Semantic satiation revisited with a lexical decision task

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The semantic satiation hypothesis suggests that continuous verbalization of a word leads to a reduction in its meaning. This hypothesis was examined by having subjects repeat a priming word either once or for 30 sec prior to making a word-nonword lexical decision about a visually presented target. The primes were associated with (Experiments 1 and 3), identical to (Experiment 2), or unassociated with the word targets. As is usually found, target lexical decision times were significantly facilitated by oral priming with both the associated and identical words. While the magnitude of this facilitation effect was reduced slightly by continuous repetition of the prime in Experiment 1, no such reduction was observed in Experiments 2 and 3. These results are discussed in the context of a two-factor theory of semantic processing with the aid of Morton's logogen model. It was concluded that semantic satiation may not be semantic at all.

Recent attempts to understand the nature of the semantic network underlying cognitive processing (Collins & Loftus, 1975; Meyer, Schvaneveldt, & Ruddy, 1975; Rosch, 1975) have given rise to a renewed interest in the phenomenon of semantic satiation: the apparent loss or decrement of the meaning of a word following prolonged verbal repetition or visual inspection. (See Amster, 1964; Esposito & Pelton, 1971, for extensive reviews of the literature.) Such a phenomenon is of interest because it suggests that the lexical or semantic representation of a word is susceptible to fatigue through continuous activation, thus slowing any cognitive operations that rely on the word's meaning. For example, in one experiment it was found that continuous repetition of the number 7 prior to adding $7 + 7$ increases response time compared to a condition of repeating the number 1 (Jakobovitz & Lambert, 1962). In general, if awareness of a word's meaning can be equated with activating the underlying semantic representation, then any measure of decrement in meaning that is used to monitor the extent of lexical fatigue would, in effect, also be measuring the extent of semantic satiation.

In addition to the loss of meaning experienced for the repeated word, there exists some evidence in the

literature that the satiation effect may extend to associated words as well. For example, after the constant repetition of a word, the number of associates to that word that a subject can name has been shown to decline (Kanungo & Lambert, 1963). Furthermore, the associates of the repeated word that *are* named tend to not be the typically high associates for that word, but rather, the less common associates (Smith & Raygor, 1956). The repetition of an associated word for 1 min has also been found to affect the time required to decide whether or not a subsequent pair of words are synonyms (Fillenbaum, 1964), although perhaps in a surprising manner. In the study by Fillenbaum (1964), when the repeated word was a high associate of one of the two target words, it took longer to decide that the targets were synonymous than when the satiated word was identical to one of the targets in the test pair. Fillenbaum argued that when the repeated word was itself a target word, a facilitatory "sensitization" effect overrode the usual inhibitory semantic satiation effect that he believed to occur.

The above findings suggest that any inhibition produced through repeated activation is not confined to the lexical unit involved, but tends to spread to related lexical units as well, that is, to common associates of the word. If this is the case, the tracing of inhibitory effects following satiation could provide a useful technique for mapping the cognitive network. Unfortunately, the methodologies described above have not yielded unequivocal results. In their review of the satiation literature, Esposito and Pelton (1971) describe four studies that show no decline in the number of associates produced following satiation treatment. In fact, these authors contend that whenever a difference in the number of elicited associates is reported, this difference occurs only if some associate responses are defined by the experimenter as being

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irrelevant and therefore excluded from the count. This is a questionable procedure, given that the distinction between relevant and irrelevant responses is apparently difficult to make (Paul, 1962).

Examination of studies that have employed the commonality of associates measure leads to similar contradictions; there exist at least three reported experiments (Baras, 1968; Cramer, 1968; Paul, 1962) that failed to show any satiation effects. Furthermore, the apparent decline in commonality of associations reported in some studies may sometimes be accounted for by a plausible alternative explanation (Esposito & Pelton, 1971).

Fillenbaum's (1964) study with synonyms has also been criticized by Esposito and Pelton (1969) on the grounds that extended repetition of a word unrelated to a target pair led to longer decision latencies than repetition of a related word, a result that is in direct contradiction with the semantic satiation hypothesis. In addition, Esposito and Pelton (1969) were able to replicate the increase in decision latency following presentation of a high associate in a condition that included no repetition treatment, suggesting that the Fillenbaum results could not be accounted for in terms of a satiation effect. In conclusion, examination of the procedures thus far employed to trace the spread of inhibition following word repetition fails to provide clear evidence as to whether such a spread of inhibition actually occurs.

In contrast to the difficulties encountered with the above procedures in attempting to demonstrate a spread of inhibition following prolonged activation, a task that has shown itself to be extremely sensitive to both inhibitory and facilitatory effects with associated words is the lexical decision task, a task in which subjects are shown a string of letters and are asked to determine whether or not the string is an English word. The time required to make this lexical decision is significantly reduced if the letter string is preceded by itself (Forbach, Stanners, & Hochhaus, 1974) or by a high associate (Meyer & Schvaneveldt, 1971), thus providing evidence for a priming effect. Further, this task appears to be susceptible to inhibitory effects as well, since latency for the word-nonword decision is longer following the presentation of an unrelated word than following a neutral nonverbal stimulus (Neely, 1976).

Since the lexical decision task is one in which both priming and inhibitory effects have consistently been found to occur, it is of interest to discover whether this task will demonstrate a similar susceptibility to any inhibitory effects suggested by the semantic satiation hypothesis. If semantic satiation involves inhibition not only of the repeated word but of associated words as well, it would be predicted that the priming effect typically observed after a single presentation of an associate should either reverse itself (i.e., become an inhibitory effect) or, at any rate, be substantially

reduced following continuous repetition of the associate. The experiments reported here were designed to examine this hypothesis.

A similar approach has recently been adopted by Neely (1977a). Following either prolonged visual inspection of a word (with verbal repetition of an unrelated number) or visual inspection plus verbal repetition of the word, subjects were shown a prime word and then a target word that was either associated with or unrelated to the prime. On half of the trials, the word being "satiated upon" was the prime itself. Lexical decision times for the targets yielded no evidence for any inhibition of the associates. However, as Neely used a relatively short repetition period (11 sec), the absence of an inhibitory effect could have been due to insufficient fatiguing of the original lexical unit. Further, the absence of a nonrepetition condition in the Neely study makes difficult the interpretation of some of the data, such as the general effect of verbal repetition, *per se*, on semantic facilitation.

The experiments reported here were designed to examine the effect of satiation in the lexical decision task using a period sufficiently long to potentially produce satiation. A nonrepetition control was included to permit an appropriate assessment of the magnitude of any satiation effect that might be found. In these experiments, the first word of a prime-target pair was presented orally and the subject was asked to repeat it just once or for 30 sec, depending upon the condition. No lexical decision concerning the prime was required; Neely (1976, 1977a) has demonstrated that overt processing of the prime is not necessary for it to facilitate a word-nonword decision about a subsequent associated target. The target letter string was always presented visually and the subject decided whether or not it was a word. Regarding this cross-modality stimulus presentation, both Jacobson (1973) and Rosch (1975) have shown that an aural prime is quite capable of facilitating the response to a visual target. Although these authors did not use a lexical decision task, a similar facilitation effect would nevertheless be anticipated in the present study.

EXPERIMENT 1

Method

Subjects. Nine undergraduate and graduate students from the University of Toronto volunteered for the experiment. One of the authors (D.K.) served as a 10th experimental participant. The students were paid \$2 per session plus a bonus for fast and accurate responses. These bonuses were calculated by awarding 1 cent for every correct response and deducting 2 cents for every error; also, 1 cent was deducted for every 100 msec of mean reaction time per block of trials. Average payment amounted to \$7.50 for the experiment.

Stimuli and Apparatus. Every trial involved a prime (presented orally) and a target (presented visually), as described below.

The test targets consisted of 20 words and 20 pronounceable nonwords, each five letters in length. The nonwords were formed

by changing one letter of the word stimuli. The position of the letter that was changed was evenly distributed across the set of 20 words.

Each target word was paired with both an associated and an unassociated prime. The 20 associated prime-target pairs (e.g., life-death) were made up of nouns and adjectives selected from among the association norms of Palermo and Jenkins (1964), Bousfield, Cohen, Whitmarsh, and Kincaid (Note 1), and Russel and Jenkins (Note 2). The stimulus word of each association norm constituted the prime and the response word served as the target. The median letter length of associated primes was five letters, with a range from three to six letters. The median word frequency was about 60 words/million (Kučera & Francis, 1967). Another 20 primes for "unassociated" word pairs (e.g., work-death) were selected so as to be minimally associated with the targets but having characteristics similar to the associated primes in terms of frequency, length, and semantic classification. These 40 primes were also randomly assigned as the primes for nonwords, with the limitation that a nonword not be paired either with the target from which it was derived or with its associate.

In all, then, there were 80 prime-target combinations. The stimulus set consisted of 20 target words paired with 20 associated primes, the same 20 target words paired with 20 unassociated primes, and 20 target nonwords (each presented twice) paired with the 40 primes.

In addition to the test stimuli, 60 word-word pairs and 60 word-nonword pairs were constructed for use in practice. The degree of association in the word-word pairs was not varied systematically.

The letters for the target stimuli were printed in black by a Varityper (Model V24-197) and arranged horizontally on 35-mm slides. The slides were displayed on a reflecting screen by means of a Kodak carousel projector. A cross served as the fixation point and was visible at all times. The onset of a target presentation was signaled by a Hewlett-Packard tone generator (Model 200 CD). The duration of the slide projection was controlled by a Gerbrands shutter (Model G1165). Durations of the tone, the shutter, and the interstimulus interval were determined by Hunter timers (Model 100-C). The participants were provided with two pushbutton response switches that were held one in each hand. The reaction time from stimulus onset to the subject's response was measured by an Electronics Research digital clock (Model 2613).

Procedure. The participants were tested individually over a 5-day period in three sessions (one a double session described below), with each session lasting about 50 min. The subjects sat in front of a darkened screen during the experiment. At the beginning of a trial, the experimenter, who was seated behind the subject, announced the prime. In two of the sessions, the subject then repeated the prime out loud (repeat condition) for 30 sec. To signal termination of the verbal repetition period, the tone sounded for 500 msec and the participant was given an additional 1 sec to repeat the prime once more. At the end of this 1-sec interval, the target was flashed on the screen and the subject responded as quickly as possible as to whether the target was a word or nonword. Half of the subjects used their preferred hand to indicate that the letter string was a word and their nonpreferred hand to indicate that the string was not a word; the other half of the subjects did the reverse. The response and its reaction time were then recorded. The target display remained visible for 3 sec, during which time the subject was able to verify the accuracy of his decision. Stimuli on which errors were made were repeated at the end of the session with additional "dummy" trials added in to reduce the subject's awareness that these were repeated stimuli. The results of dummy trials were not included in any analyses.

Every subject was tested with the complete set of 80 prime-target stimulus pairs. The set was divided equally in half over two prime repetition sessions. The 40 stimulus pairs of a single

session were further divided into two separate blocks of 20 prime-target trials. Each block contained five target words with associated primes, five target words with unassociated primes, and 10 target nonwords with primes. While the overall experimental design required that every prime and target be used twice, each stimulus was used only once in a particular repetition session. Furthermore, no prime was used with a nonword if that prime's associated target appeared in the same test block.

This experimental design was replicated for each participant with the 30-sec prime repetition period eliminated. In this condition (nonrepeat), the experimenter's announcement of the prime was followed immediately by the tone and subjects repeated the prime just once after the tone. Because this modified procedure greatly shortened the time required for testing, the two nonrepeat sessions were administered as a single session with a 10-min break between the two parts.

The order of the three main test sessions was balanced across 9 subjects with a 10th subject receiving the repeat-nonrepeat-repeat order. The 80 prime-target stimulus pairs were arranged to form two different orderings of test blocks with half of the subjects receiving each arrangement. The ordering of stimulus pairs within any test block was randomized. Presentation order of the test blocks was balanced approximately evenly among the subjects, while observing the set of constraints already described.

A practice session was administered prior to the series of test sessions. This practice consisted of two successive blocks of 20 trials each without prime repetition followed by two blocks with prime repetition. Each block of prime-target trials contained half word-word pairs and half word-nonword pairs. Additional practice was provided at the beginning of the individual test sessions. For prime repetition sessions, practice involved one block of nonrepeat trials followed by one block of repeat trials. The session without prime repetition was preceded by two blocks of nonrepeat trials with an additional practice block following the 10-min break.

Results and Discussion

The reaction times for correct lexical decisions and error data from the test trials were each subjected to treatments by subjects analyses of variance (Winer, 1971). Prior to analysis, an arc-sine transformation was applied to each subject's error rates. Standard errors and *F* ratios were computed using error terms derived from the Treatments by Subjects interactions.

The mean response times to the target letter strings are shown in Table 1, together with the standard error and percent error for each condition, averaged across stimuli and subjects. As is usually found for word-

Table 1
Results for the Lexical Decisions in Experiment 1

Target Type	Repetition Type	Mean Reaction Time*	Percent Errors
Associated Word	Repeat	473 (27)	2.5
	Nonrepeat	452 (18)	3.5
Unassociated Word	Repeat	517 (21)	4.0
	Nonrepeat	515 (15)	5.5
Nonword	Repeat	573 (29)	5.0
	Nonrepeat	549 (14)	4.0

Note—Values in parentheses represent standard errors of the means.

*In milliseconds.

nonword decisions, target words were responded to 71 ± 24 msec faster than nonwords. These values represent the difference between the two averages, plus or minus one standard error. This difference was highly significant [$F(1,9) = 26.00, p < .001$]. In addition, target words were recognized 57 ± 14 msec faster when they were preceded by associated words than by unassociated words [$F(1,9) = 68.28, p < .001$]. Consistent with Neely (1976, 1977a), this result indicates that lexical decisions can be facilitated by providing a semantic context simply by having subjects verbalize the prime, rather than requiring a lexical decision as Meyer and his colleagues have typically done (e.g., Meyer et al., 1975). Further, it does not appear to be a necessary prerequisite that the two stimuli be presented in the same modality for semantic facilitation to occur in the lexical decision task.

The comparison of most interest in the experiment involves the effect on lexical decisions of repeating vs. not repeating an associated prime. It was predicted that continuous repetition of an associated word before the target is read might serve to reduce the contextual semantic facilitation provided by the prime. Accordingly, a contrast was formed to examine the mean reaction time difference between prime repetition and nonrepetition for associated word pairs, as compared to unassociated word pairs (the control). Analysis indicated that the repetition procedure slowed up responding by 19 ± 16 msec more in the associated condition than in the unassociated condition. However, while this result was in the predicted direction, it did not attain the usually accepted level of statistical significance [$F(1,9) = 3.95, p < .10$]. Also, the act of repeating a prime did not slow down responding in either the associated or unassociated conditions (both $F_s < 1$). Similarly, for nonword targets, a difference of 24 ± 27 msec favoring the nonrepeat condition over the repeat condition was not statistically reliable [$F(1,9) < 1$]. It is interesting to note that the standard errors of the means in Table 1 were much greater for repeat conditions than for nonrepeat conditions, thus indicating a greater degree of response variability with the continuous oral repetition procedure compared to the nonrepeat procedure.

A sessions effect was observed for response times to words, in that decision latencies were faster by 36 ± 13 msec in the second session for each condition (mean latency = 471 ± 13 msec) compared to the first session (mean latency = 507 ± 16 msec). This difference was statistically significant [$F(1,9) = 13.28, p < .01$]. A significant difference was also obtained for nonwords whereby decisions in the second session (mean latency = 542 ± 15 msec) were 37 ± 14 msec faster than in the first session (mean latency = 579 ± 19 msec) [$F(1,9) = 14.37, p < .005$]. No interactions between the sessions variable and any other variables were seen.

The error rates were all less than 6%. Percent errors did not vary reliably across the different conditions.

Slightly fewer errors ($.6\% \pm 1.0\%$) were observed for words than nonwords [$F(1,9) = 2.41, p > .10$], and fewer errors ($1.8\% \pm 1.2\%$) were observed for associated words than unassociated words [$F(1,9) = 1.42, p > .20$]. It is unlikely that a speed-accuracy tradeoff was responsible for the observed differences in reaction time, since the mean error rates tended generally to correlate positively with the mean reaction times. Nevertheless, it may be noted that for words, while the reaction times were faster in the nonrepeat condition, their error rates were slightly larger relative to the repeat condition. This might possibly suggest a small speed-accuracy tradeoff for the words across conditions, although the overall error rate differences are nevertheless unreliable.

It is noteworthy that in a between-experiments comparison, Neely observed a larger semantic facilitation effect in a condition with no overt verbalization prior to the prime (Neely, 1977b) than in a condition with 11 sec of prime repetition (Neely, 1977a). He referred to this slowing of lexical decisions, a slowing that he believed to be a consequence of verbalization *per se*, as a "nonspecific" inhibitory effect because it was not attributable to the degree of semantic relatedness in the prime-target pair. The present study included the appropriate nonrepetition condition within the experimental design, and the nonspecific effect was not obtained. With this in mind, and because Neely based his conclusion upon data gathered in two quite different experiments (albeit with similar stimuli), one should be cautious in accepting the nonspecific inhibition hypothesis without additional support.

The results of Experiment 1 provide further evidence that the lexical decision procedure is well suited to studying contextual effects of semantic memory through the use of oral priming. However, the experiment did not yield the results necessary to support the hypothesis that "semantic satiation," by fatiguing the lexical unit, inhibits lexical decisions about related units. It is conceivable that continuously repeating a word fatigues only its own lexical representation and not that of its associate. For example, the gradient of inhibition may be much steeper than the gradient of spreading activation. Thus, any fatigue and its inhibitory effects may be short-lasting and well localized compared to the facilitation effects provided by spreading activation. If this line of reasoning proves to be the case, then we would expect that repeating a particular prime word should increase the time necessary to make a lexical decision about an identical target word, relative to a decision about some other unrelated word. Forbach et al. (1977) have shown that preceding a target word by an identical prime (which is presented only once) does facilitate lexical decisions. While Fillenbaum (1964) found that repetition did not reduce this effect for identical primes, he did not use a lexical decision task, nor did he include a nonrepetition control. Experiment 2 was therefore designed to test whether

repetition of an identical prime would diminish the usual facilitation effect for word-nonword decisions. The oral priming technique was consequently employed with the lexical decision paradigm.

EXPERIMENT 2

Method

Subjects. The subjects were five undergraduate and graduate student volunteers from the University of Toronto. They were paid \$2 per session with the bonus for fast and accurate responses. Average payment was \$7.50 per participant.

Apparatus and Stimulus Materials. The experimental equipment was the same as for Experiment 1. The stimulus targets also remained the same. However, the primes for the associated word pair condition (e.g., life-death) were changed so that the primes would be identical to the targets (e.g., death-death). Primes for the nonword condition were correspondingly modified.

Procedure and Design. The experiment was carried out in essentially the same manner as in Experiment 1.

Results and Discussion

The data were analyzed in the same way as they were in Experiment 1. Table 2 summarizes the data averaged over stimuli and subjects. As expected, words were recognized 84 ± 18 msec faster than nonwords [$F(1,4) = 119.81$, $p < .001$]. Also, the mean reaction time for targets preceded by identical primes was 69 ± 25 msec faster than for unrelated primes [$F(1,4) = 29.94$, $p < .01$].

The prime repetition procedure was not found to differentially influence this facilitation effect, the differences being only 10 ± 22 msec [$F(1,4) < 1$]. Repeating the prime for 30 sec did not significantly affect responses to identical words, unassociated words, or nonwords (all $F_s < 1$). As in Experiment 1, the standard errors of the means for the repeat conditions (see Table 2) were substantially higher than those for the nonrepeat conditions. This again indicates a greater amount of response variability with the oral repetition procedure compared to the nonrepeat procedure.

Performance for both words and nonwords seemed to speed up between the first and second sessions of each condition, but this effect failed to reach a level

of statistical significance. None of the other variables significantly interacted with the sessions variable.

Error rates for the various conditions ranged from 0% to 10%. A pattern of error rates was observed that roughly paralleled the response times. More errors ($5.3\% \pm 1.5\%$) were made in response to nonwords than words [$F(1,4) = 9.75$, $p < .01$], indicating the greater difficulty in recognizing letter strings that do not form words. In addition, identical targets were somewhat easier to recognize as words than unassociated targets, the difference in error rates being $4.0\% \pm 1.6\%$ [$F(1,4) = 4.67$, $p < .10$]. The findings for error rates would indicate that the variation of reaction times was probably not the result of a speed-accuracy tradeoff.

The results of Experiment 2 suggest, then, that vocalizing a word immediately before the same word is presented visually serves to speed up a lexical decision to the target. The subjects, of course, were unaware precisely when an identical prime-target word pair would occur. Continuous oral repetition of the prime was ineffective in modifying this facilitation.

As outlined earlier, other investigators have obtained similar results using a lexical decision task but without prime repetition (Forbach et al., 1974) and also using prime repetition but with a quite different semantic task (Fillenbaum, 1964). It may be recalled that Fillenbaum examined decision latency as his dependent variable, whereby subjects repeated a word for 1 min and then decided whether a subsequent pair of words were synonyms. The latencies were shorter when the repeated word was identical to one of the two target words, as compared to when it was associated or unrelated. Later, it was argued by Esposito and Pelton (1969) that semantic satiation had no effect on the decision latency in this task, since, as these authors correctly claimed, the effect could be obtained in the absence of repetition. It was also demonstrated in the present Experiment 2 that repetition does not influence the facilitation produced by identical priming. This would suggest either that the lexical decision task is a procedure that is not sensitive to the degree of a word's meaningfulness or perhaps that the phenomenological change that occurs following word repetition involves something other than meaning. The latter possibility will be discussed later.

EXPERIMENT 3

The repetition procedure of Experiment 1 was seen to diminish the degree of semantic priming, but not to a level of statistical significance. Prior to concluding that this procedure does not reliably interfere with facilitation in a lexical decision task, it seemed desirable to gather additional evidence. For this reason, a third experiment was conducted in which a larger number of subjects participated with a new enlarged set of stimuli. Other modifications were also incorporated to improve the original design.

Table 2
Results for the Lexical Decisions in Experiment 2

Target Type	Repetition Type	Mean Reaction Time*	Percent Errors
Identical Word	Repeat	454 (31)	1.0
	Nonrepeat	460 (11)	0.0
Unassociated Word	Repeat	527 (21)	2.0
	Nonrepeat	523 (14)	2.0
Nonword	Repeat	575 (14)	10.0
	Nonrepeat	547 (11)	6.0

Note—Values in parentheses represent standard errors of the means.

*In milliseconds.

Method

Subjects. The subjects were 20 ninth- to twelfth-grade high school student volunteers from Woburn Collegiate in Toronto. They were paid \$2 per session with a bonus for fast and accurate times. Average payment amounted to \$9.25 for three sessions.

Apparatus and Stimulus Materials. The experimental equipment was the same as for the previous experiments. The stimulus materials were also quite similar, but in order to allow for the generalization of results, 60 new associated prime-target word pairs were selected from those used by Meyer et al. (1975). These were randomly distributed over two lists of 30 pairs each. The median length of target words was five letters and ranged from three to seven letters. The median word frequency was 59 words/million (Kučera & Francis, 1967). Unassociated prime-target pairs were formed by randomly exchanging the associated primes between the two lists. Pronounceable nonword targets were formed by altering one and occasionally two letters in the target words. Sixty primes for the nonword targets were selected from Meyer et al. (1975). These primes were similar to the associated primes in terms of frequency and length.

There were, then, 240 prime-target combinations. The stimulus set consisted of 60 target words with associated primes (30 in each of two lists), the same 60 targets again with unassociated primes, and the 60 target nonwords (each presented twice) with 60 word primes (also presented twice). In addition to these test stimuli, 90 word-word pairs and 90 word-nonword pairs were constructed for use in practice.

The letters for the target stimuli were printed with IBM Courier 72 type, and then positive transparencies were mounted in 35-mm slides. All other aspects of the stimuli were the same as before.

Procedure. While the general procedure remained unchanged from the previous experiments, the experimental design was modified somewhat. The participants were tested in three sessions, one practice and two experimental, each lasting about 1 h and 15 min. No more than 24 h and no less than 2 h elapsed between sessions.

Over the two experimental sessions, a subject was presented with the complete set of 240 prime-target stimulus combinations, half of these under conditions of prime repetition and half with repetition eliminated. One block of 60 repetition trials and one block of 60 trials without repetition were included in each experimental session. A repetition block in a particular session consisted of 30 trials using all the target words from one of the two prime-target lists (e.g., List A), 15 of these targets with their associated primes and 15 with unassociated primes; the remaining 30 trials in the block involved word-nonword pairs with the nonwords being formed from the targets of the other list (e.g., List B). The nonrepetition block of the same session was similarly constructed, but contained the target words from List B along with the nonword targets derived from List A. An identical block composition was employed for the second experimental session, but with the assignment of previously associated and previously unassociated word pairs within a block being reversed. Thus, a subject was tested in four blocks, two per session, with the target words on one list used in the prime repetition condition and the target words of the other list used in the nonrepetition condition. Each subject responded to every target with both an associated and an unrelated prime over the two sessions. The primes and targets all appeared once in each test session and no single prime-target combination was ever presented again to a subject.

To avoid any confounding between the repetition variable and the list variable, half of the subjects viewed List A during repetition blocks and List B during nonrepetition blocks, and the remaining subjects did the reverse. The order of block administration was balanced within and between sessions. The ordering of stimulus pairs within blocks was randomized.

A practice session consisting of 100 prime-target stimuli preceded the experimental sessions. One block of 50 trials

without prime repetition was followed by a second block of 50 trials with prime repetition. Both blocks contained half word-word pairs and half word-nonword pairs, randomly arranged. Additional practice was provided at the beginning of each test block in the two experimental sessions. This practice involved 20 trials (half word and half nonword targets) with or without prime repetition according to whether the test block involved repetition or not.

Results and Discussion

The reaction times for correct lexical decisions were initially examined to determine whether the stimulus materials of the two lists differed in any way. No main effects or interactions involving list as a between-subjects variable were obtained, so the data for all subjects were combined. The reaction times and error data from the test trials were each subjected to treatments by subjects analyses of variance. An arcsine transformation was applied to each subject's error rates. Standard errors and *F* ratios were calculated using error terms derived from the Treatments by Subjects interactions.

Table 3 summarizes the data averaged over stimuli and subjects. Words were again recognized significantly more rapidly than nonwords, this time by 70 ± 16 msec [$F(1,19) = 42.38$, $p < .001$]. In addition, the mean reaction time for targets preceded by associated primes was 53 ± 8 msec faster than for unrelated primes [$F(1,19) = 93.97$, $p < .001$], once more indicating that lexical decisions are facilitated by establishing a semantic context.

Continuous repetition of the prime, if anything, tended to speed up rather than slow down word-word decisions, although not reliably for either associated words [$F(1,19) < 1$] or unassociated words [$F(1,19) = 2.00$, $p > .10$]. Also, the semantic facilitation effect was not differentially influenced by prime repetition, the difference between repeating and not repeating the prime being only 12 ± 7 msec less for associated words than for unassociated words [$F(1,19) < 1$]. These results therefore provide unequivocal support for the previously tentative conclusion of Experiment 1, suggesting that continuously repeating a word does not inhibit a lexical decision about a related word.

Table 3
Results for the Lexical Decisions in Experiment 3

Target Type	Repetition Type	Mean Reaction Time*	Percent Errors
Associated Word	Repeat	551 (17)	1.0
	Nonrepeat	554 (16)	1.8
Unassociated Word	Repeat	598 (15)	3.3
	Nonrepeat	612 (16)	4.5
Nonword	Repeat	647 (19)	3.3
	Nonrepeat	651 (18)	2.7

Note—Values in parentheses represent standard errors of the means.

*In milliseconds.

A sessions effect that could be attributed to practice was observed. Subjects responded 46 ± 14 msec faster to word targets in the second experimental session (mean latency = 558 ± 13 msec) compared to the first (mean latency = 601 ± 15 msec) [$F(1,19) = 22.86$, $p < .001$]. Nonwords were also recognized 40 ± 9 msec faster in the second session (mean latency = 629 ± 15 msec) than in the first (mean latency = 669 ± 19 msec) [$F(1,19) = 20.82$, $p < .001$]. An interaction was observed whereby the decrease in decision time from the first to the second session was 36 ± 6 msec greater for the nonword-repetition condition (Session 1 = 731 ± 32 msec; Session 2 = 638 ± 19 msec) than for the nonword-nonrepetition condition (Session 1 = 692 ± 24 msec; Session 2 = 664 ± 23 msec) [$F(1,19) = 8.31$, $p < .01$]. A similar although not statistically significant interaction was observed for word targets, with reaction times decreasing by 23 ± 8 msec more in the repetition condition than in the nonrepetition condition in the second experimental session [$F(1,19) = 4.02$, $p < .10$]. Indeed, while responses were slowed down somewhat by the prime repetition procedure during the first session, they were speeded up in the second session, suggesting at the very least that after sufficient practice, word repetition does not slow down target responses. Thus, these results are consistent with Neely's (1977a) finding that within a single-session experiment, continuous overt verbalization of the prime may slow down responding (whether or not the prime is related to the target). We may speculate, however, that had Neely administered an additional session, this difference would have disappeared with practice.

In the present experiment, there were no differences in error rates between the two sessions that could account for the above-mentioned Repetition by Session interaction for words or nonwords. As in Experiment 1, the error rates were all less than 6%. The pattern of errors was almost identical to but slightly lower than in Experiment 1. An analysis of transformed error rates indicated that a difference of $.4\% \pm 1.0\%$ errors observed between words and nonwords was not statistically significant [$F(1,19) = 4.01$, $p < .10$], but the difference was in a direction consistent with the typical finding that subjects find words easier to recognize than nonwords. As well, $2.5\% \pm 1.1\%$ fewer errors were made in response to associated targets than to unassociated targets [$F(1,19) = 12.75$, $p < .01$]. Percent errors did not vary reliably across any of the other conditions. The analysis of percent errors suggests that differences in reaction times were probably not influenced by a speed-accuracy tradeoff.

In general, then, the results of Experiment 3 support the findings and conclusions of Experiment 1.

GENERAL DISCUSSION

Three experiments were conducted to determine whether semantic satiation of a word, through its

continuous repetition, would result in any satiation or loss of meaningfulness for related words as well. Previous attempts to demonstrate a satiation effect for associated words, using such dependent measures as the number of associations elicited after repetition or the commonality of such associations, have failed to provide convincing evidence that repeatedly saying a word has any influence upon its associates. In contrast to the failure of these measures to demonstrate any inhibition of associates, a consistent priming or facilitating effect among related words has been observed (in the absence of repetition) when employing a lexical decision task. This task requires that subjects indicate whether or not a string of letters is a word. The procedure appears to be sensitive to inhibitory effects as well, since decision latency is longer following the presentation of an unrelated word than after a neutral stimulus such as XXX (Neely, 1976). Therefore, it was suggested that the lexical decision task, with continuous repetition of word associates, might provide a more sensitive index of the changing activation levels among semantically related units than the methods previously employed, thus yielding some evidence relevant to the issue of loss of meaningfulness. Such a decline in meaning after repetition of an associated prime would be revealed either by increased reaction time in deciding that a string of letters is a word or, failing to demonstrate a reversal of the priming effect, by a reduction in the amount of facilitation. Evidence of neither sort was found in the present study. In contrast with the prediction of the semantic satiation hypothesis, that there should be some inhibition of associates following continuous overt verbalization, the priming effect observed for related words in the repetition condition was equal in magnitude to that in the nonrepetition condition. This outcome is consistent with Neely's (1977a) results in indicating the absence of semantic satiation effects in a lexical decision task, despite the use of a longer satiation period here. One must therefore question the basis for this general failure to find any loss of meaning among associated words under conditions of prime repetition.

One possibility is that the lexical decision task is not the best paradigm to employ in the study of meaning. Subjects, it may be argued, might be able to ascertain whether a given word is in the lexicon without actually activating its meaning. Thus, any procedure that leads to a decline in the meaning of the word would not necessarily influence the time to decide if that word is in the lexicon. However, James (1975) has shown that when pronounceable nonwords are used, the latency of the lexical decision task for concrete words is shorter than that for abstract words, a difference that clearly depends upon the meaning of the word. Since the nonwords employed in this study were all pronounceable, it would therefore appear that subjects must rely upon the meaning of the word to perform the task.

A second possibility is that the phenomenon of "semantic satiation" is somewhat an artifact, in that it may not really involve a reduction in the degree of meaningfulness of a word (as Esposito & Pelton, 1972, have argued). If this is true, it would explain why the number and the commonality of associations that subjects produce for a word following repetition is inconsistent across studies and also, why there is no loss of meaning for associated words, as indicated by our own results and by those of Neely (1977a).

Why, then, would subjects report an apparent loss of meaning after continuous repetition of a word? Such an effect can be understood by invoking Morton's (1970) logogen model, which is replicated in Figure 1. According to this model, verbal long-term memory (the cognitive system) contains logogens: memory structures involving stored information about words. Such information includes meaning, pronounceability, and spelling. Logogens for semantically related words are assumed to be located nearer to each other in long-term memory than are logogens for semantically unrelated words.

Employing this model, Neely (1977b) and Posner and Snyder (1975a, 1975b) account for the semantic facilitation effect, which is typically observed after presentation of an associate, by two factors. The first factor is the spread of activation among related logogens, a mechanism that operates automatically and very rapidly, and that has no inhibitory effect upon unrelated logogens. Strong evidence for this spreading activation in a lexical decision task has also been provided by Schvaneveldt and Meyer (1975). The second factor

involves a limited-capacity attentional mechanism that can shift between semantically related logogens more rapidly than between unrelated units. This mechanism is under conscious control, is slower acting, and, by directing attention away from unrelated logogens, results in inhibition of the latter.

Our failure to find a decline in meaning (i.e., a reduction in semantic facilitation) with continuous repetition of a stimulus may be accounted for by considering in greater detail the logogen model along with the above-mentioned two-factor theory of semantic processing. As may be seen in the diagram, a given logogen can be activated in three ways. The first method is via the sensory (visual or acoustic) analysis mechanism that employs a bank of feature detectors to count either the visual or auditory features of the verbal stimulus. A second means of activation is via the cognitive system, which performs an analysis upon the semantic attributes of the stimulus. Thus, the level of activation can be increased via semantic context and memory factors within the cognitive system, in addition to the sensory features of the word. Finally, available responses go to the response buffer, from which they emerge as actual responses or are recirculated to the logogen system in a vocal rehearsal loop or in a silent rehearsal loop.

Continuous activation, either through prolonged visual inspection (which, it may be argued, induces implicit speech and therefore activation of the silent rehearsal loop; see Neely, 1977a) or through overt repetition, which activates the vocal rehearsal loop, causes fatigue in the response buffer. Consequently, it becomes increasingly difficult to pronounce a word during repetition. (The reader need only repeat the word "large" for 30 sec to convince himself of this.) As a result, the information leaving the response buffer via the rehearsal loops is not identical to the response entering it. If we may assume that the amount of attention directed to any one of the three systems (cognitive, logogen, or response) is task-dependent, then a perceived change between the input and output at the response buffer can cause attention to be shifted to it, thereby reducing the attention available for sensory or semantic analysis. Alternatively, a shift of attention to the phonetic characteristics may become necessary because of the increasing difficulty in pronouncing a word during repetition. In either case, it is probably the transfer of attention from the cognitive system to the response buffer that results in the phenomenological loss of meaning that subjects report after continuous repetition of a word. However, as there is no fatiguing of the cognitive system, subsequent tests of the meaningfulness of the word would fail to provide reliable evidence of any semantic satiation.

Returning to our particular experimental paradigm, we can now suggest why there is no change in the time required to make a lexical decision about a repeated

Figure 1. Morton's logogen model of verbal information processing (adapted from Morton, 1970).

word or the associate of a repeated word. Repetition appears to fatigue neither the sensory nor the semantic analysis systems. The response buffer does suffer fatigue in terms of pronunciation; however, the lexical decision task does not require that subjects pronounce the printed word and so this fatigue does not influence the word-nonword decision. Consequently, there is no effect on the decision time. Similarly, since it is not the logogen inside the cognitive system that becomes fatigued, there can be no spread of inhibition to related logogens.

Finally, some mention should be made about the effect of overt verbalization, *per se*, on semantic priming. Neely (1977a), observing that the facilitation effect obtained in his repetition was only 29 msec, which is about one-half the magnitude of the facilitation usually found (when there is not continuous repetition), was led to conclude that there may be some nonspecific effect of overt verbalization which tends to reduce the priming effect. Neely speculated that repetition might either inhibit the spread of activation among semantically related logogens or inhibit the ability of a subject to direct limited-capacity attention to logogens semantically related to the priming word. However, as mentioned earlier, Neely's study did not itself include a nonrepetition condition, and conclusions were based upon comparisons between data collected in two different experiments. The experiments reported here do include a nonrepetition control in which the prime was verbalized only once and no nonspecific effects of overt continuous verbalization were found. That is, the magnitude of the semantic facilitation effect was equally great in verbal repetition and nonrepetition conditions, thus suggesting that continuous verbalization produces neither specific nor nonspecific effects on lexical decisions. In conclusion, these data fail to provide evidence of reduced semantic facilitation when making lexical decisions about words whose associates have been continuously repeated. This finding adds further support to the accumulating body of data (Esposito & Pelton, 1971; Neely, 1977a) that semantic satiation may be a pseudophenomenon, not truly related to the loss of meaning of a word.

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