INTRODUCTION

Although it is beyond dispute that contextual information plays an important role in reading (and, for that matter, in speech perception), there is much debate about what processing stage or stages it can affect. The major question is whether or not context can influence word recognition. According to the autonomy view, context cannot affect word processing before the processes that lead to recognition of the word have finished. Instead, context is exploited later on, for instance, when the recognized word is to be integrated in the representation of the preceding text. In contrast, the interactive view claims that context does affect the processes leading up to recognition. It may do so by allowing a more cursory or less complete analysis of the information comprised in the stimulus word (e.g., Morton, 1969).

Originally, the main impetus for the type of research reported on here, word-context priming, was to help resolve this dispute. (Hereafter, word-context priming refers to a situation where the test words are preceded by a single word that serves as context.) Subsequently, in numerous word-context experiments a context effect on the recognition of visually presented words has been observed, but these experiments have also shown that the effects are largely due to processes that under more natural reading conditions are not effective (see Mitchell, 1982, for an extensive discussion). So, these data are not crucial with respect to the discussion on autonomous versus interactive word recognition. A second goal of word-context studies, obviously also of relevance to
an associative-priming effect due to automatic-spreading activation presupposes some network structure in memory in which the nodes for associatively related words are connected to each other. The activation that arises in one of the nodes in this network in response to the presentation of the corresponding word spreads along the paths in the network, activating the nodes that it encounters en route. If a word represented in one of these preactivated nodes is subsequently presented (and if accessing this particular node is indeed part and parcel of word processing in the particular task being used), this prior activation will influence its processing. Depending upon the task, responding is accelerated (e.g., in lexical decision and in word pronunciation) or slowed down (e.g., in a Stroop task). The network structure involved in the effect is generally regarded to be semantic memory (e.g., Collins & Loftus, 1975).

An important characteristic of this spreading-activation view of associative priming, acknowledged by Meyer and Schvaneveldt in their seminal 1971 article, is that it is thought to arise from the structure of memory: The effect is presumably due to the existence of a link between the nodes for associatively related words. The semantic content of the nodes connected by these links does not have to be accessed for the effect to occur.

The plausibility of a structural interpretation of the effect allows one to go further than to doubt that semantic analysis underlies the effect. It also becomes questionable whether the semantic level of representation is indeed the (only) place where the effect occurs. Collins and Loftus's (1975) often-cited memory model includes a second level of representation in addition to the semantic level. This level has been typically ignored in the associative-priming literature. They call it the lexical level, but for reasons that need not concern us here I refer to it as the word level. Whereas the nodes at the semantic level are organized according to semantic similarity, the nodes at the word level are organized according to orthographic and acoustic similarity. In word processing tasks, access of the semantic level proceeds via the word level.

It is plausible that, in addition to the connections between nodes for orthographically and acoustically similar words, the word level also contains links between nodes for associatively-related words (irrespective as to whether these words are orthographically or acoustically similar). Such links may have come about through past spatiotemporal contiguity of the corresponding words, for instance, through their verbal contiguity (in both inner thought and outer speech) during concept acquisition: Acquiring the concept CALF may not only result in the formation of a relationship (link) between the concepts CALF and COW, but because language undoubtedly is an important means via which concepts are learned, a link may also be formed between the words that refer to these concepts. In other words, at the semantic level of representation a connection may exist between the concepts COW and CALF, and additionally, at the word level a connection may exist between the words referring to these concepts. Assuming that links at all representational
levels give rise to an automatic spread of activation from a node activated by a word input, such a word level of representation could then be an additional locus of the associative-priming effect. A priming effect originating at this level would again be a structural effect, but now the structure concerned would be nonsemantic by nature. In tasks that do not necessitate semantic processing of the stimuli, the word level could under certain circumstances be the primary or even the only locus of the effect.

The present research addresses the question of where to localize the associative-priming effect in the mental lexicon. In spirit, it is very similar to studies by Fischler (1977) and Lupker (1984), but the approach is different. Fischler was the first to question the assumption that the underlying semantic relation in pairs of associatively related words is responsible for what was typically referred to as semantic priming, and to suggest that the accidental association between these words was responsible for the effect (Fischler, 1977). He approached this question by comparing, in a lexical decision experiment (wherein subjects categorize letter strings as words or nonwords), the priming effect for two sets of word pairs. One set was both associatively and semantically related (AS-pairs; the type of related word pairs exclusively used in the present study); the other set consisted of word pairs not occurring as word association but judged nevertheless to be semantically related to one another (S-pairs). Fischler observed a small difference between the size of the priming effects for AS-pairs and S-pairs (the latter effect being somewhat smaller), but the difference was not significant. Thus, he concluded that the same type of relationship (i.e., the semantic relationship) presumably underlies the effect on both types of material.

Lupker (1984) also compared performance on AS- and S-pairs (using a different type of S-pairs), in both lexical decision and in word pronunciation. In contrast to Fischler’s results he obtained a significantly larger priming effect for AS-pairs than for S-pairs in the lexical decision task. Furthermore, in word pronunciation he found a much smaller priming effect on AS-pairs than in lexical decision, and the effect on S-pairs lessened to 6 ms. Lupker (1984) argued that this residual effect on S-pairs in pronunciation may best be regarded as a null effect, and that the priming effect on AS-pairs in pronunciation is solely due to the associative links between primes and targets. He attributed the larger priming effects in lexical decision, rather than in pronunciation, to post-lexical processing.

The present study builds on those by Fischler and Lupker by focusing on the level(s) in the memory system where the priming effect originates. This study did not compare priming effects on both AS- and S-materials in lexical decision and/or naming, that is, in tasks that per se do not require access of the semantic level of representation (but see Balota, this volume, for ample indications that at some stage in lexical decision, semantic processing of at least some of the test words occurs). Rather, the general approach here was to compare the effect on (only) AS-test words in lexical decision with the effect on these same words in two tasks in which access of the semantic level is compulsory. One of the semantic tasks was animateness categorization, in which the referents of the test words were categorized as animate or inanimate. The second was size categorization, in which the test words were categorized according to the size of their referents. More specifically, subjects decided whether the test words referred to entities larger or smaller than an average-sized, nonportable TV set.

Although similar in that they both require the retrieval of semantic information, categorization on animateness and (the present) categorization on size appear to require quite different processing. For instance, size categorization may involve imagery, whereas this is less likely to be the case for animateness categorization. A more marked difference is that the size categorization task presumably generally requires an additional processing stage: Upon accessing the test word’s node in semantic memory, all information relevant for animateness categorization is available in this very node, whereas it is likely that only part of the relevant information, namely, the size of the test word’s referent, is available there in the case of size categorization. A second piece of information relevant for size categorization, the size of the standard of comparison, here the TV set, has to be accessed in the TV set’s semantic node, and subsequently a comparison has to be made between the size of the test word’s referent and the standard. Occasionally, the subject may skip this comparison stage when a test word’s semantic representation, in addition to information about the actual size of the referent, explicitly contains the information that it concerns a large (elephant; whale) or a small (needle; ant) entity. Upon accessing this information, the subject may directly use it to categorize the test word. However, such a strategy may cause errors. The examples given are all entities that are large or small relative to most other entities that surround us, including TV sets, and skipping the comparison stage would not lead to an error. But now consider hut and cottage. The semantic representations of these words are also likely to contain the information ‘small’, because this information is crucial in distinguishing them from house. Yet, huts and cottages are larger than TV sets, and the comparison stage would thus be necessary if a correct response is to be output. It is not clear for which concepts “large” or “small” is explicitly represented, but the fact that, unlike “animate” and “inanimate”, they are relative terms (a small building and a large spoon are not small or large in absolute sense) suggests that this is the exception rather than the rule. This, as well as the discussed risk of producing errors, suggests that on most trials the size comparison between a TV set and the target’s referent will indeed have to be made.

As a starting point, the working hypothesis is that if associative connections exist at both the word and the semantic representational levels, the associative-priming effect may be expected to be smaller in lexical decision than in semantic classification. This prediction is based on the notion that in the latter type of task the categorization process
would benefit from preactivation in nodes at both levels on relatively many trials. This prediction holds under either of two different states of affairs (of which the first is unlikely, given the evidence that at some stage in lexical decision semantic processing of the test words occurs; see also the earlier discussion): (a) The subjects may execute control over what levels of representation to access and adapt themselves to the task requirements. Thus, in lexical decision the subjects may decide to switch off the semantic level so that their lexical categorizations will only be affected by the activation spread from the prime's word node to the target's word node. (b) No such control over processing levels can be exerted. Instead, activation in the system takes its natural course, and a classificatory response is made as soon as the information critical for classification has been gathered. Concentrating on the lexical decision task again, if at that moment preactivation in the target's semantic node has had time to spread back to the target's word node, the priming effect, accumulating from two levels, will be relatively large. If not, it will be small, attributable to prior activation spreading from the prime's word node only. Note that the complete route of activation that is assumed here is as follows: Prime presentation results in activation of the prime's word node. From this node, activation spreads to the test word's word node as well as to the prime's semantic node. From the latter, it subsequently spreads, among others, to the semantic node of the test word. From there, activation spreads back to the test word's word node at the word level of representation, where, in case the classification has not been made yet, it will affect the response.

Unlike in lexical decision, in semantic classification the exploitation of semantic information and, hence, accessing the semantic node, is obligatory. This fact underlies the prediction that, if associative connections exist at both levels, the associative-priming effect should be larger in semantic classification than in lexical decision. In the case of (a) above, in lexical decision only spreading activation at the word level will cause priming. However, in semantic classification this effect is augmented by the priming that results from all trials where at the time of access, the test word's semantic node has already received preactivation from the prime's semantic node. Because semantic classification necessitates the retrieval of semantic information, response latency in this task may be expected to be longer than in lexical decision. This is why also in the case of (b) above, larger priming effects may be expected in semantic classification than in lexical decision: More often than in lexical decision, there will be sufficient time for activation from the prime's semantic node to spread to the test word's semantic node in time to affect responding. In sum, according to both schemes, more associative priming should occur in semantic classification than in lexical decision.

Note that in both accounts, I have ignored the possibility of a contribution to the priming effect of processes other than automatic spreading activation. I will make up for this later.

5. THE LOCUS OF THE ASSOCIATIVE-PRIMING EFFECT IN THE MENTAL LEXICON

METHOD

Materials

Lexical Decision versus Animateness Categorization

Five experiments were run in which associative-priming effects in lexical decision and animateness categorization were compared. In all these experiments, the set of critical stimuli consisted of the same 92 pairs of Dutch nouns, the first noun of each pair serving as prime, the second as target (the stimulus to which the subjects had to respond). In half of these stimuli, the target was either the primary (in 43 cases) or secondary (in 3 cases) response to the prime in a corpus of Dutch association norms (de Groot, 1980), in which the latter occurred as the stimulus word. The remaining half of the stimuli consisted of a pair of words not associatively related to one another. They were formed by dissociating and recombining primes and targets of the associated stimuli. Half of the targets of the related stimuli had an animate referent and half had an inanimate referent. Similarly, half of the targets of the unrelated stimuli had an animate referent and half had an inanimate referent. The overall associative strength of targets to primes in the condition with prime-related targets referring to animate entities was about the same as that in the condition with prime-related targets referring to inanimate entities (46.9% and 49.3%, respectively, with corresponding standard deviations of 16.4 and 14.4).

In selecting materials from the association norms it turned out that in the majority of stimulus/primary response combinations the two words either both referred to animate beings or they both referred to inanimate entities. Consequently, this was also the case with the present experimental materials. In fact it was true for all of them. In order to prevent the subjects discovering the systematic relation between animateness of prime and target, and strategically using the (in)animateness of the prime as a cue to category membership of the target, 46 filler prime-target pairs were constructed in which category membership of prime and target differed. Half of these included primes and targets that were associatively related, as judged by the author and three of her colleagues. The remaining half were unrelated. The latter were formed by recombining primes and targets of the associated filler stimuli. Half of the targets in the filler stimuli had an animate referent and were preceded by an inanimate prime. For the remaining half of the fillers, animateness of prime and target were reversed. Finally, a further 92 stimuli were added to the set of materials for the lexical decision part of the experiments. For these stimuli the primes were words and the targets were pseudowords, that is, nonwords conforming to the sound and spelling rules of Dutch. An example set of these stimulus materials is presented in Table 5.1.
Lexical Decision versus Size Categorization

Two experiments were run in which associative-priming effects in lexical decision and in size categorization were compared. In both experiments, the set of critical materials consisted of 104 pairs of Dutch nouns. Half of these items included targets that were the primary response to the prime in a corpus of word associations (de Groot, 1980). The remaining half of the stimuli were word pairs consisting of words not associatively related to one another, formed as before. Of both the related and the unrelated stimuli, half had a target referring to an entity larger than the standard TV set and half had a target referring to an entity smaller than this standard. The overall associative strength of targets to primes in the related condition with target referents larger than the standard was about the same as that in the related condition with target referents smaller than the standard (45.3% and 45.1%, respectively, with corresponding standard deviations of 18.3 and 19.1).

In selecting materials from the association norms it turned out that the size of the referents of the stimulus words and that of their primary responses were often about the same, and only few pairs could be selected in which the referents of stimulus and primary response belonged to different size categories. In other words, on the relevant dimension once again a systematic relation existed between prime and target that could come to be used strategically by the subjects (see earlier discussion). In order to prevent this, a set of filler stimuli, now consisting of 52 word pairs (26 related and 26 unrelated), was again constructed in which category membership of prime and target differed, so that subjects could not strategically use size of the prime’s referent as a cue to target classification. Finally, 104 prime-target pairs with a word as prime and a pseudoword as target were added to the set of materials for the lexical decision part of the experiments. An example set of the stimulus materials is presented in Table 5.2.

<table>
<thead>
<tr>
<th>Target Referent</th>
<th>Related</th>
<th>Unrelated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Larger</td>
<td>monk</td>
<td>branch</td>
</tr>
<tr>
<td></td>
<td>monastery</td>
<td>monastery</td>
</tr>
<tr>
<td></td>
<td>branch</td>
<td>branch</td>
</tr>
<tr>
<td></td>
<td>tree</td>
<td>tree</td>
</tr>
<tr>
<td></td>
<td>harbour</td>
<td>harbour</td>
</tr>
<tr>
<td></td>
<td>ship</td>
<td>ship</td>
</tr>
<tr>
<td></td>
<td>foal</td>
<td>foal</td>
</tr>
<tr>
<td></td>
<td>horse</td>
<td>horse</td>
</tr>
<tr>
<td>Smaller</td>
<td>fork</td>
<td>thumb</td>
</tr>
<tr>
<td></td>
<td>knife</td>
<td>thumb</td>
</tr>
<tr>
<td></td>
<td>finger</td>
<td>finger</td>
</tr>
<tr>
<td></td>
<td>vase</td>
<td>vase</td>
</tr>
<tr>
<td></td>
<td>flower</td>
<td>flower</td>
</tr>
<tr>
<td></td>
<td>hammer</td>
<td>hammer</td>
</tr>
<tr>
<td></td>
<td>nail</td>
<td>fork</td>
</tr>
<tr>
<td>Fillers</td>
<td>head</td>
<td>pill</td>
</tr>
<tr>
<td></td>
<td>body</td>
<td>body</td>
</tr>
<tr>
<td></td>
<td>doctor</td>
<td>head</td>
</tr>
<tr>
<td></td>
<td>frog</td>
<td>sink</td>
</tr>
<tr>
<td></td>
<td>tap</td>
<td>tap</td>
</tr>
</tbody>
</table>

Subjects, Apparatus, and Procedure

In each of the five lexical decision versus animateness categorization experiments and in both lexical decision versus size categorization experiments, 40 students of the University of Nijmegen participated as subjects. Different subjects participated in each experiment. In each experiment, 20 subjects performed the lexical decision task and 20 performed the semantic categorization task. Of each of these groups, half indicated their word/animate/larger decisions by pushing the right one of two buttons and nonword/inanimate/smaller decisions by pushing the left button. The response-to-button assignment was reversed for the remaining 10 subjects within each group of 20.

The same apparatus was used in all experiments. Stimuli were presented on a TV monitor. Individual stimulus presentation and the recording of response times and errors were under program control. Prime and target were always presented pairwise, that is, without intervening stimuli, and successively, and the subjects only responded overtly
to the target. The target remained on the screen until the subject responded or until a deadline had expired. Apart from the variation in the type of semantic classification to be made, the various experiments varied on two dimensions, namely, the stimulus-onset-asynchrony (SOA) between prime and target and the unmasked versus masked presentation of the prime. In the experiments with unmasked primes, the prime was always clearly visible. In the masked-prime experiments, conscious identification of the prime was prevented. The reason for the masking manipulation is given later.

**UNMASKED-PRIME EXPERIMENTS**

**Lexical Decision versus Animateness Categorization**

The outcome of the first three experiments comparing lexical decision with animateness categorization is presented in Table 5.3 (collapsed across the two response-to-button-assignment conditions). Experiments 1 and 2 were exact replications of one another. Prime-target SOA in these experiments was 440 ms (prime duration: 400 ms; interval between prime offset and target onset: 40 ms). Experiment 3 differed from Experiments 1 and 2 in that the prime-target SOA was 240 ms (prime duration 200 ms; interval between prime offset and target onset: 40 ms).

The main goal was to determine whether or not there is more priming in animateness categorization than in lexical decision. In Experiments 1 and 2 the relevant interaction, that between task and relatedness, was significant in the item analysis ($p < .05$ in both cases), but only marginally so in the subject analysis ($0.05 < p < .10$ in both cases). In Experiment 3 it was nonsignificant in both analyses ($F < 1$ in both cases). Consistent with the prediction of the priming-at-two-levels view, the overall associative-priming effect in Experiments 1 and 2 was larger in animateness categorization than in lexical decision. But, as can be seen in Table 5.3, the priming effect was only larger in animateness categorization than in lexical decision in the condition wherein target referents are animate. This result is reflected by a significant second-order interaction between task, relatedness, and animateness of the target ($p < .05$ or better in both the subject and the item analysis in all three experiments). A further relevant outcome is that in all analyses but one (the subject analysis of Experiment 3 being the exception), animateness categorization took significantly longer than lexical decision ($p < .05$ or better).

**Lexical Decision versus Size Categorization**

The data of the two experiments comparing lexical decision with size categorization are summarized in Table 5.4 (again collapsed across the response-to-button-assignment conditions). These experiments (Experiments 4 and 5) were exact replications of one another. As in Experiments 1 and 2, prime-target SOA was 440 ms (prime duration: 400 ms; interval between prime offset and target onset: 40 ms).
In Experiment 4 the interaction between task and relatedness was significant (p < .05 and p < .01 in the subject and item analyses, respectively), but the direction of the effect was unexpected: More priming was observed with lexical decision than with size categorization. However, as can be seen in Table 5.4, this was only the case when targets referred to entities smaller than the standard. The second-order interaction between task, relatedness, and size was statistically reliable in the subject analysis (p < .05) but only marginally so in the subject analysis (.05 < p < .10). Finally, the main effect of task was significant (p < .001 in both the subject and the item analyses), size categorization taking 90 ms longer overall than lexical decision.

**TABLE 5.4**

Experiments 4 and 5: Mean Response Times (RT) in ms and Error Rates (ER) as a Function of Task, Relatedness and of Target-Size (Unmasked Primes).

<table>
<thead>
<tr>
<th></th>
<th>Experiment 4</th>
<th>Experiment 5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Task</td>
<td>Lexical</td>
</tr>
<tr>
<td></td>
<td>Categorization</td>
<td>Decision</td>
</tr>
<tr>
<td>Size</td>
<td>RT</td>
<td>ER</td>
</tr>
<tr>
<td>Larger Related</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unrelated</td>
<td>583</td>
<td>5.8%</td>
</tr>
<tr>
<td>Priming Effect</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>Smaller Related</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unrelated</td>
<td>606</td>
<td>6.2%</td>
</tr>
</tbody>
</table>

In Experiment 5 the interaction between task and relatedness failed to approach significance (F < 1 in both the analysis by subjects and by items), but the second-order interaction was statistically reliable in the subject analysis (p < .05), and marginally significant in the item analysis (.05 < p < .10). The main effect of task was also again significant, with size categorization now taking 46 ms longer than lexical decision (p < .05 in the analysis by subjects and p < .001 in the analysis by items). As in Experiment 4, in size categorization the associative-priming effects on larger and smaller targets were equally large, whereas in lexical decision more priming occurred on the smaller targets. The only difference between the two experiments was that in Experiment 5 the priming effects in the size categorization conditions were larger than in Experiment 4. In an overall analysis of Experiments 4 and 5, the task by relatedness interaction was not significant (p > .10 in both the subject and the item analyses). The task by relatedness by size interaction was significant both by subjects (p < .01) and by items (p < .05). The overall priming effects in the larger and smaller size categorization conditions and in the larger and smaller lexical decision conditions were 38 ms, 35 ms, 30 ms, and 56 ms, respectively.

The finding that in lexical decision more priming occurs on smaller targets was not anticipated, but in hindsight it is not all that surprising. It may be due to a contamination of the size variable with word frequency. When targets in the larger and smaller word groups were checked on word frequency, it turned out that the frequency values of the targets with referents smaller than the standard were reliably (p < .05) smaller than those with referents larger than the standard (this contamination did not occur in the experiments comparing lexical decision with animateness categorization). Becker (1979) has shown the priming effect in lexical decision to be larger for low-frequency words than for high-frequency words. The present data show a tendency in the same direction: A small, marginally significant negative correlation occurred (r = -.19, .05 < p < .10) between the frequency of the targets in the critical (nonfiller) stimuli and the amount of priming observed for these words (collapsed across the two experiments) with lexical decision. Interestingly, there is no hint of any such correlation with size classification (r = .03, p = .42).

**Discussion**

The data so far seem to warrant the dismissal of the two-level view of associative priming introduced earlier: It is not generally the case that semantic categorization produces more associative priming than lexical decision. There is, however, one semantic categorization condition that consistently shows far more priming than any of the other experimental conditions, namely, the one in which targets referring to animate beings are categorized according to animateness. What is so special about this condition? The conclusion that only in this condition two levels in the memory system contribute to the priming effect appears to be wrong, as in terms of potential memory levels contributing to the effect, this condition is no different than the other semantic categorization conditions.

Thus, I looked for an interpretation in terms of the different sources of information that the subjects may have been using in the various experimental conditions. More sources of facilitatory information may have been available in the related condition with animate targets in animateness categorization than in any of the other experimental conditions. In animateness categorization, the outcome of a categorization of the prime on animateness may have been an additional source of information used by the subjects (recall that in all critical stimuli the referents of both
prime and target were animate or they were both inanimate). As mentioned earlier, the strategic use of such information was prevented by including filler stimuli in which prime and target belonged to different animateness categories. That the inclusion of these filler stimuli has indeed had the effect of preventing such strategy is clear from the low error rate for these stimuli in the error-prone animateness-categorization conditions. In Experiments 1, 2, and 3, the overall error rates in the animateness-categorization filler conditions were 3.5%, 2.9%, and 5.0%, respectively. But a categorization of the prime on animateness may have come about automatically, and the output of this process may automatically have cued the response. Information about the size of the prime’s referent may also become available automatically during prime processing, but in contrast to prime animateness in the animateness-categorization task, this information per se is presumably not a valid cue for responding in size categorization. What would have been useful prior information for classifying the target in size categorization is prime size in relation to the size of a TV set (recall that most of the time the referents of prime and target were on the same side of the TV set on the size dimension), but this information would certainly not become available automatically, it has to be computed on the spot (see the discussion on size categorization in the Introduction).

The postlexical associative-priming process of meaning integration, briefly alluded to in the introduction, may also have influenced responding in animateness categorization. The processes entail that the subjects exploit their recognition of the relationship or non-relationship between prime and target in target classification. Verbal reports of the subjects strongly suggest that in categorizing targets on animateness they transform the animate and inanimate responses to yes and no responses, respectively. These positive and negative decisions may be differentially affected by a given output of meaning integration, a related (= positive) output speeding up responses to animate targets by a response bias in the right direction but slowing down responses to inanimate targets by biasing the wrong response. Conversely, an unrelated (= negative) output of meaning integration may slow down responses to animate targets and it may speed up responses to inanimate targets. It has been argued (e.g., de Groot, 1985) that, similarly, in lexical decision related and unrelated outputs of meaning integration speed up and slow down, respectively, responding to words. In general, meaning integration may be assumed to affect processing in all binary tasks in which the two responses, as the two different outputs of meaning integration themselves, are quite naturally associated with yes and no.

In sum, there is reason to believe that responding in the condition wherein animate targets that are associatively related to their primes have to be categorized on animateness, was favored by the operation of a number of processes confounding the effects of automatic spreading activation. These processes may have been differentially operative or altogether inoperative in the remaining experimental conditions, causing the priming effects in those conditions to be smaller. The purpose of the following experiments, in which the primes were masked such that they could not be identified by the subjects, was to try to prevent the workings of these confounding processes in order to obtain a purer assessment of the magnitude of the associative-priming effect due to spreading activation.

**MASKED-PRIME EXPERIMENTS**

In a number of lexical decision studies (Balota, 1983; de Groot, 1983; Fowler, Wolford, Slade, & Tassinary, 1981; Marcel, 1983) an associative-priming effect has been reported on targets preceded by masked primes. The masked-prime technique has been used for various reasons. For the present purposes it is used to render postlexical meaning integration inoperative (see de Groot, 1983). If, as suggested here, the effects of this process boost the associative-priming effect in animateness categorization on prime-related targets with animate referents, this effect should decrease when the primes are masked. Of course, rendering meaning integration inoperative should also affect the associative-priming effects in the lexical decision part of the experiment. Thus, the associative-priming effect should generally be smaller under masked-prime presentation than in Experiments 1-5. Furthermore, if it is assumed that exploiting a categorization of the prime on animateness also requires conscious prime identification, such a process should also be rendered inoperative by the masking manipulation, and the associative-priming effect should decrease further in the animate, related condition in that task. The total decrease of the priming effect should thus be larger in animateness categorization than in lexical decision. Thus, because a number of other sources of priming have been removed, the resulting priming effects should more purely reflect priming due to automatic-spreading activation in the memory system than those obtained when the primes were not masked.

A further remark concerning the masked-prime technique is due here. As anybody who has worked with it realizes, this is not the easiest and most dependable of experimental techniques. Yet it is assigned a crucial role in this study. The problems with the technique are especially tedious when the purpose of an investigation is to find out whether or not priming occurs under perfect masking conditions, that is, when none of the subjects can identify any of the primes (see Holender, 1986, for an extensive discussion). I would like to stress that here the technique is merely used as a tool to get rid of processes obscuring the workings of spreading activation, without claiming that the prime was always perfectly masked (in fact, some subjects reported that they had occasionally identified a prime). The data themselves indicate whether or not this goal is fulfilled.

The prime-masking manipulation that was used here is based on the technique used by Forster and Davis (1984), who had the prime preceded by a stimulus serving as a forward mask and followed by the target,
serving as a backward mask. In the present two masking experiments (Experiments 6 and 7) the forward mask consisted of a string of 11 hashes (#). It was presented for 480 ms. Twenty ms after its offset, the prime appeared and remained on the screen for 40 ms. Twenty ms after prime offset, the target appeared and remained on the screen for 500 ms. In both experiments, associative priming in lexical decision and in semantic classification was compared, with animateness categorization being used as the semantic-classification task.

**Results and Discussion**

Table 5.5 summarizes the results of Experiments 6 and 7. Consistent with the view that masking the prime has the effect of rendering inoperative a number of processes that contribute to the associative-priming effect, the priming effects turned out to be smaller on the whole than in the experiments with unmasked prime presentation. Most interesting for our present purpose is the finding that there is hardly any trace left of the task by relatedness by animateness interaction that occurred before (p > .10 in both the analysis by subjects and the analysis by items in both Experiments 6 and 7). The task by relatedness interaction was also nonsignificant (F < 1 in both analyses in both experiments). Yet, the main effect of relatedness was statistically reliable in both experiments (p < .01 or better in both analyses in both experiments). In short, in all experimental conditions an equally reliable priming effect was now observed. Finally, in Experiment 6 the main effect of task was again significant, animateness categorization producing longer RTs than lexical decision (p < .05 in the subject analysis, and p < .001 in the item analysis). Also, in Experiment 7 animateness categorization took longer than lexical decision, but here the effect was only significant in the item analysis (p < .001).

All of these findings are consistent with the view that, with unmasked prime presentation, the priming effect on related, animate targets in animateness classification is boosted by the use of animateness information about the prime. This process, together with another, that with unmasked prime presentation is an effective source of priming in both animateness categorization and lexical decision (postlexical meaning integration), is rendered inoperative by the masking manipulation.

**GENERAL DISCUSSION**

Contrary to the predictions of the two-level view of associative priming, in Experiments 1 through 5, all with unmasked-prime presentation, the priming effect was not consistently larger in the semantic categorization tasks than in lexical decision. Semantic categorization only showed a larger priming effect in lexical decision when animate prime-related targets were categorized for animateness. The relatively large priming effect in this condition was attributed to a number of processes that operate automatically in the masked-prime experiments (Experiments 6 and 7), these processes were rendered ineffective. In these experiments, equally large priming effects were obtained for both animate and inanimate targets in lexical decision and animateness categorization. A further important result is that the data generally indicate semantic categorization takes longer than lexical decision (only in the subject analyses of Experiments 3 and 7 was the effect of task not reliable). This finding is important because longer processing time in semantic classification than in lexical decision may be a prerequisite in testing the two-level view of associative priming. According to the more likely of the two processing accounts of two-level priming (alternative (b) in the Introduction), a larger priming effect should be obtained in semantic classification than in lexical decision, because in the former more often than in the latter the priming effect arising at the semantic level can join the word level priming effect in time to affect responding. If semantic classification and lexical decision would take equally long, both levels could contribute to the overall priming effect equally often in both tasks, and hence there would be no grounds for expecting more priming in semantic classification. In other words, the present finding of equally large associative-priming effects in lexical decision and semantic classification would not refute the two-level view of priming. However, because semantic categorization indeed appears to take longer than lexical decision, the finding that the two tasks produce equally large priming
effects suggests that the two-level view of priming is incorrect and that associative priming originates at one level only.

The reason semantic classification was assumed to take longer than lexical decision (see the Introduction) was that in the former task the response *always* has to await an output from the semantic-representational level, whereas in lexical decision on a subset of trials (the number of which will vary with stimulus characteristics that affect processing time, such as length and frequency) all information relevant for response selection may already be available and the response can be executed prior to access of the semantic level. However, there are other possible causes for a longer overall response time in semantic classification than in lexical decision. One is that word/nonword discrimination is an easier task than semantic classification. Yet another is the possibility of differential postlexical priming influences in the two types of tasks. In order to rule out the latter interpretation, an additional experiment was conducted, in which responses were collected to the targets from the earlier lexical decision versus animateness-categorization studies (Experiments 1, 2, 3, 6, and 7), but now these targets were not preceded by their primes. It turned out that also *unprimed* RT was faster (by 67 ms) in lexical decision than in animateness categorization (*p* < .001 on both the subject and the item analyses). This finding rules out an interpretation of the difference in overall RT between the two tasks under priming conditions in terms of differential postlexical priming effects.

To recapitulate, the findings that larger associative-priming effects were not obtained in the semantic classification tasks than in lexical decision and that overall RT was generally larger in semantic classification than in lexical decision together suggest that the priming effect in both types of tasks originates at a single representational level. That the level concerned is the semantic level (cf. Collins & Loftus, 1975) is strongly suggested by two lexical decision experiments that I conducted together with Gerard Nas of the University of Utrecht. The purpose of those experiments was to investigate the lexical structure of Dutch-English compound (Ervin & Osgood, 1954) bilinguals. We did so by looking at both the associative-priming effect and the repetition-priming effect in two within-language and two between-language conditions. In the within-language conditions, prime and target were either both Dutch words or they were both English words (e.g., associative priming: *kalf*-kalf or *calf*-cow; repetition priming: *kalf*-kalf or *calf*-kalf). In the between-language conditions, primes were presented in Dutch and targets in English or vice versa (e.g., associative priming: *kalf*-cow or *calf*-koe; repetition priming: *kalf*-kalf or *calf*-kalf). In one of the experiments the primes were clearly visible. In the second they were masked, using the same masking technique as in the two masking experiments here. As materials we only used pairs of Dutch-English cognates, that is, words of which the Dutch form and its English equivalent are perceptually similar, both in sound and in spelling (*kalf*-calf, but not dak-roof).

In both experiments, we obtained about the same pattern of results: Overall, the repetition-priming effects were larger than the associative-priming effects. The analyses further showed that the repetition-priming effects tended to be larger in the within-language conditions than in the between-language conditions, whereas the associative-priming effects were equally large within and between languages. A full explanation of these results is provided elsewhere (de Groot & Nas, 1989). For the moment I'll concentrate on the finding of equally large associative-priming effects within and between languages, because that finding appears to be particularly relevant to the present research.

The assumption of connections between associatively related words at the word level of representation is only plausible within a language system. As mentioned earlier, such connections would be the result of contiguity of associatively related words during concept acquisition. But such contiguous associatively related words will typically be words from the same language (e.g., some English person may be told that a *calf* is a young *cow* but not that a *calf* is a young *koe*). So, if associative links at the word level would come to be formed during concept learning, this would only be the case within a language system. (Note that it is very plausible that at the word level between-language connections do exist between repeated words, e.g., between *cow* and *koe*, because in school second languages are typically learned in a paired-associate paradigm. If these between-language connections do indeed exist, then at the word level associatively related words from different languages may be linked indirectly, e.g., *calf*-cow-koe. This possibility is not elaborated here.) In other words, the word level of representation can only be a locus of the associative-priming effect in the within-language conditions. Following my earlier reasoning, in case of the appropriateness of the two-level view (rejected earlier), this additional level of associative priming should have resulted in larger associative-priming effects in the within-language conditions than in the between-language conditions. The single-level view that would localize all of the effect at the word level of representation should have predicted an associative-priming effect only to be obtained in the within-language conditions. That the associative-priming effects were in fact equally large within and between languages (see earlier discussion) thus suggests that the semantic level of representation is the only locus of the effect. A relevant implication of this conclusion is that, also within a language system, there appear to be no links between nodes representing associatively related words at the word level of representation. Had they existed, they would have unconditionally led to spreading activation and, hence, to a priming effect.

The conclusion that at the word level no connections exist between associated words is surprising, as undoubtedly words referring to related concepts co-occur during concept acquisition. How can the formation of a link at the word level be prevented? One possibility is that the formation of links between nodes anywhere in the memory system requires a certain minimal amount of attention to be paid to the corresponding elements. We may furthermore assume that during concept acquisition
attention is primarily focused on the semantic relation between the to-be-learned concept on the one hand and related concepts on the other, and not to the words that name them. It may then be that there's simply too little attention left for the formation of links between the word nodes. The suggestion that the formation of links is an attentional process converges with my interpretation of the finding that word frequency hardly affects word association RT (de Groot, 1989). There, I concluded that the strengthening of a link between two nodes appears to require attention to be drawn to these nodes. A more radical solution would be to give up the present notion of a stratified lexical memory, with separate levels representing words and concepts, and to assume integrated lexical representations with links departing from one and the same node to nodes related to it on various dimensions, acoustically, orthographically, associatively, and semantically. The associative links in these amalgamated representations may then solely be responsible for the associative-priming effect in both lexical decision and semantic categorization (under conditions that prevent priming processes other than automatic spreading activation to operate), and equally large effects should thus indeed be obtained across tasks.

How do the present data fit in with those of Fischler (1977) and Lupker (1984)? As mentioned before, their studies were concerned with very much the same issue as the one investigated here, although they were not aimed at localizing the priming effect in the underlying memory structure. To recapitulate, unlike Fischler, Lupker obtained more priming for targets that were associatively and semantically related to their primes (AS-targets) than for targets that were only semantically related to their primes (S-targets) in lexical decision. In word pronunciation, both effects decreased considerably, and Lupker argued that the residual (6-ms) effect on S-targets in pronunciation might best be regarded as a null effect. He suggested that the relatively small (as compared to lexical decision) but reliable AS-effect in pronunciation is solely due to the associative links between prime and target and that the effects in lexical decision are larger than in pronunciation because only in the former does postlexical processing contribute to them. Consistent with Lupker's findings, in an unpublished experiment Hudson, Thomassen, and I also obtained more priming on AS-targets than on S-targets in lexical decision. (It should be noted that Lupker's and our S-materials were different in that the words in his S-pairs both referred to [nonassociated] members of the same semantic category, e.g. body parts, clothing, whereas our S-pairs were typically not taken from common semantic categories, although for the members of these pairs ad-hoc categories [Barsalou, 1983] could be created [mud-pudding; pepper-sand; pin-thorn].)

These data suggest that an association component in related word pairs causes priming prelexically, for instance, through spreading activation along links in the memory system, and that a semantic component causes priming postlexically, for instance, through meaning integration, but only in tasks that can tap the output of this postlexical process.

In other words, the priming effect on AS-targets in lexical decision is a compound effect composed of a prelexical associative component and a postlexical semantic component; the priming effect on AS-targets in word pronunciation is a simple prelexical associative effect; the priming effect on S-targets in lexical decision is a simple postlexical semantic effect; and finally, the null effect of priming on S-targets in word pronunciation suggests that no priming process is effective under these particular experimental conditions.

In Lupker's (1984) study, both primes and targets were clearly visible. In the present study, postlexical meaning integration was argued to be inoperative (so that the prelexical component could be isolated) when the primes are masked. If the analysis presented is correct, the priming effect on S-targets in lexical decision, attributed solely to meaning integration here, should disappear under masked-prime presentation conditions. Such a result would have an interesting consequence for the underlying memory model (cf. Lupker, 1984): As already mentioned, in case of a link between two nodes, activation from the first unconditionally spreads to the second, and a priming effect on the word represented by this node should occur. A null effect of priming on S-targets under masked-prime conditions would thus indicate that in the memory system no (direct) links exist between nodes for semantically related words that are not at the same time associatively related to one another (mud-pudding). Considering this, the label associative-priming effect for the effect occurring on AS-pairs now seems very appropriate. Of course, the memory nodes of the words in these S-pairs may come to be connected (and a priming effect under masked-prime conditions should subsequently occur) when attention is drawn to their semantic relation, and an association is thus formed. (For instance, when at the time I set out to construct pairs of words that are semantically but not associatively related, I first thought up [incomplete] featural descriptions of the concept referred to by a word, e.g., pepper: yellow/brownish and gritty, and then actively searched memory for the presence of a second word matching this description, e.g., sand. This procedure may have caused the two words to become linked in my memory.) Finally, the present data indicate that, as suggested by the masked-prime data, the links that do exist, namely, those connecting AS-words, are localized at the semantic-representational level.

ACKNOWLEDGMENTS

Most of the experiments reported here were run when I was at the University of Nijmegen and were supported by the Netherlands Organization for the Advancement of Pure Research (ZWO: Grant H56-279). I am grateful to both ZWO and to the Department of Experimental Psychology at the University of Nijmegen for their invaluable support.
REFERENCES


