (test) x 3 (number of presentations) ANOVA on the semantic condition yielded a significant interaction, whereas a similar ANOVA for the graphemic condition did not yield a reliable interaction; $F(2,68)=3.67$, MSe = .02; and $F<1$; respectively.

Experiment 2

Experiment 2 was designed to replicate and extend the main finding of Experiment 1. That is, word fragment completion benefited from massed repetition in a graphemic but not a semantic study condition, whereas massed repetition in both study conditions benefited an explicit test. In Experiment 2, target words were presented once or 16 times in a massed fashion. The presentation of a target word (e. g., cheetah) was followed by a "comparison" word (e. g., library). In the graphemic condition, subjects selected a letter from the target and indicated whether the letter was in the comparison word. In the semantic condition, they rated the similarity of meaning of the target and comparison word. The tests were word fragment completion and recognition.

Method

Subjects. Thirty-two University of Toronto students participated for an experimental credit in an undergraduate course.

Design, materials and procedure. The experiment was a 3 (presentation condition) x 2 (study task) x 2 (test) mixed design. Number of presentations (1 or 16) and test type (word fragment completion, recognition) were within-subjects, and study task (graphemic, semantic) was between-subjects. An equal number of subjects were assigned to the two study conditions.

The materials were same as those used in Experiment 1. The 108 target words were randomly separated into 4 sets of 27 items. A study list was constructed that included 27 single presentations and 27 massed-repeated presentations, with the single and massed-repeated conditions occurring randomly in the list. Every single and massed-repeated presentation was followed by the presentation of a comparison word selected from a third set of 27 words; the comparison words were selected repeatedly in a pseudorandom fashion so that they were distributed throughout the list. The four sets of 27 items were counterbalanced across the three presentation conditions and nonstudied condition. The study list contained 936 target words, which included 9 buffer words at the beginning and at the end of the list.

Subjects were told a list of words would be presented on a computer screen. The target word was presented for 1 s in the centre of a computer screen, followed by a 1-s presentation of the comparison word about 1 cm below the location of the target word. In the graphemic condition, subjects were told to randomly select a letter from the first word and indicate whether the letter appeared in the second word. In the semantic condition, they were told to focus on the meaning of each word and to rate the relation in meaning between the first word and the second word (on a low, medium and high rating scale.) In both study conditions, subjects responded aloud. There were several practice items. After the study phase, subjects wrote the names of countries for 3 min as a distracter task.

The first test was word fragment completion. The test procedure was the same as in Experiment 1, except word fragments were presented for 7 s. After the fragment completion test, subjects wrote names of countries for 3 min and then received a recognition test. They were given two test sheets containing 162 typed words; the 108 target words and 54 fillers. Subjects were told to circle the words they recognized as being presented in the study phase. It was emphasized that this was a memory test for words presented during the study phase, and that it was irrelevant whether a word was presented on the fragment completion task. The recognition test was subject paced.

Results and Discussion

Performance on word fragment completion and recognition is presented in Table 2.

In primed word fragment completion, a significant massed repetition effect occurred in the graphemic but not the semantic condition. Planned comparisons of the once-presented and massed-repeated conditions yielded a significant effect for the graphemic condition but not the semantic condition; $F(1,15) = 10.96$, $MSe = .01$; and $F(1,15) = 1.66$, $MSe = .01$;

Table 2 Proportions of Targets Produced in Word Fragment Completion and Recognition Performance (SE in parentheses), in Experiment 2

Test	Encoding condition	Number of presentations 1	16	Nonstudied
Word fragment completion	Graphemic	.33(.03)	.45(.05)	.25(.03)
	Semantic	.42(.04)	.44(.04)	.16(.02)
Recognition	Graphemic	.27(.04)	.44(.05)	.14(.03)
	Semantic	.47(.05)	.88(.02)	.07(.02)

respectively. There was significant priming in all study conditions, $Fs > 9.00$.

Recognition performance benefited from massed repetition in the graphemic and semantic conditions. Planned comparisons of the single and massed-repeated conditions were significant for both conditions; $F(1,15) = 19.91$, $MSe = .01$; and $F(1,15) = 98.44$, $MSe = .01$; respectively. The recognition test followed word fragment completion, which may raise concerns. We tested another group of subjects ($n = 12$) using the same procedure except subjects were administered only a recognition test. The findings showed the same pattern as the recognition results presented in Table 2. In the semantic condition, massed-repeated (.92) exceeded once-presented (.53). In the graphemic condition, massed-repeated (.55) exceeded a single presentation (.27). These differences were all reliable, $Fs > 6.20$.

Experiment 2 replicated Experiment 1: Word fragment completion benefited from massed repetition in a graphemic but not a semantic condition. Recognition, like word-fragment cued recall, benefited from massed repetition in both encoding conditions.

General Discussion

The reported findings, in conjunction with previous research by Challis and Sidhu (1993), extend our knowledge of massed repetition effects on implicit and explicit tests. In word fragment completion, massed repetition increases priming when subjects searched for letters in presented words, but not when subjects answer a meaning-based question about each repeated word or monitor the presentation of repeated words. Explicit tests of word fragment cued recall and recognition benefit from massed repetition when subjects perform graphemic or semantic tasks on presented words or when they simply monitor repeated presentations. Similarly, other conceptually-driven tests (question cued recall, general knowledge) benefit from massed repetition when subjects perform graphemic or semantic tasks on presented words or when they simply monitor repeated presentations (Challis & Sidhu, 1993).

The effects of massed repetition on word fragment tests and explicit tests can be understood in terms of a processing framework described in the Introduction and in Challis and Sidhu (1993; also see Jacoby & Dallas, 1991; Roediger & Challis, 1992). The theoretical interpretation encompasses the following ideas:

Massed repetition of stimuli does not necessarily mean a repetition of all cognitive processing. Rather, memory for the prior presentation may attenuate certain processing on repeated presentations (e.g., data-driven processing). The attenuation of processing on repeated presentations can depend on the study conditions, among other things (e.g., spacing of repetitions; Challis, 1993). Massed repetition of stimuli benefits memory to the extent that the type of processing promoted at study overlaps with the type of processing required for performance on the memory test. Primed word fragment completion depends largely on data-driven processing, whereas performance on word fragment cued recall and recognition involves meaning-based processing.

When subjects answer a semantic question about presented words or count the number of times a word was presented, data-driven processing that supports priming in word fragment completion does not occur on massed-repeated presentations of a word. The extent of data-driven processing on a word is functionally similar if the word was presented once or massed-repeated, so that repetition does not increase priming beyond a single presentation. In a graphemic study condition, subjects are required to search for letters in a presented word so data-driven processing is promoted on repeated presentations to the benefit of word fragment completion. Processing of meaning occurs on repeated presentations when subjects performed a graphemic or semantic task or they counted the number of times a word was presented, so repetition in these study conditions benefits word fragment cued recall.

Turning to once-presented words, the present results revealed that priming on word fragment completion tended to be greater in the semantic than graphemic condition. This trend towards a conventional level-of-processing effect in word fragment completion is a common finding in the literature. Researchers have proffered several explanations for a small level-of-processing effect on word fragment completion. (The empirical findings and theoretical issues were reviewed by Challis & Brodbeck, 1992).

One explanation is that explicit retrieval contributes to performance on the test, resulting in greater retrieval of semantically-studied items. This interpretation seems incompatible with the present findings, given the dissociation of word fragment completion and word fragment cued recall (e.g., Roediger, Weldon, Stadler, & Riegler, 1992). A second explanation is that a semantic study task promotes more data-driven processing than a graphemic task, but again this would be inconsistent with the present findings; if the semantic task promotes data-driven processing then one would expect a massed repetition effect on word fragment completion.

A third explanation is that the graphemic study task induces degraded perceptual processing of words, relative to the semantic task. This view may account for the findings: After 1 presentation, due to the degraded perceptual processing, priming is lower in the graphemic condition than the semantic condition. By 4 presentations, the graphemic condition has caught up to the semantic condition, presumably because additional graphemic study has allowed for more perceptual processing. The additional perceptual processing that occurs with 16 presentations means that the graphemic condition exceeds the semantic condition.

The reported research was guided by a processing view of repetition effects in primed word fragment completion and other tests, although the findings may be accommodated by any view that distinguishes between perceptual and conceptual components of tasks. One example is Tulving and Schacter's (1990) proposal that a perceptual representation system exists for words and other systems (semantic and episodic memory) represent conceptual information. Presumably, such a perspective would assert that massed repetition of a word under certain study conditions (e.g., in a semantic condition) does not entail repeated encoding of perceptual information relevant to primed word fragment completion but that performing a graphemic task on repeated presentations ensures the encoding of perceptual information, so that repetition benefits priming in word fragment completion.

Whatever the theoretical perspective, a common idea is that repetition of a stimulus does necessarily mean a repetition of all cognitive operations or processes. It appears that in many study situations, meaningful processing is performed on repeated presentations of a word, whereas data-driven analyses is circumvented by relying on memory from a prior presentation of the stimulus. This is rather adaptive in that we are more interested in attaching meaning to a stimulus than in carrying out perceptual analyses on the stimulus.

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