Greg B. Simpson

Context and the Proceesing of Ambiguous Words

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GREG B. SIMPSON

I. INTRODUCTION

By the time that Fodor's *Modularity of Mind* was published in 1983, there was already a sizable literature concerned with the problem of lexical ambiguity (i.e., the retrieval of meanings of multiple-meaning words). The vast majority of these studies were concerned with a single question: To what extent do higher level semantic representations, such as those arising from the processing of a sentence, constrain the activity of a lower process (in this case, the identification of a word)? A decade ago, the area appeared to have matured to the point where an attempt at some closure seemed possible (Simpson, 1984). With the publication of Fodor's book, however, research in lexical ambiguity blossomed anew, as the question of interactions among comprehension subsystems assumed central status in cognitive science. In a box score approach, studies old and new were placed in the appropriate column. Those that found evidence that multiple meanings of an ambiguous word were activated in all contexts were interpreted as supporting the modularity position. Studies finding access only for the one meaning cued by the context were held to support the hypothesis that the various components of comprehension are highly inter-active. The purpose of the present chapter is to provide an updated review of recent literature in ambiguity, some discussion of methodological issues, and a perspective on the future of the area. I will argue that the box score approach to the modularity debate has outlived its usefulness, and that researchers in this area need to move beyond this basic question to discuss issues concerning the nature of context and a person's interaction with it, and how these may affect processing.

In Section II of this chapter, I attempt to review some of the issues that were raised in the earlier discussion of the literature (Simpson, 1984) and to consider the bearing of recent research on those issues. The following section discusses the nature of context and suggests that further progress will be possible only by viewing context more comprehensively than has typically been the

case, considering not only local sentence context but also the context of the experimental situation itself.

II. AN OVERVIEW OF LEXICAL AMBIGUITY PROCESSING

Previously, models of ambiguous word processing were subdivided into three broad theoretical classes (Simpson, 1984). Context-dependent (or selective access) models are those that claim that when an ambiguous word occurs in a context, only the single contextually appropriate meaning is activated in memory (Glucksberg, Kreuz, & Rho, 1986; Schvaneveldt, Meyer, & Becker, 1976; Simpson, 1981). Such a view is most compatible with an interactive conception of language comprehension (McClelland, 1987).

The remainder of the models hold that the initial activation of word meanings is not influenced by prior context. According to one version of this context-independent view (e.g., Hogaboam & Perfetti, 1975), the order of access to meanings is based on their relative frequencies. Whenever an ambiguous word is encountered, regardless of context, the most common meaning is retrieved. If this meaning is discovered to be inconsistent with the context, then it is discarded and a second meaning is retrieved. This process will continue until an acceptable match is found. In most cases, the result will be the same as under the context-dependent model. That is, because the context is most often consistent with the most frequent sense of the ambiguous word, an ordered access model predicts the processing of only one meaning on most occasions, but multiple meanings when the context is consistent with the less frequent (subordinate) meaning.

Finally, an exhaustive or multiple access model contends that all meanings are activated whenever an ambiguous word is encountered, and this activation proceeds without reference either to the context or meaning frequency (Conrad, 1974; Lucas, 1987; Onifer & Swinney, 1981; Swinney, 1979). The selection of the appropriate meaning (the one that matches the context) is a process that takes place only after all meanings have undergone initial processing. It is this model that generally has gained most acceptance and is the one that is compatible with a modular account of language comprehension processes. It is also easy to see now why the proposal of the lexicon as an autonomous module has led to such a proliferation of ambiguity research. The case of multiple-meaning words seems ideal for addressing the question of whether context can influence lexical access. If a meaning of a word can be shown to be activated despite being incompatible with its context, then this is taken as strong evidence that lexical processing proceeds without regard for sentence-level contextual factors.

It was also possible in the earlier review to divide the extant studies along methodological lines. The classes of methods used most frequently were identified as processing complexity tasks, ambiguity detection, and priming methods. Processing complexity tasks are those that infer the activation of one or more meanings based on a comparison of sentences containing homographs with unambiguous control sentences. Such methods include sentence verification, sentence completion, recall of rapidly presented (RSVP) sentences, phoneme monitoring (see Ferreira & Anes, this volume), and eye-movement techniques

(see Rayner & Sereno, this volume). Generally, with these methods it is found that a sentence containing an ambiguous word leads to poorer performance. It is inferred that the performance decrement occurs because of extra processing caused by the necessity of selecting a single meaning of the ambiguity when more than one has been activated. Generally speaking, most of these methods have seen a decline in their use in recent years, owing principally to two criticisms. First, they are only indirect measures of meaning activation. That is, we may infer the activation of two meanings from the increased processing time, but the relative activation levels of each meaning cannot be discerned. Some recent views of ambiguity processing emphasize degrees of activation of different meanings, effectively striking a middle ground between pure context-dependent and exhaustive access models (e.g., Duffy, Morris, & Rayner, 1988; Neill, Hilliard, & Cooper, 1988). The processing complexity tasks usually are not suited to the testing of such models. A second criticism with respect to these methods is that they tend to be off-line tasks. As we have become very sensitive to the time course of lexical access processes, it has been seen as critical that we identify tasks that measure the processes up to the point of access, rather than later post-access processes. For most of the processing complexity tasks, it is not clear whether the effects that we see are traceable to initial meaning activation or to later selection processes that take place after multiple meanings of an ambiguity have been activated.

Recently, however, one task that relies on a processing complexity measure (eye movement) has been used to study ambiguity (Duffy et al., 1988; Rayner & Duffy, 1986; Rayner & Frazier, 1989; Rayner & Morris, 1991). In these studies, subjects read ambiguous words embedded in sentences that provide disambiguating information either prior to or following the ambiguity. Generally, these studies have found gaze duration on the ambiguous word to be affected by both the location of the disambiguating context and the type of homograph (balanced ambiguous words, whose meanings are relatively equal in terms of their frequency, and unbalanced ambiguities, for which one meaning is much more frequent).[1] When the disambiguating context follows the ambiguous word (i.e., when either meaning is still potentially appropriate), subjects look longer at balanced ambiguous words than at unambiguous control words, but unbalanced ambiguities do not show this difference. These data suggest that the processing load is increased for the balanced words as the subject processes both meanings of these homographs. For the unbalanced words, on the other hand, gaze duration is no longer than for unambiguous words, because the much more common meaning alone is retrieved immediately, with the result that these words function in the way that unambiguous (i.e., single-meaning) words do. When the critical context precedes the ambiguity, however, gaze duration on the homograph depends also on which meaning is biased by the context (Rayner & Frazier, 1989). For dominant-biased sentences, there is no difference in gaze duration for balanced and unbalanced homographs. However, for subordinate-

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[1] Rayner and his colleauges (e.g., Rayner & Morris, 1991) use the terms "nonbiased" and "biased" for what are here called "balanced" and "unbalanced" homographs, respectively. The present terms were chosen to avoid confusion with the use of "bias" as a description of a contextual manipulation.

biased sentences, unbalanced ambiguous words now show longer gaze durations than do the balanced. In this case, it appears that the context has raised the activation level of the subordinate meaning to such a level as to make it compete with the dominant meaning for access. In other words, providing context biased toward the less common meaning effectively turns the unbalanced homograph into a balanced one. Rayner and his colleagues refer to this as REORDERED ACCESS.

These eye-movement studies do not seem to be as vulnerable to one of the criticisms often raised in objection to other processing complexity tasks, namely that they are off-line measures of processing. That is, because the eye movements are measured while the subject engages in normal reading, they are more clearly an unintrusive on-line assessment of processing. The second criticism of the processing complexity methods, that they only allow an inference about single versus multiple access, rather than permitting the separate indexing of activation levels, may still be relevant. On the other hand, by varying the type of homograph and the location of the biasing context, these studies appear to allow a stronger inference than do most of the tasks in the processing complexity family. That is, by showing that individual homographs can lead to greater or lesser load (i.e., longer or shorter gaze durations) depending on surrounding context, these studies come closer than other complexity measures to capturing directly the relative activation of different meanings. Perhaps the best advice would be to consider eye-movement measures in conjunction with the more popular priming methods (discussed below) that better index activation levels but are more intrusive (Rayner, 1991).

In the ambiguity detection method, the subject is presented with a sentence ending in a homograph and is asked to decide as rapidly as possible whether that word has another meaning (Forster & Bednall, 1976; Hogaboam & Perfetti, 1975; Neill et al., 1988). Hogaboam and Perfetti showed that subjects are faster to identify a word as ambiguous if its context is biased toward the less frequent meaning than if it is biased toward the more frequent, a result that has been replicated more recently in an experiment which better controlled subject strategies (Neill et al., 1988). The reason for this is that the more frequent meaning is assumed to be activated first in all contexts. If the person must search for a second meaning, this search will take longer the less frequent that meaning is. If the context biases the ambiguous word toward its subordinate meaning in the first place, however, the search for the other, more common, meaning will be very fast, as that meaning has already been activated by virtue of its frequency. Neill et al. argued for a model much like that of Rayner and his colleagues above: parallel access for all meanings, but access that is sensitive to the frequency of the meanings and to the context. In general, the criticisms of this task are similar to those raised regarding the processing complexity tasks. It is difficult to identify relative activation levels with the detection task, and the method's ability to capture on-line processes is not clear. However, the use of this method has been critical to our appreciation of the relative frequency of meanings, a factor largely ignored until the mid 1970s (Forster & Bednall, 1976; Hogaboam & Perfetti, 1975).

In the past decade, ambiguity studies have been dominated by priming tasks. In these methods, the subject hears or reads a sentence containing an ambiguous word. Upon the presentation of this ambiguous word, a target word

is presented for a speeded response, usually naming or a lexical decision (see Haberlandt, this volume, for a more complete discussion of these tasks). The target is a word related to one of the homograph's meanings or is an unrelated control word. This technique has several characteristics to recommend it. First, it is generally believed to be more sensitive to on-line word recognition processes than the kinds of tasks discussed previously. Second, the method gives us a better idea of the degree of activation of different meanings than do the other families of tasks. Targets are usually words that are related to the same meaning of the ambiguity as that indicated by the context, related to another meaning, or unrelated. For example, a sentence such as *The church bought new pipes for the* **organ** might be followed by the targets MUSIC, HEART, or PAPER. By comparing the response times in these three conditions, we can estimate the degree of activation of each meaning relative to the unrelated control. Finally, priming methods are best suited to studying the time course of meaning activation, through manipulation of the time elapsing between the presentation of the homograph and the onset of the target. Because so much of the recent research has used the priming paradigm, it is appropriate that we devote some discussion to the results of these studies. Such a discussion is particularly important because it has often been the case that differences in results are attributed to one or more (often subtle) differences in methodology. The following discussion focuses on several of the variables that have been suggested as responsible for differences in results. It will be argued that in fact we are not able to account for the discrepancies in the literature by any straightforward classification of priming studies.

A. Priming by a Sentence Context

As discussed above, the priming procedure is implemented in several ways, varying according to the method of presentation of the context, the location of the ambiguity in the sentence, and the task performed on the target. The majority of the studies have used the cross-modal procedure, in which subjects hear a sentence and are presented with a visual target (Conrad, 1974; Glucksberg et al., 1986; Lucas, 1987; Oden & Spira, 1983; Onifer & Swinney, 1981; Seidenberg, Tanenhaus, Leiman, & Bienkowski, 1982; Simpson, 1981; Swinney, 1979; Tabossi, 1988; Tabossi, Colombo, & Job, 1987; Tanenhaus, Leiman, & Seidenberg, 1979). A much smaller number of studies have used visual presentation of the context as well as the target. Each sentence is presented at once (Simpson & Krueger, 1991) or word by word, using either an RSVP procedure in which each word replaces the previous one at the center of the screen (Kintsch & Mross, 1985; Till, Mross, & Kintsch, 1988), or an unfolding procedure in which each word appears to the right of the preceding word as it would in normal text (Paul, Kellas, Martin, & Clark, 1992). There is no a priori reason to think that these differences in the way that the context is presented should lead to a difference in results (specifically, that one method should favor context-dependent access while others favor multiple activation), and indeed, the results cannot be divided in this way. A number of the cross-modal studies have found priming for both meanings of the ambiguous word, regardless of context (Conrad, 1974; Lucas, 1987; Onifer & Swinney, 1981; Seidenberg et al., 1982; Swinney, 1979; Tanenhaus et al., 1979), while others have found selective

access (Glucksberg et al., 1986; Oden & Spira, 1983; Simpson, 1981; Tabossi, 1988; Tabossi et al., 1987). Likewise, some of the studies using visual presentation support multiple access (Kintsch & Mross, 1985; Till et al., 1988), while the remainder find evidence for selective context effects (Paul et al., 1992; Simpson & Krueger, 1991).

Similarly, we cannot predict the results based on the target task. Word recognition tasks have come under close scrutiny in recent years, with particular emphasis on the lexical decision task. Because this task requires a binary decision, it has been likened to a signal-detection task (Balota, 1990; Seidenberg, Waters, Sanders, & Langer, 1984), and it has been suggested that a variable (such as context) that may appear to affect lexical access instead has its effects at a later post-access decision stage (but see Paul, Kellas, & Juola, 1992). The implication of this criticism is that the lexical decision task may be more likely to lead to results consistent with a context-dependent view, as it is more sensitive to postlexical processes, in this case the integration of a meaning with the context. Therefore, perhaps the naming task is preferable for examining initial activation processes. However, we again see several lexical decision experiments favoring a selective access account (Glucksberg et al., 1986; Simpson, 1981; Tabossi, 1988; Tabossi et al., 1987), and others not (Kintsch & Mross, 1985; Lucas, 1987; Onifer & Swinney, 1981; Swinney, 1979; Till et al., 1988). Likewise for naming, some studies support selective access (Simpson & Krueger, 1991) and others support a multiple access view (Seidenberg et al., 1982; Tanenhaus et al., 1979). Finally, a small number of studies have used the Stroop task, in which subjects are required to name the color of ink in which the target is printed. One such study found evidence for multiple access, showing color naming interference to be equal for targets related to either meaning (Conrad, 1974), while the two remaining studies showed selective effects of context (Oden & Spira, 1983; Paul et al., 1992). In summary, while it has occasionally been implied that the choice of experimental task may be critical in identifying the role of context, no straightforward division of results can be made according to task.

A third potential candidate for categorizing ambiguity studies is the location of the homograph within the context sentence. Many priming studies have used the homograph as the last word in the sentence (Conrad, 1974; Oden & Spira, 1983; Paul et al., 1992; Seidenberg et al., 1982; Simpson, 1981; Simpson & Krueger, 1991; Tanenhaus et al., 1979), while others place the homograph within the sentence, interrupting the subject's sentence comprehension to present the target (Blutner & Sommer, 1988; Kintsch & Mross, 1985; Lucas, 1987; Onifer & Swinney, 1981; Swinney, 1979; Tabossi, 1988; Tabossi et al., 1987; Till et al., 1988). On its face, this seems like a factor that could well have an impact on the pattern of activation that is found. One might argue, for example, that the sentence-final homograph allows sentence wrap-up processes peripheral to lexical access to influence the subject's target response. Seen in this light, the sentence-medial procedure would appear to be preferable. On the other hand, the competing demands of the two tasks (sentence comprehension and target response) would appear to be greater when one task is interrupted to perform the other. The hypothesis here might be that extra resource demands of the sentence-medial procedure could delay target recognition and allow more time for post-access processes to occur. In addition, it could be suggested that

consistently interrupting the sentence to present another task leads, over the course of the experiment, to processing that is different from normal sentence comprehension. Depending on the outcome, hypotheses such as these could be used to bolster the case for either selective or multiple access. As it turns out, however, this candidate also cannot divide the studies in any simple way. Some experiments using sentence-final homographs have concluded that multiple meanings are initially activated (Conrad, 1974; Seidenberg et al., 1982; Tanenhaus et al., 1979), while others have argued for selective access of meaning (Oden & Spira, 1983; Paul et al., 1992; Simpson, 1981; Simpson & Krueger, 1991). Similarly, support can be found in the sentence-medial studies for multiple (Blutner & Sommer, 1988; Kintsch & Mross, 1985; Lucas, 1987; Onifer & Swinney, 1981; Swinney, 1979; Till et al., 1988) and for selective (Tabossi, 1988; Tabossi et al., 1987) access.

One factor that is clearly important for any discussion of lexical ambiguity (or indeed for any issue regarding on-line language comprehension processes) concerns the temporal relations between the context and the target. Since the first time-course studies were published (Swinney, 1979; Tanenhaus et al., 1979), it has become quite apparent that any explanation of ambiguity processes that does not include an account of changing activation patterns over time simply cannot hope to capture the complete picture of the processes relevant to the selection of a single appropriate meaning. It is easy to see why this should be the case: It is obvious that the outcome of the complete processing of an ambiguous word in context is awareness of a single meaning. The controversy concerns the timing of contextual effects. The context-dependent position is that the context acts immediately to restrict access to the appropriate meaning, while the context-independent view is that context is used only later, after all meanings are activated, to select the appropriate one. Swinney (1979) used a cross-modal procedure in which sentences containing ambiguous words were presented auditorily, and the homograph was followed by a target that was related to the contextually biased meaning or to the other meaning (or was unrelated). Targets were presented either immediately after the offset of the ambiguity or after a delay of three syllables. Lexical decisions to targets related to either meaning were facilitated relative to unrelated targets in the immediate condition, but only contextually appropriate targets were facilitated after the delay. Several studies have shown a similar pattern (Blutner & Sommer, 1988; Kintsch & Mross, 1985; Lucas, 1987; Onifer & Swinney, 1981; Seidenberg et al., 1982). These results led to a consensus that the initial activation of word meanings took place without input from contextual processes, which were used only in the post-access selection process. The results of studies that contradicted this conclusion (e.g., Simpson, 1981) could be faulted if any time had been allowed to elapse between the ambiguity and the target.

However, some more recent time-course studies (or studies using only an immediate presentation condition) have found patterns of results that are in conflict with this received view. Tabossi (1988; Tabossi et al., 1987) has found evidence that selective access may occur immediately if the context is sufficiently constraining. Her subjects performed lexical decisions immediately following the presentation of an ambiguous word in a cross-modal procedure. She found that sentences biased toward the dominant meaning led to the activation of that meaning only, provided that the context primed a salient feature of that

meaning. For example, Tabossi et al. presented subjects with sentences such as *The violent hurricane did not damage the ships which were in the port, one of the best equipped along the coast.* This sentence highlights the salient feature of *port* that it is a safe haven for ships, and targets appropriate to that feature were primed. This result was extended in several ways by a recent series of studies by Paul, Kellas, Martin, and Clark (1992). These researchers used a Stroop task following sentences ending in ambiguous words and activating features appropriate to that word's dominant or subordinate meaning. Targets appropriate or inappropriate to the contextual meaning were presented 0, 300, or 600 ms following the sentences. Paul, Kellas, Martin, and Clark found slower color-naming times for the contextually appropriate targets than for the inappropriate (both for sentences biased toward the dominant meaning and for those biased toward the subordinate), even at the 0 ms interval.

In a study comparing priming and event-related potential (ERP) results (see Kutas & Van Petten, this volume), Van Petten and Kutas (1987) found that naming latencies to targets related to either meaning of a homograph showed priming relative to unrelated words, at stimulus onset asynchronies of 200 and 700 ms. These results, of course, are in line with the multiple access view. The ERP data, however, painted a different picture. The onset of the N400 response (i.e., the electrical potential that occurs around 400 ms after the onset of a stimulus and is associated with language processing) to the targets was earlier for contextually appropriate targets than for the inappropriate or unrelated targets. The authors concluded that the ERP results indicated a role for context in the initial processing of the homograph, and that the naming facilitation for the contextually inappropriate target was due to backward priming (in which the target reactivates the prime, and the two are processed in parallel; see Koriat, 1981; Peterson & Simpson, 1989).

Finally, Simpson and Krueger (1991) have recently extended the earlier research by Simpson (1981) to include a time course manipulation. Simpson used sentence-final homographs in a cross-modal experiment and found context-dependent meaning activation. In that study, however, an interval of 120 ms occurred between the offset of the ambiguous word and the presentation of the lexical decision target. A number of authors (e.g., McClelland, 1987; Onifer & Swinney, 1981) have pointed out that this may have been a long enough interval to compromise these results as an account of immediate activation processes. To test this possibility, Simpson and Krueger displayed sentences visually and presented targets 0, 300, or 700 ms following the subject's reading of the last word in the sentence (the homograph). At all three of these intervals, only the contextually appropriate targets were facilitated, for both the dominant- and subordinate-biased sentences. In sum, although there can hardly be any disputing the need for careful consideration of time-course issues, the existing studies still are not able to provide a coherent picture of the timing of access to different meanings of an ambiguity.

B. Summary

The above discussion, it must be admitted, does not paint a very encouraging picture, at least for the hope that ambiguity research may provide a definitive answer for questions of the autonomy of language comprehension processes.

Indeed, one might conclude at this point that the research examining the role of sentence context on lexical activation has run its course. All the models of ambiguity processing have found support from one or more studies, and, as the above discussion has attempted to make clear, there is no simple way of classifying studies methodologically in any way that sheds light on the discrepancies among results.

In an earlier review (Simpson, 1984), I tried to argue that the constellation of results at that time could best be explained by positing a system whereby all meanings are activated, but with the degree of activation being sensitive to influence by the relative frequencies of the meanings and by the context in which the ambiguous word occurs. There does not seem to be any compelling reason to change that position now. First, such a model has found converging support from research using methods quite different from priming, including ambiguity detection (Neill et al., 1988) and eye movements (Duffy et al., 1988; Rayner & Frazier, 1989). Second, it could also be argued that the confusing set of results among priming studies demands such a flexible view. It appears (in the absence of any other methodological basis for classifying the research) that some kinds of context are able to lead to the activation of a single meaning, while others do not constrain access. Such variable context effects across studies should not be surprising unless we become better able to provide an adequate account of what good context is, and what relevant information is contained in it. It is to a discussion of context, therefore, that we now turn.

III. On the Nature of Sentence Context

Discussions of context are, of course, frequent in the ambiguity literature, but there have been relatively few attempts to develop a principled account of context types. Simpson (1981) used three kinds of sentences in a cross-modal experiment: unbiased, weakly biased toward one meaning, and strongly biased toward a meaning. Classification of the sentences was determined by subject ratings. For example, for the homograph *bank*, the sentences were (1)–(5).

(1) *The men decided to wait by the bank.* (unbiased)
(2) *The fishermen decided to wait by the bank.* (weak bias-subordinate)
(3) *The businessmen decided to wait by the bank.* (weak bias-dominant)
(4) *I pulled the fish up onto the bank.* (strong, bias-subordinate)
(5) *I opened a checking account at the bank.* (strong bias-dominant)

Subjects did not find the rating task to be at all difficult, and their ratings did successfully predict the pattern of meaning activation in the lexical decision experiment: Unbiased sentences led to facilitation for the dominant meaning only; strongly biased sentences resulted in activation for the contextually appropriate meaning. Frequency and context both showed influences with weakly biased sentences: Those biased toward the dominant meaning facilitated that meaning only, but when frequency and context were in conflict (weakly biased toward the subordinate meaning), both meanings were activated. However, although there was a clear empirical distinction between strong and weak contexts, the qualitative differences among the contexts that led to that distinction are not easy to specify.

Seidenberg et al. (1982) proposed that the determining factor in whether a context sentence should constrain lexical access is whether it contains a strong lexical associate of one of the meanings of the homograph. For example, in the sentence *I opened a checking account at the* **bank,** it may be that the financial meaning of *bank* is primed not by the message-level representation of the sentence as a whole, but simply by the presence of words like *checking account.* Even worse, it could be that apparent priming would not require access of any meaning of *bank,* but simply that words like *checking account* directly prime a target such as *money.* As this kind of priming involves nothing more than word-level associations, the principle of an autonomous lexical processor is left intact. Although such direct priming has been shown in some cases (Burgess, Tanenhaus, & Seidenberg, 1989), it does not seem to be able to account for all the priming effects seen with sentences (O'Seaghdha, 1989; Simpson, Peterson, Casteel, & Burgess, 1989). In addition, it is difficult to distinguish the strong and weak contexts in Simpson (1981) based on the presence of lexical associates. Many of the sentences rated as strongly biased did not contain words that could serve as such associative primes (e.g., *While downtown I signed up for the* **draft**), while many weakly biased sentences did contain such words (e.g., *The doctor found something wrong with the* **organ**). Consequently, we are so far without a convincing candidate for distinguishing those contexts that will constrain meaning activation from those that will not.

The recent work of Tabossi (1988, 1989, 1991; Tabossi et al., 1987) has focused on the idea that context must activate certain kinds of information in order to restrict access to a single meaning. Specifically, a context sentence should be constrained such that it activates a salient feature of a single meaning (as discussed previously). A series of studies by Kellas and his colleagues (Kellas, Paul, Martin, & Simpson, 1991; Paul et al., 1992) has extended the arguments on the importance of feature activation for lexical access. These authors have attempted as well to expand on the concept of SALIENCE. They define the salience of a target in terms of the hypothesized overlap of semantic features of the target and the homograph in a certain context. They began by gathering normative associations to ambiguous words in biasing sentence contexts. Subjects generated as many aspects of the meaning of the homograph in that sentence context as they were able in one minute. This procedure is in contrast to the more common practice of using targets generated to homographs in isolation (e.g., as in the norms of Cramer, 1970, or of Nelson, McEvoy, Walling, & Wheeler, 1980). Targets can then be identified as relatively high or low on a continuum of salience relative to the meaning of the homograph in that context. For example, instead of generating a single associate to a word such as *plant* in isolation (the common method for association norms), subjects instead generated multiple responses to a sentence such as *The boy dropped the* **plant.** One frequently produced associate in this procedure was *leaves,* which is produced as well when *plant* is given in isolation (Cramer, 1970). However, another response that was produced to the above sentence (though by fewer subjects) was *spill.* This word would be very surprising as a response to the ambiguous word *plant* alone, but it can be seen as related to the word in the context of that sentence. In a Stroop experiment (Paul et al., 1992), both *leaves* and *spill* (high- and low-salient targets, respectively, for this sentence) showed slower color-naming times than targets related to the other meaning

(*factory* and *people*), even at an immediate context-target interval. At longer intervals, only the highly salient target (*leaves*) still showed slowed responses. The same result was found for sentences biased toward the subordinate meaning. That is, immediately following the sentence *They closed that part of the plant,* both *factory* and *people* were activated, but after 500 ms, only *factory* still led to slowed color-naming.

These results suggest that context can activate substantially more information than simply the lexical associates of the homograph. The study also suggests again that intralexical priming is not the operative principle behind context effects, as these sentences do not seem particularly rich in the kind of lexical information that would be likely by itself to activate a meaning. In the example above, perhaps one could argue that the target *spill* is an associate of *dropped.* Therefore, perhaps *leaves* is primed by *plant* and *spill* by *dropped.* However, most of the sentences used in this study did not include associates of this kind. In addition, we would have to ask why the time course of priming between *plant* and *leaves* should differ from that of *dropped* and *spill.* Even if one argued that the former pair is more strongly associated than the latter, we would normally expect strength-of-association effects to differ at earlier points in the time course, rather than later. Instead, it appears as if context makes available certain kinds of information relevant to the semantic and pragmatic relations among words. For example, one would not expect to find color-naming interference for *spill* if the sentence had been *The boy dropped the* **television.** It seems, in other words, as if the information activated constitutes a range of features of an item that are relevant in context. We have not typically been able to discover these kinds of relations because of the common practice of selecting as targets only words that are generated to a homograph out of context. While this is a practice that is necessary for determining the relative dominance of a meaning, it may well miss a substantial amount of further information that will be activated under other circumstances.

It should be noted, however, that these results appear to be at odds with those obtained by Till et al. (1988). Subjects in Till et al. read sentences ending in homographs (sentence pairs were presented, and on the critical trial, the homograph was the last word in the first sentence). Following the homograph, a lexical decision target was presented. Targets were associates of the ambiguous word (from standard homograph norms), or they were inference words generated by subjects in a norming procedure. For instance, given the sentence *The old man sat with his head down and did not hear a word of the sermon during* **mass,** subjects generated *sleep* as an inference target (*church* was the appropriate associate target for this sentence, and *weight* was the inappropriate). Consistent with the multiple access view, both associates were primed following the sentence. The inference words are of particular interest here, as they appear to bear some similarity to the low-salient targets of Paul, Kellas, Martin, and Clark (1992) (i.e., in both cases, the targets appear to be words that are related to the sentence as a whole, rather than being associated with the ambiguous word in isolation). These inference words were primed at long intervals between the homograph and the target, but not at short ones, indicating that discourse (nonlexical) effects take more time to develop than do associative priming effects.

This time-course pattern found by Till et al. for inference targets appears to be quite different from that found by Paul, Kellas, Martin, and Clark (1992),

whose subjects showed immediate activation even for low-salient targets related to one meaning of the homograph (e.g., *spill* following *The boy dropped the plant*), which, like the Till et al. stimuli, appear to be targets that would be inferred from the context rather than associated to the homograph. The discrepancy may be due to differences in the instructions to subjects in the respective norming procedures. Whereas the targets used by Paul et al. were words generated by subjects with the instructions to list features of the homograph as it is conceived in that sentence, those of Till et al. were words generated in response to instructions to read the sentence containing the honograph and write down a word that represented what they thought the sentence was about. These procedures clearly ask for different kinds of information. The instructions given by Paul, Kellas, Martin, and Clark (1992) were designed to tap a lexical representation of the homograph, albeit a lexical representation influenced by context. The inference targets used by Till et al., on the other hand, seem to come from something like a script level of comprehension. The fact that Paul, Kellas, Martin, and Clark (1992) showed priming for these targets earlier in the time course than did Till et al. may indicate that the Paul et al. targets were closer to the representation of the homograph itself in that context than were the targets used by Till et al.

This discrepancy in the research of Tabossi and Paul, Kellas, Martin, and Clark (1992) on the one hand, and Till et al. on the other, suggests that our approach to context must be undertaken very thoughtfully. It appears not to be enough to claim that a sentence context "biases one meaning" of an ambiguity. This kind of claim would imply that there are two possible outcomes of encountering an ambiguous word in context: Context makes available the information related to one meaning or to another. As indicated in the above example, however, it is hard to see how *spill* is related to any "meaning" of *plant*. The tendency in the past has been to consider the meanings of an ambiguous word as consisting of discrete sets of features, each set representing one of the meanings. The role of context is one of selecting among these feature sets. The results obtained by Paul, Kellas, Martin, and Clark (1992) challenge this view and suggest instead that the homograph and its context combine to activate a unique constellation of features that will overlap to varying degrees with features represented by the target.

Our difficulty in seeing this problem is due to our preoccupation (pointed out by Gerrig, 1986) with the PROCESS of comprehension, to the exclusion of an appreciation for the PRODUCTS of comprehension. Our focus on the processes involved in lexical access is understandable: They are central to the modularity/interaction issue. Nevertheless, as Gerrig points out, any theory of processes must take into account the product of comprehension, as our conclusions about the nature of comprehension processes will be different under different conceptions about the nature of the information stored in the lexicon, and which of this information is made available upon the access of a word on a particular occasion. To take another example from Paul, Kellas, Martin, and Clark (1992) in order to appreciate that *business* is primed following *The woman bought the company,* all we need assume is that a spreading activation process has operated between the representations of *company* and *business*. We must conclude that very different kinds of processes are occurring, however, once we know that this sentence will prime *rich* as well. It also is not very helpful to claim that *rich* is facilitated by processes occurring after lexical access for *company* unless

we know what information was made available on that access (i.e., what information is being acted on by the putative post-access processes).

Equally important, we may often not be certain that different experiments emphasize a common level of comprehension. This may in fact be an additional factor that underlies the discrepancy between Paul, Kellas, Martin, and Clark (1992) and Till et al. The sentence pairs in the latter study were much longer and more complex than the very simple sentences in Paul, Kellas, Martin, and Clark (1992). Till et al., therefore, may have been more likely to tap a script level of comprehension, which led to slower activation of a lexical target. The sentences used by Paul, Kellas, Martin, and Clark (1992), on the other hand, would have had less of a tendency to call on such higher level comprehension processes, making them more appropriate as contexts for a task performed on single lexical targets.

In fact, an unpublished study by Killion (1979) has demonstrated directly the effects that differences in sentence processing task can have on context effects in ambiguous word recognition. In a series of five experiments, Killion found selective access when subjects performed a sentence verification task on the context (deciding whether the sentence made sense according to their real-world knowledge) before responding to the target, and when they were instructed to "read and understand" the sentence. Roughly equal facilitation for each meaning was found under instructions simply to read the sentence. Finally, when the subjects were instructed to use the sentences as a prime (i.e., when they were told explicitly that the targets were often related to the sentences and that they should use the sentence to speed their word recognition response), or when they had to recall some of the sentences, both meanings were activated, but the facilitation for the contextually appropriate meaning was significantly greater than that for the inappropriate. Because all these experiments used the same materials, the differences must be attributed instead to differential processing of the context as a function of the sentence task. This set of experiments shows very plainly the critical relationship between the kinds of operations carried out during sentence processing and the output of lexical access. In this case, the scope of information activated during sentence comprehension is influenced by the processing task that is performed on the context, which, in turn, affects performance on the word recognition task.

The foregoing discussion is not meant to imply that heeding Gerrig's advice to consider the products of comprehension will suggest an ambiguity experiment that will resolve, once and for all, the modularity/interaction problem. It is still the case that a large number of well-designed and executed experiments have yielded discrepant results for reasons that have proven impossible to pinpoint. The point being made here is simply that we should not fail to consider the kinds of information that might be available as a result of processing a sentence. As Gerrig points out, only by such consideration will we be able to argue coherently about the comprehension processes that act on that information.

IV. CONCLUSIONS

The purpose of this chapter has been to discuss the progress that has been made in research in lexical ambiguity in the last decade. I have attempted to discuss progress on the theoretical front as well as to review the methodological

issues that have plagued this area since its beginnings. Principal among these is the problem of identifying the earliest activation processes and their sensitivity to context. It appears that this concern has led to seemingly endless methodological refinements, but unfortunately the problem remains stubborn. It is not clear that any experiment will be able to resolve the issue unequivocally. Indeed, it is not clear that such resolution is necessary or even desirable. The range of results obtained in ambiguity studies suggests clearly that the extreme views of the lexicon as either fully autonomous or promiscuously interactive are not tenable. The fact that a number of studies have found strong evidence of multiple access, while another group has provided equally compelling evidence supporting a role of context, should suggest to us that the truth must almost surely lie somewhere in between and must be highly dependent on characteristics of the context and on characteristics of the tasks required of the subject.

In the earlier review (Simpson, 1984), it was argued that nearly all the priming studies showed a common pattern: Arguments of statistical reliability aside, virtually every study showed fastest responding to contextually appropriate targets, slower responding to inappropriate targets, and slowest responses to unrelated targets. In other words, there is consistent evidence that both meanings are facilitated relative to an unrelated control, but equally consistent evidence that the appropriate meaning is facilitated to a greater degree. Because all the meanings of an ambiguity map on to a common orthographic form, activation should accrue for all of them any time that form is encountered. However, it now seems clear also that we can hardly deny some role of context in constraining the degree of activation for a meaning. What is required is that we expand our overly narrow definition of context, which has traditionally encompassed only the meaning conveyed within a single sentence. We must realize that different sentence types (e.g., single proposition vs. script-inducing), different tasks, and even different procedures for constructing stimuli make important contributions to the context within which our subjects perform, and these may have profound effects on subjects' performance, and, by extension, our theories. Only by taking a broader view of context will we be able to direct our efforts more productively to understanding the nature of lexical ambiguity and its relation to other aspects of language comprehension, rather than focusing on it exclusively as a means to settle a single theoretical debate.

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