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Imagery and meaning in semantic memory

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Two experiments were conducted to investigate the potential role of imagery and meaning in semantic memory. Through the use of the lexical decision task, facilitation was found for all conditions in two experiments, whereas inhibition was not obtained for any condition. Results are interpreted as consistent with predictions about the value of imagery and meaning in the extraction of information and inconsistent with the two-process model of semantic memory.

There exists a growing body of evidence (e.g., Paivio, 1971) that suggests that when subjects are presented with words, it is likely that they form images of those words. These images have been shown to produce positive effects on performance (Paivio & Smythe, 1971). The idea that images may have functional significance in verbal learning and memory extends to the phenomenon of meaning. Paivio (1971) held that the meanings of words are also central because both imagery and meaning are linked to the semantic attributes of verbal and nonverbal stimuli. It is this link with semantics that was addressed by the present experiments: Specifically, what role do imagery and meaning play in the extraction of information from semantic memory?

The two-process model of Posner and Snyder (1975a, 1975b) proposes a network of nodes or logogens (e.g., Morton, 1970) and the concepts of spreading activation and the limited-capacity attentional mechanism. Spreading activation is an unconscious, fast-acting process in which activation of a particular node in memory spreads to related nodes. This activation facilitates extraction of that related node. The limited-capacity attentional mechanism, on the other hand, is a conscious, slow-acting process that inhibits extraction of unrelated nodes. Specifically, nodes of related words are located closer together than nodes of unrelated words, and the facilitation that occurs is due to shorter distances between semantically related nodes. Likewise, inhibition occurs due to longer distances between unrelated nodes.

With this as a starting point, we postulated that the nature of a word's imagery and meaning could affect both spreading activation and/or the limited-capacity attentional mechanism in a lexical decision task.

The purpose of Experiment 1 was to explore the nature of imagery and meaning when they were independently controlled and manipulated in a lexical decision task. Words high in meaning and imagery may serve as better primes and bring about greater facilitation. Similarly, they may also bring about a great deal of inhibition. If either imagery or meaning is a potent variable, this can change the way we conceptualize semantic memory.

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EXPERIMENT 1

Method

Subjects. The subjects were 50 undergraduate introductory psychology students at the University of South Carolina whose participation in the experiment fulfilled a course requirement.

Stimulus construction: Primes. Primes were words that were either high or low in imagery, high or low in meaning, or a string of six Xs (neutral condition). Primes were chosen from 925 nouns rated on imagery and meaning by Paivio, Yuille, and Madigan (1968). The imagery rating of a word was in terms of its capacity to arouse nonverbal images. Paivio et al. used a 7-point scale and obtained a mean rating of 4.97 (standard deviation = 1.93). The meaning rating was defined in terms of the mean number of written associations to a word in 30 sec. They obtained a mean rating of 5.81 (standard deviation = 1.21). Primes were chosen such that they were high or low in imagery and were controlled with respect to meaning. Similarly, words high or low in meaning varied little on imagery. To this end, the norms presented by Paivio et al. were used to find stimuli that met the specific criteria.

High-imagery stimuli consisted of words that had mean imagery ratings greater than 4.97 and that fell within .5 standard deviations of the mean on meaning (i.e., between 5.21 and 6.41). Low-imagery stimuli consisted of words that had mean imagery ratings less than 4.97 and that fell within .5 standard deviations of the mean on meaning (i.e., between 5.21 and 6.41). High-meaning stimuli consisted of words that had mean meaning ratings greater than 5.81 and that fell within .5 standard deviations of the mean on imagery (i.e., between 4.01 and 5.93). Low-meaning stimuli consisted of words that had mean meaning ratings less than 5.81 and that fell within .5 standard deviations of the mean on imagery (i.e., between 4.01 and 5.93).

Stimulus construction: Target words. Target words were related words, unrelated words, or nonwords. All target words were high in imagery and high in meaning (i.e., a mean rating greater than 4.97 on imagery and a mean rating greater than 5.81 on meaning). Related target words were chosen from lists of association norms provided by Deese (1965), Palermo and Jenkins (1964), and Postman and Keppel (1970). Each prime was examined to find target words that were highly related and that also met the criteria for imagery and meaning. Unrelated target words and neutral-prime target words were chosen solely on the basis of their imagery and meaning ratings and met the same meaning and imagery criteria as related target words. Nonword targets were constructed by changing the vowels of the related word targets so that they formed pronounceable nonwords.

Design. The experiment consisted of 14 conditions. High- and low-imagery primes and high- and low-meaning primes were paired with related and unrelated targets. In addition to these 8 conditions, each subject was also tested on 4 nonword target conditions and 2 neutral (XXXXXX) conditions. In the neutral condition, the row of six Xs was followed by a word or a nonword. The duration of the prime was 200 msec. The interstimulus interval between the prime and target was 500 msec, resulting in a stimulus onset asynchrony (SOA) of 700 msec.

Before any experimental trials, each subject saw a 75-trial practice list and then one of the two test lists. With 14 conditions repeated four times, there were 56 trials in a list. Two different test lists of 56 trials each were constructed and used for different subjects for counterbalancing purposes. Pairs of words were assigned to the two lists such that in each one there were four instances of each condition in each list and no target word appeared twice in one list. The conditions were organized such that, within each block of 14 trials, each condition appeared once. With 14 trials per block, four blocks per list, and two lists, there were 112 experimental trials.

Apparatus. Stimuli were presented on a 9-in. video monitor. Stimulus presentation and duration were controlled by an Apple II Plus computer. The software controlling stimulus presentation and timing was developed by uisng both BASIC and machine language subroutines for millisecond accuracy in the timing sequences. Modifications of the Apple II were made in accordance with those suggested by Reed (1979) for millisecond timing accuracy. The Apple II was enhanced with a Mountain Hardware clock. The BASIC program that controlled stimulus presentation called up machine language timing subroutines to turn the clock on and off in response to the subject's pressing a key. The subject was provided with a response board that consisted of two keys spaced 50 mm apart.

Procedure. The subjects were tested individually. General instructions were read to subjects prior to the experimental session. Each trial began with a fixation point in the middle of the screen; the point signaled the subject to press the foot pedal located under the video console to begin the trial. The response keyboard was located on the table to the right of the subject. Each trial consisted of two letter strings: a prime (word or XXXXXX) and a target (word or nonword). The subjects were instructed to respond as quickly as possible to the second letter string. They responded by pressing one of the two keys marked "word" and "nonword" on the response board, and reaction time was recorded as the dependent measure.

Results and Discussion

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

The reaction time results of this experiment showed facilitation, which was calculated by subtracting the mean reaction time for the related word condition from the mean reaction time for the neutral condition, for both high- and low-imagery and high- and low-meaning primes. As can be seen in Table 1, there was 150 msec of facilitation in the high-meaning condition and 136 msec of facilitation in the low-imagery condition. The ANOVA showed a significant main effect of imagery (high vs. low) [$F(8,49) = 7.19$, $p < .01$, $\omega^2 = .015$]. Pairwise contrasts showed each condition to be significantly different from the neutral condition, with the high-meaning related condition showing the greatest difference from the neutral condition, a difference of 150 msec [$F(8,49) = 72.99$, $p < .001$, $\omega^2 = .064$].

There was no significant difference found between the high- and low-meaning conditions; all were effective in producing facilitation. Surprisingly, the data showed that reaction time to the low-imagery condition was faster than reaction time to the high-imagery condition. It is possible that, due to the high-imagery content of some words, subjects were doing a complete search of meaning for all associates (and images) of a word before responding, from which resulted the longer response times in the high-imagery condition.

The nonword target data showed that reaction times to the word-prime conditions were on the average 31 msec faster than those to the neutral-prime condition, thus showing facilitation for the word primes. This facilitation for word primes is consistent with the work of Neely (1976) and with the more recent work of Schvaneveldt and McDonald (1981).

Quite surprising were the data for the unrelated condition. This condition showed reaction time to be 94 msec *faster* than that in the neutral condition. The unrelated condition, which was expected to show inhibition, in fact showed facilitation. We expected, consistent with the literature (i.e., Balota, 1981; Posner & Snyder, 1975a, 1975b; Neely, 1976) that reaction time in the

Table 1
Mean Reaction Time (in Milliseconds) to the Target: Experiment 1

Condition	Prime: Related	Prime: Neutral	Prime: Unrelated	Priming	Reaction Time
		Word Data			
High imagery	674 (2)	748 (7)	684 (2)	74	
Low imagery	612 (.5)		647 (.5)	136	
High meaning	598 (2)		654 (2)	150	
Low meaning	619 (.5)		632 (3)	129	
Mean	625		654	122	
		Nonword Data			
High imagery nonword					856 (6)
Low imagery nonword					873 (9)
High meaning nonword					844 (4)
Low meaning nonword					905 (11)
Neutral nonword					900 (7)

Note—Priming = neutral minus related. Numbers in parentheses represent error rates (in percent).

unrelated condition would be slower than that in the neutral condition. The present findings are inconsistent—no inhibition was evidenced.

Recent theory holds that an unrelated prime shares a different space in memory and thus requires additional time and attention for a subject to move from its processing to the processing of the target word. This inhibition (or slowing of response time) is calculated by subtracting the mean reaction time for the unrelated condition from the mean reaction time for the neutral condition. The neutral condition is assumed to give the subject no information about the target word, and thus reaction times should be faster than reaction times in the unrelated condition. Results in this direction would lend support for the limited-capacity attentional mechanisms suggested by Posner and Snyder (1975a, 1975b) and the concept of inhibition. This trend was not present in these data. No support for the operation of a limited-capacity attentional mechanism was evidenced.

These limited-attention mechanisms that account for inhibition are assumed to build up slowly and thus to be most effective at long SOAs. Thus, it was postulated that perhaps the obtained results were due to the SOA used. If Posner and Snyder (1975a, 1975b) were correct, then it could be that an SOA of 700 msec does not provide enough time for the limited-capacity processor to have this inhibition effect. Accordingly, in Experiment 2 the SOA was increased to 2,200 msec.

EXPERIMENT 2

If long SOAs yield greater effects due to the limited-capacity processing mechanism, then an effect of inhibition should be obtained by increasing SOA from its Experiment 1 level of 700 msec to 2,200 msec. Furthermore, the effects of facilitation obtained in the imagery and meaning conditions might also be modulated by a longer SOA.

Method

Subjects. The subjects were 50 undergraduate introductory psychology students.

Design. The design and procedure utilized in Experiment 2 were exact replications of those in Experiment 1, with the exception of the SOA used. In Experiment 2, the target was presented at an interstimulus interval of 2,000 msec, resulting in an SOA of 2,200 msec.

Results and Discussion

The overall error rate for Experiment 2 was 13%. An ANOVA of the errors showed no pattern of results other than the neutral condition's accounting for the greatest percentage of errors.

Results showed facilitation for high- and low-imagery and high- and low-meaning primes. As can be seen in Table 2, there was 161 msec of facilitation in the high-meaning condition and 145 msec of facilitation in the low-imagery condition. The ANOVA showed a main effect of imagery (high vs. low) [$F(8,49) = 5.29$, $p < .05$, $\omega^2 = .01$].

Results for the high-imagery and low-imagery conditions again showed reaction time for the low-imagery condition to be faster than that for the high-imagery condition. Pairwise contrasts showed each condition to be significantly different from the neutral condition; low-meaning related primes showed the greatest difference from the neutral condition, a difference of 181 msec [$F(8,49) = 79.42$, $p < .001$, $\omega^2 = .08$].

Consistent with the results of Experiment 1, when comparisons of the unrelated conditions with the neutral condition were made, no inhibition was found. Unrelated trials again took less time than the neutral trials. Overall, these conditions showed reaction time in the unrelated conditions to be an average of 121 msec faster than those in the neutral condition. Again, through facilitation, there is evidence that the automatic activation process was operative. However, because no inhibition was found, there is no evidence that the limited-capacity processing mechanism was operative.

Table 2
Mean Reaction Time (in Milliseconds) to the Target: Experiment 2

Condition	Prime: Related	Prime: Neutral	Prime: Unrelated	Priming	Reaction Time
		Word Data			
High imagery	766 (3)	857 (13)	765 (3)	91	
Low imagery	712 (1)		725 (2)	145	
High meaning	696 (4)		719 (5)	161	
Low meaning	676 (0)		738 (.5)	181	
Mean	625		736	145	
		Nonword Data			
High imagery nonword					857 (5)
Low imagery nonword					934 (7)
High meaning nonword					908 (8)
Low meaning nonword					963 (19)
Neutral nonword					983 (10)

Note—Priming = neutral minus related. Numbers in parentheses represent error rates (in percent).

Overall reaction time results showed an increase in Experiment 2 over those in Experiment 1. This increase is attributed solely to the longer SOA used, because the extent of facilitation obtained in the two experiments was essentially the same. Also consistent with Experiment 1, nonword target data showed reaction time for a word prime was on the average 43 msec faster than reaction time for a neutral prime.

GENERAL DISCUSSION

These experiments were designed to investigate the role that imagery and meaning might play in the extraction of information from semantic memory. Experiment 1 revealed that both high- and low-imagery primes and high- and low-meaning primes produced an average of 122 msec of facilitation. The most facilitation was produced by the high- and low-meaning primes (i.e., 150 and 129 msec, respectively). In Experiment 2, an increase in SOA to 2,200 msec brought an increase in facilitation to an average of 145 msec. Again, the high- and low-meaning primes were the most effective (i.e., 161 and 181 msec, respectively). These results support contentions made by Paivio (1971) that the meaning of words is central to semantics. By virtue of this alone, meaning should play a central role in the extraction of information from semantic memory, and it does. This is evidenced in the greater amounts of facilitation produced for the meaning conditions.

Most surprising in these data was the absence of any inhibition. The notion of the limited-capacity attentional mechanism suggests that unrelated word pairs should yield slower reaction times than neutral word pairs. The present data show results in the opposite direction. In fact, they show *facilitation* for the unrelated pairs. Thus, we conclude that, in accordance with the two-process model of Posner and Snyder (1975a, 1975b), facilitation is evidence that the spreading activation process is operative. With no inhibition, however, we have no evidence to support the notion of a limited-capacity attentional mechanism. We interpret the present results in terms of a model of facilitation in semantic memory in which inhibition is not evident when the meaning of words is so high that all words in semantic memory, whether related or unrelated, exhibit facilitation.

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