Memory & Cognition
1978, Vol. 6 (6), 636-643

Priming dominant and unusual senses of ambiguous words

JACK YATES
University of Northern Iowa, Cedar Falls, Iowa 50613

The priming technique was used to investigate the conditions under which a homograph's dominant and/or nondominant semantic sense will be retrieved. Subjects verified whether "A(n) A is a(n) B" when A was an ambiguous word and B was a word corresponding to either a dominant or an unusual semantic sense of word A. When word B most often corresponded to the dominant sense of word A (Experiment 1), a Priming by Dominance interaction was obtained in the reaction time (RT) data; viz, the facilitatory effect of priming was greater for the dominant-sense sentences than for the unusual-sense sentences. When the word B equally often corresponded to the dominant and unusual senses of A (Experiment 2), the facilitatory effect of priming was equal for the dominant-sense and unusual-sense sentences. These results were interpreted within the framework of a two-stage model of lexical access (cf. Posner & Snyder, 1975; Neely, 1977). An application of this two-stage model to the now rather extensive literature on homographic processing helps clear up the apparent contradictions that have been prevalent in this literature.

When we encounter an ambiguous word, do we automatically retrieve all its meanings? The question is important, since a casual glance through any dictionary provides convincing evidence that most words are ambiguous. Thus, the answer to this question has profound consequences for models of language processing.

Casual observation indicates that only one meaning of an unambiguous word is retrieved. In ordinary discourse, puns frequently go unrecognized, and metaphors gradually die so that the metaphoric word ceases to evoke both a literal and a metaphoric meaning. "Garden path" sentences [like Lashley's (1951) "Rapid writing/righting with his uninjured hand saved from loss the contents of the capsized canoe"] would be impossible if all meanings of ambiguous words were made available to consciousness.

Jenkins (Note 1) has provided experimental evidence designed to reveal the psychological nature of lexical ambiguity. He and his co-workers performed a series of studies designed to show that, when an ambiguous word is embedded in a disambiguating context, subjects rarely show any response to the inappropriate sense of the word, whether they are tested using recognition or recall. In fact, Jenkins' data also show that even when words are presented in isolation, subjects again respond to only one sense. Except for the fact that context can apparently determine the meaning that becomes conscious, subjects' responses seem identical whether or not context is present: Generally, only one meaning of an ambiguous word is retrieved.

Other studies of recognition memory have also suggested that only one meaning of an ambiguous word is processed (Gartman & Johnson, 1972; Winograd & Conn, 1971; Winograd & Raines, 1972). Results from memory studies may, of course, reflect memory storage phenomena rather than retrieval processes occurring at the time the ambiguous word is encountered. However, Schvaneveldt, Meyer, and Becker (1976) recently used a lexical decision task to investigate the retrieval process itself. Their experiment made use of the fact that lexical decisions are faster when preceding words are related to the target word (Meyer & Schvaneveldt, 1971; Meyer, Schvaneveldt, & Ruddy, 1975). In an experiment utilizing this facilitation effect, Schvaneveldt et al. (1976) predicted that an ambiguous word preceding a word related to only one of its senses should consistently facilitate a lexical decision on the second word only if all meanings of the ambiguous word are retrieved. Their results, while equivocal at some points, seemed to support selective retrieval instead.

In direct contrast to this conclusion, several experimental studies indicate that all meanings of an ambiguous word are retrieved. Conrad (1974), using the Stroop phenomenon, and Foss and Jenkins (1973), using a phoneme-monitoring task, showed that the presence of an ambiguous word can influence reaction time (RT), even when the word appears in a disambiguating context. Other studies (e.g., Bever, Garrett, & Hurtig, 1973; Foss, 1970; MacKay, 1966) have shown that syntactic as well as lexical ambiguities influence language processing. These facts have been used to argue for automatic retrieval of all senses of a word. Conrad

Acknowledgments are due to Andrew Gilpin for his assistance at various points in the execution of this project and for his constructive comments on earlier drafts of this paper, to James Neely for valuable comments that led to substantial revision of the paper, and to Jim Selby for collecting the data for Experiment 1. I also wish to thank Craig Menning for his indispensible assistance in data tabulation and analysis. Requests for reprints should be sent to Jack Yates, Department of Psychology, University of Northern Iowa, Cedar Falls, Iowa 50613.

(1974) called this the "exhaustive computation hypothesis."

Thus casual observation plus some experiments with memory or lexical decision time as the dependent variable indicate that only one meaning of an ambiguous word is retrieved, whether or not a context is present. Experiments using other techniques such as phoneme monitoring indicate two or more meanings may be retrieved.

One possible resolution to the conflicting evidence is that, while all senses of an ambiguity are activated or retrieved, only one sense is allowed to enter awareness and influence action. That awareness may be an important parameter in resolving discrepant findings on lexical ambiguity is suggested by a separate line of evidence from experiments on attention, where it has been found that unattended material, for which the subject has no memory after a few seconds, is nevertheless fully processed (e.g., MacKay, 1973; Norman, 1969). The apparently simultaneous processing of two messages in attention studies with subsequent awareness of only one suggests that similar preconscious and conscious stages may occur in processing an ambiguous word, thus making the outcome of an assessment of ambiguity dependent on the temporal parameters of the assessment.

Cairns and Kamerman (1975) have recently provided evidence concerning the temporal characteristics of ambiguities that is relevant to this suggestion. Using a phoneme-monitoring task to assess the effect of a lexical ambiguity in an unbiasing sentence context, they found an effect of lexical ambiguity, but only within several milliseconds of the occurrence of the ambiguous word. These results are similar to those from Conrad's (1974) experiment in which Stroop interference was used to assess the exhaustive computation hypothesis. When assessment immediately followed an ambiguity located at the end of a sentence, both senses of the ambiguous word produced interference, supporting the exhaustive computation hypothesis. When an ambiguity occurred early in a sentence, thus producing a delay between the ambiguity and the Stroop word, only one sense of the word resulted in interference.

Experiments by Swinney also demonstrate the importance of the temporal relationship between ambiguity and assessment. Swinney and Hakes (1976) present evidence from a phoneme-monitoring task that indicates only one meaning of ambiguous words is retrieved, a finding that appears to violate the contrast constructed here. However, Swinney (Note 2), using the same materials and an assessment of processing load temporally closer to the lexical ambiguity, did find an ambiguity effect. Swinney's findings, plus those of Cairns and Kamerman (1975) and Conrad (1974) imply that, while several meanings of an ambiguous word are briefly retrieved, the ambiguity is quickly resolved and therefore may never enter awareness. Lexical access may be a two-stage operation, the first a preattentive retrieval of all senses of a word, the second a selection of one sense for awareness.

Neely (1977) and Posner and Snyder (1975) have developed an explicit two-stage model of attention that can help to explicate the discrepant findings of lexical ambiguity studies. According to this model, an input item preattentively activates all of the automatic processes associated with the stimulus, presumably including semantic information when the input is a word. This stage is relatively fast acting and automatic and involves no inhibition. When the number of activated automatic processes exceeds one, as with ambiguous words, a limited capacity attentional mechanism must select and focus on one alternative before a response can be made. This second process of focusing on one alternative begins some time after the first process and entails an inhibition or suppression of other alternatives. Whether and when the attentional mechanism is engaged is not automatic; it depends on the costs and benefits associated with its use, and hence the ecology of the situation being considered.

The Posner-Snyder (1975) model implies that the outcome of a study of lexical ambiguity crucially depends on two variables: the time at which lexical retrieval or activation is assessed, and the strategy subjects are encouraged to adopt. In studies where assessment occurs long after presentation of the stimulus, as in the recognition memory paradigm, or in studies where there is a benefit in quickly focusing in one meaning but no cost associated with choosing one meaning over another, as in the Schvaneveldt et al. (1976) study, results are likely to support selective lexical access. However, in studies where assessment of ambiguity effects occurs before focusing can occur, as in the Conrad (1974) study and other studies using phoneme monitoring, or when the cost of rapid focusing outweighs the benefit, results are likely to support exhaustive processing.

The success of Posner and Snyder's (1975) theory in integrating disparate results on lexical ambiguity invites experiments designed to explicitly test the predictions from the theory. The present experiments manipulate the costs and benefits associated with quickly focusing on one meaning of an ambiguous word in order to test the Posner-Snyder prediction that this variable is important in determining whether indications of exhaustive processing will be present. The experiments used a modified semantic-priming paradigm (Loftus, 1973; Meyer et al., 1975) in a sentence-verification task. Subjects were asked to verify statements utilizing dominant or unusual senses of ambiguous words, such as "A mug is a cup" (dominant) or "A mug is a face" (unusual). On some trials, the statement was preceded by a priming stimulus, the word "mug"; on other trials, the statement was preceded by an irrelevant word. In Experiment 1, a large number of

primed trials using dominant senses of the prime were included to increase the benefit of quickly focusing on the dominant sense upon presentation of the prime. In Experiment 2, these trials were omitted and the number of dominant and unusual trials was equal, encouraging deferment of focusing until presentation of the full statement.

According to the Posner-Snyder (1975) hypothesis, presence of a priming word should lead to retrieval of all senses of the word. However, when the dominant sense is quickly focused upon, as in Experiment 1, only trials utilizing dominant senses should show facilitation compared to unprimed trials. Trials utilizing unusual senses should show inhibition compared to unprimed trials, as a consequence of the inhibitory effects resulting from the almost immediate operation of the attention mechanism. Thus, the results of Experiment 1 should favor selective retrieval of alternative meanings. On the other hand, when there is no advantage to rapid selection of one meaning, as in Experiment 2, primed dominant and unusual senses should both show facilitation, since both remain activated until the attention mechanism selects one meaning. Thus, the results of Experiment 2 should favor the exhaustive computation model of ambiguity.

A secondary aim of the study was to explore the limits of the processing effects of ambiguities. The studies mentioned earlier as supporting the exhaustive computation hypothesis have not as a rule distinguished between ambiguous words with related senses (e.g., copper as metal or as coin) and ambiguous words with relatively unrelated senses (e.g., bug as insect or listening device). Although Rubenstein, Lewis, and Rubenstein (1971) have provided evidence that both systematic and unsystematic homographs are multiply represented in the lexicon, it is possible that both senses of a word are retrieved only if they are related. Therefore, only homographs with unrelated senses (unsystematic homography) were included in the present experiments to provide the strongest possible test of the exhaustive computation hypothesis.

METHOD

Experiment 1

Subjects. Forty students in a psychology course at the University of Northern Iowa participated in Experiment 1. The experiment was one alternative for fulfilling an out-of-class participation requirement.

Materials. A four-step procedure was used to obtain a set of words, each of which possessed a dominant sense and an unrelated unusual sense. (1) Over 100 candidate stimuli were presented to 50 subjects in the sentence frame, "A(n) X is a(n) . . . ." Subjects were instructed to respond in a way that resulted in a true statement. (2) The responses were tabulated and stimuli that did not possess both a dominant ($n \geq 30$) and an unusual ($n \leq 20$) response were eliminated. Many of the remaining stimuli possessed unusual senses that received zero or near-zero responses. (3) The resulting set of biased ambiguous words was judged as having related or unrelated dominant and unusual senses by the author and an independent judge. These judgments were based on current usage, not etymology. Only those words unanimously judged as having unrelated senses were retained in the stimulus set. (4) The remaining stimuli and their senses were inserted into sentence patterns of the form, "A(n) X is a(n) Y." This set of sentences, randomly ordered, was presented as a paper-and-pencil test to a new set of 60 subjects, who were asked to judge whether each sentence was true or false. This step was necessary because of the very low frequency with which some senses were produced in Step 1. It was deemed desirable to assay the subjective truth value of such senses for this population of subjects. Senses receiving less than 90% "true" responses were excluded from the stimulus set.

The resulting 32 stimuli appear in Table 1, along with their associated senses and the frequency with which each sense was produced in the first step. The very low dominance of the unusual senses is important for testing the hypotheses sketched earlier.

For each of the 32 stimuli, four 5.1 x 5.1 cm slides were prepared containing: the stimulus word (the priming slide), the stimulus word with the dominant sense appearing immediately below it, the stimulus word with the unusual sense appearing immediately below it (verification slides), and a slide containing an unrelated word (the nonpriming slide).

In addition to the experimental stimuli, the experiment included 100 filler stimuli: 12 stimuli with senses of roughly equal dominance, 44 false statements, of which an equal number were primed and unprimed, plus 44 primed true statements using a dominant sense. High dominance for these statements was defined as the most frequent response to the stimulus in the category norms of Loftus and Scheff (1971).

Procedure and Design. Experimental stimuli were divided into four sets so that only one of the four possible presentation modes for each stimulus appeared in each set. Presentation modes were: (1) primed dominant ("mug" preceding "mug-cup"), (2) primed unusual ("mug" preceding "mug-face"), (3) unprimed dominant ("flower" preceding "mug-cup"), (4) unprimed unusual ("flower" preceding "mug-face"). Presentation modes were randomly assigned to sets so that eight trials of each type appeared in each stimulus set. The 100 filler stimuli were included in each set, so that of the 132 trials presented to each subject, one-third were negative, two-thirds were primed, and 68% of the positive stimuli appeared with a dominant sense. The order of experimental and filler stimuli were randomized for each set, and the 40 subjects were equally and randomly distributed across the four stimulus sets. Each subject saw only one set.

During the experiment, subjects initiated each trial by pushing a button, whereupon a word appeared on a rear-projection screen. After a 2-sec delay, the verification slide containing a vertically arranged pair of words appeared; the top word was either identical (primed) or unrelated (nonprimed) to the preceding word. Subjects were instructed to verify whether "top concept" could be "bottom concept" and to press one of two response keys designated "true" and "false." Reaction times for this decision were recorded to the nearest millisecond.

Experiment 2

Subjects. Sixteen students from a psychology course at the University of Northern Iowa participated in Experiment 2 as part of a class project.

Materials and Procedure. Except for the omitted filler stimuli, materials and procedure were identical to Experiment 1. Four subjects were assigned to each stimulus set. Of the 88 trials included in each of the four stimulus sets, the number of negative and positive by primed and unprimed trials was equal. Twelve of the 44 positive stimuli were of equal dominance; the remainder were divided equally between high and low dominance. Thus, 36% of the positive trials in each stimulus set utilized a dominant sense and 36% utilized an unusual sense.

Table 1
Frequencies of Dominant and Unusual Senses for Ambiguous Words (N = 50)

Word	Dominant Sense	f	Unusual Sense	f
ball	round object	42	formal dance	2
bug	insect	48	Volkswagen	0
cap	hat	45	lid	4
capsule	pill	46	spacecraft	5
cardinal	bird	47	priest	4
club	social organization	34	golf instrument	0
clutch	shifting device	39	grasp	1
crook	criminal	44	bend	2
diamond	jewel	49	shape	0
distributor	auto part	33	wholesale businessman	14
drill	tool	44	routine exercise	4
fork	utensil	51	branching road	0
heart	body organ	44	valentine shape	6
jar	container	50	jolt	1
king	ruler	47	playing card	1
limb	branch	30	body part	20
lock	security device	42	hair	4
log	piece of wood	47	daily record	2
magazine	thing to read	50	gun part	0
match	fire starter	48	identical pair	1
mint	candy	47	plant	0
mole	animal	35	skin blemish	14
mug	cup	48	face	0
note	message	36	tone	9
notion	idea	43	sewing item	5
pen	writing device	49	enclosure	1
pit	deep hole	33	messy place	2
plate	dish	49	denture	0
puzzle	game	35	mystery	6
rattle	baby's toy	38	noise	4
rug	floor covering	47	hair piece	1
shower	standing bath	34	party	1
Mean		42.9		3.6

RESULTS AND DISCUSSION

Experiment 1

To equalize variances, all analyses were carried out on log-transformed data. Geometric mean RTs for subjects and for stimuli in the four presentation modes (priming by dominance) constituted the data for separate analyses, following Clark (1973). Reaction times from trials on which an incorrect response occurred were excluded from this analysis.

Table 2 shows the mean RT and error rate for each presentation mode. Both priming [$\min F'(1,47) = 76.27$, $p < .01$] and dominance [$\min F'(1,55) = 31.71$, $p < .01$] were significant factors, as was their interaction [$\min F'(1,55) = 7.64$, $p < .01$]. Primed trials were significantly faster than unprimed trials, and dominant-sense trials were significantly faster than unusual-sense trials. These general statements correctly describe the data even though the Priming by Dominance interaction was significant. Tests on cell means show that although the effect of priming on unusual senses was less than on dominant senses, the effect was significant [$\min F'(1,60) = 21.00$, $p < .01$]. Also, while RTs for dominant and unusual senses were closer in magnitude on unprimed trials than on primed trials, the effect of dominance was significant even on unprimed trials [$\min F'(1,49) = 11.96$, $p < .01$]. This last finding of a consistent effect of production frequencies on RT is in accord with the results of other studies manipulating production frequency (Ashcraft, 1976; Conrad, 1972; Glass, Holyoak, & O'Dell, 1974).

Sign tests were performed for the distributions of errors over the four presentation modes, with words and subjects serving as the unit of frequency for separate analyses. Errors were more frequent for unusual-sense trials than for dominant-sense trials ($p < .05$ for subjects and for words as the unit of frequency), but no other contrasts were significant in either analysis. In particular, for unusual stimuli, there was no trend for unprimed trials to produce more errors than primed trials, even

Table 2
Geometric Means (in Milliseconds), Error Rates, and Differences for Priming and Dominance in Experiment 1

	Prime		No Prime		
Dominance	Mean	Percent Errors	Mean	Percent Errors	Difference
High	1270	3	1675	8	405
Low	1660	22	1893	23	233

though RTs to unprimed trials were longer. Errors in this instance do not merely reflect processing difficulty as measured by RT. It should be noted that these errors are not readily attributed to the structure of the lexicon in this population. Step 3 of materials construction was designed to eliminate this possibility.

The results of the RT data are in accord with a nonselective view of lexical access, since presentation of the prime facilitated both dominant and unusual senses of the ambiguous word. This outcome is in a strict sense inconsistent with the hypothesis attributed to the Posner-Snyder (1975) theory in the introduction, which predicts that when rapid focusing on the dominant meaning is encouraged, as in Experiment 1, primed unusual-sense trials should have longer RTs than unprimed unusual-sense trials. However, if we assume, as does Neely (1977, p. 233), that the effects of preattentive activation and postattentive inhibition are additive, then the Posner-Snyder theory requires merely that unusual-sense trials show less priming than dominant-sense trials. The significant interaction between priming and dominance shows that this was the case. The results are therefore similar to those of Neely (1977), who found that lexical decisions on expected words were always facilitated by a related prime, while lexical decisions on unexpected words, similar to the unusual-sense predicates used here, were either inhibited or merely less facilitated, depending on the delay between prime and decision stimulus. The fact that unusual-sense trials were successfully primed in Experiment 1 may indicate that, given the delay between prime and stimulus used in this experiment, average postattentive inhibition had not yet exceeded the average activation due to preattentive processes at the time the full stimulus was presented.

The pattern of error results in Experiment 1 are more problematic for the Posner-Snyder (1975) theory. It seems reasonable to assume that errors should reflect availability of semantic information in the same way as RT; hence, the results of the two dependent variables should parallel each other. Yet, unusual senses produced equivalent numbers of errors regardless of priming, while primed unusual senses had shorter RTs than unprimed unusual senses. This discrepancy might be the result of the insensitivity of sign tests; differences in errors between primed and unprimed trials, while quite small, were in the correct direction. On the other hand, the stability of error rates over priming may indicate something more fundamental about the processing of ambiguous words. MacKay (1970) has proposed that before an unusual sense of an ambiguous word can enter awareness, more dominant senses must be "suppressed," a mental act that varies in difficulty with the dominance of the sense to be suppressed. Thus, according to MacKay's hypothesis, on unusual-sense trials, the dominant meaning must be suppressed before the unusual sense can enter awareness, regardless of the priming condition. Because this suppression factor is, unlike Posner and Snyder's inhibition, constant whether or not a prime is present, it could account for the fact that errors were sensitive to the dominance variable but not the priming variable in Experiment 1. Thus, while attending to the meaning of a word may entail a general inhibition of other, unrelated meanings, it may also, in the case of unusual meanings, require the specific suppression or inhibition of more dominant meanings, regardless of whether the unusual meaning has been activated by a prime. Neill (1977) has provided some evidence from a Stroop color-word task for specific suppression of competing responses, as opposed to general inhibition, which might occur as a by-product of allocating attentional resources to one response.

Experiment 2

Data were analyzed as in Experiment 1. Table 3 displays the mean RT and the error rate for each presentation mode.

As in Experiment 1, both priming [min $F'(1,43) = 20.46$, $p < .01$] and dominance [min $F'(1,43) = 30.65$, $p < .01$] were significant factors. However, the Priming by Dominance interaction was not significant, and neither of its component Fs was significant.

The pattern of errors in this experiment was identical to that of Experiment 1. Sign tests were performed on the distribution of errors over the four presentation modes. Using subjects or words as the unit of frequency, unusual-sense stimuli resulted in more errors than dominant-sense stimuli ($p < .05$). Unprimed stimuli did not result in more errors than primed stimuli, even when only unusual senses are considered.

The consistent effect of priming on both dominant and unusual senses again supports a nonselective view of lexical access. Also, since engaging selective attention during the priming interval was not encouraged by the equal frequencies of dominant and unusual senses in this experiment, the Posner-Snyder (1975) theory predicts an attenuation of the Priming by Dominance interaction found in Experiment 1. The complete absence of this interaction, however, is not only a confirmation of the Posner-Snyder prediction and an indication of the absence of the operation of the selective attention mechanism during presentation of the prime, it also is informative with respect to the nature of activation. Collins and Loftus (1975) described

Table 3
Geometric Means (in Milliseconds), Error Rates, and Differences for Priming and Dominance in Experiment 2

	Prime		No Prime		
Dominance	Mean	Percent Errors	Mean	Percent Errors	Difference
High	1509	0	1757	4	248
Low	1813	19	2020	21	207

a spreading-activation theory of semantic processing that assumes that when a concept is processed, activation spreads from the concept along a decreasing gradient. On the basis of the normative study used to define dominant and unusual senses of ambiguous words, unusual senses should be more "remote" from the prime than dominant senses, and so, lying further along the activation gradient, should always receive less activation than dominant senses. The equal effect of priming on dominant and unusual senses observed in Experiment 2 constitutes an apparent counterexample that indicates activation may not always "spread" in the fashion described by Collins and Loftus (1975).

The error data follow the same pattern in Experiment 2 as in Experiment 1, an indication that errors are due to factors other than those affecting RT. Specifically, inhibition due to deployment of an attentional mechanism does not account for the error results, since this inhibition was presumably absent in Experiment 2. Instead, the errors may reflect MacKay's (1970) processing requirement that dominant senses must be suppressed before unusual senses can enter awareness.

GENERAL DISCUSSION

The primary result of the experiments reported here is that in both experiments, a nonselective version of lexical access was supported. Both senses of ambiguous words were successfully primed, even though one sense was quite unusual and semantically unrelated to the more dominant sense. Successful priming of such stimuli constitutes a strong confirmation of the exhaustive computation hypothesis.

Equally important is the resolution of conflicting data on lexical ambiguity suggested by the experiments. The Posner-Snyder (1975) hypothesis not only accounts for the overall pattern of results obtained but also is able to show how the outcome of an assessment of ambiguity effects will depend on the timing of the assessment and the strategies subjects are encouraged to adopt. The results of the present experiments support the Posner-Snyder hypothesis by showing that, depending on the subject strategies encouraged, the same stimuli and experimental paradigm can lead to different outcomes, consistently supporting the exhaustive computation hypothesis in Experiment 2, while yielding mixed results in Experiment 1, where subjects were encouraged to focus on only one meaning of the prime. If instructions explicitly encouraged this strategy, if larger numbers of dominant filler trials were included, or if the interval between prime and full stimulus were lengthened, a modified experiment would presumably produce results fully consistent with a selective model of lexical access.

The Posner-Snyder (1975) hypothesis resolves most dicrepancies among the experimental findings on lexical ambiguity by suggesting that access to the meaning of a word occurs in two stages. In the first stage, all (or at least several) alternative meanings are activated (Posner & Snyder, 1975) or retrieved and transferred to "working memory" (Foss & Jenkins, 1973). But this does not mean that the subject has conscious access to these meanings or that both meanings will be recalled at a later time. The subjects in the experiments reported here gave little indication of being aware of the ambiguous nature of some stimuli. In a postexperimental interview, no subject spontaneously mentioned ambiguity in response to the question, "Did you notice anything different about these words?" Only 7 (out of 56) responded positively to a second question, "Did you notice that some of the words were ambiguous?"

Nor does context seem to exercise any influence on the first stage; similar results from postexperimental questions have been reported by Foss and Jenkins (1973), in a study where ambiguous words were embedded in biasing contexts, and by Conrad (1974), in a study where ambiguous words were in sentences that made one sense anomalous. Thus, whether an ambiguous word appears in isolation, as in the experiments reported here or in those of Jenkins (Note 1), in a disambiguating context (Conrad, 1974), in a biasing context (Foss & Jenkins, 1973), or in a neutral sentential context (Cairns & Kamerman, 1975), its fate is constant; a single meaning is quickly selected and, presumably, only it becomes conscious. It seems as if consciousness may always require an instantiated or particularized version of a stimulus (MacKay, 1970), even in the absence of context.

One of the methodological implications of this generalization is that because the outcome of processing an ambiguity does not depend on the environment of the ambiguity, ambiguity effects will not necessarily be detected merely because a word remains linguistically ambiguous, as in the Schvaneveldt et al. (1976) study. Instead, the processing of ambiguity appears sensitive to the demand characteristics and temporal parameters of a study, as illustrated by the experiments reported earlier.

During a second stage of lexical access, one of the candidate meanings receives focal attention and enters awareness. It is at this point that other senses may be inhibited, either in a general, passive fashion resulting from the allocation of attention to one meaning (Posner & Snyder, 1975), as suggested by the presence of the Priming by Dominance interaction in Experiment 1 and its absence in Experiment 2, or in the specific, active fashion suggested by MacKay's (1970) suppression hypothesis and supported by the consistently greater error rate for unusual senses even when they had been activated. Longer latencies and more errors on unusual-sense trials suggest the dominant meaning must be rejected and suppressed before other, less dominant meanings may be tested, or equivalently, that senses are ordered according to some principle and are tested

serially in that order, as suggested by Hogaboam and Perfetti (1975). Whatever this procedure may involve, it is understandably related to production norms and to association norms (Hogaboam & Perfetti, 1975) of the senses.

Presumably, it is during the second stage that context may have influence, by accepting some senses as suitable and rejecting others. In the absence of any context, as in the first step of materials construction for these experiments, there appears to be a "default" procedure for choosing one sense, usually the most "dominant" one.

Only after the second stage is complete does a selected interpretation enter awareness. Experiments that assess the effects of ambiguity after Stage 1 and before the completion of Stage 2 will find evidence that all meanings of an ambiguous word are accessed (Cairns & Kamerman, 1975; Conrad, 1974; Foss & Jenkins, 1973; Swinney, Note 2), and experiments that assess ambiguity after the completion of Stage 2 will find that ambiguity does not lead to higher processing load (Cairns & Kamerman, 1975; Swinney & Hakes, 1976) or that only one meaning is accessed (Conrad, 1974; Schvaneveldt et al., 1976; Jenkins, Note 1).

One apparent exception to this contrast deserves mention. Warren and Warren (1976) have used a modified Brown-Peterson paradigm to show that homophone and homograph intrusions can occur across trials, that is, after a significant amount of time, when processing of the homograph should have without doubt entered Stage 2. However, the rate of such intrusions is quite low, occurring on the average on about 1 trial in 15; in fact, other experiments using memory paradigms have also found relatively low rates of such intrusions (Underwood, 1965; Jenkins, Note 1), an effect that has generally been ignored. Several explanations of such results are possible within the two-stage framework outlined above. For instance, the intrusions may reflect those instances in which both senses of the ambiguity achieved consciousness (albeit one at a time, according to the perceptual suppression hypothesis); or, instead of recalling an encoded meaning, occasionally the original homograph or homophone may be retrieved so that subsequent processing leads to an intrusion. A third possibility, compatible with the low frequency of these intrusions, is that activation may persist in attenuated form for a relatively long period.

The present experiments used an ambiguous word itself rather than a semantically related word as a prime, and since the prime appeared once again on the verification slide during primed trials, it is conceivable that priming facilitated performance by reducing reading times rather than by reducing semantic retrieval times. Two aspects of the data suggest the effect of priming is not due to reduced reading times. First, this interpretation of the priming results makes the interaction in Experiment 1 between dominance and priming problematic. Why would a pure reading time effect interact with the dominance of the predicate term? Second, Experiment 2, differing from Experiment 1 in the lower probability of a dominant predicate, produced no such interaction. It seems unlikely that an automatic reading-facilitation effect would be sensitive to this procedural modification.

A second difference between Experiments 1 and 2 suggests another reading time explanation. The probability that a trial was primed, hence the probability of a match between priming word and the first word of the verification slide, was greater in Experiment 1 than in Experiment 2. The difference could have encouraged a strategy in which the first word of the stimulus slide was not read in Experiment 1. Yet this sort of reading strategy is equally unable to explain a Priming by Dominance interaction or its inconsistent occurrence in the two experiments. Furthermore, such a strategy would have resulted in large numbers of errors on unprimed trials, where stimuli on the priming and test slides did not match, an effect that was not observed. While it is still possible that the results of these experiments reflect reading times, such an interpretation seems very unlikely.

REFERENCE NOTES

1. Jenkins, J. J. *Context conditions meaning.* Invited address presented at the meeting of the Midwestern Psychological Association, Chicago, 1977.

2. Swinney, D. A. *Does context direct lexical access?* Paper presented at the meeting of the Midwestern Psychological Association, Chicago, 1976.

REFERENCES

Ashcraft, M. H. Priming and property dominance effects in semantic memory. *Memory & Cognition,* 1976, **4**, 490-500.

Bever, T. G., Garrett, M. F., & Hurtig, R. The interaction of perceptual processes and ambiguous sentences. *Memory & Cognition,* 1973, **1**, 277-286.

Cairns, H. S., & Kamerman, J. Lexical information processing during sentence comprehension. *Journal of Verbal Learning and Verbal Behavior,* 1975, **14**, 170-179.

Clark, H. H. The language-as-a-fixed-effect fallacy: A critique of language statistics in psychological research. *Journal of Verbal Learning and Verbal Behavior,* 1973, **12**, 335-359.

Collins, A. M., & Loftus, E. F. A spreading activation theory of semantic processing. *Psychological Review,* 1975, **82**, 407-428.

Conrad, C. Cognitive economy in semantic memory. *Journal of Experimental Psychology,* 1972, **92**, 149-154.

Conrad, C. Context effects in sentence comprehension: A study of the subjective lexicon. *Memory & Cognition,* 1974, **2**, 130-138.

Foss, D. J. Some effects of ambiguity upon sentence comprehension. *Journal of Verbal Learning and Verbal Behavior,* 1970, **9**, 699-706.

Foss, D. J., & Jenkins, C. M. Some effects of context on the comprehension of ambiguous sentences. *Journal of Verbal Learning and Verbal Behavior,* 1973, **12**, 577-589.

Gartman, L. M., & Johnson, N. F. Massed versus distributed repetition of homographs: A test of the differential-encoding hypothesis. *Journal of Verbal Learning and Verbal Behavior,* 1972, **11**, 801-808.

GLASS, A. L., HOLYOAK, K. J., & O'DELL, C. Production frequency and the verification of quantified statements. *Journal of Verbal Learning and Verbal Behavior,* 1974, **13**, 237-254.

HOGABOAM, T. W., & PERFETTI, C. A. Lexical ambiguity and sentence comprehension. *Journal of Verbal Learning and Verbal Behavior,* 1975, **14**, 265-274.

LASHLEY, K. S. The problem of serial order in behavior. In L. A. Jeffress (Ed.), *Cerebral mechanisms in behavior.* New York: Wiley, 1951.

LOFTUS, E. F. Activation of semantic memory. *American Journal of Psychology,* 1973, **86**, 331-337.

LOFTUS, E. F., & SCHEFF, R. Categorization norms for fifty representative instances. *Journal of Experimental Psychology Monograph,* 1971, **91**(Whole No. 2), 355-365.

MACKAY, D. G. To end ambiguous sentences. *Perception & Psychophysics,* 1966, **1**, 426-436.

MACKAY, D. G. Mental diplopia: Towards a model of speech perception at the semantic level. In G. B. Flores d'Arcais & W. J. M. Levelt (Eds.), *Advances in psycholinguistics.* New York: American Elsevier, 1970.

MACKAY, D. G. Aspects of the theory of comprehension, memory and attention. *Quarterly Journal of Experimental Psychology,* 1973, **25**, 22-40.

MEYER, D. E., & SCHVANEVELDT, R. W. Facilitation in recognizing pairs of words: Evidence of a dependence between retrieval operations. *Journal of Experimental Psychology,* 1971, **90**, 227-234.

MEYER, D. E., SCHVANEVELDT, R. W., & RUDDY, M. G. Loci of contextual effects on visual word recognition. In P. M. A. Rabbitt & S. Dornic (Eds.), *Attention and performance V.* New York: Academic Press, 1975.

NEELY, J. Semantic priming and retrieval from lexical memory: Roles of inhibitionless spreading activation and limited-capacity attention. *Journal of Experimental Psychology: General,* 1977, **106**, 226-254.

NEILL, W. T. Inhibitory and facilitatory processes in selective attention. *Journal of Experimental Psychology: Human Perception and Performance,* 1977, **3**, 444-450.

NORMAN, D. A. Memory while shadowing. *Quarterly Journal of Experimental Psychology,* 1969, **21**, 85-93.

POSNER, M. I., & SNYDER, C. R. R. Facilitation and inhibition in the processing of signals. In P. M. A. Rabbitt & S. Dornic (Eds.), *Attention and performance V.* New York: Academic Press, 1975.

RUBENSTEIN, H., LEWIS, S. S., & RUBENSTEIN, M. A. Homographic entries in the internal lexicon: Effects of systematicity and relative frequency of meanings. *Journal of Verbal Learning and Verbal Behavior,* 1971, **10**, 57-62.

SCHVANEVELDT, R. W., MEYER, D. E., & BECKER, C. A. Lexical ambiguity, semantic context, and visual word recognition. *Journal of Experimental Psychology: Human Perception and Performance,* 1976, **2**, 243-256.

SWINNEY, D. A., & HAKES, D. T. Effects of prior context upon lexical access during sentence comprehension. *Journal of Verbal Learning and Verbal Behavior,* 1976, **15**, 681-689.

UNDERWOOD, B. J. False recognition produced by implicit verbal responses. *Journal of Experimental Psychology,* 1965, **70**, 122-129.

WARREN, R. E., & WARREN, N. T. Dual semantic encoding of homographs and homophones embedded in context. *Memory & Cognition,* 1976, **4**, 586-592.

WINOGRAD, E., & CONN, C. P. Evidence from recognition memory for the specific encoding of unmodulated homographs. *Journal of Verbal Learning and Verbal Behavior,* 1971, **10**, 702-706.

WINOGRAD, E., & RAINES, S. R. Semantic and temporal variation in recognition memory. *Journal of Verbal Learning and Verbal Behavior,* 1972, **11**, 114-119.

(Received for publication June 8, 1978;
revision accepted October 26, 1978.)