Automatic Activation in Semantic and Episodic Memory: Implications for the Utility of Conscious Awareness

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The primary issue addressed in the present research is to what extent does nonattended semantic activation influence long-term episodic memory storage? In reviewing the relevant literature it became clear that one major difficulty in conducting such a study was to insure that the semantic activation being produced was actually nonattended or automatic in nature. For example, there has recently been research utilizing an incidental learning paradigm which purports to indicate that aspects of a stimulus can be automatically encoded in long-term memory (Hunt, Elliot, & Spencer, 1979; Hunt & Elliot, 1980). The results of this research indicate that certain attributes of words, such as meaningfulness (cf. Hunt et al.), influence recall performance even though subjects are engaged in an irrelevant orthographic task at encoding. Such results have been viewed as indicating that meaningfulness can be stored automatically without the subject's attention (Hasher & Zacks, 1979). However as Hunt et al. have indicated, these incidental retention effects may also be given an alternative explanation. That is, these effects may reflect the "leakage" of encoding processes which are actually attentional in nature. Obviously, as Kellogg (1980) has recently pointed out, it is very difficult to unambiguously infer that aspects of a meaningful and perceptible stimulus are truly nonattended.

In one particularly relevant study, MacKay (1973) utilized a dichotic listening task to investigate nonattended processing. In this study, ambiguous sentences were presented to the attended auditory channel and disambiguating words were presented to the unattended channel. For example, if the attended sentence was "They threw stones at the <u>bank</u> yesterday," then to the unattended channel either the word <u>river</u> or <u>money</u> was presented concurrently with the ambiguous word <u>bank</u>. The results of a later recognition test yielded a small

(7%) biasing influence of the nonattended disambiguating word on the interpretation of the attended ambiguous word. Unfortunately, however, there are a few interpretive difficulties with the MacKay study. First, primary task performance (shadowing or writing the attended sentences) was set at 100% accuracy, and therefore, it is unclear whether the primary task demanded all of the subject's attentional capacity or was less than totally demanding, thereby allowing any available capacity to be allocated to the "unattended" words. Second, since on some trials only one word was presented to the unattended channel there should have been an auditory trace available for a considerable time (2 seconds, Crowder, 1976) during which subjects could have extracted meaning from the "unattended" word. Thus, in light of these difficulties, it is unclear whether MacKay's unattended biasing effects were actually due to subjects completely ignoring (not attending) to meaningful and perceptible disambiguating words. (Also, see Kellogg, 1980, for a number of different, but relevant, inferential difficulties with the general use of the dichotic listening task to investigate unattended processing.)

Given that there are these potential alternative accounts of the past research, an attempt was made in the present study to utilize a different experimental approach to investigate nonattended processing. The major problem with the studies reviewed above appears to be in making the inference that subjects are able and/or willing to "totally nonattend" to a meaningful and perceptible stimulus. One potential way to avoid this problem is to present a stimulus which is necessarily not perceptible, i.e., at a stimulus duration and intensity level which precludes the subject's awareness of the stimulus occurring. As Dixon (1971) points out, on purely logical grounds, a subject should not be able to attend to a stimulus if she/he is unaware of the occurrence of that stimulus. Clearly, in this light by investigating the influence of such a stimulus, one can avoid the inherent problem of inferring that the subject is not attending to a meaningful and perceptible stimulus. The current study is such a utilization of a subthreshold stimulus to investigate whether nonattended activation can influence the storage of a long-term episodic memory trace.

The memory aspect of the present research is based, in part, on a study by Light and Carter-Sobell (1970). In the present study a list of to-be-remembered (TBR) homographs and nonhomographs were visually presented. For half of the subjects, before the presentation of each TBR target word, a subliminal context item was presented; the remaining half received a supraliminal context item as a control. This context item was either 1) a word related to the target, 2) a word unrelated to the target, or 3) a neutral row of Xs or Ys. Subjects were then given a recognition memory test for the target words. In this recognition test, all of the targets were paired with a supraliminal context item. Half of these targets were paired with the same context item which was earlier presented at encoding, whereas, the remaining half were paired with a different context item. For the present purposes it is useful to focus on the related condition in which the TBR word is a homograph. In this case the predictions are straightforward. That is, if in the subliminal condition, the preceding context item influences the encoded memory trace of the TBR homograph, then one should find superior recognition performance when the same related context item is presented at recognition than when a different related context item is presented. For example, if the target word jam is presented with the context word grape then later recognition of jam should be higher when it is paired with the word grape than when it is paired with the word traffic. This is precisely the pattern of data reported by Light and Carter-Sobell with supraliminal context items presented at both encoding and at the time of the recognition test.

Although the influence of a subliminal stimulus on long-term storage is in and of itself interesting, it is also noteworthy that such an effect has relevance for one of the more contemporary models of memory and encoding; the Anderson and Bower (1973, 1974) model. According to Anderson and Bower, context serves to disambiguate the sense (concept) of an item which is encoded. That is, Anderson and Bower suggest that words are connected to multiple senses that are stored in memory. When a context word and a target are presented, activation spreads from the senses of the context and the senses of the target. The point at which there is an intersection between this spreading activation will determine which sense of the target is encoded in the propositional list structure (Anderson, 1976). Since this same disambiguation process occurs at recognition, a subject may access a different concept of a target if the context is switched between study and test; thereby, accounting for the context effects reported by Light and Carter-Sobell. With respect to the present research, if one finds evidence that activation is spreading from the subliminal context item _grape_ to the target _jam_ then, within the Anderson and Bower framework, one would also expect this same activation to bias the concept of _jam_ which is stored in the propositional list structure. That is, it seems unlikely that a subject would store in memory a sense of _jam_ which refers to _traffic tie-up_ if the context item _grape_ has just activated the sense of _jam_ which refers to _jelly_. However, this prediction is, of course, based on the assumption that one can find evidence that the subliminal context item is producing activation for the target. We shall now turn to a paradigm which has been viewed as reflecting such activation; semantic priming.

Semantic Priming

Typically, in a semantic priming experiment two stimuli are sequentially presented; the response latency to the second stimulus often being the primary variable of interest. The basic finding in this research is that subjects are both faster and more accurate in responding to the target when the prime and target are semantically related (e.g., nurse doctor) than when they are unrelated (e.g., bread doctor). Before describing how semantic priming will be used in the present study as an indicant of activation, it will be useful to first briefly describe a particularly relevant account of priming effects; the Posner and Snyder (1975) two process model.

The first process Posner and Snyder postulate is an automatic spreading activation mechanism which involves a spread of activation from the prime stimulus to related areas of memory. This spreading activation is 1) fast acting, 2) occurs without attentional allocation, and 3) only facilitates the retrieval of related information without inhibiting the retrieval of unrelated information. In the above example, this automatic activation would spread from the concept nurse to related concepts in memory such as doctor, thereby activating that concept and producing the decreased response latency for that item. The second process in the Posner and Snyder model is a limited capacity attentional mechanism which involves the prime directing a limited capacity processor to a certain area in lexical memory. Subsequently, when the target is presented this attentional mechanism must shift to a different area of memory to identify the target. Since related words should be represented relatively "closer" together than unrelated words, this attentional mechanism will shift a "shorter distance" for related words, thereby producing an attentional semantic priming effect.

In the present research an attempt was made to use the semantic priming paradigm to determine if a subthreshold context item (prime) is activating a concept underlying a target word. Since the subjects were unaware of the occurrence of the primes, any obtained priming effect should clearly fall under Posner and Snyder's automatic spreading activation mechanism. That is, activation from the prime should automatically spread to related areas in memory. Such activation would be reflected in faster response latencies to targets (bark) which follow a related prime (dog) than either a neutral (xxxxx) or unrelated prime (chair). More importantly, returning to the Anderson and Bower framework described above, if one finds evidence of such activation, via a semantic priming effect, then one would expect this same activation to influence the meaning of the word bark which is encoded in the propositional list structure. Such an influence would be reflected by context effects in later recognition memory performance.

Interestingly, some evidence already exists for subliminal priming (Fowler, Wolford, Slade, & Tassinary, 1981; Marcel, 1980; Marcel & Patterson, 1978; McCauley, Parmelee, Sperber, & Carr, 1980). For example, in one particularly relevant study, Fowler et al. found a significant semantic priming effect in both the RT and error rates of their fifth experiment, even though the prime was presented at a preexperimentally determined duration (and followed by a patterned mask) at which subjects could not discriminate between a word and a blank field. In their sixth experiment, Fowler et al. also manipulated the SOA between the prime and target. They argued, within the Posner and Snyder framework, that since the influence of a subliminal prime should be automatic in nature, and therefore fast acting, there should be significant priming effects at both the short (200 msec) and long (2000 msec) prime target SOAs. Interestingly, the results of this experiment only yielded a priming effect in RT at the long SOA. There are however a few interpretive difficulties with this experiment. First, there was evidence of a speed-accuracy tradeoff, i.e., although the related primes speeded RT by 32 msec there was also a 5% increase in errors, compared to the unrelated condition. This speed-accuracy tradeoff is problematic when one considers that the results of this experiment failed to replicate their fifth experiment which also utilized a 2000 msec prime-target SOA and yielded a priming effect in <u>both</u> errors and RT. Second, since there was no neutral control against which to measure facilitation and inhibition, it is unclear whether the effects at the long SOA were due to facilitation of the related condition or inhibition of the unrelated condition. The current study was an attempt to further investigate the nature of subliminal priming effects by 1) manipulating the prime-target SOA and 2) including a neutral prime condition to distinguish between facilitation and inhibition effects.

<u>Overview of the Experiment</u>

The experiment entailed two different sessions for each subject. During the first session each subject's threshold at which they could no longer discriminate between the presentation of a blank field and a word was individually determined. During Session 2, prime duration (subliminal vs supraliminal) and prime target SOA (350 msec vs 2000 msec) were factorially crossed to produce four between-subjects conditions. In the first half of Session 2, subjects participated in a primed LDT. The primes in this task were either related (<u>traffic</u>), neutral (<u>xxxxx</u>), or unrelated (<u>box</u>) to the targets (<u>jam</u>). The results of this priming task should provide data regarding 1) the phenomenon of subliminal priming with verbal materials (a phenomenon which has received support from experiments which were only partially reported in chapters by Marcel, 1980, and Marcel and Patterson, 1978; and the Fowler, et al., 1981, study discussed above), 2) the nature of any obtained subliminal priming effects, i.e., inhibitory vs facilitative effects, and 3) whether there is any activation spreading from the subliminal context to influence the encoding of the target. With respect to this latter issue, the crucial question is if one finds such subliminal priming effects, will the automatic activation reflected by such effects also bias the long-term memory trace of the targets? It seems unlikely that a subject would encode the sense of the word jam referring to traffic tie-up if there is evidence, via the priming task, that the subliminal context grape has automatically activated the sense of jam referring to jelly. This prediction was tested in a context recognition test in which each target was either presented with the same context item that earlier occurred in the LDT or a different context item.

Method

Subjects

Ninety-six subjects participated in this study for course credit. Twenty-four subjects participated in each of the four between-subjects conditions. Each subject was assigned to one of these conditions on the basis of their order of appearance at the laboratory. No condition was repeated until all four conditions had the same number of subjects.

Apparatus

A four-channel Gerbrands tachistoscope was used for stimulus presentation. Two of the channels and both of the eyepieces were fitted with polaroid filters. One of the eyepieces was rotated 90 degrees in order to present the stimulus and mask dichoptically to insure central masking. Following Fowler et al., the fixation field was adjusted to a lower luminance level than the remaining three fields to prevent forward brightness masking of the prime. Reaction time was measured to the nearest msec by a Lafayette clock/counter and printer.

Materials

Seventy-two homographs were chosen from the Cramer (1970), Kausler and Kollasch (1970), and the Perfetti, Lindsey, and Garson (1971) norms. These homographs had a median-frequency value of 57/million, as measured by the Kučera and Francis (1967) norms, ~~and a mean length of 4.3 letters~~. Furthermore, for each of these homographs, two high associates were also chosen from these norms and the Schvaneveldt, Meyer, and Becker (1976) and Yates (1978) papers. One of these associates was related to one of the meanings of the homograph, whereas the second associate was related to a different meaning. Also, for each homograph, two unrelated words were selected from the Kučera and Francis norms which approximately matched the related associates to that homograph in both frequency and letter length.

Kucera and Francis (1967) norms. Further-

Seventy-two nonhomographs were chosen from the Palermo and Jenkins (1964) and the Postman and Keppel (1970) norms. These nonhomographs had a median-frequency value of 101/million. Furthermore,

norms and two unrelated words were selected from the Kučera and Francis norms which approximately matched the related associates to that nonhomograph in both frequency and letter length.

List Construction. During the priming aspect of Session 2, each subject received a total of 152 trials; the first 24 of which were practice trials. Each 128 item test list consisted of 64 word trials and 64 nonword trials. Table 1 displays the different prime-target conditions. As shown in Table 1

Table 1

Word and Nonword Prime Conditions as a

Function of Homograph vs Nonhomograph Targets

Homographs				Nonhomographs			
Word				Word			
Conditions	Prime	Target	Trials	Conditions	Prime	Target	Trials
Related 1	Fence	Yard	16	Related 1	Milk	Cow	16
Related 2	Inch	Yard	16	Related 2	Bull	Cow	16
Neutral	XXXXX	Yard	16	Neutral	YYYYY	Cow	16
Unrelated	Glue	Yard	16	Unrelated	Wall	Cow	16
Nonword				Nonword			
Conditions	Prime	Target	Trials	Conditions	Prime	Target	Trials
Related 1	Fence	Yold	16	Related 1	Milk	Cel	16
Related 2	Inch	Yold	16	Related 2	Bull	Cel	16
Neutral	YYYYY	Yold	16	Neutral	XXXXX	Cel	16
Unrelated	Glue	Yold	16	Unrelated	Wall	Cel	16

each of the homographs and nonhomographs occurred in each of the prime conditions. Since no target was repeated within a particular list, there were 8 different lists constructed in order to counterbalance items across the prime conditions. Furthermore, as shown in Table 1, each homograph and nonhomograph target occurred in two different related conditions; each with a different related prime. For the homographs, these two different related primes biased different meanings of the homograph, whereas, for the nonhomographs the two different related primes were related to the same general meaning of the target.

All nonwords were produced by simply changing two letters in each target word to produce a pronounceable nonword. This method of nonword construction was utilized to insure that subjects attempted to access the meaning of the target in making their lexical decision instead of relying on gross physical features of the stimulus (cf. James, 1975). Also, as shown in Table 1, nonwords occurred in the same prime conditions as the word targets.

In sum, with the list construction displayed in Table 1, a particular word or nonword occurred only once in a particular list, and across lists each word and nonword (homographs and nonhomographs) served in each of the three major priming conditions (related, unrelated, and neutral). Furthermore, across the first four vs second four lists, each prime-target word pair served once in the word target conditions and once as a basis for the pronounceable nonword target conditions.

Once the prime-target pairs for a given list were designated, the trials across the prime conditions were randomly ordered with the only constraint being that each of the prime conditions occurred equally often during the first and second half of the prime trials. In this way, one could later analyze the first vs second half of the priming trials to test for any changes across time. Each subject received only one of the 8 lists.

Letter strings were printed in Schoolbook face 14 point print. All letters were capitals and each letter string was centered on a 5 x 8 inch white card. The letter strings subtended .28 degrees of vertical and from .66 to 2.2 degrees of horizontal visual angle. A horizontal pattern mask was produced by scrambling letter pieces of the same type. This pattern mask subtended an area of .45 degrees of vertical and 3.6 degrees of horizontal visual angle. The fixation mark consisted of a black "+" which subtended a vertical and horizontal visual angle of .30 degrees. Both the fixation mark and the pattern mask were centered on 5 x 8 inch white cards.

Recognition Test Construction. The recognition test consisted of 128 test items; 64 targets and 64 lures. Half of the targets (32) occurred with a context item at recognition which was the same item that served as a prime during the earlier LDT. For example, if the subject received INCH YARD during the LDT, then in the same context condition the subject received INCH YARD at recognition also. On the other hand, the remaining half of the recognition targets occurred with a context item which was not presented earlier as a prime during the LDT. For the homographs and nonhomographs which served in the related condition this different context word was the word which served as the prime in the corresponding different list in which that target also occurred in the related condition. For example, if the subject received INCH YARD during the LDT, then in the different context condition the subject received FENCE YARD at recognition (see Table 1). On the other hand, for the homographs and nonhomographs which served in the unrelated condition, this different context item was simply a different unrelated word which approximately matched the unrelated prime in word-frequency and letter length. For example, if the subject received WALL COW during the LDT, then in the different context condition the subject received BOOK COW at recognition. And finally, for the homographs and nonhomographs which served in the neutral condition this different context item was simply a row of Xs or Ys. That is, if the subject received XXXXX JAM during the LDT, then in the different context condition the subject received YYYYY JAM at recognition.

The 64 word lures in the recognition test were actually based on the nonword prime-target pairs which occurred in the earlier LDT. That is, the nonword targets for lists 1-4 during the LDT were based on the word targets used in lists 5-8 and vice versa. Thus, the lure pairs in the recognition test for those receiving either lists 1, 2, 3, or 4 were actually the word target pairs for those receiving either lists 5, 6, 7, or 8 and vice versa.

For example, if a subject received yold as a nonword during the LDT, then the subject would receive the word yard as a lure on the recognition test. Furthermore, as in the case of the recognition targets, half of the lures within each condition occurred with the same context item that earlier served as a prime, and the remaining half occurred with a different context item. This method of recognition lure pair construction was used because 1) These lure pairs mimicked the target condition, and therefore, each recognition target had a corresponding recognition lure in the same condition; 2) Subjects were not able to simply use the recognition context item to make their recognition decision since half of the lures had the same contexts that were presented earlier in the LDT and half did not.

The 128 item recognition test was typed in lower case on 2 pages. At the top of each page appeared a 5 point rating scale which ranged from 5 which meant "I am positive that word occurred on the list" to 1 which meant "I am positive that word did not occur on the list" with a rating of 3 meaning "just guessing." For each pair the context item occurred at the left of the underlined target and a space to the right was available for the confidence rating. A total of four different recognition tests were constructed. The same recognition test was used for Lists 1 and 5; 2 and 6; 3 and 7; 4 and 8, since the only difference between these list pairs was whether the targets occurred in the word or nonword conditions. Target and lure recognition pairs were randomly intermixed on the recognition test sheets.

Procedure

Session 1. During Session 1, each subject's subliminal threshold was individually determined by the method of descending limits. This session lasted approximately 35 minutes including a 10 minute dark adaptation period at the beginning of the Session. The procedure for setting these thresholds was based largely on the procedure described in Fowler et al. (1981).

Upon their arrival at the laboratory, each subject determined their dominant eye by binocular and monocular alignment of their index finger with a stimulus in the visual background of that finger. Following their dark adaptation, each subject was instructed to fixate on the center cross displayed in the tachistoscope and when they heard the tone to press a foot-switch which initiated the following sequence; (a) a word or blank card presented to the nondominant eye for 15 msec; (b) a dark field initially presented for 250 msec but was adjusted by the experimenter throughout the session; (c) a pattern mask presented to the dominant eye; (d) a return to the fixation cross. The subject's task on each trial was to verbally indicate whether or not a word had been presented. Subjects were told that their response should not be based on the identification of a word or letters of a word but rather they should respond "yes" even if they only saw a flash or blur. The inter-stimulus interval (ISI) was lowered on each block of six trials in which there were four or more correct responses according to the following sequence: 250 msec; 150 msec; 100 msec; 70 msec; 50 msec. The stimuli were originally presented at these long ISIs in order to allow the subject to become accustomed to the desired discrimination. When the 50 msec ISI was reached, there were 5 msec decreases in ISI at each block of six trials. The point at which the subject could no longer respond correctly on four or more trials at a particular ISI was initially that subject's subliminal threshold. Furthermore, to insure that the subject was at this threshold, the subject received a further 20 trials and if the subject did not respond correctly on, at least, 12 of these trials, this ISI was used as the subject's threshold. If the subject did respond correctly on 12 or more trials, the ISI was again reduced by 5 msec until the subject's threshold was reached. Subjects averaged approximately 120 trials in which these presence/absence judgements were made. Furthermore, in order to determine if this threshold changed across time, those subjects in the subliminal group had their thresholds again determined by this same procedure after Session 2 was conducted.

The stimuli used during Session 1 were those priming stimuli that a given subject did not receive (because of list counterbalancing) the following day during Session 2. Furthermore, only those priming stimuli which were five letters or longer (i.e., those words which should be the easiest to make the presence/absence discrimination) were utilized to establish a subject's threshold.

Session 2. During Session 2 subjects were individually tested in a session which lasted approximately 1 hour and 30 minutes including 10 minutes for dark adaptation. In order to record the subject's responses, two response keys were placed in front of the subject. Subjects were told that the left and right keys indicated nonword and word targets, respectively.

For those subjects receiving the primes at their subliminal threshold, the following stimulus sequence occurred on each trial: (a) the fixation cross; (b) the tone which indicated that the subject had 2.5 seconds to initiate the stimulus sequence by pressing the footswitch; (c) the priming stimulus presented to the nondominant eye for 15 msec; (d) a dark field presented for the critical ISI determined during Session 1; (e) the pattern mask presented to the dominant eye for 30 msec; (f) a dark field presented for a duration such that phases c-f (prime-target SOA) summed to either 350 msec or 2000 msec; (g) the target stimulus presented binocularly for 2000 msec during which the subject made her/his lexical decision; (h) a return to fixation. This same basic sequence was used for those subjects receiving the primes at supraliminal durations except that: (a) the priming stimulus was presented for 300 msec; (b) no mask was presented; (c) the dark field was presented for either 50 or 1700 msec depending upon the prime-target SOA condition. After the subject's response was made, the experimenter recorded the response (word vs nonword) and gave immediate oral feedback regarding the accuracy of the response. The ISI was kept constant at 10 seconds across the between-subjects conditions.

Subjects were instructed to respond as quickly and as accurately as possible. All subjects were first given 24 practice trials in which the prime word and nonword conditions occurred in the same proportion as the subsequent test trials. Subjects were given a 3-minute break between the first and second half of the LDT. Also, an informal inquiry at the end of the LDT indicated that no subject in the subliminal conditions reported being able to see any of the priming stimuli.

Before participating in the LDT, subjects were told that they would later be asked to try and remember the target words; the nature of the memory test was unspecified. After the LDT subjects were asked to count backwards by 3 from the number 150 for 1.5 minutes. This "counting" task was presented to eliminate any recency effects. Subjects were then given a short one-minute break before they were given instructions for the forthcoming recognition test. During these instructions, the subjects were first familiarized with the 5 point rating scale they would be using during the recognition test. Subjects were told that for each pair of items on the recognition test, they should first read the item on the left (the context) and then read the underlined word on the right (the target). Subjects were told to give a confidence rating to each of the underlined words, independent of whether they thought they had seen the context item during list presentation. It was emphasized, however, that for the present study it was important that the item on the left be read before the word on the right. After the recognition test was completed, those subjects who received the primes at the subliminal threshold again had their thresholds tested.

Design

For the LDT, the between-subjects factors threshold level (subliminal vs supraliminal) and prime-target SOA (350 vs 2000 msec) and the within-subjects factors prime condition (related, neutral, unrelated), target word class (homograph vs nonhomograph), trials (first half vs second half), and lexicality (word vs nonword) produced a 2 x 2 x 3 x 2 x 2 x 2 mixed-factor design. With respect to the recognition test, the same between-subjects factors threshold level and prime-target SOA and the within-subjects factors prime condition, target word class, context condition (same vs different), and test type (target vs lure) produced a 2 x 2 x 3 x 2 x 2 x 2 mixed-factor design.

Results

Threshold Setting Task

The mean critical prime-target ISIs that were determined for the sublimal conditions during Session 1 were 17 msec for the short SOA and 19 msec for the long SOA condition. After Session 2, these thresholds were 16 msec for the short SOA and 19 msec for the long SOA conditions. Therefore, there was virtually no change in threshold across the first and second testing, thereby indicating that the subjects' threshold did not change across time. It is also noteworthy, on a more informal level, that as subjects approached their threshold, they reported making their discrimination based on differences in brightness or temporal delay between words and blank fields. Thus, at these short ISIs, subjects were not, at least, aware of basing their decision on letters or letter features.

Lexical Decision Task

For each within-subjects cell, a median RT and a mean number of errors were calculated for each subject. These scores were submitted to separate analyses on each of the following: 1) Median Word RT; 2) Median Nonword RT; 3) Mean Word Errors; 4) Mean Nonword Errors. These analyses were 2 (SOA) x 2 (Trials) x 3 (Prime Condition) x 2 (Word Class) mixed-factor ANOVAs. In order to ease the exposition of these results, the supraliminal and subliminal priming data will be discussed separately and will then be followed by a brief overall analysis section of the priming data.

Supraliminal Priming. The mean of the subjects' median RT and their mean error data for the supraliminal word conditions are shown in Table 2. There are

Table 2

Mean RT (in msec) and Percent Error Data[a] for the Supraliminal Word Conditions as a Function of SOA, Trials, and Prime Condition

	Prime Condition		
SOA Condition	Related	Neutral	Unrelated
Short SOA			
First Half	571 (3.1)	627 (3.6)	636 (6.8)
Second Half	553 (2.1)	583 (2.1)	601 (4.2)
Mean	562 (2.6)	605 (2.9)	619 (5.5)
Long SOA			
First Half	758 (3.6)	775 (3.1)	777 (2.6)
Second Half	693 (3.1)	734 (3.1)	776 (8.3)
Mean	726 (3.4)	755 (3.1)	777 (5.5)

[a]The numbers in parentheses indicate the percent error data.

three general points that should be made from Table 2: (a) Overall RT was consistently faster at the short SOA than at the long SOA; (b) Subjects were faster during the second half than during the first half of the priming trials; (c) RT was consistently faster to the word targets following a related prime than neutral or unrelated primes. These observations were supported by the above-described ANOVA. (All differences referred to as statistically significant have p values $< .05$.) This analysis yielded highly significant effects of SOA, $F(1,46) = 29.30$, MSe = 121284.5, Trials $F(1,46) = 10.92$, MSe = 15459.1, and Prime Condition, $F(2,92) = 17.39$, MSe = 832.7. Also, this analysis indicated that response latency to homographs (685 msec) was significantly slower than to nonhomographs (661 msec), $F(1,46) = 14.91$, MSe = 5693.5.

The more interesting aspect of this analysis was a significant interaction between SOA, Trials, and Prime Condition, $F(2,92) = 5.54$, MSe = 3668.2. The data displayed in Table 3 will aid in interpreting this interaction. In Table 3 are displayed the mean facilitation, inhibition, and relatedness effects for the supraliminal conditions. As shown in Table 3 at the short SOA, there was more facilitation than inhibition during both the first and second half of the priming trials. A simple effects analysis on the short SOA data indicated that the apparent interaction between Trials and Prime Condition did not reach statistical significance, $F(2,46) = 1.94$, MSe = 2267.99. Furthermore, post hoc t-tests based on the error term for the main effect of Prime Condition at the short SOA yielded a significant facilitation effect, $t(46) = 3.51$, with the inhibition effect not approaching significance, $t(46) = 1.16$.

A different pattern emerges at the long SOA. As shown in Table 3, there is some evidence of facilitation (17 msec) during the first half of the priming trials, however, there is little evidence of inhibition (2 msec). On the other hand, during the second half of the priming trials, there is a 25 msec increase in facilitation and a dramatic 39 msec increase in inhibition. In

Table 3

Mean Facilitation, Inhibition, and Relatedness Effects[a], in both RT and Percent Errors[b], for the Supraliminal Conditions, as a Function of SOA and Trials

SOA Condition	Facilitation	Inhibition	Relatedness
	Type of Effect		
Short SOA			
First Half	56 (0.5)	9 (3.1)	65 (3.6)
Second Half	29 (0)	19 (2.1)	48 (2.1)
Mean	43 (0.25)	14 (2.6)	57 (2.85)
Long SOA			
First Half	17 (-.5)	2 (-.5)	19 (-1.0)
Second Half	42 (0)	41 (5.2)	83 (5.2)
Mean	29 (-.25)	22 (2.35)	51 (2.1)

[a]Facilitation = Neutral - Related Prime Conditions;
Inhibition = Unrelated - Neutral Prime Conditions;
Relatedness = Unrelated - Related Prime Conditions.

[b]The numbers in parentheses indicate the percent error data.

support of this observation, a simple effects analysis on the long SOA data yielded a significant interaction between Prime Condition and Trials, $F(2,46) = 4.95$, MSe = 5068.39. Post hoc t-tests based on the error term from this interaction yielded nonsignificant facilitation, $t(46) = 1.18$, or inhibition, $t(46) = .12$, effects during the first half of the priming trials, whereas, for the second half, there were both significant facilitation, $t(46) = 2.87$, and inhibition, $t(46) = 2.85$, effects.

In sum, the supraliminal RT data indicates that at the short SOA there is primarily evidence for facilitation with little inhibition, whereas, at the long SOA there is evidence for both facilitation and inhibition, the latter of which primarily occurred during the second half of the priming trials.

With respect to the error rates, as shown in Table 2, they are generally low with little evidence of a speed-accuracy tradeoff. The ANOVA on the error data yielded three significant effects. First, error rates were higher in the unrelated (5.5%) than either the neutral (3%) or the related (3%) prime conditions, $F(2,92) = 5.69$, MSe = 68.87. This is especially noticeable in the unrelated condition during the second half at the long SOA where error rates were 5% higher than in either the neutral or related conditions. Second, an interaction between SOA and Trials, $F(1,46) = 8.13$, MSe = 53.40, indicated that error rates decreased 1.8% for the short SOA during the second half, whereas, they increased 1.7% for the long SOA. Third, there were overall more errors for homographs (4.9%) than for nonhomographs (2.8%), $F(1,46) = 9.44$, MSe = 66.24.

Subliminal Priming. The mean of the subjects' median RT and their mean error data for the subliminal word conditions are shown in Table 4. There

Table 4

Mean RT (in msec) and Percent Error Data[a] for the Subliminal Word Conditions as a Function of SOA, Trials, and Prime Condition

	Prime Condition		
SOA Condition	Related	Neutral	Unrelated
Short SOA			
First Half	549 (3.1)	572 (2.6)	555(3.1)
Second Half	532 (3.1)	544 (3.1)	550 (5.7)
Mean	541 (3.1)	558 (2.9)	553 (4.4)
Long SOA			
First Half	678 (3.1)	696 (3.1)	704 (3.1)
Second Half	651 (3.6)	664 (5.2)	694 (3.6)
Mean	665 (3.4)	680 (4.2)	699 (3.4)

[a]The numbers in parentheses indicate the percent error data.

are three general points to be made from Table 4: (a) Overall, RT is faster at the short SOA than at the long SOA; (b) Subjects were faster during the second half than during the first half of the prime trials; (c) Most importantly, RT appears to be consistently faster to the word targets following a related prime than an unrelated prime, thereby suggesting a subliminal priming effect. These observations were supported by the appropriate ANOVA. This analysis yielded significant effects of SOA, $\underline{F}(1,46) = 18.00$, MSe = 136431.2, Trials, $\underline{F}(1,46) = 6.47$, MSe = 8884.4, and Prime Condition, $\underline{F}(2,92) = 5.71$, MSe = 4862.2. Post hoc $\underline{t}$-tests based on the error term from the main effect of Prime Condition yielded a significant facilitation (17 msec) of the related condition,

$t(92) = 2.34$, whereas, the inhibition (7 msec) of the unrelated condition did not approach significance, $t(92) = .95$. The overall analysis also indicated that response latency to homographs (628 msec) was significantly slower than to nonhomographs (604 msec), $F(1,46) = 25.73$, MSe = 3075.3, thereby replicating the supraliminal conditions. No other effect or interaction approached significance (all $Fs < 1.8$).

SEE TABLE 5

In Table 5 are displayed the mean facilitation, inhibition, and relatedness effects found for the subliminal prime conditions. A curious pattern emerges in Table 5. That is, 1) the priming effect appears to be larger at the long SOA than at the short SOA and 2) there appears to be a considerable amount of inhibition at the long SOA especially during the second half of the priming trials. Both of these trends would suggest that an attentional factor may be underlying these priming effects. However, there are a number of points that should be noted about this pattern. First, neither the interaction between SOA, Trials, and Prime Condition, $F(2,92) = .04$, MSe = 4082, nor a simple effects interaction between Trials and Prime Condition for the long SOA condition, $F(2,46) = .54$, MSe = 5619.4, approached significance, thereby suggesting that the apparent increase in inhibition during the second half of the priming trials was not statistically reliable. In further support of this conclusion, a post hoc analysis on just the unrelated and neutral prime conditions at the long SOA also indicated that the increase in inhibition during the second half of the priming trials did not approach significance, $F(1,23) = 1.08$, MSe = 5009.5. Second, although the neutral condition is

Table 5

Mean Facilitation, Inhibition, and Relatedness Effects[a], in Both RT and Percent Errors[b], for the Subliminal Conditions, as a Function of SOA and Trials

SOA Condition	Facilitation	Inhibition	Relatedness
		Type of Effect	
Short SOA			
First Half	23 (-.5)	-17 (0.5)	6 (0)
Second Half	12 (0)	6 (2.6)	18 (2.6)
Mean	18 (-.25)	-6 (1.55)	12 (1.3)
Long SOA			
First Half	18 (0)	8 (0)	26 (0)
Second Half	14 (1.6)	29 (-1.6)	43 (0)
Mean	16 (0.8)	19 (-0.8)	35 (0)

[a]Facilitation = Neutral - Related Prime Conditions;
Inhibition = Unrelated - Neutral Prime Conditions;
Relatedness = Unrelated - Related Prime Conditions.

[b]The numbers in parentheses indicate the percent error data.

considerably faster than the unrelated condition during the second half of the priming trials, there is also a 1.6% increase in errors in the neutral condition. Thus, this inhibition may reflect some tradeoff between accuracy and speed. Third, since an attentional factor should produce both facilitation and inhibition, it is unclear why there is not also an increase in facilitation during the second half, as occurred in the supraliminal prime trials.

Although the interaction between SOA and Prime Condition, as noted above, did not approach significance, separate simple effects ANOVAs on the short SOA and the long SOA data did in fact indicate that the priming effect did not reach significance at the short SOA, $F(2,46) = 2.23$, MSe = 3438.2, $p = .12$, but was significant at the long SOA, $F(2,46) = 4.58$, MSe = 6286.2. Thus, the present data appear to support the Fowler et al., data in finding a subliminal priming effect primarily at the long SOA.

One could potentially argue that since the long SOA subjects had critical thresholds which were slightly longer than the short SOA subjects, it is possible that subjects at the long SOA were picking up letters or letter features which inturn led to the observed priming effect. In an attempt to test this possibility, both the long SOA group of subjects and the short SOA group of subjects were divided into two further groups depending on whether a given subject's threshold was above (high-threshold group) or below (low-threshold group) the median threshold for that SOA condition. The mean prime-mask critical ISIs for the low-threshold groups were 5.4 msec and 5.4 msec for the long and short SOA conditions, respectively, whereas, the mean prime-mask critical ISIs for the high-threshold groups were 33 msec and 29.2 msec for the long and short SOA conditions, respectively. This low- vs high-threshold group variable was then added as a factor in the overall above-described ANOVA. The results of this analysis indicated that this factor did not participate in any significant effects. Furthermore, the mean differences between the related and unrelated conditions were actually larger for the low-threshold groups (41 msec and 14 msec for the long and short SOA conditions, respectively) than for the high-threshold groups (29 msec and 10 msec, for the long and short SOA conditions, respectively). In light of this analysis, it seems unlikely that the observed subliminal priming effects were due to the fact that certain subjects who had long critical prime-mask thresh-olds were actually above their critical threshold, and therefore, able to pick up letters or letter features which inturn led to the observed priming effects. Furthermore, it is quite startling that one would find a 41 msec priming effect for a group of subjects whose critical prime-mask ISI was only 5.4 msec.

Turning to the error data displayed in Table 4, one can see that the error rates are quite consistent across conditions, ranging from 2.6% to 3.6%. The only two exceptions to this observation are: 1) the error rate for the unrelated prime condition during the second half of the short SOA trials (5.7%) and, 2) as noted above, the neutral prime condition during the second half of the long SOA trials (5.2%). Furthermore, only the latter of these observa-tions could potentially reflect a speed-accuracy tradeoff. The results of the ANOVA on the error data yielded no significant effects at the subliminal conditions.

In sum, the word data for the subliminal conditions provides evidence which indicates 1) an overall subliminal priming effect, i.e., subjects were faster in the related than either the neutral or unrelated conditions, 2) that the subliminal priming effect is primarily localized at the long SOA,

3) that the subliminal priming effect at the long SOA appears, at least in RT, to reflect both facilitation and inhibition, and 4) that these priming effects are relatively independent of a given subject's critical prime-mask ISI.

Overall Analysis of the Priming Data. In order to test for any differences between the supraliminal and subliminal priming conditions, an overall analysis of the priming data was conducted. The results of this analysis on the word RT yielded two significant effects in which the threshold variable participated. First, subjects were overall faster when they received the primes subliminally (616 msec) than supraliminally (674 msec), $F(1,92) = 7.48$, MSe = 128857.8. This effect should, of course, be expected if reading the primes in the supraliminal condition demanded capacity thereby slowing RT compared to the subliminal conditions in which subjects were unable to either read or allocate capacity to the primes. Second, a significant interaction between Threshold and Prime Condition, $F(2,184) = 3.48$, MSe = 6594.6, indicated that the priming effect was simply larger for the supraliminal than for the subliminal conditions. A similar analysis on the error data yielded no significant effects in which the threshold variable participated.

An overall ANOVA on the nonword RT data, indicated that subjects were again faster when they received the primes subliminally (749 msec) than supraliminally (799 msec), $F(1,92) = 4.71$, MSe = 155313.5. Also a significant interaction between Threshold and Prime Condition, $F(2,184) = 5.83$, MSe = 7761.2, indicated that there was no effect of Prime Condition for the subliminal conditions whereas, for the supraliminal conditions, the neutral condition was slower than the related or unrelated nonword conditions. This effect should be expected if in the supraliminal conditions reading the word primes demanded more processing capacity than reading the nonword primes, thereby slowing RT in the word prime condition; whereas, in the subliminal conditions, because subjects were unable to either read or attend to the primes, there was no influence of prime condition on nonword RT. A similar analysis on the nonword error data only yielded a seemingly spurious Threshold x SOA x Trials significant interaction, $\underline{F}(1,92) = 4.46$, MSe = 98.95.

Recognition Memory Task

For each subject, a mean % hit and false alarm rate was calculated for each within-subject cell, with targets and lures receiving a confidence rating of 4 or 5 being counted as hits and false alarms, respectively. Following this calculation, a mean accuracy score was calculated for each subject/cell, based on a high-threshold measure where accuracy = % hits - % false alarms. Furthermore, in order to equalize the number of observations per subject/cell across conditions and since the homograph vs nonhomograph distinction is of primary interest in the related conditions, this word class variable was collapsed across in the neutral and unrelated conditions.

Supraliminal Prime Conditions. Table 6 displays the mean accuracy scores and false alarm rates for the supraliminal conditions. There are three general points that should be made from Table 6. First, there is little influence of changing context in the neutral context condition for either the short or long SOA prime conditions. Actually, this finding was expected because these items did not have the same context manipulation during the recognition test, i.e., these items were either always paired with a row of Xs or Ys. In light of this, the related homograph, related nonhomograph, and the unrelated context conditions will take precedence in the following discussion and analyses, and will be referred to as the word-context conditions. Second, recognition accuracy was consistently higher when the target occurred with the same context word that earlier served as a prime than when it occurred with a different context word. Third,

Table 6

Mean Accuracy[a] and Percent False Alarm Rate[b] for the Supraliminal Conditions as a Function of SOA, Context Target Condition, and Context

	Context Target Condition			
SOA Condition	Related Homograph	Related Nonhomograph	Unrelated	Neutral
Short SOA				
Same Context	67 (15)	67 (15)	65 (11)	49 (13)
Different Context	51 (13)	51 (16)	47 (9)	47 (16)
Mean Context Effect	16 (2)	16 (-1)	18 (2)	2 (-3)
Long SOA				
Same Context	76 (14)	69 (17)	55 (19)	48 (15)
Different Context	45 (16)	58 (12)	46 (11)	46 (21)
Mean Context Effect	31 (-2)	11 (5)	9 (8)	2 (-6)

[a]Mean Accuracy = Percent Hits - Percent False Alarms.

[b]The numbers in parentheses indicate the false alarm rates.

at the short SOA, there is little difference in the effect of switching contexts across the word-context conditions, whereas, at the long SOA, there is a much larger effect of switching contexts for the related homograph than either the related nonhomograph or the unrelated conditions.

These observations were supported by a 2 (SOA) x 2 (Same vs Different Context) x 3 (Word-Context Conditions) mixed-factor ANOVA. The main effect of switching context was indeed highly significant, $\underline{F}(1,46) = 34.65$, MSe =

586.37. Also, the three-way interaction between SOA, Context, and Word-Context Condition reached significance, $F(2,92) = 3.25$, MSe = 327.6. Separate simple effects ANOVAs on the short and long SOA data indicated that there was little, if any, difference in the context effects across the word-context conditions at the short SOA, $F(2,46) = .09$, MSe = 288.54, whereas, at the long SOA, there was a significant interaction between Context and Word-Context Condition, $F(2,46) = 4.92$, MSe = 366.6. Post hoc t-tests based on the error term from this interaction indicated that the effect of switching context was larger for the related homograph (31%) than for the related nonhomograph (10%), $t(46) = 3.71$, or the unrelated condition (9%), $t(46) = 3.96$.

Subliminal Prime Conditions. Table 7 displays the mean accuracy score and false alarm rate for the subliminal conditions. There are two general points that should be made from Table 7.
First, there is little evidence of a context effect for the neutral context condition. In fact, the different context neutral condition appears to be slightly higher than the same context at the short SOA (this difference, however, did not reach significance, $F(1,23) = 3.08$, MSe = 740.3). Second, and more importantly, there is little evidence that performance in the same context condition is higher than in the different context condition for either the short or the long SOA conditions.

This latter observation was supported by a 2 (SOA) x 2 (Same vs Different Context) x 3 (Word-Context Conditions) mixed-factor ANOVA. Neither the main effect of Context, $F(1,46) = .06$, MSe = 242.77, the interaction between Context and Word-Context Condition, $F(2,92) = .74$, MSe = 309.64, nor the interaction between SOA, Context, and Word-Context Condition, $F(2,92) = .01$, MSe = 309.6, approached statistical significance. It is also noteworthy that the overall absolute effect of the context manipulation came remarkably close to zero (-.5%), thereby, clearly indicating that switching context had no effect on recognition memory performance for the subliminal prime conditions.

Table 7

Mean Accuracy[a] and Percent False Alarm Rate[b] for the Subliminal Conditions as a Function of SOA, Context Target Condition, and Context

	Context Target Condition			
SOA Condition	Related Homograph	Related Nonhomograph	Unrelated	Neutral
Short SOA				
Same Context	64 (15)	54 (15)	55 (15)	53 (21)
Different Context	59 (15)	55 (14)	52 (17)	61 (15)
Mean Context Effect	5 (0)	-1 (1)	3 (-2)	-8 (6)
Long SOA				
Same Context	55 (18)	56 (12)	58 (16)	60 (12)
Different Context	55 (14)	62 (11)	61 (12)	58 (13)
Mean Context Effect	0 (4)	-6 (1)	-3 (4)	2 (-1)

[a]Mean Accuracy = Percent Hits - Percent False Alarms.

[b]The numbers in parentheses indicate the false alarm rates.

Overall Analysis of the Recognition Memory Task. The results of the overall analysis yielded two significant interactions in which the threshold variable participated. First, an interaction between Context and Threshold, $F(1,92) = 25.83$, MSe = 414.57, indicated, as expected from the above analyses, that the context effect for the supraliminal condition (17%) was significantly larger than for the subliminal condition (-.5%). Second, a significant Threshold x SOA x Word Context interaction, $F(2,184) = 3.73$, MSe = 324.6, indicated that at the supraliminal long and short SOA, accuracy was higher in the related homograph and nonhomograph conditions than in the unrelated condition; however, at the subliminal short SOA accuracy was higher in the related homograph than the related nonhomograph and related conditions whereas at the long SOA accuracy was higher in the related nonhomograph and unrelated conditions than in the related condition.

Discussion

The results of the present research are quite clear. In the supraliminal conditions, which were primarily used as control conditions, both the priming results and the recognition memory results indicated that the intended manipulations had large effects on performance. More specifically, at both the short and long SOA supraliminal conditions, response latency was faster to word targets which followed a semantically related prime than those which followed an unrelated prime. Furthermore, the recognition memory results for the supraliminal conditions clearly indicated that accuracy for the target was considerably higher when it occurred at recognition with the same context word which earlier was used as a prime than when it occurred with a different context word. The results of the subliminal conditions also indicated that response latency was faster to word targets which followed a semantically related prime than those which followed an unrelated prime. Although these subliminal priming effects indicated that subliminal context items can indeed influence response latency in a LDT, the results of the later recognition test clearly yielded no effect of these items on long-term storage. In order to ease the discussion of these results, the LDT will be discussed first and then the recognition memory task will be discussed.

Lexical Decision Task

In the introduction, the Posner and Snyder (1975) model was outlined as a useful framework to interpret semantic priming effects. The present supraliminal priming results fit quite nicely within this framework. For example, according to Posner and Snyder automatic spreading activation is relatively fast acting and therefore one should be more likely to find evidence of such activation at short SOAs, as demonstrated by Neely (1977). The present short SOA results supported this notion in two ways. First, automatic activation should primarily yield facilitation with little inhibition, as the short SOA results indicated. Second, because automatic activation should be independent of attentional strategic processes, this facilitation dominance effect should occur both during the first and second half of the priming trials, again, as the results indicated. On the other hand, Posner and Snyder's limited capacity attentional mechanism is relatively slower acting and therefore one should be more likely to find evidence for this mechanism at the long SOA, again, as demonstrated by Neely. The present long SOA results supported this notion also in two ways. First, semantic priming which reflects an attentional mechanism should produce both facilitation and inhibition, as the long SOA results indicated. Second, since attentional priming should reflect the development of attentional/strategic processes (e.g., focusing attention on the semantic characteristics of the prime to facilitate target processing), one may expect an increase in both facilitation and inhibition across the priming trials, again, as the long SOA results indicated. Thus, the results of the supraliminal priming conditions fit nicely within the Posner and Snyder framework with the short SOA condition primarily reflecting the automatic spreading activation mechanism and the long SOA condition primarily reflecting the limited capacity attentional mechanism.

Unfortunately, however, the Posner and Snyder model has some difficulty in accounting for the subliminal data. That is, since in the subliminal conditions, subjects were unaware of the presence of the prime, there should be primarily evidence for facilitation, and moreover, this facilitation should occur at both the long and short SOAs. The overall analysis of the subliminal priming data did, in fact, yield a semantic priming effect which primarily reflected facilitation, however, upon closer inspection of the data, an interesting pattern emerged. First, although there was some evidence of priming at the short SOA, the priming effect primarily occurred at the long SOA. This is the same pattern found by Fowler et al. (1981). Possibly, it may take more time for the semantic activation to accrue with a subliminal prime simply because the original activation produced by the prime is relatively weaker than a supraliminal prime. Therefore, at the short SOA there may not have been enough time for the activation from the prime to sufficiently activate the target. If this account is correct, then one should find larger semantic priming effects primarily at the shorter SOAs as one increases the prime stimulus duration/brightness level. This prediction will have to await empirical validation.

Second, the priming effect at the long SOA appears to reflect both facilitation and inhibition; the latter of which primarily occurred during the second half of the test trials. At first glance, this pattern would appear to suggest an attentional priming effect. However, there are a number of points that should be noted about this pattern. First, and foremost, an attentional priming effect should entail the subjects' awareness of the prime. Since subjects were unaware of the subliminal primes being presented, it is highly unlikely that they were able to attend to the primes. Of course it is possible that subjects were not actually at their subliminal threshold. However, if this were the case then it is unclear why there was no effect of context on their later recognition memory performance, as was clearly found in the supraliminal conditions. In this light, the lack of an influence of context in recognition performance provides further support that the primes during the LDT were truly subliminally presented. Second, if the apparent increase in inhibition in RT reflects an attentional mechanism, it is unclear within the Posner and Snyder framework, why there was not a corresponding increase in facilitation, again, as the supraliminal data indicated. Third, although there was an increase in inhibition reflected in RT during the second half of trials, there was also a potential speed-accuracy tradeoff in the neutral condition. Thus, one cannot make any strong statements about the inhibition produced during the second half of the priming trials. However, it should be noted, that there has been some recent evidence which appears to reflect an automatic type of inhibition (Antos, 1979; Fischler & Bloom, 1979, 1980). The results of the present long SOA subliminal priming data may also reflect such a mechanism. If automatic inhibition does exist, a considerable modification of both the Posner and Snyder model and current views regarding automatic activation in semantic memory would be mandated.

The next obvious issue that must be addressed is how can a stimulus in which the subject is unaware, influence his/her response latency in a LDT? Recently, Marcel and Patterson (1978) and Allport (1977) have advanced models which are able to account for such subliminal effects. These theorists reject the widely held assumption that central masking completely "stops" perceptual processing (Turvey, 1973). Rather, they suggest that central masking simply interferes with the visual record of the stimulus, but does not completely stop the processing of all activated codes. More specifically, they argue that when a word is presented it simultaneously and automatically activates a series of independent codes/processes (e.g., a grapheme to phoneme conversion code, a visual code, a semantic/lexical code). These codes are later integrated at a comparator (or "blackboard") stage of processing; the output from which leads to conscious awareness of the stimulus. With respect to the present study, as the subliminal primes were presented they activated the codes involved in word recognition. However, when the pattern mask quickly followed the prime, it actually "destroyed" or displaced one of these codes; namely, the visual record of the prime. Now, since for both Marcel and Patterson and Allport awareness of a visual stimulus depends on an appropriate visual record of that stimulus (a reasonable assumption), once this visual record was lost due to masking the subject was unaware of the presence of the stimulus. However, since the processing codes were activated independently, the stimulus may still have received analysis by the semantic/lexical system if that system was activated. Any activation which reached the semantic/lexical system should have spread to related representations, thereby producing a semantic priming effect without awareness of the priming stimulus. Thus, in this light, the present results provide evidence for automatic and unconscious semantic analysis of a stimulus subsequent to the central masking of that stimulus.

Although the notion of unconscious semantic analysis at first seems somewhat startling, clearly such unconscious processing must be involved in a considerable amount of normal cognitive functioning. For example, in reading these words, one is probably unaware of the utilization of orthographic constraints, eye fixations, regressions, and the parsing of complex sentence structures, although few would question the occurrence of such processes. The present subliminal priming results are provocative because a situation was created, via central masking, in which the existence of one such unconscious process (semantic/lexical activation) was demonstrated. The question that will now be addressed is to what extent does such activation influence long-term memory storage.

Recognition Memory Performance

Before discussing the subliminal context conditions, a theoretically interesting pattern which emerged in the supraliminal context conditions will first be discussed. That is, at the short SOA the size of the recognition context effect was relatively constant across the word context conditions, whereas, at the long SOA, the size of the context effect was considerably larger for the related homograph than the related nonhomograph or unrelated conditions. This interaction was particularly puzzling. More specifically, according to Anderson (1976, page 387), one should clearly expect larger context effects for homographs than nonhomographs. That is, one should be more likely to access the same sense of a nonhomograph which is studied and tested with different context words (e.g., sit chair vs table chair) than a homograph which is studied and tested with different context words (e.g., river bank vs money bank). Very simply, there should be more semantic overlap, and therefore a decreased likelihood of accessing different context induced senses, for nonhomographs than for homographs. Although this pattern was found at the long SOA there was little difference between homographs and nonhomographs at the short SOA.

One resolution to this paradox is to use the priming data as an indicant of "how" the prime semantically influenced the encoding of the target. That is, as described above, at the short SOA, the semantic influence of the prime appeared to be automatic in nature, whereas, at the long SOA, it appeared to be attentional. Possibly, since at the short SOA the activation was automatic it had less of a semantic influence on the long-term memory trace of the target than the more attentional activation occurring at the long SOA. That is, it may be the case that the context effects found in recognition for the short SOA condition reflected a more nonsemantic influence of the context on the encoding of the target. In fact, Hunt and Elliot (1980) have recently argued, and demonstrated, that nonsemantic information (e.g., orthographic distinctiveness) can play an important role in long-term memory performance (also, see Hunt & Mitchell, 1978; Jacoby, 1974). Furthermore, since the present memory test involved a recognition test, nonsemantic information such as spelling patterns may have been especially influential. Although one would be premature, based on the present study, to attempt to specify the nonsemantic features underlying the context effects at the short SOA, it does seem reasonable that these context effects were not totally semantic in nature, as indicated by the lack of difference between the related homograph and nonhomograph conditions. On the other hand, at the long SOA there were considerably larger context effects for the related homograph than nonhomograph conditions. Possibly, since subjects were able to attend to the semantic attributes of the prime during the two second prime-target SOA, this attention served to semantically disambiguate the encoded memory trace of the homograph. In fact, both Swinney (1979) and Marcel (1980) have recently argued that disambiguation for homographs does indeed involve attentional allocation.

In the present study, this homograph disambiguation at the long SOA, compared to the short SOA, should have served both to increase performance in the same context condition and decrease performance in the different context condition, as the present results indicated (see the Related Homograph Condition in Table 7).

Now, within the framework outlined above, what should be the effect of a shift in context in recognition for the subliminal prime conditions? First, it should be noted that since subjects were unaware of the priming stimulus any semantic influence of the prime on the target should have been automatic in nature. Furthermore, since the pattern mask appeared to have overridden the visual record of the prime, any nonsemantic features of the prime (e.g., orthographic information) should have been unavailable for encoding. Therefore, according to the present arguments, the net memory context effect of an automatic semantic influence of a prime <u>and</u> a loss of nonsemantic information due to pattern masking should approach zero, as the results clearly indicated.

One could still counteragure, however, that the reason no context effects were found at the subliminal prime conditions was because the activation produced by the subliminal primes was relatively weaker than the activation produced by the supraliminal primes, as indicated by the smaller priming effect for the subliminal conditions. Thus, in the subliminal conditions there was insufficient activation produced by the primes to semantically influence the encoding of the targets. Interestingly, however, if one considers the priming effect for the homographs (those items which should be the most influenced in later memory performances by any semantic biasing effects of the primes), one finds that this effect is actually larger for the subliminal (48 msec) than for the supraliminal (31 msec) long SOA condition. However, turning to recognition memory performance, one finds a dramatically larger context effect for the supraliminal (31 %) than for the subliminal (0%) long SOA condition. In this light, it seems clear that the semantic activation reflected by semantic priming does not necessarily reflect activation which semantically influences the long-term storage of a target.

With respect to this last issue, it was argued, within the Anderson-Bower framework, that activation reflected by semantic priming effects "should" influence the long-term encoding of the target. That is, it seems unlikely that a subject would store in the propositional list structure a concept underlying the homograph jam which refers to traffic tie-up if the context word grape has just activated the concept of jam (as evidenced by the semantic priming effect) which refers to jelly. Moreover, Anderson (1976, page 125) specifically argues that activation in the memory network serves to focus attention on that portion of the network. If this were the case then one would clearly expect that activation produced by the subliminal prime should have focused attention and biased the semantic interpretation of the homograph. However, the present recognition memory results for the subliminal prime conditions clearly did not support this contention. In this light, it seems useful to distinguish between attentional and nonattentional activation with only the former underlying semantic biasing effects in long-term memory performance. Unfortunately, however, it is difficult to delineate this distinction within the Anderson and Bower (1973, 1974) models or the Anderson (1976) model. That is, would attentional activation be an increased level of activation along the associative pathways within the memory network or possibly increased activation at a particular concept node in the system? In either case one is simply suggesting that attentional activation is simply "more" than nonattentional activation.

One potential way out of this dilemma is to argue that semantic priming reflects activation in a separate memory system (semantic memory) than the system which reflects context effects in recognition memory performance (episodic memory). In fact, Tulving (1976) and his associates (Tulving & Thomson, 1973; Tulving & Watkins, 1975) have argued, within their encoding specificity approach, that context effects such as those found in the present supraliminal conditions specifically depend upon the context being perceived, attended, and stored as part of the unique episodic memory trace of the target. Furthermore, they argue that this episodic memory trace does not necessarily depend upon preexisting associative/semantic information. Thus, one would not expect context effects in episodic memory if the subliminal context item was not perceived and attended, independent of whether it produced activation in the separate semantic memory system. Unfortunately, the advocates of the encoding specificity approach have failed to specify under what circumstances (and how) semantic information ever influences an episodic trace. Since this specification was of major importance in the present study, I have opted to interpret this study within Anderson and Bower's unitary store framework. However, the fact that a subliminal prime can have a substantial influence on a target in LDT but have no influence on the semantic encoding of that target in long-term memory, at the very least, will need to be addressed by advocates of the unitary store approach. Particularly, by those unitary store advocates (Anderson & Ross, 1980; McKoon & Ratcliff, 1979) who have recently argued that since one can find transfer between episodic and semantic memory tasks, there is no functional utility of making the episodic-semantic distinction. Clearly, the present results failed to provide evidence for such transfer.

Implications of the Present Study

The first and probably most important implication is that a stimulus in which the subject is unaware can meaningfully influence their performance on a cognitive task. Thus, the present results do support the distinction between conscious and unconscious activation in memory. Moreover, the present results suggest that unconscious activation may not be a determinant of focusing attention in the storage of long-term memory information. Although this last statement may appear to question the utility of unconscious activation in normal cognitive functioning, obviously one would be premature to make this argument simply based on the present long-term memory results.

However, the present research does serve to emphasize the importance of specifying the function of automatic unconscious activation. It may be the case that such activation would have an influence in an immediate memory task or an episodic task which is highly sensitive to semantic activation. Clearly, if the semantic priming paradigm, in any way, reflects semantic activation similar to the activation which occurs during reading (see, for example, Carr, 1981), one must begin to be concerned with how this activation influences the extraction of meaning in complex sentence structures; an extraction process which demands an active working memory (Just & Carpenter, 1980). In this light one should be concerned with the "utility" of conscious and unconscious activation and their interplay in cognitive task performance. Based on the present results, one would be compelled to argue that automatic unconscious semantic activation has little, if any, utility in long-term memory encoding.

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