

CONTEXT EFFECTS IN WORD IDENTIFICATION

Walter Kintsch & Ernest F. Mross

University of Colorado, Boulder

March 6, 1984

Send Proofs To: W. Kintsch

Department of Psychology

University of Colorado

Boulder, CO 80309

Technical Report No. 131

Institute of Cognitive Science  
University of Colorado  
Boulder, Colorado 80309

## Abstract

Word identification comprises both sense activation and sense selection. It is hypothesized that sense activation is affected by associative relationships among words, but not by the thematic context of a discourse. Experiment I confirms this prediction using a cross-modal lexical decision task. Subjects listened to a discourse containing a target word and made a word/non-word decision to a visually presented test string. If the target word was a homograph, test words that were associates of the homograph were primed irrespective of the thematic context. On the other hand, thematically appropriate test words that were not associatively related to the target word were not primed. This result was confirmed in a second experiment where the text was presented visually at a very rapid rate. In contrast, when subjects were given enough time to process each word (Experiment 3), only thematically appropriate associates were primed. No priming effects at all were obtained in a final experiment using a rapid presentation rate where the test word was separated from the target word by two other, interfering words. It is concluded that sense activation functions as a module independent of thematic context.

Does context affect word identification? If one asks this question in this undifferentiated way, the answer is obviously 'yes', and the question appears silly. However, we shall argue that this, if it is properly elaborated, is a very interesting and important question, and that we don't know the full answer yet.

First of all, the process by which people assign meanings to words is not monolithic. Various subprocesses must be distinguished, which may be sensitive to quite different variables. We make the following assumptions. Words are represented lexically by one or more word senses. The first subprocess of word identification consists of the activation of these word senses (Swinney, 1979). Next, the contextually appropriate meaning will be selected from the activated word senses. Usually, this sense selection process provides no more than a sketchy schema to be enriched through contextual elaboration (van Dijk & Kintsch, 1983). Not infrequently, indeed, the lexicon provides so little help that the process is one of sense creation, rather than the activation-selection-elaboration sequence described here (Clark & Gerrig, 1983). In the present report, we shall focus on the initial process of sense activation. Thus, we can formulate our question somewhat more precisely: does context affect sense activation?

'Context', however, is not a monolithic concept either. On the one hand, there are some relatively stable properties of context: certain words are associated with certain other words, some words are used more frequently in the language than others. On the other hand, there are some highly variable elements, such as the thematic content of the text in which the to-be-identified word happens to occur. Certainly, the former aspects are historically dependent on the latter (words are associated because they have occurred together frequently in the past). Nevertheless, it is not at all clear that stable and variable context properties have identical effects on the word identification

processes considered here. Thus, the final form of our question may be formulated as: how do associative and thematic contexts affect sense activation?

This is an interesting and important question because certain general notions about the nature of cognitive processes indicate that these two kinds of contexts may have different effects on sense activation. At issue is the question whether the cognitive system is a single, fully interactive system, in which at least potentially everything may influence everything else, or whether certain autonomous components exist which function, and can be studied, independently of the rest of the system. Simon (1969) has introduced the notion of partially decomposable systems, which may have autonomous components which interact with the other components of the system only at the level of outputs. Fodor (1983) has put forth the hypothesis that some cognitive processes function as modules, independently of whatever else is going on in the system. Sense activation may be such a module. If so, sense activation in word recognition may be uninfluenced by certain types of context, specifically the variable thematic context in which the word is being used. On the other hand one might very well expect that the sense activation module would be sensitive to such relatively stable features of context as word associations and word frequency. Thus, we would expect that if a homograph such as IRON is encountered in a text both of its meanings would be activated initially, irrespective of the thematic context in which this word is being used (which, of course, will determine which sense will be selected for further processing). We already know that this is the case (for evidence and/or good arguments see Forster, 1976; Onifer & Swinney, 1981; Seidenberg, Tanenhaus, Leiman, & Bienkowski, 1982; Swinney, 1979; Tanenhaus, Leiman, & Seidenberg, 1979.) (1)

Conversely, we expect that whether or not a particular word fits into a thematic context has no effect on sense activation, if associative effects are

controlled. Thus, even though one may expect IRON in the context of a particular discourse, its senses are activated no faster than when it appears in a thematically less constrained context (though sense selection will, of course, be much easier in the former case than in the latter). To test this prediction is the main goal of the series of experiments reported here.

The method which will be used here is a lexical decision task, either concurrent with a listening task or embedded in a reading task. It is, of course, not the case that lexical decision always reflects the process of sense activation in word identification, which is what we are interested in here. In sentence completion tasks (e.g. "THE NURSE ASKED THE -----" with DOCTOR as the test item for which a lexical decision is required) the time to decide that the test item is a word certainly will reflect both the speed of sense activation and sense selection (West & Stanovich, 1982). Although the latter is not logically required to make a word/non-word decision, it is apparently impossible to suppress it in tasks like this. However, there are other versions of lexical decision tasks, which may provide more nearly pure measures of sense activation by itself. In Swinney's (1979) cross-modal task, the subject hears a word as part of a larger discourse (e.g. IRON) and concurrently makes a lexical decision response to a visually presented test word (e.g. STEEL). There is thus a clear separation between the primary comprehension task and the secondary decision task. As Swinney's data indicate, the response times on the decision task reflect sense activation only (that is, as long as both senses of IRON are activated, response times to STEEL and CLOTHES are equal and faster than response times to control words). Below we shall describe a visual analogue of this cross-modal lexical decision task: the main text as well as the test word are both presented visually, but the latter interrupts the text presentation and is clearly marked as a separate task. In neither case is the test word ever an appropriate replacement for any of the words in the primary listening or reading

task, hence subjects appear able to judge simply whether the test item is a word or not, rather than whether it fits into the text.

In the experiments reported below the question of interest is whether certain words (the priming words or primes) in a discourse that is being either listened to or read prime certain test words in a lexical decision task. The main experimental hypothesis is that priming words will prime test words in the lexical decision task if the activated word sense (or senses) of the priming word are associatively related to the test word, but not if the relationship between priming word and test word is only a thematic one. Table 1 provides illustrations for these two cases. In the first part of the table, the priming word IRON is used in the sense of "mineral", not "utensil"; nevertheless we predict that it will facilitate lexical decision responses to both CLOTHES and STEEL, if they are made immediately after IRON is presented. In the bottom half of the table, the text is constructed in such a way that when the priming word PLANE is perceived, the comprehender expects the action to proceed to the GATE; thus GATE, at this point, would be highly appropriate thematically, but since it is not related associatively to PLANE, no facilitation in the lexical decision task is expected; i.e. we hypothesize that the thematic context alone does not prime the sense activation of GATE.

A qualification was made in the predictions above, namely, that the test word must follow the priming word immediately. If the reader is given enough time to study the priming word (Experiment 3), the context-appropriate sense of IRON will be selected, and hence priming will be obtained only for STEEL, but no longer for CLOTHES. If time is allowed to lapse between the reading of the priming word and the presentation of the test word, the reading of intervening words generates interference and no associative priming will be obtained at all (Experiment 4).

Experiment 1: Cross-modal lexical decision.

The first part of the experiment consisted of a replication of Swinney (1979) with materials in which the relation between the priming and test words was strictly controlled: the priming words were homographs and the test words were always strong, symmetric associations of the priming words. Presumably, most of Swinney's test words were associatively related to the primes, too, but this factor was not explicitly controlled in his experiment. In the second part of the experiment, the test words were thematically appropriate words that were not associates of the primes.

#### Method

**Subjects.** Eighty seven students from the University of Colorado participated as subjects as part of a course requirement. The data from 15 subjects were lost because of equipment failures, and those from two subjects were discarded because their error rates were more than three standard errors above their group mean. The subjects were randomly assigned to three groups of equal size.

**Design and Materials.** The three groups of subjects differed in the type of test word they received, as described below. A within-group factor was text type (Homograph and Scriptal), with 12 texts nested under each type.

Twenty-four short (approximately 70-100 words) paragraphs were constructed. The first 12 of these will be referred to as the homograph texts. Each of them was constructed around an ambiguous noun which was used as the priming word to prime a lexical decision test item. These nouns were selected from the association norms for homographs of Cramer (1970). The homographs (which were always homophones also) were chosen such that among their top associates there was a pair of approximately equally strong associations to both senses of the word. For example IRON was selected because its two strongest associates are STEEL (13%) and CLOTHES (12%). The paragraphs were written in such a manner

that only one meaning of the ambiguous word was appropriate for each paragraph. For half of the paragraphs the word sense related to the stronger associate was appropriate, and for half the word sense related to the weaker associate was used. Table 1 provides an illustration. Each paragraph was also assigned a control word. Word length and word frequency were controlled in the sense that the average word frequency and the average number of syllables for the three sets of words (appropriate associates, inappropriate associates, and control words) were approximately the same.

The other 12 texts were constructed from the script norms of Galambos (1982). For each of several common activities, 12 component activities were identified and rated on a number of dimensions, such as centrality. Of these, six adjacent activities were selected as a skeleton around which brief story-like paragraphs were written. For instance, the scriptal paragraph in Table 1 is based on the "Catching a plane" script, from which we have selected the following activities (the number after each component is its centrality rating): 1.Go to airport (9.1), 2.Buy ticket (8.2), 3.Find airline (8.2), 4.Check bags (3.5), 5.Go to gate (8.7), 6.Get boarding call (6.3). Item 5, Go to gate, is not mentioned in the paragraph and left as an inference item: according to the norms, readers who have just read a text based on items 1-4, are now expecting step 5. Hence GATE, at this point in the text is highly appropriate thematically. When the word PLANE appears in the text, GATE is presented for a lexical decision: GATE is not a common associate of PLANE, but it is thematically related to the text. The main question of interest here is whether priming effects will be obtained for thematic test words, like GATE. Two other test words were used with each paragraph in the lexical decision task: one was an unrelated control word, and one was a strong associate of the priming word (in the present example, FLY). These words were selected in such a way that the average word frequency and average number of syllables were



approximately equal for the thematically related, unassociated words, for the associated words, and for the control words. As a consequence of all of these restrictions, it was not possible to select strong associates in such a way that they all were clearly thematic or non-thematic. The priming word was always the script header, e.g. PLANE in Table 1.

-----

Insert Table 1 here

-----

Since most of the priming words in the paragraphs used here could not be found in standard association norms, a separate group of 50 subjects were given an association task with a large set of words, including the primes, as stimuli. These subjects were asked to write down the first word that came to their mind in response to each stimulus item which was read aloud by the experimenter. In order for a stimulus word to qualify as a test word, it was necessary that none of the subjects used it as a response on the association test. This is not a very strict criterion, and it is likely that with a larger subject population some evidence for an association might have been obtained. Thus, it might be better to talk about weakly associated words than about unassociated words. It is probably not possible to find a large enough set of words that are both strongly related thematically but not at all associatively to the priming items. However, there is certainly a clear difference in associative strengths between the thematic items and the associative items: the former never occurred as responses in the present subject pool, while the latter were either the most or second-most frequent response.

While subjects listened to each text, they performed three lexical decisions. The one that is of experimental interest has been described above. The other two trials were distractor trials, designed to mask the real purpose of the experiment. On some of these trials common words unrelated to the text

were presented, while on other trials pronounceable nonwords taken from Taft (1982) were shown. The number of non-words equalled the number of words (primes plus distractors) overall. Distractor trials were placed so that they never appeared within 15 words or the same sentence as the critical test item. Also, subjects were not tested with more than two real words per text. The lexical decision task was always separated from the text comprehension task: in no case did the test word form a syntactically and semantically well formed continuation of the sentence being comprehended.

Each subject listened to all 24 texts which were presented in random order. The priming condition, however, was varied between subjects. Thus, subjects in Group I received as test words in the lexical decision task appropriate associations for the homograph texts and thematic words for the scriptal texts; Group II subjects received inappropriate associations for the homograph texts and associates of mixed thematicity for the scriptal texts; Group III subjects received only control words.

The 24 experimental texts were recorded onto one channel of two different tapes, with a new random ordering for each tape. On the other channel of each tape inaudible tones (17000hz) were placed at those points where a lexical decision trial was to be initiated.

Procedure. The subjects wore headphones and were seated in front of a CRT with a button box. They were instructed to listen to the stories that were going to be presented over the headphones, and be prepared to answer questions about them later. At the same time as they were listening, they were also asked to perform a second task as fast as they could and without errors: every now and then a letter string would appear in the center of the CRT screen before them, and their task was to determine whether the letters formed an English word or not by pressing either the "yes" or "no" button before them. Index fingers were to be kept on these buttons all the time.

Subjects then listened to four warm-up texts, during each of which three lexical decision trials were presented. Next this procedure was repeated with 12 of the experimental paragraphs. After the 12 paragraphs were presented, a relatively difficult comprehension question was asked about each paragraph. Finally, the remaining 12 texts were shown, followed by further comprehension questions.

### Results and Discussion

All latencies above 2000 msec were truncated at that value (0.1% of cases), and latencies more than 3 standard deviations above the mean were treated as errors. The over-all error rate was 2.7%. A significance level of .05 will be used.

-----

Insert Table 2 here

-----

Homograph Texts. The results for the homograph texts are shown in Table 2. A priming effect of 81 msec was obtained for contextually appropriate associations and 84 msec for contextually inappropriate associations. These results were statistically reliable,  $F(2,67)=4.04$  in an analysis by subjects and  $F(2,33)=10.01$  in an analysis by texts.

Scriptal texts. The results for the scriptal texts are also shown in Table 2. The lexical decision times were significantly different statistically for the three types of test items,  $F(2,67)=6.00$  in the analysis by subjects and  $F(2,33)=4.74$  in the analysis by texts. A strong priming effect (119 msec) was obtained for the associated items, as well as marginally significant effect for the thematically appropriate, unassociated items ( $F(1,67)=3.91, p=.052$  for the comparison with the control group).

Since the same subjects who received the associated/thematic testwords in

the homograph passages were given the non-associated/thematic testwords in the scriptal texts, a within-subjects test of the role of associative relationships is also possible: subjects responded significantly faster to associated test words (810 msec) than to non-associated testwords (863 msec) when all test words were thematically appropriate,  $t(22)=4.54$ .

Thus, the homograph data clearly replicate Swinney (1979) in that a significant priming effect was observed for both thematically appropriate and inappropriate associations in the case when (1) the test word was presented visually immediately after subjects listened to the priming word, and (2) the relationship between the test words and the primes was always an associative one, the strengths of contextually appropriate and inappropriate associations being about equal. As far as the thematic test words which were not associatively related to the priming word are concerned, the present results are less clearcut. The smaller, marginally significant priming effect observed here may be interpreted as evidence that such items are primed, but less strongly than associatively related items. Or, which would be more consistent with our experimental hypothesis, whatever priming was observed for such items may reflect some residual associative links between the priming and test items that were too weak to be picked up in the normative data we have collected. Clearly, associations do matter in lexical decision tasks; whether thematic context alone matters, over and above the associative effects, is at least doubtful.

#### Experiment 2: All-visual presentation

The materials as well as the experimental design were the same in this experiment as in Experiment 1, but the way in which the materials were presented has been changed. Instead of listening to the texts and performing the lexical decision task concurrently, subjects read the text, and the lexical decision trials interrupted their reading. The text was presented visually, one word at a time on a screen before the subject; at predetermined points the text was

stopped and replaced by a test string clearly marked with asterisks, to which the subject made a word/non-word response. Thereupon the presentation of the text resumed.

### Method

**Subjects.** Ninety students from the subject pool of the psychology department served as subjects, 30 each in Group I (contextually appropriate associations for the homograph texts, appropriate unassociated words for the scriptal texts), Group II (contextually inappropriate associations for the homograph texts and associated words of mixed contextual appropriateness for the scriptal texts), and in Group III (control words for all texts, i.e. unassociated as well as contextually unrelated). Six subjects were lost due to various causes.

**Materials and Design.** These were identical to Experiment 1.

**Procedure.** All texts were presented by the rapid serial visual procedure (RSVP) in the center of a CRT screen. That is, the words followed each other on the same central screen location, each word being presented for 150 msec with about 40 msec between words. Judging from the subjects' reports as well as their ability to answer the comprehension questions, this presentation rate was sufficient for comprehension of the text. At the same points as in Experiment 1, lexical decision trials were given. These trials interrupted the reading of the text: the target string appeared in the same location as previous words, but was flanked by four asterisks (e.g., \*\*\*\* fly \*\*\*\*). It remained on the screen until the subject made a yes/no response as in Experiment 1. At that point, the text presentation resumed. A comprehension question about each paragraph was asked right after reading each paragraph.

### Results and Discussion

The data were treated as in Experiment 1. The over-all error rate was 2.8%; 0.3% of the reaction times exceeded the 2000 msec cutoff.

**Homograph Texts.** The mean reaction time to the test words embedded in the homograph texts are shown in Table 2. Significant priming effects were obtained both for contextually appropriate (86 msec) and contextually inappropriate (106 msec) associates,  $F(2,85)=3.86$  by subjects and  $F(2,33)=6.15$  by texts.

**Scriptal Texts.** As Table 2 also shows, responses to associated words were significantly faster in the scriptal texts also (91 msec),  $F(2,72)=3.80$  in the analysis by subjects and  $F(2,33)=4.75$  in the analysis by texts. However, test words that were thematically but not associatively related to the targets took about as long as unrelated control words.

A within-group comparison of the associated/thematic test words in the homograph texts with the unassociated/thematic test words in the scriptal texts revealed that subjects responded significantly faster to the associated test words,  $t(23)=3.18$ , (861 vs 913 msec, respectively).

Thus, as far as the homograph texts are concerned, the present results replicate both Swinney (1979) and the present Experiment 1: As long as test words are associatively related to the priming word, their thematic appropriateness does not matter in the initial process of sense activation. There are two important qualifications to this statement. The first concerns the time relationships between the test word and the priming word. The test word must follow the prime directly, before sense selection processes become effective: In the cross-modal presentation, the test word appears at the end of the spoken priming word, while with the all-visual RSVP presentation the interval between the onset of the priming word and onset of the test word was only a little more than 150 msec (the time required to change screens in our system is around 40 msec). Thus, in either case what produces the priming effect is the activated lexical trace of the priming word, before the thematic context

has had a chance to settle upon a particular sense of the homograph priming words. Secondly, it is presumably important that the lexical decision task and the comprehension task are clearly separated (in one case the two are in different modalities, in the other the test strings for the lexical decision task are clearly differentiated visually from the to-be-comprehended text).

The main experimental hypothesis concerned the thematically appropriate, unassociated test words in the scriptal condition: no priming effect was expected for these words. While this hypothesis was only weakly supported in Experiment 1 (a non-significant priming effect was found, which was reliably smaller than that for associated test words), the present results unambiguously support it. There was no indication that unassociated, thematically appropriate words were identified more rapidly than control words, and such words were responded to significantly more slowly than associatively related test words.

On the whole then, the results of these two experiments suggest that thematic context, unlike associative context, is indeed irrelevant to the sense activation phase of word identification. With Experiment 3 we turn to an experimental design that allows us to investigate priming effects at a later stage in the process, when sense selection has already taken place.

#### Experiment 3: Self-paced presentation.

Swinney (1979) reports that when the test string is sufficiently delayed, only the thematically appropriate meaning of a homograph produces a priming effect in a cross-modal lexical decision task. Presumably, at this point the inappropriate meaning is no longer activated, and therefore is no longer capable of priming its associates. In Experiment 3 a self-paced presentation is used: as before, the words of the text appear one-by-one at a central location of the screen, but words are changed only when the reader signals his or her readiness to the computer by pressing a special button. People read relatively slowly in this way (informal impressions suggest a rate of about two or three words per

second). It appears that they do not go on to the next word until they are fairly clear about the present one. That is, they at least initiate sense selection processes before calling for the next word. Hence, the homograph texts used in the present experiment should produce results comparable to Swinney's delay condition: thematically inappropriate associates should no longer be primed. On the other hand, the predictions for the scriptal texts are not so unambiguous: if readers take enough time to think about each word, the lexical decision task may very well become sensitive to thematic top-down effects, because the over-all slowdown may bring into play sense selection effects. In other words, with the more leisurely self-paced procedure the task may become more similar to a sentence completion experiment, where priming effects are determined not only by what word senses are activated, but also by what sense is appropriate.

#### Method

**Subjects.** Ninety undergraduate students from the University of Colorado participated in this experiment in partial fulfillment of a course requirement. Thirty subjects were randomly assigned to each of the three experimental conditions, as in the previous two experiments.

**Materials, Design and Procedure.** The same materials were used as in the previous experiments. The experimental design remained unchanged, too, and only the procedure was modified from that used in Experiment 2. Successive words of the to-be-comprehended text did not appear on the screen automatically, but only when the subject pressed a button marked "Advance".(2)

#### Results and Discussion

Six subjects were lost because their error rates exceeded 10%. The mean error rate for the remaining subjects was 3.4 % (once again, latencies three standard deviations above the mean were counted as errors; 2.7% of the



latencies were truncated at 2000 msec.

-----  
Insert Table 3 here  
-----

Homograph Texts. Test words that were thematic associates of the priming words were responded to 147 msec faster than unrelated control words, while the average reaction time for thematically inappropriate associates was virtually the same as that for control words. The data are shown in Table 3. The differences between the means of the three types of test words in the homograph texts were significant statistically,  $F(2,81)=4.38$  in the analysis by subjects and  $F(2,33)=8.37$  in the analysis by texts.

Scriptal texts. In contrast, the response times for the three types of test words did not differ significantly in an over-all analysis of variance,  $F(2,81)=1.75$  by subjects and  $F(2,33)=1.54$  by text. The fact that associates were not primed here is understandable in the light of the homograph results: since some of the associates in this condition were thematically appropriate, while others were not, the data reflect a mixture of the thematically-appropriate and thematically-inappropriate associates in the homograph texts. Hence, a small, non-significant priming effect is exactly what one would expect for this condition.

Thematic test words which were unassociated to the target word were responded to faster than control words, but the effect is not statistically reliable, even with an orthogonal comparison,  $F(1,81)=3.43$ ,  $p=.068$ , due to the high variability of the response times with the self-pacing procedure.

A within-group test, comparing performance for thematically appropriate test words when they are associatively related to the target words ( Homograph texts) and when they are not (Scriptal texts), shows that the response times to the former are significantly faster,  $t(26)=4.11$ .

The results for the scriptal texts replicate those obtained in the previous two experiments as far as the unassociated thematic test words are concerned: we now have observed twice a small, non-significant priming effect for these items (in Experiments 1 and 3), and once no priming effect at all (in Experiment 2), and in all three experiments performance was significantly better when thematic test words were associatively related to the prime than when they were not. The results for the homograph texts, on the other hand, were quite different from those of Experiments 1 and 2, and replicate the delay condition of Swinney (1979), reflecting in both cases the influence of the sense selection process in word identification. In a final experiment, we provide a visual analogue of the delay condition of Swinney (1979): the test words do not follow the priming word immediately, but are shown only after the next two words in the text have been presented.

#### Experiment 4: Delayed visual presentation of test words

The general format is the same here as in Experiment 2, with one crucial exception: the words of the to-be-comprehended text are presented with the RSVP procedure at a rate of one every 150 msec (plus 40 msec between words), and the test words requiring a lexical decision response interrupt this flow of words - except that the test words do not appear immediately after the priming words, but after a lag of two intervening words. Thus, the interval between the onset of the priming word and the onset of the test word is about 570 msec long (three words presented for 150 msec each, plus the time to change screens). Presumably, this is long enough for sense selection to occur; on the other hand, the delay interval is filled with two interfering words, which may also affect the amount of priming that will be obtained.

#### Method

**Subjects.** Eighty students from the same pool as in the previous

experiments served as subjects.

**Materials, Design, and Procedure.** The experiment was identical to Experiment 2, except that test words were shown at a different place in the text: Instead of following the priming word immediately, the normal RSVP procedure was continued for two more words before the test word, marked with asterisks, interrupted the presentation of the text. The two intervening words were always unrelated associatively to either the test or priming word. Some of the paragraphs had to be slightly rewritten to assure that no sentence or major phrase boundary occurred between the priming word and the presentation of the test word.

### Results and Discussion

**Homograph Texts.** The mean reaction times for thematically appropriate and inappropriate associated test words as well as for control words are shown in Table 3. These means do not differ from each other reliably,  $F(2,77)=.21$  by subjects, and  $F(2,33)=.47$  by texts.

**Scriptal Texts.** Similar results were obtained for the scriptal paragraphs, also shown in Table 3: none of the differences between the three means are reliable statistically,  $F(2,68)=1.45$  in the analysis by subjects and  $F(2,33)=1.54$  in the analysis by texts. Even if one tests the numerically largest difference (unassociated/thematic versus control) separately, it falls short of conventional significance levels ( $F(1,68)=2.52$ ,  $p=.12$ ).

It appears, therefore, that no priming effects at all were obtained in Experiment 4. Unlike the results obtained by Swinney with a cross-modal presentation, even a relatively brief lag between prime and test word cancels all priming effects with the all-visual RSVP procedure. These results are not really surprising in view of the literature. First, there is the parallel

finding in sensory memory experiments, where auditory information is retained much longer than visual information, which is totally lost within about 500 msec in the presence of a visual mask (Sperling, 1963, versus Glucksberg & Cowan, 1970). There is also some direct evidence that if a prime word is presented only briefly and followed by a 50 msec visual mask, no associative priming effect is obtained (Fischler & Goodman, 1978).

### General Discussion

The main purpose of this series of studies was to determine whether the thematic context of a text that is being read affects the sense activation stage of word identification differently than do more fixed aspects of context, such as the stable lexical relations among words that are reflected in the pattern of inter-word associations. The data reported here suggest that the answer to this question is positive. First of all, we find associative priming independent of thematic context: the homograph results of Experiment 1 and 2 show this quite clearly, confirming the findings reported by other investigators, most directly by Swinney (1979). Our second major finding is the converse of this context-free associative priming: words embedded in a text do not prime the identification of other words, unless they are associatively related; mere thematic appropriateness is not enough. What readers say they expect at a certain place in a text has no effect on sense activation, or in other words, there are no top-down effects of thematic context in discourse comprehension on the sense activation phase of word identification.

The evidential support that the data provide for these two claims is stronger for the first than for the second. While the first conclusion is clearly established, there is some ambiguity concerning the second conclusion. However, we believe it, too, is justified, even though the data are not entirely clearcut regarding the presence or absence of thematic priming effects: in two

experiments (Experiments 1 and 3) marginally significant thematic priming effects of 70 and 98 msec were obtained, while a numerical priming effects of 84 msec was observed in Experiment 4, which yielded no statistically significant results; only Experiment 2 provided unambiguous support for our conclusion. Thus, it might appear that our failure to find statistically significant thematic priming effects is more a question of statistical power than of the non-existence of such effects. We argue, nevertheless, that our conclusion is a reasonable one. First of all, our experiments do not lack statistical power, in that reliable and strong priming effects due to associative relations were always found (except in Experiment 4, employing an interference paradigm, which we can therefore discount). At the same time, thematic effects were minor or absent. The numerically largest thematic priming effect was obtained in Experiment 3; as was pointed out in the Introduction to that study, it would not have been surprising to see significant thematic priming under the conditions of that experiment, for much the same reasons as we did not expect (or obtain) associative priming for nonthematic test words. Thus, these results of Experiment 3 are irrelevant to the present argument. That leaves the marginally significant thematic priming effect in Experiment 1 as an embarrassment for our conclusion. Our preferred interpretation is that this effect probably reflects some residual associative relations between the primes and the test words that were too weak to be picked up in our norming study, rather than a genuine thematic effect that just did not reach acceptable levels of statistical significance because of lack of statistical power. In support of this interpretation we point out that in all three experiments that yielded statistically reliable results, significant associative effects were always present for thematically appropriate test words. Thus, there seems to be no reason to hedge on our main conclusion: Stable lexical properties of words matter in sense activation, such as the associative network in which these words

are embedded, but not the currently active theme of the text that is being processed.

Seidenberg, Tanenhaus, Leiman, & Bienkowski (1982) have obtained results with a naming task which further support this conclusion. Thus, converging results are now available for the functional independence of sense activation, based upon naming as well as lexical decision experiments.

These results support Fodor's claim (Fodor, 1983) that word identification may be an input module, which operates independently of context. Input modules, according to Fodor, are characterized by the following properties. They are mandatory - the reader can't help seeing a word as a word, and not just as a letter string. They provide for limited central access, usually one is conscious of the end result of a process only; thus, sense activation is usually unconscious, and only the thematically appropriate word sense that is eventually selected ever enters the reader's consciousness. Input modules are fast, since there is no need to make decisions; word identification in these experiments appears both fast and stupid - the price paid for speed. The most interesting property that Fodor assigns to input modules is that they are informationally encapsulated - they cannot take into account information from other sources that may be potentially relevant; this is of course the point where the present results provide confirming evidence for Fodor's arguments: the thematic context in discourse is unable to reach all the way down to affect the process of sense activation. Finally, Fodor claims that input modules provide only a shallow output, which must be filled in and elaborated by further processes. This is a very important point, that makes experimentation in this area so complicated. Selecting word senses works differently than activating word senses, and elaborating and/or creating word senses works differently yet. Experimental results can become hopelessly confusing if these rather subtle distinctions advocated here are not carefully observed.

What, indeed, about the many studies in the literature that indicate, or seem to indicate, various kinds of context effects in word identification? Some, it can be argued, are readily reinterpretable within the present framework. Often, the effects are clearly post-lexical, i.e. affecting sense selection rather than activation, or they are due to the fixed lexical environment of the words, which is presumably internal to the module. Thus, Mitchell (1982, pg.118) reports a study using scriptal texts not dissimilar to the ones used here. He interprets his results as showing global, top-down effects, over and above local word-based priming effects. However, a self-paced presentation procedure was used in this study, which makes these results parallel to the ones obtained in the present Experiment 3, and thus irrelevant to the question whether global context influences the sense activation component of word identification. Other results are more difficult to evaluate. Frequently, information that is relevant, even crucial from the present viewpoint, is not provided in these studies. For instance, Seidenberg et al. (1982) is one of very few studies that makes a distinction between associative and thematic relationships among words, which according to their and our results matters a great deal, but usually both are lumped under some term like 'semantic relatedness'. We cannot, therefore, discuss the many apparently conflicting results in the literature.

There are a number of other results in this paper which bear discussion, especially the comparison between the cross-modal and all-visual procedures. As Experiments 1 and 2 show, it is quite possible to duplicate the results of the cross-modal paradigm with an all-visual procedure. However, small procedural details matter a great deal: a rather rapid presentation rate had to be used, so that priming effects can be observed before they are influenced by post-lexical processes. If subjects were allowed to pace themselves, they read so slowly that this condition is violated, and a very different pattern of

results was obtained (Experiment 3). Furthermore, interference effects with the all-visual presentation mode are more pervasive and operate much more rapidly than with the cross-modal procedure (Experiment 4). In normal reading associated word pairs are usually separated in a text by several other words, more like the present Experiment 4 than Experiment 2. Hence, associative priming of word activation may not play an important role in this situation, according to Experiment 4, at least if the RSVP procedure is used. However, whatever the practical significance of these phenomena in reading may be, their theoretical significance is considerable. Together with the results of Seidenberg et al. (1982), they suggest that word senses are activated in a context-free manner, i.e., that we are dealing with a module in the sense of Fodor (1983).



## REFERENCES

- Blank, M.A. & Foss, D.J. (1978) Semantic facilitation and lexical access during sentence processing. Memory & Cognition, 6, 644-652.
- Clark, H.H. & Gerrig, R.J. (1983). Understanding old words with new meanings. Journal of Verbal Learning and Verbal Behavior, 22, 591-608.
- Cramer, P. A study of homographs. In L. Postman & G. Keppel (Eds.) Norms of word association. New York: Academic Press, 1970.
- van Dijk, T.A. & Kintsch, W. Strategies of Discourse Comprehension. New York: Academic Press, 1983.
- Fischler, I. & Goodman, G.O. (1978) Latency of associative activation in memory. Journal of Experimental Psychology: Human Perception and Performance, 4, 455-470.
- Fodor, J.A. (1983) The modularity of mind. Cambridge, Mass.: MIT Press.
- Forster, K. (1976) Accessing the mental lexicon. In R.J. Wales & E.C.T. Walker (Eds.), New approaches to language mechanisms. Amsterdam: North-Holland.
- Galambos, J.A. Normative studies of six characteristics of our knowledge of common activities. Cognitive Science Technical Report 14, Yale University, 1982.
- Glucksberg, S. & Cowan, G.N. (1970) Memory for nonattended auditory material. Cognitive Psychology, 1, 149-156.
- Marslen-Wilson, W.D. & Tyler, L.K. (1980) The temporal structure of spoken language understanding. Cognition, 1-71.
- Marslen-Wilson, W.D. & Welsh, A. (1978) Processing interaction and access during word recognition in continuous speech. Cognitive Psychology, 10, 29-63.
- Mitchell, D.C. (1982) The process of reading. New York: Wiley.
- Onifer, W. & Swinney, D.A. (1981) Accessing lexical ambiguities during sentence comprehension: Effects of frequency of meaning and contextual bias. Memory & Cognition, 9, 225-236.
- Seidenberg, M.S., Tanenhaus, M.K., Leiman, J.M., & Bienkowski, M. (1982) Automatic

- access of the meaning of ambiguous words in context: Some limitations of knowledge-based processing. Cognitive Psychology, 14, 489-537.
- Simon, H.A. (1969) The sciences of the artificial. Cambridge, Mass.: MIT Press.
- Simpson, G.B. (1981) Meaning, dominance, and semantic context in the processing of lexical ambiguity. Journal of Verbal Learning and Verbal Behavior, 20, 120-136.
- Sperling, G. (1963) A model for visual memory tasks. Human Factors, 5, 19-30.
- Swinney, D.A. (1979) Lexical access during sentence comprehension: (Re)consideration of context effects. Journal of Verbal Learning and Verbal Behavior, 18, 645-659.
- Taft, M. (1982) An alternative to grapheme-phoneme conversion rules? Memory & Cognition, 10, 465-474.
- Tanenhaus, M.K., Leiman, J.M., & Seidenberg, M.S. (1979) Evidence for multiple stages in the processing of ambiguous words in syntactic contexts. Journal of Verbal Learning and Verbal Behavior, 18, 427-440.
- West R.F. & Stanovich, K.E. Source of inhibition in experiments on the effect of sentence context on word recognition. Journal of Experimental Psychology: Learning, Memory and Cognition, 1982, 8, 385-399.

## FOOTNOTES

This research was supported by grant MH 15872-16 from the National Institute of Mental Health.

1) We shall, for the moment, disregard opposing evidence and arguments (Blank & Foss, 1978; Marslen-Wilson & Tyler, 1980; Marslen-Wilson & Welsh, 1978; Simpson, 1981).

2) This experiment was actually the first one performed in this sequence, before we were sufficiently aware of the importance of the exact timing relations in this kind of work. Hence, we unfortunately did not record the response times for pressing the "Advance" button. Later reconstruction suggests that these times ranged between 300-500 msec for content words.

3) Other lexical features also matter, such as word frequency. Note that in the present study only homographs with two approximately equally strong senses were used; if frequency differences exist, these also affect the pattern of priming effects (Simpson, 1981).

TABLE 1. Sample stimulus materials.

(A) An example of a HOMOGRAPH text. The target word is IRON; the test words are shown below the text. They were presented at the ### following the target word.

Visits to old houses are often a delight. Last summer, the whole family took a tour through an old Victorian mansion in Georgetown. The rooms had high ceilings and large windows, almost as in a chapel. Heavy mahogany furniture stood in most of the rooms, which were decorated with old, brownish oils and worn but still striking rugs. The children liked best the huge wood stove in the kitchen which was made out of iron ### and the bathtub which stood on lion's paws.

Test Words:

GROUP I:	GROUP II:	GROUP III:
ASSOCIATED/THEMATIC	ASSOCIATED/NON-THEMATIC	CONTROL
steel(13%)	clothes(12%)	menu

(B) An example of a SCRIPTAL text. The target word is PLANE; the test words are shown below the text. They were presented at the ### following the target word.

George was only vice-president of "Soap International", and he knew he would never get to be president unless he got to Boston on time. He took a cab to Kennedy airport and promised the driver a fat tip if he made it in half an hour. He found out that TWA had the next flight to

Boston and bought a ticket. He had no bags to check, so he hurried down to his plane ### right away. He waited impatiently until his boarding call finally came.

## Test Words:

GROUP I:	GROUP II:	GROUP III:
UNASSOCIATED/THEMATIC	ASSOCIATED/MIXED	CONTROL
gate	fly	stack

---

TABLE 2. Mean reaction times in msec for cross-modal (EXPERIMENT 1) and all-visual (EXPERIMENT 2) lexical decisions as a function of text type (Homograph and Scriptal) and the nature of the relationship between targets and test words. Significant priming effects are indicated in brackets next to each mean.

		CROSS-MODAL	ALL-VISUAL
HOMOGRAPHS	ASSOCIATED/THEMATIC	810(81)	861(86)
	ASSOCIATED/NON-THEMATIC	807(84)	841(106)
	UNASSOCIATED/NON-THEMATIC	891	947
SCRIPTAL	UNASSOCIATED/THEMATIC	863	913
	ASSOCIATED/MIXED	814(119)	827(91)
	UNASSOCIATED/NON-THEMATIC	933	918

---

TABLE 3. Mean reaction times in msec for self-paced (EXPERIMENT 3) and delayed (EXPERIMENT 4) lexical decisions as a function of text type (Homograph and Scriptal) and the nature of the relationship between targets and test words. Significant priming effects are indicated in brackets next to each mean.

		SELF-PACED	DELAYED
HOMOGRAPHS	ASSOCIATED/THEMATIC	945(147)	952
	ASSOCIATED/NON-THEMATIC	1093	919
	UNASSOCIATED/NON-THEMATIC	1092	942
SCRIPTAL	UNASSOCIATED/THEMATIC	1026	897
	ASSOCIATED/MIXED	1063	913
	UNASSOCIATED/NON-THEMATIC	1124	981

---