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Facilitation without inhibition

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Two experiments employing the lexical decision task were conducted. In each experiment, an attempt was made to replicate Neely's 1976 study; however, in both experiments, although facilitation was exhibited, there was never any inhibition found. Results were affected by time parameters but were affected little by the nature of the prime. Results fail to verify the two-process model of semantic memory as proposed by Neely.

Semantic memory is memory for rules, ideas, concepts, and general properties about the world. One of the most influential models of human memory, and especially of the retrieval process in memory, has been the one put forth by Morton (1970). Morton's notion of logogens as memory units has led to a series of studies using the lexical decision task. In this task, subjects decide, as quickly as possible, whether a "target" word is a word or nonword, and reaction times are measured. Usually a "prime" word precedes the target, and its semantic relation to the target is the main experimental manipulation. The critical finding is that the extraction of information from semantic memory is affected directly by the amount of association between the prime and target (i.e., "NURSE" has an effect very different from that of "BREAD" on reaction time to the subsequent word "DOCTOR").

Initial theoretical ideas focused on Morton's (1970) logogens and the way that they might be organized in memory. Early models developed out of the ideas that there is a spreading activation from one logogen to another and that semantically related logogens share some kind of memory map space. Accordingly, when one logogen is activated, related (close) logogens will also be activated. Thus, a word that has received some activation will be easier to extract from memory, and reaction time should be short—at least relative to reaction time to a nonprimed stimulus or to an unrelated stimulus. Thus, there is a facilitation effect for the processing of related word pairs. In general, this model is called a *spreading activation model*.

Alternative explanations to spreading activation were quickly posited; Schvaneveldt and Meyer (1973) noted that perhaps logogens of semantically related words are located closer together than those of unrelated words. With this organization, the facilitation and speeded reaction time might be due to attentional mechanisms; facilitation occurs because of shorter distances between semantically related logogens. Also, because unrelated words are located farther apart, extraction of these unrelated words from semantic memory is slowed down. Thus, with unrelated pairs, reaction time is slower to the target word; that is, there is an *inhibition* in processing. In general, this notion is referred to as a *location shifting model*.

Posner and Snyder (1975a, 1975b) proposed that spreading activation and attentional ideas like location shifting can be conceived of as complementary processes rather than as mutually exclusive ones. The idea that Posner and Snyder developed was that there exist two processes, a fast-acting, automatic, and unconscious process of *spreading activation*, and a slow-acting, conscious process that might be termed a *limited-capacity attention mechanism*. Posner and Snyder differed from their predecessors in arguing that these two processes work together. They especially noted that there were conditions in which inhibition occurred without facilitation and conditions in which enhanced facilitation occurred coupled with inhibition.

Of the studies that utilized the lexical decision task, most addressed only spreading activation as evidenced by facilitation effects. For example, Fischler (1977a) manipulated subject expectancy and found no processing bias introduced by expectancy; Fischler (1977b) used semantically similar words and found they produced as much facilitation as association norms; Tweedy, Lapinski, and Schvaneveldt (1977) varied the proportion of semantically related pairs and found that increasing the proportion of related pairs increased recognition of related pairs but did not significantly decrease the recognition of unrelated pairs. Becker (1979) varied semantic context and word frequency and found that they did interact such that semantic context facilitated low-frequency words more than high-frequency words; Koriat (1981) varied the amount of relatedness between word pairs and found that facilitation did not vary as a function of relatedness; and Lorch (1982) varied stimulus onset asynchrony (SOA) and found no significant differences due to SOA between high- and low-associated pairs.

The research designed to investigate the limited-capacity attentional mechanism, however, has not been as extensive as that designed to investigate facilitation. Of these studies (i.e., Becker, 1980, 1982; Neely, 1976, 1977; Stanovich & West, 1979, 1981; West & Stanovich, 1982),

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the most direct test of the two-process model was conducted by Neely (1976). Neely argued that if a prime were a row of Xs, then it would neither activate a specific logogen, or set of logogens, nor create facilitation for related pairs or inhibition for unrelated pairs, and these effects could therefore be more readily assessed. Neely found that, as SOA increased in the lexical decision task, facilitation for related word pairs increased (e.g., 56 msec at the 2,000-msec SOA). Inhibition for unrelated word pairs, however, did not increase as SOA increased. These results show the action of both processes but do not directly comply with the predictions of Posner and Snyder (1975a, 1975b). Specifically, the limited-capacity attentional mechanism is assumed to be a slow-to-operate, conscious process, and, thus, there should be greater effects at longer SOAs. This, however, is not what Neely found.

Models of semantic memory have stressed the role of both facilitation and inhibition to explain the extraction of information. The two-process model requires both. Since the limited-capacity attention mechanism has been studied relatively little, in comparison with spreading activation, the present experiments were conducted in an attempt to replicate the findings of Neely (1976) and thus provide baseline results from which logical extensions could be made to investigate further the two-process model.

Both of the present experiments were designed to reexamine the work by Neely (1976) on the time parameters involved in the extraction of information from semantic memory. Neely (personal communication, December 3, 1981) provided additional detailed information about the stimuli, design, and procedures from his 1976 study. The aim was to establish a baseline set of data replicating the Neely study.

Neely (1976) Study

Design. The dependent measure used by Neely (1976) was the amount of time it took a subject to respond that a visually presented target string was either a word or a nonword. On 50% of the trials, the target string was a common English word, and on 50% of the trials, the target string was a pronounceable nonword. Prior to the presentation of the target letter string, a prime was shown for 360, 600, or 2,000 msec. Neely preceded the target letter strings with related primes, unrelated primes, and neutral primes (which consisted of a row of six Xs). In short, the design for word targets was a 3 (prime duration) × 3 (prime type) design, whereas that for nonword targets was a 3 (prime duration) × 2 (prime type) design (there was no distinction between related and unrelated primes for nonwords). Each subject received each of the nine word and six nonword conditions.

Stimulus materials. The stimuli were chosen from the normative free-association data of Shapiro and Palermo (1968). In the related-word condition, the target letter string was the primary associate to the prime. In the unrelated condition, the primes were rearranged such that no prime appeared with its primary associate on any trial, and for the word prime-nonword condition, the primes were chosen solely on the basis of word frequency such that they matched with the primes for both the related and unrelated conditions. This frequency was based on the norms of Kučera and Francis (1967). The nonword targets were drawn from the Shapiro and Palermo norms. By changing one letter in each of these words (e.g., "BRUSH" to "GRUSH" and "CREDIT" to "CREMIT"), Neely (1976) constructed pronounceable nonwords.

With these materials, six blocks of 42 trials each were constructed. Each of the word targets never appeared more than once in the experiment, but each of the nonword targets appeared twice, once in the first three blocks and once in the second three blocks. Through random assignment within each block of 42 trials, there were 7 observations each of related-word, unrelated-word, neutral-word, and neutral-nonword conditions and 14 observations of the word-nonword condition.

One critical feature of Neely's (1976) design was the SOAs used. As noted earlier, immediately prior to each target, a prime was presented for 360, 600, or 2,000 msec. These SOAs were assigned randomly to each of the six blocks such that eacch block received each SOA and no two successive blocks were assigned the same SOA.

A practice block was also constructed that consisted of 14 word and 14 nonword targets, a total of 28 trials. Within this block of practice trials, the first 14 always had an SOA of 2,000 msec, and the second 14 trials had an SOA of 360 msec. No related-word pairs appeared in the practice block; only unrelated and neutral primes were used.

EXPERIMENT 1

Method

Subjects. The subjects were 18 undergraduate introductory psychology students.

Design. The design used was nearly a direct replication of that used by Neely (1976), although there were differences. Neely used a tachistoscope, and all of our experiments were conducted with an Apple II computer. Neely had a 9-sec intertrial interval. In this experiment, the subjects were allowed to take as long as they wanted before initiating a trial. Neely's trials were experimenter paced, whereas our trials were subject initiated; we felt that this difference was unlikely to be a significant source of variance. Neely had a 2-min block change; our subjects were given a signal on the screen that the durations for the next series of trials would be different. This signal lasted 5 sec.

Procedure. The subjects were tested individually. Instructions read to the subjects were those given to Neely's (1976) subjects (i.e., to make fewer than 10% errors and to fixate visually on both the prime and the target for as long as they remain displayed). Each trial began with a subject's pressing a footpedal located under the video console. The response keyboard was located on the table to the right of the subject. After the subject had made a response, the reaction time for that trial was displayed on the screen. The subjects were not told whether they had responded correctly. For the change in SOA between blocks, the subjects received a message on the screen that the next series of trials would be shown for a different duration.

Results and Discussion

The overall error rate for Experiment 1 was 8%. An ANOVA of the errors showed no pattern of results other than the unrelated condition's accounting for the greatest percentage of errors.

Results of the nonword target conditions showed that reaction time to the word prime conditions was an average of 27 msec faster than reaction time to the neutral prime condition. This facilitation for the word prime was found at all three SOAs. This result is consistent with that of Neely (1976), who found reaction time to the word prime condition to be an average of 12 msec faster than that to the neutral condition.

The reaction time results for the primes and targets showed a large facilitation effect at all SOAs. At 360 msec, there was 53 msec of priming. The greatest amount was obtained at the 600-msec SOA: 66 msec. There was only 29 msec of priming obtained at the 2,000-msec SOA. This is inconsistent with Neely's (1976) results in that he obtained the most facilitation at the 2,000-msec SOA: 56 msec.

Pairwise contrasts showed the related condition to be significantly different from the neutral condition at all three SOAs. The greatest difference was found at the 600-msec SOA [$F(4,17) = 16.48, p < .001$]. When comparisons of the unrelated conditions with the neutral conditions were made, 7 msec of inhibition was found at the 360-msec SOA, none at the 600-msec SOA, and only 2 msec at the 2,000-msec SOA. These findings are inconsistent with those of Neely (1976), who obtained as much as 24 msec of inhibition at the 2,000-msec SOA; Neely also obtained 16 msec of inhibition at the 360-msec SOA and 10 msec at the 600-msec SOA. The ANOVA on the present data showed that these inhibition effects did not reach significance. These results were surprisingly different from those of Neely; therefore, an additional study, in which twice as many subjects were used to obtain support for this pattern of results, was performed.

EXPERIMENT 2

This experiment was conducted to provide further evidence for the pattern of results obtained in Experiment 1. This study was another replication of Neely's (1976) design, but with twice as many subjects.

Method

Subjects. The subjects were 36 undergraduates.

Design. The experiment was a direct replication of that of Experiment 1.

Results and Discussion

The overall error rate for Experiment 2 was 6%. An ANOVA showed no particular pattern other than the unrelated condition's accounting for the greatest percentage of errors.

The reaction time results of this experiment showed facilitation at all three SOAs. At 360 msec, the greatest amount of priming was found: 80 msec. This is again inconsistent with Neely (1976), who obtained the largest effects at an SOA of 2,000 msec. Pairwise contrasts showed the related conditions to be significantly different from the neutral conditions at every SOA. The greatest difference was obtained at the 360-msec SOA [$F(4,35) = 71.33, p < .001$]. When compaisons of the unrelated conditions with the neutral conditions were made, no inhibition was found. This again contradicts Neely's results, but it supports the results we obtained in Experiment 1.

The results of the nonword data are consistent with those found in Experiment 1. Facilitation was found at all SOAs, with the average reaction time for the word prime being 29 msec faster than that for the neutral prime.

Further analyses were performed on the combined results of Experiments 1 and 2 (a total of 54 subjects). As can be seen in Figure 1, when Experiment 1 (top) and Experiment 2 (middle) are considered together (bottom), the largest facilitation was obtained at the 360-msec SOA. As can be seen in Figure 2, these results are distinctively different from those of Neely (1976); in fact, the extent of inhibition is in the opposite direction. When pairwise contrasts were conducted on the two studies combined, they again showed the related conditions to be significantly different: Reaction times to every condition at every SOA are different from those obtained by Neely (1976).

In our attempted replication, we did not provide accuracy feedback to the subjects. Therefore, an additional group of 18 subjects was tested. After every trial in which a subject made an error, the subject received an error mes-

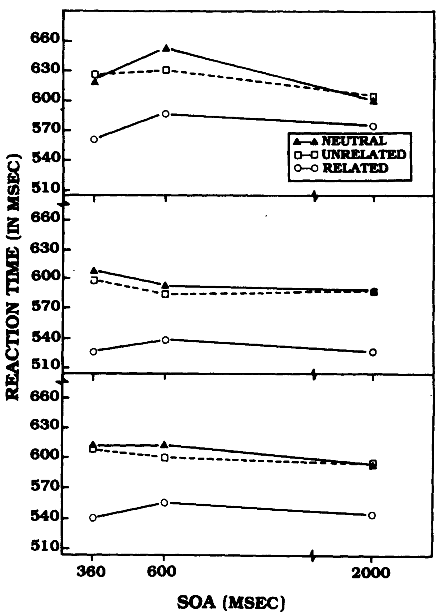

Figure 1. The upper panel shows mean reaction time (in milliseconds) to the target for Experiment 1 (18 subjects)—each data point represents the mean of 756 observations; the middle panel shows the results of Experiment 2 (36 subjects)—each data point represents the mean of 1,512 observations; the lower panel combines the results for Experiments 1 and 2 and shows the overall results for 54 subjects—each data point represents the mean of 2,268 observations.

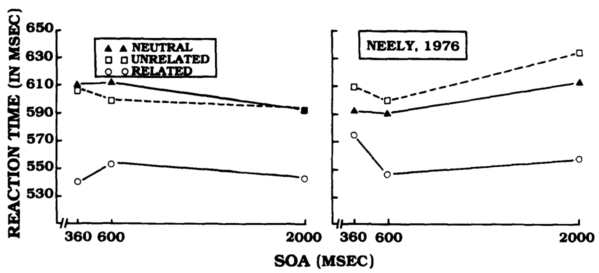

Figure 2. The left-hand panel shows mean reaction time (in milliseconds) to the target at each SOA for Experiments 1 and 2 (combined results)–each data point represents the mean of 2,268 observations on 54 subjects; for comparison purposes, the right-hand panel shows Neely's (1976) results–each data point represents the mean of 756 observations on 18 subjects.

sage on the screen and his or her overall error rate. Results of these additional 18 subjects were in the same direction as those of Experiments 1 and 2. The overall error rate decreased to 5%. The largest facilitation was obtained at the 600-msec SOA—66 msec—which is consistent with results from Experiment 1, in which there were also only 18 subjects. An ANOVA and pairwise contrasts showed the same patterns as those for the other experiments. Again, when the unrelated and neutral conditions were compared, no inhibition was found. Thus, with or without feedback, the results were virtually the same.

GENERAL DISCUSSION

The failure to replicate Neely's (1976) results in two separate experiments conducted under conditions virtually identical to those of the original experiment was surprising. It was also disturbing, since so much theorizing has taken place that uses the Posner and Snyder (1975a, 1975b) conception of semantic memory and Neely's (1976) data to back up the theory. The results of the present series of studies call into question not only the inhibition found by Neely, but also the nature of the prime in semantic memory. The present results fail to support the idea of inhibition, but they are predicated on the idea suggested by Posner and Snyder and implemented by Neely, that is, that a row of Xs is a neutral nonlogogen-stimulating stimulus. Neely's 16 msec of inhibition was a weak effect; the present results failed to confirm it with the same methodology and many more subjects. One serious possibility is that inhibition in semantic memory does not exist. Equally compelling as an explanation, however, is the idea that the "neutral" prime of six Xs is not neutral. Other, ongoing research in our laboratory suggests that this failure to find inhibition may be due to conceiving of a string of Xs as a neutral prime. If all calculations of facilitation and inhibition are made using this condition as baseline, and it is an inappropriate baseline, then further studies need to be conducted to determine the actual extent of *real* facilitation and/or inhibition.

We conclude that Posner and Snyder's (1975a, 1975b) conception of semantic memory may be the best explanation to date. Inhibition in semantic memory may be a real and robust phenomenon. However, with the use of Xs as a neutral prime, evidence for inhibition is illusory.

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