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Semantic priming of lexical and conceptual representations:
Manipulating depth of processing of the prime

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SEMANTIC PRIMING OF LEXICAL AND CONCEPTUAL REPRESENTATIONS: MANIPULATING DEPTH OF PROCESSING OF THE PRIME

by

JENNIFER ROSE SHELTON

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE

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Abstract

SEMANTIC PRIMING OF LEXICAL AND CONCEPTUAL REPRESENTATIONS: MANIPULATING DEPTH OF PROCESSING OF THE PRIME

by

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Researchers often assume that automatic semantic priming effects found in lexical decision tasks are due to spreading activation at a conceptual knowledge level. Recent research questions this assumption by demonstrating that automatic priming does not occur for word pairs that are semantically related but not normatively associated (e.g., Shelton & Martin, 1992). The present research investigated priming at a conceptual level by manipulating depth of prime processing which forced subjects to access semantic knowledge. To ensure the priming effects were due to automatic processing two tasks were used which were designed to lessen the likelihood that subjects would engage in strategies making use of the semantic relationship between the word pairs. The first task used a single word presentation procedure and a low proportion of related words in the stimulus set which has been shown to uncover automatic priming in a lexical decision task (Shelton & Martin, 1992). Several experiments were conducted where subjects were required to make semantic decisions about each of a sequence of words. The second task was a modified Stroop task in which subjects either processed the prime
nonsemantically or semantically and named the color of a subsequent target word. Previous studies have shown that an associative relationship between the prime and target slows naming of the color of the target. It has been argued that the inhibition in this task results from automatic processing because noticing prime-target relationships would only produce greater interference. The results showed that priming was found for semantically related, unassociated word pairs in the semantic judgment tasks but not in the modified Stroop task. A final experiment demonstrated that the relatedness priming found in the semantic judgment experiments only came about when the prime-target pairs were related and the decision between the prime and target was the same. The results from the semantic judgment experiments suggest that the priming effect is due to the similarity in the information used to make the decision rather than activation of all semantic features shared between two concepts. The results from the modified Stroop task suggest there is no immediate influence of conceptual information on lexical access.
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Figure 2  Organization of Lexical and Conceptual Knowledge
Semantic Priming of Lexical and Conceptual Representations:
Manipulating Depth of Processing of the Prime

by
Jennifer Rose Shelton

OVERVIEW

This dissertation investigated whether automatic spreading activation occurs between semantically related concepts. Although it has often been assumed that semantic priming in the lexical decision task reveals spreading activation between semantically related concepts, recent research suggests this may not be the case, at least when the task uncovers automatic rather than controlled processing (e.g. Shelton & Martin, 1992; Lupker, 1984,1985). This leaves open the question of whether priming can occur at a conceptual level. The work reported here was carried out under the assumption that forcing subjects to semantically process the prime would reveal priming at a semantic level, if such priming actually occurs. An interrelated issue that was addressed was the appropriate way to measure priming to ensure that the priming was automatic rather than due to subject strategies.

The literature review begins with a brief discussion of what is meant by "levels" of knowledge. Following this is a discussion of the paradigms that have been used to look at semantic priming. These are divided into single word contexts (the lexical decision task, the naming task and the modified Stroop task) and sentential contexts (cross-modal priming, word detection and the modified Stroop task). Within the discussion of each paradigm, criticisms of the conclusions drawn from previous studies are raised and it is
argued that there has been no clear answer to the question of whether it is possible to uncover automatic spreading activation within a semantic knowledge network. After the various paradigms have been considered, there is a discussion of how semantic knowledge is thought to be organized and what priming effects one would predict given this organization. Several experiments are reported which address the issue of priming at a conceptual level. Finally, there is a general discussion of all the findings and the implications of these findings for theories of contextual influence on lexical access and the notion of semantic priming.

**COGNITIVE ARCHITECTURE**

Many researchers discuss various levels of knowledge when considering how information is processed. For example, in reading a word, it has been suggested that feature analysis of the letters occurs at one level, analysis of letter information occurs at a second level, access to a mental lexicon occurs at a third level, and access to a semantic knowledge level occurs at a fourth level (e.g. McClelland & Rumelhart, 1981). At each level, different types of information are stored and there may be differences in access to and organization of this information. In this dissertation, the focus is on the lexical knowledge level and the semantic knowledge level and is concerned only with visual processing. It is assumed that meaning information about a word is stored at a conceptual level and not as part of a lexical knowledge level (e.g., Shelton & Martin, 1992). Information at the lexical level concerns word form information (e.g., orthographic and perhaps phonological properties) as well as linguistic information (e.g., part of
speech). The figure below illustrates what type of information is stored at each level as well as how information at the lexical and conceptual level might be connected.

![Diagram of cognitive architecture for visual input]

**Figure 1:** Cognitive Architecture for Visual Input

A review of the findings concerning contextual influences (especially for single word contexts) on access to word meanings makes clear the need for a distinction between a lexical level and semantic level. This literature is reviewed below and the implications for how information is organized at each level is considered. One issue that has received considerable debate in the research on ambiguity resolution in sentential context (to be reviewed below) concerns the influence of processing at a "higher" level (e.g., semantic level) on processing at a "lower" level (e.g., lexical level). For
now, the issue of interactive processing (higher levels influencing processing at lower levels) versus autonomous processing (little or no influence of higher level processing on lower level processing) will not be considered. This issue is addressed in the General Discussion.

ASSESSMENT OF PARADIGMS PURPORTED TO UNCOVER AUTOMATIC SEMANTIC PRIMING

In priming paradigms, a preceding context is shown to facilitate or to impede processing of the target. A broad distinction can be made in discussing these paradigms in terms of complexity of context: single word versus sentential contexts. An example of a single word paradigm is the lexical decision task where the context (or prime) is a word and the subject's task is to decide if the target letter string is a word. An example of a sentence context is the cross-modal lexical decision task where the context is an auditorily presented sentence and at some point in the sentence a visual target letter string is presented to which subjects have to make a lexical decision. Results from the two types of context will be discussed separately and two important issues concerning these results are considered. These issues are whether the priming effect occurred automatically and if so, at what level of knowledge did the spreading activation occur. The focus, however, is on the single word context since the experiments presented later all deal with a single word context. There is a brief review of the sentence priming results and a discussion of the
methodological problems that surround the interpretation of the results from these studies.

**Single Word Context**

**Lexical Decision and Pronunciation Paradigms**

A great deal of research has focused on the issue of automatic and/or controlled processing in the lexical decision task. In recent years, many researchers have argued that priming in this task derives from controlled processing, i.e. subject strategies, and not automatic processing (e.g. Balota & Lorch, 1986; Seidenberg, Waters, Sanders, & Langer, 1984). This contention is based on a number of priming effects obtained in the lexical decision task which, it is claimed, could only come about due to controlled processing. These priming effects include: 1) a proportion effect, in which the greater the proportion of associated words in the stimulus set the greater the amount of priming; 2) inhibition, in which responses to targets followed by an unrelated prime are slowed down relative to targets following a neutral prime; and 3) backward priming, in which priming occurs for word pairs (e.g. "hop-bell") that are associated only in a forward direction (e.g. "bell-hop"). Two strategies have been suggested to account for these effects. One is an expectancy generation strategy wherein subjects generate possible associated targets that might appear after the prime has been recognized (e.g. Becker, 1980; Neely, 1991). The second has been termed "post-lexical checking" in which subjects assess the relationship between the prime and target after the target has been recognized (e.g. Seidenberg et al., 1984; Balota & Lorch, 1986). When the prime and target are associated in some
fashion, these strategies facilitate responding but when they are not associated, subjects are slowed down in responding.

Researchers have, however, demonstrated that priming in a pronunciation task, where the goal is to name the target, may come about due to automatic processing. Unlike the lexical decision task, backward priming and the proportion effect do not occur in naming (Seidenberg et al., 1984). Furthermore, a mediated priming effect has been demonstrated in the naming task (Balota & Lorch, 1986). Mediated priming is priming for associated concepts such as "swim" - "winter" which are mediated by another associated concept, "summer". The mediator, "summer", is directly associated to both "swim" and "winter", but "swim" and "winter" are not directly associated to one another. If priming is due to spreading activation, one would expect a mediated priming effect because activation can spread from "swim" to "summer" and from "summer" to "winter". This would lower the recognition threshold of "winter" when the prime is "swim", thus speeding the response latency to the mediated target. If subjects were only using strategies, they would not generate the target when the prime is read nor would they see the prime and target as related. Because mediated priming has been demonstrated in the pronunciation task, researchers argued that the priming effect in this task is due to automatic and not controlled processing. However, Neely and Keefe (1990) demonstrated that subjects may use an expectancy generation strategy while doing the pronunciation task, at least under certain conditions. These researchers found a proportion effect in the naming task when the difference in proportions was larger than that used by other researchers. Thus, when the proportion of associated
words in the stimulus set is large, subjects may use strategies even in the
naming task.

Recently, McNamara and Altarriba (1988) demonstrated mediated
priming in a version of the lexical decision task that was modified to
discourage subjects' use of strategies. In this task (to be called the "single"
presentation lexical decision task), subjects responded to every letter string
presented, rather than performing the more typical procedure of reading the
prime and responding to the target. The procedure was designed to make it
unlikely that subjects recognized that there was any relationship between two
successive letter strings. Shelton and Martin (1992) also investigated
priming using this single lexical decision task. To further reduce the
probability that subjects would notice prime-target relationships they used a
low proportion of related words in the stimulus set. They replicated
McNamara and Altarriba's finding of mediated priming and also
demonstrated a lack of backward priming and inhibition. Thus, it appears
that priming can be automatic in a lexical decision task that is designed to
reduce subject strategies.

Several studies have demonstrated that priming in a single word
context may be obtained both from words having an associative relationship
(e.g. words that are highly associated according to free association norms;
"coffee-cup") and from words having a semantic or conceptual relationship
(e.g. "spider-ant") (e.g. Fischler, 1977; Seidenberg et al., 1984; Hines et al.,
1986). However, it is unclear if the priming for related but unassociated
word pairs was due to automatic rather than controlled processes (Fischler,
1977) and if this effect generalized over items (Seidenberg et al., 1984;
Hines et al., 1986). Other studies have failed to find priming for related word pairs under conditions designed to ensure automatic processing. For example, Shelton and Martin (1992) demonstrated that automatic priming, as assessed with the single lexical decision task, does not come about for words that have similar semantic features but share no association. Napps (1989), also using this task, demonstrated no priming for synonyms (words that are very highly related). A study which used the pronunciation paradigm failed to find evidence that the related priming effect generalized across categorically related, unassociated items (Lupker, 1984). Shelton and Martin argued that automatic priming derives from spreading activation through a lexical network that is devoid of word meaning. They argued that lexical items which are associated may frequently co-occur in the language and would be linked in a lexical network. In fact, Collins and Loftus (1975), in their network model of knowledge, argued that there could be two types of networks, a lexical network which contains word form information, and a semantic network which contains meaning and relationships between semantically related concepts. Thus, even though one can measure automatic priming using the lexical decision or pronunciation paradigm, the level at which the effect is taking place appears to be a lexical one, rather than a semantic one. Therefore, these tasks are not appropriate to use if one is interested in questions concerning automatic spreading activation at a conceptual knowledge level.

**Can Priming Occur Through Activation in a Conceptual Network in Single Word Contexts?**

Assuming separate lexical and conceptual networks, it might be hypothesized that activation should spread within each network between
concepts which are linked in some fashion. As argued above, lexical items may be linked depending on co-occurrence frequency rather than being linked by conceptual similarity. In the lexical decision task, it is not necessary to access the conceptual network to perform the task; thus, priming would not be expected to occur for concepts which are linked due to semantic relatedness. However, if the task required subjects to access conceptual information, activation should occur for words that are semantically related.2

Automatic conceptual priming, interpreted according to the semantic memory model of Collins and Loftus' (1975), would occur because activation of a given concept spreads to related concepts in the network. For example, if the prime in a task is the word "dog", concepts close to this in the network, e.g. "cat, fur, four legs, animal", would also receive activation. According to Collins and Loftus, the network of concepts is organized according to semantic similarity. Thus, concepts which have many properties in common will have many links between them. The more links two concepts share, the more closely related these concepts are. Therefore, priming which occurs at a semantic level should be found for word pairs that share many properties, regardless of whether these concepts are highly associated. As discussed earlier, automatic priming in the lexical decision task does not occur at a semantic level but it is possible that priming would occur at a semantic level if subjects were forced to process the meaning of the prime. The following sections consider previous evidence from tasks reflecting deeper processing of the prime to determine if true semantic priming is obtained.
**Animacy and Size Judgments**

In the single word context, subjects could be forced to access semantic knowledge by having them make a semantic decision about a word, for example, whether the word denotes an animate or inanimate object. de Groot (1990) investigated lexical decision versus animacy judgments or size judgments (judgments which require access to semantic information) for word pairs that were associated, according to Dutch norms. She found that the size of the priming effect did not differ between the type of decision that was required, but that subjects were generally slower in making the semantic decision. However, her word pairs were all associated and any effect could have occurred at a lexical level rather than a conceptual level. Several experiments described in this dissertation investigated whether priming for related but unassociated word pairs would occur when the subject made a semantic (rather than lexical) decision.

**Modified Stroop Task**

In the Stroop task, subjects are required to name the ink color of a written word. The Stroop effect (Stroop, 1938) is the finding that interference in naming is obtained when the word is a color name (e.g. "blue" printed in red ink). Researchers have used a modified Stroop task to investigate various priming effects occurring with both single word and sentential contexts. In the modified Stroop task, subjects are shown a prime (e.g. a word) and are required to name the color of ink for targets that are related or unrelated to the prime (i.e., not color words). It has been demonstrated that subjects are slower in naming the color of ink when the target word is
associated to the prime that has immediately preceded it (e.g. Warren, 1972; 1974). This interference effect is argued to come about because the concept or meaning of the target word has been primed by the preceding context (e.g. prime word). When a concept is primed, it is harder to suppress articulation of the word associated with the concept in favor of articulation of the color name (e.g., Keenan, Potts, Golding & Jennings, 1990). This argument assumes that the concept has been primed rather than simply the lexical item; however, this assumption may not be warranted. In the case of the single word context, studies using this paradigm have only investigated priming for associated word pairs (Parkin, 1979) and/or subjects have not been required to semantically process the prime (e.g. Warren, 1972, 1974; Henik, Friedrich, & Kellogg, 1983).

Warren (1972) investigated priming for category names following presentation of list items and found significant interference in color naming when a target word was the category name associated with the items presented in the list (e.g. list items: oil, gas, coal; target item: fuel). He also found that this interference effect dropped off after a thirty second interval. Warren (1974) further investigated priming for asymmetrical associated word pairs (e.g. word pairs in which the prime elicits the target as a free association response but the target does not elicit the prime; e.g., stork-baby) and found no interference in color naming when the target in the asymmetrical word pair served as the prime. This lack of backward priming would indicate the interference effect is occurring automatically as has been argued in the lexical decision literature. Henik et al. (1983) manipulated depth of prime processing to investigate how a priming effect is influenced by
the processing of the prime. However, they did not require subjects to semantically process the prime. Rather, subjects either named the prime or searched for a letter in the prime before naming the color ink the target word was presented in. The word pairs used in this study were all associated word pairs. Henik et al. found interference in color naming only when subjects named the prime and argue that to find a semantic priming effect, the prime has to be processed semantically. It is questionable, though, that reading a prime requires accessing the meaning of the word. Parkin (1979) also manipulated the depth of prime processing by having subjects either count the number of syllables (non-semantic) in the prime or make a pleasantness judgment or living/nonliving judgment (semantic) about the prime. He found interference in color naming only in the semantic processing conditions for associated word pairs and concluded semantic processing is necessary to find a priming effect. The results from these studies indicate that you can find a priming effect with a single word context using this task but the question of whether semantic processing of the prime would lead to priming at a conceptual level remains unanswered. In the third experiment presented in this dissertation, depth of prime processing was manipulated by contrasting the effect on target color naming of reading the prime versus making a semantic judgment about the prime.

One benefit of using this paradigm to look at the issue of priming at a conceptual level is that the interference effect is thought to come about automatically (Warren, 1974; Keenan et al., 1990). That is, it would not be to the subjects benefit to use any relational information between prime and target to aid them in naming the color of the word. Rather, using relational
strategies like those suggested for the lexical decision task would greatly interfere with their ability to name the color word. Although this assumption seems reasonable and Warren's (1974) data on the absence of a backward priming effect implies the priming occurs automatically, a check for this assumption seems appropriate. Experiment 3, which used the modified Stroop task, includes a test for automaticity by investigating backward priming and mediated priming.

**Summary of Single Word Context**

Although many researchers have thought that semantic priming in the lexical decision task uncovers automatic spreading activation at a conceptual knowledge level, evidence to the contrary suggests that this priming effect, when automatic, uncovers priming at a lexical, nonsemantic knowledge level (e.g. Shelton & Martin, 1992; Lupker, 1984). While priming in the lexical decision task may occur at a lexical level, it is possible that priming at a conceptual level occurs when subjects are forced to semantically process the prime, for example, by having them make a semantic judgment about the word. Although several studies have manipulated depth of prime processing, the word pairs used in these studies have all been associated word pairs and any effect could have occurred at a lexical rather than conceptual level. The experiments reported in this dissertation test the idea that forcing subjects to semantically process the prime should lead to priming of semantically related concepts which do not share an associative relationship.

A critical concern in examining lexical versus semantic priming is that the priming effect occurs automatically rather than from subject strategies. The single presentation paradigm with a low proportion of related word pairs
has been shown to lead to automatic priming when subjects are required to make lexical decisions about letter strings (e.g. Shelton & Martin, 1992; McNamara & Altarriba, 1988). Several of the experiments reported in this dissertation used the single presentation format, but subjects made semantic (e.g. animacy, size) rather than lexical decisions to words. The modified Stroop task is another procedure which appears to uncover automatic processing (e.g. Keenan et al., 1990) since using any strategies that rely on the relationships between primes and targets would interfere with performance. Two experiments are reported which investigate priming for semantically related unassociated word pairs using this task.

**Sentence Context**

Numerous studies have been carried out looking at priming of words from a sentence context. Since sentence comprehension requires access to semantics, one might expect to see priming for words that are semantically related to words in the sentence or to sentence meaning. In fact, the assumption has been made that one can assess the semantic processing occurring in the sentence by measuring the facilitation to probe words presented at various points in the sentence. Much of this research has been concerned with the resolution of ambiguous words (e.g. bank: river, institution) in the sentence; however, some research has examined semantic processing for unambiguous words using this paradigm. Other paradigms that will be briefly discussed that have used sentence processing as a way to investigate contextual effects in word processing. These include the word detection task where a subject is presented with a word which they are to monitor and respond to in an auditorily presented sentence. The other
paradigm is the modified Stroop task where the prime is a sentence(s) and
the subjects' task is to name the ink color of a following target word. Results
from these three paradigms will be briefly reviewed.

**Ambiguity Resolution in Sentence Processing: Cross-Modal Priming**

Swinney (1977), using the cross-modal priming paradigm, demonstrated that priming occurs in sentence processing for both meanings of an ambiguous word when the target is presented immediately after the prime is heard. However, if the target is presented at some distance from the prime (e.g., the prime is presented in the middle of the sentence and the target is presented at the end of the sentence), priming only occurs for the meaning of the word that is appropriate to the sentence (e.g., Onifer & Swinney, 1981). Onifer and Swinney concluded that context does not guide access to a specific meaning of an ambiguous word; access is exhaustive and context guides later selection at a post-access phase of sentence processing. Thus, context is used to guide selection to the appropriate meaning after all meanings have been accessed. This view is often termed the "exhaustive access" position. Many researchers have demonstrated that access to word meanings is exhaustive even when the context biases only one meaning of the ambiguous word and these findings have been taken as evidence for an autonomous processing system in which higher level information, such as contextual information, has no influence on lower level processing, such as lexical access (e.g. Tanenhaus, Leiman & Seidenberg, 1979; Onifer & Swinney, 1981; Seidenberg, Tanenhaus, Leiman & Bienkowski, 1982).
Other researchers have presented evidence that supports a "context-dependent" view of access to word meaning (e.g. Simpson, 1981; Tabossi, Colombo, & Job, 1987; Tabossi, 1988). Simpson (1981) demonstrated that when the sentence strongly biased the dominant meaning of the ambiguous word, subjects were facilitated only to a target related to this meaning and not to a target related to the subordinate meaning of the ambiguous word. One problem with this study is that the targets appeared 120 msec after the offset of the ambiguous word and Seidenberg et al. argued that the results may not reflect immediate access of word meaning. However, Tabossi et al. (1987) demonstrated that when the target was presented immediately after the offset of the prime, subjects were facilitated to respond to a target related to the dominant meaning when the sentence biased this meaning but were not facilitated to the subordinate meaning. Both studies also found facilitation to both the dominant and subordinate meaning of the ambiguous word when the sentence biased the subordinate interpretation of the ambiguous noun. Tabossi et al. explain the difference in results between their study and the results of earlier studies which demonstrated no effect of context by suggesting that the context used in their sentences placed stronger constraints on the specific aspect of the word, at least for the dominant meaning.

Although some of the studies above suggest that multiple meanings of a word are immediately accessed in sentence comprehension, the nature of the relationship between the prime-target pair has not been controlled. That is, in most of the studies above, the prime and target were associates of one another. In fact, many of the studies that have looked at ambiguity
resolution in sentence processing create the prime-target pairs from the "Homograph Association Norms" (Nelson, McEvoy, Walling & Wheeler, 1980). Even in sentence processing it is not necessarily the case that the priming effect is due to the conceptual relationship among word pairs. Rather, the priming effect may be due to the associative relationship among word pairs. Work by Tabossi and colleagues has specifically examined this issue. The prime-target word pairs in the Tabossi et al. (1987) study were not normatively associated, while they were associated in the Onifer and Swinney materials. Tabossi et al.'s results suggest that it may be possible to find semantic, nonassociative, priming in this paradigm. However, there is a possible confound in the Tabossi et al. study that raises questions about this conclusion. Seidenberg et al. (1982, experiment 2) demonstrated that when sentences contain a word (not the prime) that is strongly associated to one meaning of the ambiguity, subjects were faster at naming the target when the context biased this meaning, regardless of the prime-target relationship. Seidenberg et al. argue that the results of their second experiment do not reflect context-dependent access, but rather reflect intra-lexical priming. They argue that it is the organization of the lexicon (for example, if word forms which are highly associated are close in the lexicon), and not selective access, that accounts for these results. Tabossi et al.'s (1987) materials did not contain associative prime-target pairs, but it is possible that the sentence contained another word associated to the target. However, Tabossi (1988a) did control for this confound and found a priming effect for target words related to the prime in a sentence which biased the dominant meaning of the ambiguous word. Thus, according to Tabossi
(1988a), context can guide access to the dominant meaning of an ambiguous word when the context biases a specific feature of that word and this does not come about due to the associative relationship between word pairs.4

Context Effects with Unambiguous Nouns

As reviewed above, many researchers argue that access is exhaustive, i.e. not affected by context, in the retrieval of ambiguous nouns (e.g. Swinney, 1979; Onifer & Swinney, 1981; Seidenberg et al., 1982). However, there was some evidence that when the context is appropriately biasing, lexical access can be guided by this context (e.g. Tabossi et al., 1987; Tabossi, 1988a). There is also some evidence that with unambiguous nouns, access is guided by context. It should be mentioned that the term unambiguous is somewhat misleading in that ambiguity in word meaning is not an all-or-none phenomenon but rather lies on a continuum. Unambiguous nouns refers to words in which two or more meanings are not completely unrelated, as is the case with ambiguous nouns. For example, in her work with unambiguous nouns, Tabossi uses "gold" as a prime and the targets "malleable" and "yellow" as two features or meanings of the word "gold". These targets are both part of the meaning of the word. However, an example of prime-target pairs used in the work with ambiguous nouns are, prime: bank, targets: river, money. The target words are related to the prime but unrelated to each other. Tabossi (1988b), using the cross-modal priming task, demonstrated that when the sentence appropriately primes a specific meaning of the noun, subjects are facilitated in making decisions to a letter string related to this context. Tabossi argued that the difference in her results
with both ambiguous and unambiguous nouns and those of others is the nature of the sentence frame. The sentence frame must be biasing enough to make salient an aspect ("feature") of the noun.

A possible problem with Tabossi's study concerns the fact that she did not specifically control for normative associations between the prime and target. That is, the priming effect found in this study may not necessarily uncover access to word meanings. Moss (1991) examined the issue of priming for unambiguous nouns using the same procedures as Tabossi and specifically controlled for associative relationships between the prime and target. In a series of experiments, she never demonstrated significant priming for the related, unassociated pairs. She concludes from her results that activation does not spread to related features of a given noun, even when the context biases the activation of those features. However, she also did not consistently find significant priming for the associated pairs. Her results suggest that priming may not come about for related word pairs but it is not clear that her experiments were powerful enough to pick up even an associative effect. At least with regard to unambiguous nouns, there has not been a clear demonstration of priming for related, unassociated concepts.

**Review of Cross-Modal Priming Results: What's wrong with this paradigm?**

In the literature on sentence priming, evidence has suggested that priming occurs for unambiguous nouns when there is an associative relationship between the prime and target (e.g. Tabossi, 1988b) or when a word in the sentence is associated to the target word (e.g. Seidenberg et al., 1982). Although, the evidence is scant at least with relation to unambiguous nouns there is some suggestion from the studies involving ambiguous words
(Tabossi, 1988a) that, unlike the single word studies, automatic priming in sentence contexts may come about due to the semantic relationship between the prime and the target. If it is the case that the priming is semantic, one should find priming for semantically related unassociated word pairs using a sentence priming paradigm, regardless of the nature of the context.

A possible problem with the results from studies investigating priming for word meanings in sentence context concerns the automaticity of the priming effect. Although researchers have argued that priming comes about automatically when the target immediately (e.g. a zero msec lag time) precedes the prime (e.g. Simpson, 1984; Seidenberg et al., 1982), there has been no clear demonstration to date that suggests subjects are not using strategies to aid them in making the lexical decision. As discussed in the review of the single word context literature, subjects do notice the prime-target relationships and use this information to aid them in making their decision. With a sentential context, there is a great deal of information the subject could use to help them make their decision to the visually presented letter string. Although the target immediately follows the offset of the prime which would preclude expectancy generation, subjects may still use a post-lexical checking strategy. In fact, there is some evidence that subjects may use the context to aid them in making their decision (Burgess, Tanenhaus & Seidenberg, 1989). This evidence comes from issues related to the debate surrounding "multiple" access ("exhaustive access"; "autonomous processing") versus "selective" access ("context dependent"; "interactive processing") to ambiguous word meanings.
Glucksberg, Kreuz and Rho (1986) argued that the evidence of multiple access may be an artifact of backward priming. They argued that initially, access may be contextually driven (i.e., selective) but upon recognizing the target, activation spreads backwards to the prime and from the prime to the other meaning(s) of the ambiguous word. This backward spread of activation would then facilitate subjects in responding to a word related to any meaning of the ambiguous word. To test this idea, they investigated a "nonword interference" effect in sentence priming. (Backward priming could not occur from a nonword). Nonword interference is inhibition in responding to a nonword that is spelled very similarly to a word associated to the prime (e.g., interference for "weign" (weigh) when primed by "scale"), relative to responding to the same nonword target preceded by an unrelated prime. They found that nonword interference obtained when the context constrained the meaning of the prime. Burgess et al. (1989), however, demonstrated that this nonword interference effect obtained even when the ambiguous prime was not in the sentence. That is, even without the critical prime word, subjects were still inhibited in responding to a nonword that was related to the context of the sentence. These authors argue that the effect comes about due to subjects attempting to use the contextual information to aid their judgment of the visual letter string. Thus, there is some evidence that priming in the cross-modal sentence task can occur due to subject strategies. It would not be unreasonable to assume that subjects are using contextual information to aid them in making their decision. In these studies, fifty percent of the word target trials are associated to the prime in the
sentence. In the single word context literature, a high proportion of words in
the stimulus set is thought to induce subjects to engage in strategies. It is
likely that many of the cross-modal sentence priming effects reported in the
literature come about from subject strategies. Therefore, although priming
has been shown to occur for target concepts which are not associated to the
prime (Tabossi, 1988a), the question of whether this facilitation is due to
automatic or controlled processes has not been answered.

A second problem with this paradigm is one that has only recently
been discussed in any fashion other than an informal one. In a recent paper
presentation, Stoltzus, Hasher and Zacks (1992) discussed several
experiments they carried out which failed to find any priming effect using the
cross-modal priming paradigm. These researchers carefully checked their
stimulus materials and procedures but continued to fail to find an effect. They
conclude that the cross-modal sentence priming effect is not as robust and
easy to find as many may think. This conclusion is supported by the fact that
many others have also informally reported a failure to find any priming effect
using this paradigm. Thus, this paradigm can be seriously questioned as a
useful tool in helping us understand access to word meanings in sentence
comprehension.5

**Word Detection in Sentential Context**

Marslen-Wilson and Tyler (1980) have used a word detection
paradigm in sentence processing as a way to investigate the influence of
semantic and syntactic information on lexical access during sentence
comprehension. In the word detection task the subject is presented with a
target word prior to hearing a sentence and has to monitor for this word in an
auditorily presented sentence, hitting a button when the word is presented. These researchers have demonstrated that subjects are fastest at detecting a target word in normal prose but are slowed down in detecting this target word when the sentence violates either semantic or pragmatic constraints on the meaning of the verb (Marslen-Wilson, Brown, & Tyler, 1988). It is argued that these and other results similar to these (Marslen-Wilson & Tyler, 1980) support the idea of a contextual influence on lexical access (Marslen-Wilson & Tyler, 1980) in which access to information is interactive or nonmodular. This position contrasts with the position of others who argue that lexical access is modular and not influenced by contextual information (e.g., Tanenhaus, Carlson & Seidenberg, 1985). Tanenhaus et al. have suggested that the effects of anomaly in the word detection task are not due to influences on lexical access but from the inability to integrate the information after lexical access has occurred (Tanenhaus, et al., 1985). They further argue that results using this paradigm may reflect subjects' ability to predict or guess where in the normal sentence the target word is going to appear, thus speeding reaction time. These arguments suggest that this paradigm may not be the most useful to look at the issue of contextual effects on lexical access.

**Modified Stroop Task and Sentence Processing**

A final group of studies that will be reviewed involve comprehending sentences and then naming the ink color of a target word. The advantage of using this paradigm, as discussed in the section on single word contexts, is that it is likely that any interference effects are due to automatic rather than strategic processing. Various sentence processing issues have been
investigated using these paradigms such as, ambiguity resolution, contextual influence on priming of features of unambiguous nouns, and inferences drawn during sentence comprehension.

Conrad (1974) first used this paradigm to investigate the issue of contextual influences on ambiguity resolution. Like some of the findings using cross-modal priming, she found that both senses of an ambiguous word become activated immediately upon encountering an ambiguous word, regardless of the biasing context. A study by Oden and Spira (1983) also found evidence of priming for both senses of an ambiguous word even in a biasing context but that the degree of activation depended on the compatibility of the word sense with the syntactic and semantic constraints of the context. These authors suggested that initially all meanings of an ambiguous word are accessed and contextual constraints allow the incompatible meaning to be rejected. This should lead to their finding that there is some facilitation for the biased against meaning of the ambiguous word. Given that this paradigm is less likely to involve subject strategies, these studies provide stronger evidence than the studies discussed earlier of all meanings of an ambiguous word becoming immediately activated and that over time, the appropriate sense of the ambiguous word is integrated with the context. While these results might suggest that semantic processing of a prime context reflects priming at a contextual level, the materials used in these studies were not controlled for word associations. Thus, any effect could have been occurring at a lexical rather than a semantic level.

One study (Whitney, McKay, Kellas, & Emerson, 1985) that investigated processing of unambiguous nouns using this procedure
demonstrated that priming of both high and low dominant properties of a noun is context independent, at least when immediately encountered. After a brief period of time, however, the low dominant properties were only primed when the context was appropriate although the high dominant properties were primed in both appropriate and inappropriate contexts. While Whitney et al. argued that their materials controlled for association between word pairs, they actually controlled only for words (other than the prime) in the sentence being associated to the target rather than the prime and target sharing this association. Thus, as stated above, the results from this study do not necessarily reflect priming at a contextual level.

A final group of studies has used the modified Stroop task to investigate what types of inferences are drawn during text comprehension. Whitney and Kellas (1984) found significant interference in color naming to a typical exemplar of a category, even when this target was preceded by a context which should lead to inference of an atypical exemplar of the same category. For example, if the category was "bird" and the context biased the subject to draw the inference "chicken" subjects were still slower to name the ink color when the target "robin" was presented. These authors suggest that this finding reflects priming from the category name to the typical target rather than priming for an inference. Whitney (1986) found that category exemplars are inferred in contexts which bias this inference when the term is referred to anaphorically and when it is used as the subject of the sentence. It should be noted once again that no attempt was made at controlling for an associative relationship between prime context and target. Interestingly, Whitney found evidence of facilitation in color naming when the target was a typical
exemplar and when the context biased the inferencing of a typical exemplar. 
Dosher and Corbett (1982) also found facilitation in color naming when 
subjects were instructed to specifically generate an inference while 
processing the text before the target appeared. The authors of both these 
studies argued that consciously preprocessing the target leads to facilitation 
in color naming rather than interreference in color naming. Thus, one might 
conclude that if subjects were engaging in an expectancy generation strategy 
while doing the modified Stroop task, one should find a pattern of facilitation 
rather than interference. This possibility has been suggested by Keenan et al. (1988). They found interference when targets were inferred from the 
proceeding text if the text did not specifically mention the target name 
(inference condition), but found facilitation when the context did contain the 
target name (explicit condition). However, the effects of facilitation and 
interference were not significant when compared to a control condition. The 
only significant effect was that between the inference and explicit condition. 
Nevertheless, these studies suggest that it is possible to use the modified 
Stroop task to investigate automatic priming effects, but the question of 
whether the priming effect occurs at a lexical or contextual level remains 
unanswered.

Review of Sentence Context

While embedding the prime in a sentential context might appear to be 
good way to make subjects process a prime semantically, the above 
discussion suggests that there are several problems surrounding at least two 
tasks (i.e., cross-modal priming and word detection) which have been used to 
investigate various issues surrounding lexical access and sentence
processing. Because of problems with controlling for automatic versus controlled processing and non-replicability of effects, these tasks appear less than optimal for investigating priming of conceptual information. The modified Stroop task has been used with some success to investigate both ambiguity resolution and drawing inferences and appears to measure automatic rather than strategic processes. However, it seems important to first gain more information about priming in the modified Stroop task with single word contexts before moving into more complex contexts, such as sentences and text. Thus, there is no investigation of priming with sentential contexts in this dissertation. The purpose of the previous review was to demonstrate the difficulties in drawing any straightforward conclusions from the existing sentence priming literature and about priming at a conceptual level.

ORGANIZATION OF LEXICAL AND SEMANTIC KNOWLEDGE:

PREDICTIONS ABOUT PRIMING RESULTS

As discussed earlier, the research reported here assumes a distinction between a level of lexical knowledge that is devoid of word meaning and a level of conceptual knowledge that carries semantic information about words and concepts. It was argued in the discussion of the lexical decision task that information at a lexical level is organized according to word associations which may be faulty measures of co-occurrence frequency (Shelton & Martin, 1992). Information at this level is not thought to be organized according to similarity in meaning between two entries. The lack of automatic priming for conceptually related concepts that did not share an associative relationship provided support for this argument.
Information at a conceptual level is assumed to be organized according to similarity in meaning between two concepts. For example, consider a network type model like the Collins and Loftus' (1975) model discussed earlier. It was suggested that priming at a conceptual level would occur between two concepts which shared many features in common since the number of links between similar objects is greater than the number of links shared between objects that have few or no features in common. According to Collins and Loftus, the semantic network is organized according to semantic similarity which is represented by the number of properties two concepts share. The assumption here is that information about a concept is represented in terms of its semantic features. Other models of semantic memory also assume that knowledge is organized according to semantic features (e.g. Smith, Shoben & Rips, 1974).

The figure below illustrates how one small part of a semantic network might be organized. A concept is connected to features which make up that concept as well as being connected to other concepts which share those features. One of the assumptions of the Collins and Loftus model is that priming occurs between concepts that share many properties in common. Therefore, if subjects are forced to access semantic knowledge, automatic priming would be predicted for concepts that share many properties even though these concepts might not be normatively associated. It should also be noted that semantic features do not necessarily refer only to perceptual features about an object. A semantic feature could include a part relationship (e.g., hand-arm), an action relationship (e.g., hammer-nail) or functional
relationship (e.g., pilot-fly). One would predict priming for two concepts that share these types of relationships since the targets are specific properties of the prime. Priming for perceptual features and functional features is investigated in Experiment 3.

CONCEPTUAL LEVEL: MEANING OF CONCEPTS REPRESENTED IN SEMANTIC FEATURES AND RELATIONSHIP TO OTHER CONCEPTS

LEXICAL LEVEL: SPELLING, SOUND INFORMATION; CONNECTIONS TO OTHER WORDS WHICH FREQUENTLY CO-OCCUR WITH ONE ANOTHER

Figure 2: Organization of Lexical and Conceptual Knowledge

SUMMARY OF GOALS

The aim of this research was to investigate whether it is possible to uncover automatic priming that occurs at a semantic or conceptual level. By using tasks that require access to semantic knowledge, it may be possible to uncover priming in a semantic knowledge network. With this in mind, several experiments were conducted to investigate the effect of semantic processing
of the prime on the processing of a subsequent target. These experiments revolve around two issues. The first is the issue of automaticity and whether the priming effect is due to automatic processing or to subject strategies. Experimental tasks were set up so that subjects would either not be inclined to use strategies because they would not notice relationships between word pairs or because strategies might actually hinder rather than help their performance. The second issue involves determining whether priming occurs at a conceptual level when the effect is automatic. Word pairs that were both conceptually related and associated or were conceptually related only were used as a way to determine whether the effect occurred at a lexical or semantic level.

**EXPERIMENTS**

**Experiment One: Animacy Judgments**

The purpose of this experiment was to investigate whether priming would occur for semantically related, unassociated word pairs when the subject was required to make a semantic decision about the word. The word pairs used were the ones used by Shelton and Martin (1992) and Fischler (1977). Both studies found evidence for priming for these types of word pairs in the lexical decision task when there was an obvious pairing between the prime and target and the proportion of related word pairs in the stimulus set was moderate to high. Although these word pairs were not specifically tested to determine how many properties they share, they were created to be very similar and subjects rated these word pairs as very related (Shelton & Martin, 1992). Furthermore, inspection of these word pairs (see Appendix 1)
indicates that many of the pairs come from the same semantic category. According to the Collins and Loftus model, priming at a conceptual level should occur for word pairs that share many properties (i.e. would have many links) even though they are not associated. To force subjects to access conceptual information, they were required to make an animacy decision about words presented on the computer screen.

In this experiment, the single presentation task with a low proportion of related words was used to lessen the likelihood that subjects would use strategies while doing the task. Furthermore, mediated word pairs were included to test whether priming is automatic. If priming were automatic, one would expect priming for mediated word pairs and associated word pairs. If priming occurs at a semantic level, there should also be priming for semantically related, unassociated word pairs. The mediated word pairs, however, are not semantically related. One would predict priming for these word pairs since they are indirectly connected at a lexical level and the prime word in a mediated pair should activate to some degree the target word which should, in turn, facilitate recognition of the target word. This should make accessing the semantic information connected to the mediated target faster than when the mediated target is preceded by an unrelated word and should facilitate the subject's response.

Method

Subjects

Thirty-two Rice university undergraduates participated in this experiment and received extra credit for a psychology course.
Materials

The associated word pairs (as determined by word association norms, e.g. Postman & Keppel, 1970), mediated word pairs (taken from Balota & Lorch, 1986) and word pairs that were semantically related but not associated (taken from Shelton & Martin, 1991 and Fischler, 1977) used in this experiment are listed in Appendix 1. Two stimulus lists were created in which a word pair that was associated/related in list one was paired with an unassociated/unrelated word in list two. Each list has 10 associated pairs, 10 mediated pairs and 10 related pairs. There were also 10 unassociated pairs, 10 unmediated pairs and 10 unrelated pairs. 120 unrelated filler pairs were added to each list to lower the proportion of associated/related pairs to 12%. The relationship between prime and target (both were inanimate or both were animate) was the same for the critical associated/related and unassociated/unrelated trials. For the unrelated filler trials, 50% had an animate prime and inanimate target, and 50% had an inanimate prime and animate target.

Procedure

Words were presented on a Macintosh computer and keypresses were measured by the computer. Subjects were told they would see a word presented in the middle of the screen and were to decide if the word denoted an animate or inanimate object. They were to press the "1" key if it was animate and the "2" key if it was inanimate. This was counterbalanced across subjects. They were instructed to use their dominant hand and to use the index and middle finger to respond. Subjects sat approximately 2 to 2.5 feet from the computer screen.
A word appeared on the screen and stayed there until the response was made. There was then a blank screen for 250 msec and then the next word appeared. Subjects were not told anything about a relationship between the two word pairs. They were given 20 practice trials prior to the test list. Practice trials did not contain related, associated or mediated word pairs. Subjects completed 180 trials in the test list.

Results

Mean reaction times for the critical word pairs are shown in Table 1. Reaction times that were greater than 3500 msec or less than 350 msec were thrown out. Errors were also removed before analysis.

Table 1

<table>
<thead>
<tr>
<th></th>
<th>Associated</th>
<th>Related</th>
<th>Mediated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Critical</td>
<td>638 (.03)</td>
<td>669 (.02)</td>
<td>706 (.03)</td>
</tr>
<tr>
<td>Control</td>
<td>717 (.04)</td>
<td>728 (.03)</td>
<td>719 (.03)</td>
</tr>
<tr>
<td>Difference</td>
<td>+79</td>
<td>+59</td>
<td>+13</td>
</tr>
</tbody>
</table>
There was a significant effect (79 msec) of associative priming, 
$t(31)=3.08$, $p < .01$, and a significant effect (59 msec) of relatedness priming, 
$t(31)=2.73$, $p < .01$. However, there was no significant effect (13 msec) of 
mediated priming, $t(31) < 1$.

Discussion

The pattern of results for the single presentation paradigm for animacy 
judgments is strikingly different from those for the single presentation lexical 
decision task. When the subject was required to make a lexical decision, 
there was evidence of mediated priming and no evidence of relatedness 
priming (Shelton & Martin, 1992). Using this paradigm with the lexical 
decision task, a 30 ms significant associated priming effect was found, a 20 
ms significant mediated priming effect was found and a 2 ms nonsignificant 
relatedness priming effect was found (Shelton & Martin, 1992). However, 
when the subject was required to make an animacy judgment, there was no 
evidence of mediated priming yet a significant effect of relatedness priming. 
This pattern was like that obtained in the lexical decision experiments under 
conditions designed to engage strategic processing (e.g., paired 
presentation or prime and target with a high proportion of related word pairs 
in the stimulus set). In lexical decision, a 41 ms significant associated 
priming effect was found, a 34 ms significant relatedness priming effect was 
found, and a -37 ms nonsignificant mediated priming effect was found 
(Shelton & Martin, 1992). It is unclear, however, why in the present 
experiment, changing the nature of the decision would induce subjects to use 
strategies in the present experiment. Even more puzzling is what those
strategies might have been, especially because of the small number of trials on which subjects would have been facilitated by using strategies.

There was some suggestion of facilitation for the mediated word pairs, although this was far from significant. One possible reason priming was not found for the mediated word pairs could be that the decision between the prime and target "switched" for some of these word pairs. That is, the act of making an animate decision on the prime but an inanimate decision on the target may have slowed subjects on these word pairs. Although the unrelated control trials had the same relationship, the switching may still have distracted subjects. Another problem may have been the decision that was required. Subjects may not have been exactly clear as to what was meant by animate or inanimate. For example, some of the words were adjectives (e.g., "hard") rather than objects and it is strange to make an animacy decision to adjectives. The next experiment was designed to address these possible problems.

**Experiment Two: Living Judgments**

In this experiment, priming for mediated word pairs, associated word pairs and related word pairs was investigated using the single presentation task with a low proportion of related words. Instead of making animacy judgments, subjects were required to decide if the word denotes a living thing. Also, associated word pairs were constructed so that there was both a living and nonliving prime for the same living or nonliving target (see Appendix 2). Thus, if the switch in judgment is responsible for the lack of mediated priming in the previous experiment, priming should only come
about for the associated word pairs in which the prime and target require the same judgment.

Method

Subjects: Thirty six Rice University undergraduates participated in the experiment and received course credit.

Materials: The mediated word pairs and the related word pairs were the same as in the first experiment. The associated word pairs are listed in Appendix 2. Four stimulus lists were created such that a word primed by a related/associated prime in one list was primed by an unrelated word another list. In each list, there were 8 associated word pairs, 4 of which had the same decision between the prime and target and 4 of which had a different decision between the prime and target, 5 mediated pairs, 2 of had the same decision between the prime and target, and 5 related pairs, none of which switch. There were 18 critical unrelated trials. To lower the proportion of related trials (9%), 130 unrelated filler trials were added. To balance the number of switching trials within a complete stimulus list, 69 of the unrelated filler trials switch and 51 of these trials don't switch.

Procedure: The procedure was the same as in Experiment 1 except that subjects were instructed to decide if the word typically denotes a living object. If it was living, they should hit the "1" key, if not, they should hit the "2" key. This key assignment was counterbalanced across subjects.
Results

Mean reaction times and error rates are presented in Table 2. Reaction times that were three standard deviations above or below the mean were removed before analysis. The analysis was carried out only on trials in which a correct response was made.

Table 2
Mean Reaction Times and Error rates for Living Judgments

<table>
<thead>
<tr>
<th></th>
<th>Associated</th>
<th>Related</th>
<th>Mediated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Associated</td>
<td>720</td>
<td>646</td>
<td>702</td>
</tr>
<tr>
<td>Unassociated</td>
<td>750</td>
<td>707</td>
<td>710</td>
</tr>
<tr>
<td>Difference</td>
<td>+30+</td>
<td>+61*</td>
<td>+8</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Associated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Same Decision</td>
<td>Different Decision</td>
</tr>
<tr>
<td>Associated</td>
<td>761</td>
</tr>
<tr>
<td>Unassociated</td>
<td>769</td>
</tr>
<tr>
<td>+8</td>
<td>+53*</td>
</tr>
</tbody>
</table>

* p < .05, + p < .08

As shown in the table, there was significant facilitation for the related pairs, t(35)=2.15, p < .05. Facilitation for the associated pairs approached significance, t(35)=1.80, p < .08. Facilitation for the mediated pairs was not significant t(35) < 1. For the associated word pairs that had the same decision between the prime and target, there was significant
facilitation, \( t(35) = 2.12, p < .05 \). There was no significant facilitation for the associated word pairs that had a different decision between the prime and target, \( t(35) < 1 \).

Discussion

The results for this experiment are similar to those in Experiment 1 where facilitation for the associated word pairs and related word pairs was demonstrated. Also like the first experiment, some facilitation was found for the mediated word pairs, but this was not significant. It was suggested that perhaps there was no facilitation for the mediated word pairs because some of the prime-target pairs required a different decision between the prime and target and that this slowed subjects. The results in this experiment with the associated word pairs would suggest that a switch in the decision between the prime and target only leads to a small facilitation effect. However, for the mediated word pairs which switched (8 pairs), there was a 25 ms facilitation effect, and for the mediated word pairs that did not switch (12 pairs), there was a -9 ms facilitation effect. Although neither of these effects were significant, the pattern of facilitation is opposite that found with the associated word pairs. Thus, the lack of mediated priming does not seem to arrive from a different decision between the prime and target that occurred on some of the trials.

It is interesting that there is no priming for the associated word pairs when these pairs require a switch in decision between the prime and target. However, inspection of these word pairs indicates that there is very little semantic relationship between these primes and targets. For example, the
target "blouse" is primed by "girl" in the switching condition while the same target is primed by "shirt" in the nonswitching condition. Even though the prime "girl" elicits the target response in a free association task, there are no similar semantic features between the two concepts in the switching condition; thus, these words would not be expected to be linked in a conceptual knowledge network. If the priming effects are due to spreading activation between similar concepts at a semantic level, one would not predict priming for the switching word pairs. One other possible explanation for the lack of priming for these word pairs is that the effect may reflect priming of the decision process rather than priming of conceptual representations. That is, having just decided that an item is "living", one is facilitated in deciding that the next, related item is also "living". Because in this task all the items that are related also require the same decision, one could not determine whether priming occurs for word pairs that are semantically related but which require a different decision (these associated pairs are not semantically related). This idea of priming of the decision process rather than the conceptual information is examined in Experiment 5 and also in the General Discussion.

One might conclude that the priming in the first two experiments is not occurring automatically since there was no priming for the mediated word pairs. However, it is still unclear what type of strategy subjects would be using to aid them in making their decision and that would result in facilitation on the related/associated trials. The proportion of related/associated trials is quite low (12%) and any strategy subjects might use would not be useful on
the majority of trials. One possibility would be to make the proportion of related/associated trials extremely low, thus reducing the likelihood even more that subjects would notice any relationship between some of the word pairs and use this information to aid them in performing the task. Mediated priming may still not be found and we would be left with the unanswered question of whether subjects used strategies while performing the task. Instead of pursuing this line of investigation, a different task was used to look at the original question of whether priming can be found at a semantic or conceptual level. In this task, the modified Stroop task which was discussed in the Introduction, subject's performance should be hindered rather than helped by noting prime-target relationships.

**Modified Stroop Task Experiment**

As discussed in the Introduction, some evidence suggests that conceptual processing of the prime (e.g. comprehending a sentence) leads to activation at a semantic level and this automatic activation can be measured using the modified Stroop task (e.g. Keenan et al., 1988). If this is the case, conceptually processing a single word prime (e.g. making a semantic judgment) should lead to facilitation for targets that are semantically related but unassociated to the prime. However, it might be expected that nonsemantic processing of the prime should lead to priming at a lexical level only, as is the case in the lexical decision task. That is, words connected at a lexical level only (e.g. mediated word pairs) should be primed when the prime is processed nonsemantically (e.g. when it is read and no semantic judgment is required). Thus, a comparison of prime
processing and priming for different types of word pairs (e.g. associated versus related) was carried out. If depth of processing of the prime is the crucial factor for whether priming will occur at a conceptual level, it might be expected that when the prime is not processed conceptually, priming results should mimic those found with the single lexical decision task. For example, one would predict priming for the associated word pairs and mediated word pairs but no priming for the semantically related, unassociated word pairs. To test these ideas, depth of prime processing was manipulated between subjects.

To extend the generality of the findings, two different judgments about the semantic information of the prime were compared and two different types of semantic relationships between prime and target were included. Subjects were required to make either a living judgment about the prime or were required to make a size judgment about the prime. The living judgment condition was included to provide a comparison with earlier results using a different paradigm. The size judgment condition was included to test whether any semantic processing of the prime leads to priming of concepts thought to be connected at a conceptual level, regardless of whether these concepts are connected by the information included in the judgment of the prime. That is, priming should be found for semantically related word pairs regardless of whether they are similar in size. To test the idea that priming might occur because the prime and target are related by the nature of the judgment to the prime, regardless of semantic similarity, unrelated filler trials were included in which the prime and target represent similar size objects or living/nonliving objects. Priming for two large objects or two living objects
which are semantically unrelated would not be expected if conceptual knowledge is organized according to semantic relations.

Another interesting question concerns the nature of semantic knowledge organization. The previous living judgment experiments have looked only at a categorical and/or featural relationship between prime and target (i.e., both prime and target belonged to the same semantic category or shared many features). However, concepts can be semantically related in many ways, for example, part relations (e.g., arm-hand), action relations (e.g., hammer-nail) or function relations (e.g., ear-hear). To test the idea that semantic knowledge may be organized according to many types of semantic relationships, two types of semantically related word pairs were used. One set of prime-target word pairs were categorically related (i.e., belong to the same semantic category), to provide comparison with earlier findings using the living judgment task. A second set of prime-target word pairs were functionally related (i.e., one member of the pair serves some operation for the other). Within each set, word pairs were either associated or related but unassociated. This manipulation was included as a way to test priming at various levels depending on depth of processing of the prime. As discussed earlier, Keenan et al. (1988) argued that priming at a lexical level should result in facilitation in naming the ink color rather than interference. However, these researchers are referring to the same lexical item (prime and target are the same word) rather than lexical entries which are thought to be connected in some way (i.e., associated word pairs, mediated word pairs). Based on previous studies using the modified Stroop paradigm, one would expect to find interference rather than facilitation for associated words
both in the nonsemantic processing condition and in the semantic processing conditions. The new information provided by the present studies is whether interference would be obtained for semantically related, unassociated word pairs in the various depth of processing conditions.

A final issue that was addressed in this experiment is the question of whether the interference effect occurs because of automatic activation rather than controlled processing. Although it is assumed that the interference effect occurs automatically in the modified Stroop task, a check for this assumption seems appropriate. To test this, both mediated word pairs and backward associated word pairs were included. In a lexical decision task, when the priming effect is automatic, it has been demonstrated that mediated priming occurs but backward priming does not (Shelton & Martin, 1992). Backward priming does occur, however, in paradigms likely to engage subject strategies. Thus, if the interference effect is automatic, there should be evidence of a mediated priming effect but no backward priming effect. In fact, Warren (1974) demonstrated that there was no backward priming for word pairs that were unidirectional associates (i.e., word pairs in which the prime elicited the target as a free association response but the target does not elicit the prime; e.g., stork-baby). That is, there was no interference in ink color naming when the target in the unidirectional pair served as the prime. Thus, no backward priming effect was expected in any of the prime processing conditions, provided that the priming effects were automatic. As a further precaution against the possibility that subjects might engage in some strategy to overcome the interference experienced when the prime and target are related, the number of related/associated word
pairs was kept low so that subjects were less likely to notice the semantic relationship between prime and target. Also, the size related prime-target word pairs provided a way to test the idea of priming due to the relationship of prime and target based on the judgment of the prime, as discussed above.

To summarize, depth of processing of the prime was manipulated between subjects. Subjects were required to either read the prime to themselves, make a living judgment to the prime, or make a size judgment to the prime. Prime-target relationships were manipulated within subjects. Word pairs were either categorically related or functionally related and within each set the word pairs were either associated or unassociated. Mediated word pairs and unidirectional associates were included as a test of automaticity. Finally, unrelated filler trials were included and shared the same judgment relationship (e.g., both large things) or did not (e.g., a living prime and nonliving target).

To provide a comparison with the living judgment experiments presented earlier, another living judgment experiment was carried out separately from the modified Stroop experiment using the same word pairs that were included in the modified Stroop experiment. It was expected that there would be evidence of priming for the categorically related word pairs, both associated and unassociated. From the previous results, mediated priming was not expected to occur; however, an examination of backward priming was carried out to determine if the lack of mediated priming was due to subject strategies.
Experiment Three: Modified Stroop Task

Methods

Subjects

One hundred and eight Rice University undergraduates participated in the experiment for course credit. Thirty-six were assigned to the nonsemantic processing condition (read the prime), 36 were assigned to one of the semantic processing conditions (living judgment on the prime), and 36 were assigned to the other semantic processing condition (size judgment on the prime).

Materials and Apparatus

All the word pairs used in this experiment are listed in Appendix 3. There were 48 categorically related word pairs, 24 of which were associated and 24 of which were related but unassociated. Category relationship was determined using the Battig and Montague (1969) Category Norms. Four associated word pairs were not listed in these norms (mountain-hill, pot-pan, brush-comb, engine-motor) but were judged by the experimenter to belong to the same semantic category. Word association norms (Marshall & Cofer, 1969; Palermo & Jenkins, 1964) were checked to establish that the related word pairs were not associated. As a further check, 50 graduate and undergraduate students were asked to provide the first three words that came to mind when reading the prime of the semantically related word pairs. Only one subject provided the target to one of the related primes.

There were 48 functionally related word pairs, 24 of which were associated and 24 of which were related but unassociated. The functionally associated word pairs were taken from word association norms (Marshall &
Cofer, 1969; Palermo & Jenkins, 1964). Functionally related, unassociated word pairs were created and word association norms were checked for all the word pairs to ensure that the target was not given as a free association response to the prime. These word pairs were also included in the word association task given to the subjects mentioned above. None of the subjects provided the targets to any of the related primes. All the functionally related word pairs were judged by the experimenter not to belong to the same superordinate category. Rather, these word pairs reflect a functional relation to one another (e.g. ear-hear, dagger-cut) with the target being a verb representing a function of the prime.

To ensure that the associated and related word pairs were thought to be related, 30 graduate and undergraduate subjects were asked to rate how related they thought the same category word pairs were and were given instructions to rate these word pairs on the basis of similarity of meaning or shared features. Subjects were given examples and were told to rate the word pairs on a scale of 1 to 7 with 7 being "very related" and 1 being "very unrelated". Unrelated word pairs were also included. The mean ratings for the associated word pairs and related word pairs were 5.20 and 5.17, respectively. The mean rating for the unrelated word pairs was 1.33. A different group of 30 undergraduate and graduate subjects were asked to rate how related they thought the functional word pairs were. Subjects were given examples and told to rate the word pairs on the basis of how likely the second word in a pair serves a function or operation of the first word in that pair using the same scale discussed above. Unrelated word pairs with the second word in a pair always being a function were also included. The mean
ratings for the associated word pairs and related word pairs were 6.06 and 5.98, respectively. The mean rating for the unrelated word pairs was 1.43.

There were 24 mediated word pairs (Balota & Lorch, 1986; McNamara & Altarriba, 1988) and 24 unidirectional associates. The unidirectional associates were taken from either Warren (1974) or from word association norms (Marshall & Cofer, 1969; Palermo & Jenkins, 1964) with the restriction that a living and size judgment could be made to both the prime and target. To manipulate the judgment relationship between the prime-target filler trials, 24 target words were preceded by the same size relationship in one of the lists and a different size relationship in another list. For example, if an unrelated target is "truck" in one list and has the prime "elephant" (both large things), the same target would have the prime "penny" in another list. These word pairs are also included in Appendix 3.

Four separate word lists were created such that a target word preceded by a critical prime in one list was preceded by a control prime in another list. Subjects completed only one list. Each list contained 6 categorically associated word pairs, 6 categorically related word pairs, 6 functionally associated word pairs, 6 functionally related word pairs and 24 unrelated controls for targets preceded by a critical prime in another list. The list also included 6 mediated word pairs, 6 unrelated controls for these word pairs, 6 forward associates, 6 backward associates and 12 unrelated controls for these word pairs. There were 6 size related word pairs in each list and 6 unrelated controls for these word pairs. Finally, 84 unrelated filler trials were added to each list to lower the proportion of related words to 18%. Thirty of these fillers had targets which were verbs so that subjects encountered verb
targets on trials other than only on the critical trials (i.e., functional targets preceded either by a related or unrelated prime).

Words were presented on a Macintosh II computer and reaction times were measured to the prime decision (for the semantic processing conditions) through the keyboard. A Lafayette Instruments voice key was interfaced to the computer to simulate a mouse click and reaction times to name the target were measured by the computer. Accuracy in naming the target was scored on each trial by the experimenter.

**Procedure**

Subjects were seated in front of the computer and were told that they were going to be naming the colors of words presented on the computer screen and that the time taken to do this would be measured. Five colors were used: blue, black, pink, green and red. So that all subjects would use the same name for the colors and were familiar with the colors and the equipment, a practice session with the colors was first carried out. There were 25 trials which involved a row of X's in one of the five colors being presented on the computer, 5 trials in each color. The stimulus remained on the screen until the subject responded and there was a 1 s interval between trials. Subjects were to name the color of the stimulus as quickly and accurately as possible. If subjects used the wrong color name, they were corrected by the experimenter. Also, if the subject's voice failed to trigger the voice key they were either told to speak louder or the sensitivity level of the voice key was set higher. After completing this, subjects were assigned to one of the three prime processing conditions. In the "read only" condition, subjects were told they would see a word presented in black font on the
computer screen and were to read this word to themselves. After a brief period of time (750 ms), that word would disappear and, 500 ms later, a second word, which was presented in larger font than the prime, would appear in one of the five colors they just practiced naming and they were to name the color of that word as quickly and accurately as possible. There was a 1 s interval between trials. In the "living judgment" condition, subjects were told that a word would be presented on the computer in black font and they were to decide if that word represented a living object. If it did, they were to press the "1" key and if it did not, they were to press the "2" key. They were told to do this as quickly and accurately as possible and the word remained on the screen until a subject made their decision. After their decision, 500 ms later, a second word, which was presented in larger font than the prime, would appear in one of the five colors they just practiced naming and they were to name the color of that word as quickly and accurately as possible. There was a 1 s interval between trials. In the "size judgment" condition, subjects were told they would see a word presented in black font and they were to decide if that word represented an object smaller than the computer screen in front of them. If it did, they were to press the "1" key and if it did not, they were to press the "2" key. They were told to do this as quickly and accurately as possible. After their decision, 500 ms later, a second word, which was presented in larger font than the prime, would appear in one of the five colors they just practiced naming and they were to name the color of that word as quickly and accurately as possible. There was a 1 s interval between trials. In all three conditions, subjects were given 24 practice trials after which they were asked if they were sure they understood the procedure. If
they did not, they repeated the practice trials. Subjects then completed one test list. Subjects were not made aware of the relationship between the prime-target pairs.

The experimenter recorded the subject's response to each target trial on a sheet of paper and noted if an error was made. If the voice key failed to register when a subject made a response, subjects were told to repeat themselves and a note was made on the score sheet that the equipment malfunctioned on that trial.

Results

Of interest in all three prime processing conditions is reaction time to name the color for the critical and control trials in each of the word relationship conditions. Before analyzing the data, trials on which there was equipment malfunction were removed (2%). For each subject's data, reaction times to targets on which an error was made was removed from the analyses. Errors were one of two types. Subjects either misnamed the color or read the target word rather than naming the color. Across all the semantic processing conditions and word relationship conditions, errors were very low (1-3%). For the "living judgment" and "size judgment" conditions, if a subject made an error on the prime judgment, this trial was removed from the analyses. Across processing conditions and word relationship conditions, errors were also very low (2-4%).

Data and analyses are presented by word relationship condition for each of the semantic processing conditions. It should be noted that priming in this experiment is measured by amount of interference. Table 3 presents
reaction times for categorically related word pairs for each semantic processing condition.

Table 3
Mean Reaction Times for Categorically Related Word Pairs Across Prime Processing Condition

<table>
<thead>
<tr>
<th>Prime Processing Condition</th>
<th>Read Only</th>
<th>Living Judgment</th>
<th>Size Judgment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Category Related</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Associated</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Critical</td>
<td>728</td>
<td>845</td>
<td>827</td>
</tr>
<tr>
<td>Control</td>
<td>729</td>
<td>802</td>
<td>778</td>
</tr>
<tr>
<td>Difference</td>
<td>+1</td>
<td>-43*</td>
<td>-51*</td>
</tr>
</tbody>
</table>

| Related                    |           |                 |              |
| Critical                   | 739       | 828             | 803          |
| Control                    | 750       | 850             | 784          |
| Difference                 | +11       | +22             | -19          |

* p < .05

In the "read only" condition, there was no evidence of priming for either the associated word pairs, t(35) < 1, or the related word pairs, t(35) < 1. In the "living judgment" condition, there was evidence of priming for the associated
word pairs, \( t(35) = 2.30, p < .05 \), but no evidence of priming for the related word pairs, \( t(35) < 1 \). In the "size judgment" condition, there was also evidence of priming for the associated word pairs, \( t(35) = 2.41, p < .05 \), but again no evidence of priming for the related word pairs, \( t(35) < 1 \). Thus, contrary to the predictions and the findings in the living judgment experiments, semantically processing the prime did not result in priming for the categorically related word pairs.

Table 4 presents the findings for the functionally related word pairs across the prime processing conditions. Unlike the findings for the categorically related word pairs, in the "read only" condition there was a suggestion of priming for the functionally related word pairs, \( t(35) = 1.65, p = .11 \), but no evidence of priming for these word pairs in the "living judgment" condition, \( t(35) < 1 \), and in the "size judgment" condition, \( t(35) < 1 \). Similar to the findings for the categorically related word pairs, there was no evidence of priming for the functionally related word pairs in any of the processing conditions: "read only", \( t(35) < 1 \); "living judgment", \( t(35) = 1.34, p = .19 \); "size judgments" \( t(35) = 1.39, p = .17 \). Again, there is evidence that semantically processing the prime did not lead to priming for the categorically related word pairs, a result different from that found in the living judgment experiments.
Table 4

**Mean Reaction Times for Functionally Related Word Pairs Across Prime Processing Condition**

<table>
<thead>
<tr>
<th>Prime Processing Condition</th>
<th>Read Only</th>
<th>Living Judgment</th>
<th>Size Judgment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Function Related</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Associated</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Critical</td>
<td>777</td>
<td>814</td>
<td>769</td>
</tr>
<tr>
<td>Control</td>
<td>730</td>
<td>807</td>
<td>766</td>
</tr>
<tr>
<td>Difference</td>
<td>-47</td>
<td>-7</td>
<td>-3</td>
</tr>
<tr>
<td><strong>Related</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Critical</td>
<td>717</td>
<td>822</td>
<td>793</td>
</tr>
<tr>
<td>Control</td>
<td>694</td>
<td>800</td>
<td>767</td>
</tr>
<tr>
<td>Difference</td>
<td>-23</td>
<td>-22</td>
<td>-26</td>
</tr>
</tbody>
</table>

Table 5 presents the data for the asymmetrical associates in both the forward and backward direction. In the "read only" condition, there was a small suggestion of priming for the forward pairs, \( t(35)=1.63, p = .12 \), as there was in the "living judgment" condition, \( t(35)=1.70, p = .11 \) but no evidence of priming for these word pairs in the "size judgment" condition, \( t(35)=1.16, p = \).
.26. In all three prime processing conditions, there was no evidence of priming for the backward associates, all t's < 1.

Although there was no significant priming for the forward associates in any of the prime processing conditions, there was some evidence that in all three prime processing conditions subjects were interfered with in naming the ink color of the target word when it was preceded by a forward associated prime. Figures which plot the mean difference scores for each subject for the forward associates across prime processing condition are presented in Appendix 4. Inspection of these figures indicates that a majority of the subjects in each prime processing condition showed some interference in naming the ink color of the target word; however, some subjects showed large facilitation effects in naming the ink color of the target word. This variability across subjects in each prime processing condition may make it harder to detect a significant interference effect. To investigate whether there was a significant forward associate effect across prime processing conditions, a 3 (prime processing condition) X 2 (forward vs. backward associates) ANOVA was carried out on the difference scores for each subject. Across prime processing conditions, there was significantly greater priming for the forward associates than the backward associates, F(1,105)=4.22, p < .05.
Table 5
Mean Reaction Times for Asymmetrical Associated Word Pairs Across Prime Processing Condition

<table>
<thead>
<tr>
<th>Prime Processing Condition</th>
<th>Read Only</th>
<th>Living Judgment</th>
<th>Size Judgment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Forward</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Critical</td>
<td>741</td>
<td>908</td>
<td>836</td>
</tr>
<tr>
<td>Control</td>
<td>716</td>
<td>841</td>
<td>814</td>
</tr>
<tr>
<td>Difference</td>
<td>-25</td>
<td>-63</td>
<td>-22</td>
</tr>
<tr>
<td><strong>Backward</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Critical</td>
<td>747</td>
<td>849</td>
<td>810</td>
</tr>
<tr>
<td>Control</td>
<td>748</td>
<td>836</td>
<td>793</td>
</tr>
<tr>
<td>Difference</td>
<td>+1</td>
<td>-13</td>
<td>-17</td>
</tr>
</tbody>
</table>

The mediated word pairs were also included as a test of automaticity. Similar to the findings with the living judgment experiments, as shown in Table 6, there was no evidence of mediated priming and this was true across all prime processing conditions: "read only", \( t(35) < 1 \); "living judgments", \( t(35) < 1 \); "size judgments", \( t(35) = 1.12 \), \( p = .28 \). The final word relationship that was included was the "size related" pairs, the reasoning being that
priming should not occur for word pairs that are similar in size but are semantically unrelated. In both the "read only" and "living judgment" conditions, there is no evidence of priming for these word pairs, t's < 1. However, in the "size judgment" condition, there was some evidence of priming for these word pairs, t(35)=1.71, p = .11, although this was not significant.

Table 6
Mean Reaction Times for Mediated Word Pairs and Size Related Word Pairs Across Prime Processing Condition

<table>
<thead>
<tr>
<th>Prime Processing Condition</th>
<th>Read Only</th>
<th>Living Judgment</th>
<th>Size Judgment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mediated</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Critical</td>
<td>735</td>
<td>833</td>
<td>774</td>
</tr>
<tr>
<td>Control</td>
<td>730</td>
<td>836</td>
<td>793</td>
</tr>
<tr>
<td>Difference</td>
<td>-5</td>
<td>+3</td>
<td>+19</td>
</tr>
</tbody>
</table>

| **Size Related**           |           |                 |               |
| Critical                   | 777       | 854             | 784           |
| Control                    | 762       | 887             | 760           |
| Difference                 | -15       | +33             | -24           |
To summarize the results of this experiment, in the semantic prime processing conditions there was evidence of priming for the categorically related associated word pairs although there was no evidence of this in the nonsemantic prime processing condition. There was no evidence of priming for any of the semantically related unassociated word pairs in any of the prime processing conditions. While there was some suggestion of priming for the other types of associated word pairs in either the "read only" (functional associates) or "living judgment" (asymmetrical forward) prime processing conditions, these effects were not even marginally significant. One possible reason for this may be the association strength between the word pairs in each condition. The categorically associated pairs have a mean association strength of 65%. That is, more than half the time people respond with the target word given the prime word. However, the mean association strength for the functional associates and asymmetrical associates was 28% and 32%, respectively. Thus there is a much weaker relationship between these word pairs and it might be the case that only some of the word pairs in each condition would produce a priming effect. There was no evidence of mediated priming in any of the prime processing conditions, nor was there any evidence of backward priming in these conditions. Finally, there was little or no evidence of priming for word pairs that share the same judgment relationship (same size).

For several of the word relationship conditions, for example, the forward asymmetrical word pairs, there were large interference effects that failed to reach significance whereas effects of this size in the lexical decision
task or living judgment task would usually be highly significant. Other researchers who have used the modified Stroop task (e.g., Keenan et al., 1988; Whitney, 1986) have also reported large, nonsignificant interference effects. One reason the data may be noisy in this paradigm could be the difficulty of the task. That is, on every trial, subjects have to suppress reading the target word and instead name the color of the word. The priming effect was an attempt to measure greater interference on trials in which the prime-target pair was related as compared to interference on the control trials. Because subjects are interfered with on every trial, the number of trials that produce a greater amount of interference relative to a control trial may be small. This could make it difficult to find a significant priming effect for certain word relationship conditions, specifically those conditions where the relationship between prime and target is not strong (e.g., forward asymmetrical word pairs). Finally, inspection of the analyses by items shows no significant effects for any of the word pairs which were significant in the analyses by subjects. There were fewer degrees of freedom for the tests by targets which would make it even more difficult to find a significant effect if only a small number of items are producing the effect.

Before discussing the implications of the findings from this experiment, I will present the methods and results from the living judgment experiment that was carried out using the same word pairs as in the modified Stroop experiment. This was done because the results in the semantic prime processing conditions in the modified Stroop task differed from those found in the earlier living judgment experiments; specifically, there was no relatedness priming in the modified Stroop task experiment. Thus, it was
necessary to determine if priming for the related, unassociated word pairs could be found using the living judgment task.

**Experiment Four: Living Judgment III- Comparison to Findings with modified Stroop Experiment**

The word pairs used in this experiment are the same as those used in the previous experiment with the exception of the functionally related word pairs. These word pairs were removed since it is odd to require one to make a "living" judgment to a function. The verb targets were replaced with words denoting living and nonliving objects and the unrelated filler targets that were functions were also replaced with words denoting living and nonliving objects.

**Methods**

**Subjects**

Thirty six Rice University undergraduates participated in this experiment for course credit.

**Materials**

The make up of the word lists were the same as in the previous experiment except that verb targets were replaced with noun targets. Thus, each list contained 96 filler trials (rather than 84) making the proportion of related word pairs 14%.
Procedure

Subjects were seated in front of a Macintosh II computer and were told they would see a word presented in the middle of the computer screen. They were to decide if the word represented a living object. If it did, they were to press the "1" key, otherwise they were to press the "2" key. They were told to do this as quickly and as accurately as possible. Subjects were given 24 practice trials before completing one of the stimulus lists. Key response and reaction time was measured by the computer.

Results

Any reaction time greater than 3000 ms or less than 300 ms were removed from the analysis. Trials on which errors were made were also removed from the analysis. Mean reaction times for each word relationship are presented in Table 7.
Table 7

Mean Reaction Times for Living Judgments Across Word Relationships

<table>
<thead>
<tr>
<th>Category</th>
<th>Associated</th>
<th>Related</th>
<th>Forward</th>
<th>Backward</th>
</tr>
</thead>
<tbody>
<tr>
<td>Critical</td>
<td>639</td>
<td>620</td>
<td>674</td>
<td>713</td>
</tr>
<tr>
<td>Control</td>
<td>687</td>
<td>669</td>
<td>709</td>
<td>726</td>
</tr>
<tr>
<td>Difference</td>
<td>+48*</td>
<td>+49*</td>
<td>+35*</td>
<td>+13</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Mediated</th>
<th>Size Related</th>
</tr>
</thead>
<tbody>
<tr>
<td>Critical</td>
<td>732</td>
<td>705</td>
</tr>
<tr>
<td>Control</td>
<td>748</td>
<td>701</td>
</tr>
<tr>
<td>Difference</td>
<td>+16</td>
<td>-4</td>
</tr>
</tbody>
</table>

*p < .05

As shown in the table, there is evidence of priming for the categorically associated word pairs, \( t(35) = 2.13, p < .05 \), the categorically related word pairs, \( t(35) = 2.92, p < .05 \), and the asymmetrical forward associates, \( t(35) = 2.99, p < .05 \). There is no evidence of priming for the asymmetrical backward associates, the mediated word pairs, or the size related word pairs, all t's < 1. Thus, similar to the findings from the previous living judgment experiments there is evidence of priming for associated and related word pairs with no evidence of priming for the mediated word pairs. Also like the
results from the modified Stroop task, there is no evidence of priming for the backward associates or the size related word pairs. Where the findings mainly differ is the evidence of priming for the related word pairs in the living judgment experiment but no evidence of priming for these same word pairs in the modified Stroop task. This discrepancy is discussed below.

Discussion of Results from Modified Stroop Task Experiment and Living Judgment Experiment

There are two important issues that need to be addressed in relation to the findings from the modified Stroop task experiment and the living judgment experiments. The first issue relates to the question of whether the priming effects in these tasks are due to automatic processing. The second issue concerns the lack of relatedness priming in the modified Stroop task while finding relatedness priming in the living judgment task.

With reference to the automaticity issue, it was assumed that the priming found in the modified Stroop task should reflect automatic processing since any strategies which used the semantic relationship between the two words would hinder rather than help performance. For the most part, the results from this experiment support this assumption. While there is no evidence of mediated priming (predicted if priming were automatic) there is also no evidence of backward priming (predicted if priming were strategic). The lack of mediated priming mirrors the findings in the living judgment experiments which have consistently failed to find a mediated priming effect. Lack of priming may not indicate that subjects are engaging in strategies
while doing this task. In fact, across three living judgment experiments there was always a small nonsignificant effect of mediated priming (e.g., 8 - 16 ms). It is possible that the effect is there but hard to detect. Mediated word pairs are only connected indirectly at the lexical level. It was assumed a mediated prime speeds recognition of the critical target word and, in turn, facilitates access to semantic information surrounding this target word. However, the facilitation in lexical access is weak and given that semantic information needs to be accessed as well and a semantic decision needs to be made, the amount of facilitation one experiences may be negligible.

Consistently, there has been a relatedness priming effect when subjects are required to make an animacy or living/nonliving judgment about a concept. However, in the modified Stroop task there is no evidence of relatedness priming in any of the prime processing conditions, especially the semantic processing conditions. The main difference between the two tasks is that in the living judgment task, the same type of response or decision is required for both prime and target (i.e., a semantic decision) whereas in the modified Stroop task the response to the target is different from that to the prime (i.e., a semantic decision to the prime and a nonsemantic response to the target). Perhaps the priming that occurs in the living judgment task is not priming between related concepts but priming in the decision being made to the target. That is, subjects may be speeded in their response because they have just made a similar response to a similar item. For example, having just decided that a "dog" is living it is easier and faster to decide that a "wolf" is also living (related pair) than when "wolf" is preceded by "rose" (unrelated control). That is, to decide that a "dog" and a "wolf" are living items, one
would use similar or identical information whereas different information is required to decide that a "rose" is a living item. While this might at first be thought to be priming, it is not really reflecting what, for years, has been considered to be semantic priming, defined as spreading activation between concepts at a conceptual knowledge level (e.g. Collins & Loftus, 1975). If spreading activation were occurring, one would predict priming for related concepts even when the decision switches, for example, word pairs could be created such that they belong to the same semantic category but require a different semantic decision. Of course, the semantic decision in this case could not be living/nonliving (which would violate the definition of a natural semantic category). However, a judgment such as a size judgment could be used. For example, "finger" and "leg" belong to the same semantic category (body parts) but could require a different size judgment. According to the notion that priming occurs between concepts that are similar or share many semantic features, one would expect priming for word pairs belonging to the same semantic category. However, if the relatedness priming found in the previous judgment experiments reflects priming in the decision process rather than priming of conceptual information, one would expect no priming for these word pairs. An experiment investigating this idea is reported below.

One other experiment is also reported below. This experiment is a replication of the nonsemantic prime processing condition. This experiment was carried out to determine whether priming occurs in this prime processing condition, at least for the categorically associated word pairs.
Experiment Five: Size Judgment Experiment-Facilitation due to Size or Semantic Relationship?

In the above discussion it was suggested that the priming found for the related word pairs in the living judgment task was not necessarily due to the shared features between the two word pairs but rather was due to making the same judgment based on similar information. That is, it was suggested that the priming results from facilitation in the decision process rather than from spreading activation due to shared semantic features. To test this idea, an experiment was carried out which looked at priming for word pairs that were related but required a change in decision. In Experiment 2, this change in decision was investigated for the associated word pairs and no evidence of priming was found. In the following experiment, the subject's decision was changed from "living" to a size judgment because it is impossible to create word pairs that are semantically related (e.g., belong to the same semantic category) but which switch in decision for living judgments. Also, using size judgments allows one to determine if the earlier findings apply to all semantic judgments or just to living judgments. Word pairs were chosen so that they were semantically related; that is, they belonged to the same semantic category (e.g. sparrow-eagle). Reaction times to the targets were compared to the same target preceded by a word that denoted an object that required either the same decision (e.g. chair) or a different decision (e.g. pencil). Both prime words were unrelated to the target. If it is the case that the priming effect found for the related word pairs in the living judgment experiments depends on both the same decision and similar information involved in
making that decision, one would predict priming only for word pairs which share both these characteristics. One would not predict priming for word pairs that only share either the same decision or similar information.

Methods

Subjects

Twenty-four Rice University undergraduates participated in this experiment for course credit.

Materials

Twenty eight word pairs that came from the same semantic category were created using the Battig and Montague (1969) Category Norms and either required a same decision between prime and target or a different decision between the prime and target. These word pairs are listed in Appendix 5. Four stimulus lists were created such that a target preceded by a categorically related same size prime in one list was preceded by a categorically related different size prime in a second list, an unrelated prime different size prime in the third list and an unrelated prime same size prime in the fourth list. Fifty one unrelated fillers were added to each list to lower the proportion of related trials to 17%. These fillers were created such that a subject would make a "small" decision on half of the trials (including decisions to both prime and target). Thus, each list contained 14 categorically related word pairs, 14 unrelated control word pairs, and 51 unrelated filler trials. A subject completed only one list.
Procedure

Subjects were seated in front of a Macintosh II computer. They were told they would see a word presented on the computer screen and they were to decide if the word denoted an object smaller than the computer screen in front of them. They were to press the "1" key if it did, otherwise press the "2" key. They were told to work as quickly and as accurately as possible. Subjects were given 30 practice trials before completing one stimulus list. Reaction times and keypresses were recorded by the computer.

Results

Mean reaction times and error rates are presented in Table 8. Reaction times greater than 3000 ms or less than 300 ms were removed before analyses. Errors on either primes (2%) or targets were also removed before analyses. As shown in the table, there was significant facilitation for the related word pairs when the decision between the prime and target remained the same \( t(23) = 3.44, p < .01 \). However, there was no evidence of facilitation for related word pairs when the decision between the prime and target differed \( t(23) < 1 \). Finally, there was no evidence of priming for word pairs that were unrelated but which required the same decision \( t(23) < 1 \).
Table 8

Mean Reaction Times and Error Rates Size Judgments

<table>
<thead>
<tr>
<th>Category Related</th>
<th>Unrelated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Same Size</td>
<td>Different Size</td>
</tr>
<tr>
<td></td>
<td>Same Size</td>
</tr>
<tr>
<td>732 (.16)</td>
<td>802 (.14)</td>
</tr>
</tbody>
</table>

Discussion

The results of this experiment support the idea that the facilitation seen for the related word pairs in the living judgment experiments comes about because the decision process is the same between the prime and target rather than because of the semantic relationship between the two concepts. However, there must be some semantic similarity between the two word pairs to find this facilitation effect given that one does not find priming for word pairs that share the same decision but which are not semantically related. The findings from this experiment will be discussed in more detail in the General Discussion.

Experiment Six: Modified Stroop Task-Nonsemantic Prime Processing II

In the nonsemantic priming processing condition in the earlier experiment using the modified Stroop task there was no priming for any of the word relationship conditions (see Tables 3-6) even though one would expect priming at least for the categorically associated word pairs. One possibility for the lack of priming may have been the fact that subjects were
not required to pay any attention to the prime at all and may have ignored this word when it was presented. Thus, this experiment again looks at nonsemantic prime processing but forces the subjects to attend to the prime by reading it aloud rather than to themselves.

The results from the semantic prime processing conditions suggest that the word pairs most likely to produce a priming effect are the categorically associated word pairs and these are the only associated word pairs included in this experiment. The categorically related word pairs were also included as a check of whether priming is found for these word pairs in a nonsemantic processing condition when subjects are forced to attend to the prime. However, it was not expected that there will be priming for these word pairs given that there was none found when the prime was processed semantically. Since there was no evidence of priming for the asymmetrical word pairs, mediated word pairs or size related word pairs, these word pairs were not included.

Methods

Subjects

Fifty-six Rice University undergraduates participated in this experiment for course credit.

Materials

The categorically associated word pairs and categorically related word pairs were taken from Experiment 3. Two word lists were created such that a target preceded by its related prime in one list was preceded by an unrelated control in the other list. Each list contained 12 associated prime-target word
pairs, 12 related prime-target word pairs, and 24 unrelated control word pairs. Seventy-six unrelated filler trials were added to lower the proportion of related word pairs to 19%. Subjects completed one word list.

Procedure

The procedure is identical to that used before in Experiment 3 except subjects were required to read the prime word aloud before naming the target word color. There was a 700 ms interval between naming the prime and presentation of the target and a 1 s interval between trials. Practice with both the colors and the task was the same as the previous experiment. The experimenter recorded both prime and target responses on a score sheet.

Results

Mean reaction times to the targets in the associated and related conditions are presented in Table 9. Before analyzing the data, trials on which the voice key malfunctioned were removed (1%). Trials on which subjects made an error on the prime (.003) or an error on the target (2%) were also removed before the analyses. As shown in the table, there is evidence of priming for the associated word pairs, t(55)=2.01, p < .05, but no evidence of priming for the related word pairs, t < 1. Thus, it is possible to find associative priming in a nonsemantic prime processing condition when the subject is forced to attend to the prime. As expected, there was no evidence of priming for the related word pairs.
Table 9

Mean Reaction Times for Associated and Related Word Pairs

<table>
<thead>
<tr>
<th></th>
<th>Associated</th>
<th>Related</th>
</tr>
</thead>
<tbody>
<tr>
<td>Critical</td>
<td>779</td>
<td>763</td>
</tr>
<tr>
<td>Control</td>
<td>753</td>
<td>778</td>
</tr>
<tr>
<td>Difference</td>
<td>-25*</td>
<td>+15</td>
</tr>
</tbody>
</table>

*p < .05

Discussion

When subjects are forced to attend to the prime word, even though they are not forced to process this word semantically, priming is found for associated word pairs. This is similar to findings reported previously in the literature when using the modified Stroop task (e.g. Warren, 1972, 1974; Henik et al., 1983). The results here indicate that in the previous experiment, when subjects read the prime to themselves, some subjects may have ignored the prime while doing the task.

As in Experiment 3, it is evident that the data from this task tends to be noisy. Only after testing a large number of subjects (e.g., 56) was it possible to find a significant effect for the associated word pairs. As mentioned previously, subjects are interfered with in naming the color of the target on every trial. The amount of priming is measured as greater interference on the critical trials compared to the control trials. The number of trials on which
interference might occur may be small for each subject making it more
difficult to find a significant priming effect.

GENERAL DISCUSSION

The experiments reported here have implications for the notion of what
priming is and also for the debate concerning autonomous versus interactive
processing between levels of knowledge. I will first summarize the results
from all the experiments and then discuss how they bear on these issues.

Summary of Results from all Experiments

Both associated and relatedness priming was found when subjects
were required to make a living decision about a word. However, only
associated priming was found in the modified Stroop task when subjects
processed the prime either nonsemantically or semantically. It was
suggested that the priming for the related word pairs in the living judgment
experiments arose from priming of the decision process rather than priming
of the actual conceptual representation. If priming were occurring at a
conceptual level, one would expect priming for related word pairs regardless
of whether the decision to be made was the same. A final experiment which
used size judgments rather than living judgments demonstrated that there is
no priming for word pairs that belong to the same category but require a
different semantic decision. Also, there was no priming for word pairs that
shared the same decision but which were not semantically related.
Although there was never any evidence of priming for the mediated word pairs, it may not be the case that a lack of mediated priming indicates that subjects are using strategies while doing the task. There was no evidence of priming for the backward asymmetrical word pairs, which one would predict if the priming was occurring automatically. Furthermore, the modified Stroop task is set up in such a way that using strategies that rely on the prime-target relationship would hinder rather than help subjects in doing the task. In the living judgment tasks, there was always a small, nonsignificant effect of priming for the mediated word pairs. As suggested earlier, it may be harder to find a mediated priming effect in a semantic judgment task since the facilitation a mediated prime provides for a target word is at the lexical level. Because lexical access is faster for the target word following a mediated prime, one would expect access to conceptual information to be faster as well, which should result in facilitation in making the semantic decision. However, in lexical decision, mediated priming effects tend to be smaller than direct priming effects (e.g., Shelton & Martin, 1992). Therefore, there may only be a small advantage in accessing conceptual information and, across several of the living judgment experiments, there was a small, nonsignificant effect of mediated priming. Because semantic judgments take longer, slowing decision times in general, it may be harder to find a significant effect in reaction time for mediated word pairs.

**What is semantic priming?**

It was argued in the introduction that automatic priming in lexical decision and pronunciation taps into a lexical knowledge level, rather than a
conceptual knowledge level since subjects can perform the task without having to access conceptual knowledge. It was hypothesized that forcing subjects to access semantic knowledge while doing the task might lead to priming at a conceptual knowledge level. At first, this hypothesis appeared to be supported when subjects were required to make semantic judgments. However, semantic priming was not found when subjects processed the prime semantically and the target nonsemantically (Experiment 3) nor when both prime and target were processed semantically but a different semantic decision was required for each (Experiments 2 and 5).

These findings imply that the widespread notion of automatic priming as an effect that uncovers a general spread of activation through a knowledge network is incorrect. If priming were due to the spread of activation from a concept to all its related concepts (concepts that share many semantic features), one would have found a priming effect for related word pairs regardless of whether these word pairs required the same semantic decision or not. In the Collins and Loftus (1975) spreading activation model, priming was predicted to occur between concepts that shared many features in common. For example, if both the prime and target are birds these concepts should be linked in a knowledge network because they share the same semantic features. However, priming was not found for related word pairs if the decision between the prime and target was different (i.e., the prime represented a small object while the target represented a large object; e.g., "sparrow-eagle"). It might be that only the semantic features associated with a concept that are relevant to the decision are activated in the knowledge network. This explanation seems plausible for the results from
the first two experiments where subjects made animacy or living judgments about words. For example, consider the target word "lion" where the related prime is "dog" and the unrelated prime is "rose". To decide a "dog" is living, one might activate semantic features such as "mammal", "eats", or "breathes". These same features could also be activated to decide a "lion" is a living object as well. However, very different features would be activated to decide a "rose" is a living object (e.g., "grows", "needs water"). Therefore, even though the same decision is required for both primes (critical and control) and the target, different features associated with each object would be activated to make the decision. The features associated with the critical prime are the same as those features activated for the target resulting in a faster decision time in the related condition. Thus, one might conclude that spreading activation in a conceptual knowledge network does occur but that it is limited to features required to make the decision.

Consider, however, the results from Experiment 5 (size judgments) where it was shown that priming only occurred for related word pairs that shared the same decision. Is the size of an object a semantic feature of an object? Consider, for example, target "finger" and the primes "mouth" and "leg". Subjects were facilitated in making the decision to "finger" when it was preceded by "mouth" but not when it was preceded by "leg" even though these concepts are all semantically related (they should be connected in a knowledge network). For these concepts, one would not expect "small body part" or "large body part" as a semantic feature. Yet, the explanation described above would predict that the priming occurred because the semantic features required for the decision were the same for "mouth" and
"finger". Thus, "small body part" would have to be predicted as a semantic feature of these concepts. However, it is likely that if subjects were asked to list features of these objects, "small body part" would not be one of them (especially since size is a relative concept). A more likely explanation of the results from the semantic decision experiments is that subjects use certain information about an object to make their decision and when the information needed to make the decision is similar on the next trial subjects are faster at making their decision. That is, having just thought about an object in a certain way (e.g., a body part that is small) it is easier to encode the next object in the same way. Thus, activation may not spread between concepts which share the same information (i.e., semantic features) required for making the decision. Rather, the decision is facilitated when the prime and target are encoded using the same information associated with the decision process.

The explanation suggested above is similar to the "encoding specificity principle" proposed by Tulving (1983). According to this principle, remembering an event occurs only when the information provided in a retrieval cue is similar enough to the information stored in the memory trace of that event. In the context of the research reported here, the facilitation for the related word pairs comes about from having just retrieved specific information about an item which, in turn, facilitates retrieving similar or identical information on the next trial. The information which has just been used to make a semantic decision could be considered the retrieval cue. When the information in the cue is similar enough to the memory trace of the next item, subjects can retrieve that information faster, which speeds their response.
To salvage the spreading activation explanation of the results reported in these experiments, some might argue that size could be a semantic feature. However, one could come up with a semantic judgment task where the judgment would not be expected to be a semantic feature of objects but the concepts do require the same decision. For example, the semantic decision could be, "is it native to North America?" and prime-target pairs could be things like, primes: "bison" or "emu", target: "eagle", or, primes: "monkey" or "bear", target: "camel". I would predict one would find priming when the decision remains the same between prime and target but not when it switches. (It is hard to believe that "native to North America" or "not native to North America" is a semantic feature of these concepts) If priming did occur for these word pairs, it could be argued more strongly that the priming results from similar information used to make the decision between the prime and target rather than any spreading activation between semantic features in a conceptual knowledge network. It would be beneficial to try to test this hypothesis with as many types of semantic decisions as possible. The only limitation is that it is difficult to come up with appropriate semantic decisions where word pairs could be created and the decision is either the same or different between the prime and target.

If it is the case that the facilitation being measured in a semantic judgment task results from similarity in the information used to make the decision for both the prime and target, then it is not possible to use this task as a way to measure spreading activation at a semantic knowledge level. As discussed in the introduction, de Groot (1990) used a semantic judgment task to examine priming at two knowledge levels, a lexical knowledge level and a
conceptual knowledge level. As noted earlier, all the word pairs she used in her studies were associated and one could not determine if the priming was occurring at a lexical or conceptual level. However, even if de Groot had used semantically related, unassociated word pairs, the results from the experiments reported here indicate that nay facilitation observed for such pairs would not be due to spreading activation but to overlap in the information needed to make a decision for the prime and target.

**Autonomous versus Interactive Processing: The Modularity Issue**

The cognitive architecture presented in the introduction specified different levels of knowledge within a language processing system although interaction of information between levels was not discussed. Considerable debate has been carried out concerning the influence, if any, of higher level processing on lower level processing, at least during the initial processing of a stimulus (see for example, McClelland, 1988; Forster, 1985). Proponents of autonomous processing suggest that there is little or no influence of higher level processing on lower level processing. Much of the research supporting this view has looked at conceptual level influences on lexical access. For example, many researchers interpret the findings from the ambiguity resolution literature, initial access to both senses of an ambiguous word, as support for autonomy (e.g., Swinney, 1979; Tanenhaus et al., 1979; Seidenberg et al., 1982; Conrad, 1974). However, some research has suggested that strongly biasing contexts do lead to initial access of only the appropriate sense of the ambiguous word (Simpson, 1981; Tabossi, 1988a). As argued earlier, it is unclear that the results from these studies reflect automatic rather than controlled processing. Conrad (1974) and Oden and
Spira (1983) used a modified Stroop task to investigate priming for both senses of an ambiguous word and found interference in naming for both senses, even following a biasing context. These are perhaps the only studies in which it could be assumed that the priming found was due to automatic rather than controlled processing and the results support an autonomous view of processing.

An advocate for interactive processing, McClelland (1988) has suggested that the findings in the ambiguity resolution literature are misleading. He argues that looking across many studies, one finds a small advantage for the appropriately biased sense of the ambiguous word and this is what one would predict given the influence of context on lexical access. McClelland further argues that the biasing contexts which have been used in these studies are not especially biasing to one interpretation of the ambiguous word and thus, the effect of context has not been manipulated appropriately. Once again, however, the results of most of these studies remain questionable as to the nature of the priming effect. Only two studies skirt this issue. Thus, there is little evidence with regard to this literature to support either the autonomous or interactive processing position.

Unfortunately, the ambiguity resolution research is continually cited as the main body of evidence for the autonomy/interactive issue and proponents of either side of this issue believe these data must be accounted for in either type of model. Little other research has been conducted using different methodologies and different types of stimulus items to look at the issue of autonomous versus interactive processing. In fact, McClelland (1988)
suggests that more research which directly manipulates the influence of higher level information on lower level processing needs to be done. He reports a study of his which demonstrated that prior lexical context influenced later phonetic discrimination and argues that this demonstrates higher level influences on lower level processing. However, the issue of conceptual level influences on lexical processing is not addressed in this experiment.

The data from the modified Stroop experiments reported here directly bear on this issue. From an interactive perspective, one would predict that semantic processing of the prime should influence lexical processing of the target. To control for the effect being an intra-lexical effect, that is, occurring within the lexical knowledge level, word pairs that were semantically related but unassociated were used, as well as associated word pairs. The findings showed no influence of conceptual level processing on lexical processing; that is, no priming was found for the semantically related, unassociated word pairs. Only word pairs that had strong connections at a lexical level influenced processing of the target words. In fact, it was shown that these connections had to be fairly strong as the functionally associated word pairs which had only a weak associative link showed no priming effect even though these word pairs were rated as very highly related. Assuming that the priming effects were due to automatic rather than controlled processing, these results suggest that initial lexical processing is not influenced by higher level conceptual knowledge. Thus, these data support an autonomous processing view.

It should be mentioned that the results from the modified Stroop experiment demonstrate that spreading activation is occurring at the lexical
knowledge level. Priming for strongly associated concepts was demonstrated in both the nonsemantic and semantic prime processing conditions. Also, it is likely that spreading activation was occurring at a semantic level as well (at least in the semantic prime processing conditions) but that the information that was activated at the conceptual level did not "flow back down" to influence the access of the lexical target item. For example, when a subject made a semantic decision to the word "oak", features connected to that concept became activated to allow the subject to make the decision. Most likely, other concepts which shared those features became activated as well (e.g. "maple"). However, the information that was activated at a conceptual level did not feed back to the lexical level to influence the lexical access of words which shared the features that were activated when the subject made a semantic decision about the prime concept. A proponent of an interactive system would predict that there must be conceptual influence on lexical access and would predict interference in naming the color a target word is presented in when that target word is semantically related to the prime. The data presented here did not support this prediction.

One possible explanation for the lack of priming for semantically related, unassociated word pairs which would "save" the interactive position is the timing parameters between the prime and target - either the time was too long or too short. On the one hand, it might be argued that there was not enough processing time between the prime and target for the conceptual information to influence lexical access. It took subjects approximately 700 ms to make their decision to the prime (in the semantic processing conditions) and there was a 500 ms interval before the target was presented. It might be
argued that more time would be needed between the prime and target to find an effect of context on lexical access. However, by the time the subjects made their decision quite a bit of conceptual processing must have occurred (given that they made an accurate decision). If context was to have an effect on lexical access, it would seem necessary for this influence to occur immediately. Yet, there was more than 1 second between the initial processing of the prime and the presentation of a target. What good would immediate influence of conceptual information on lexical access be if it took over 1 second to exert that influence? Certainly we can read and understand a short sentence within 1 to 1.5 seconds. According to the above argument, the influence of context on our understanding of each word and the sentence as a whole would not start to occur until after the sentence was read. This does not appear to be what is meant by an interactive system in which higher level processing immediately influences lower level processing. On the other hand, one might suggest that there was too much time between the decision to the prime and the presentation of a target. That is, the influence of conceptual information has died out by the time the target is presented. However, data suggest that the lexical information associated with a concept stays active more than 500-750 ms since it is possible to find priming effects in lexical decision even when the onset of the prime and the onset of the target are separated by approximately 1200 ms (e.g., Shelton & Martin, 1992). The arguments which suggest that the time parameter between prime and target may not have been sufficient to find a semantic priming effect are weak at best but the question is ultimately an empirical one. Experiments which vary the time between prime and target could be carried out to
determine if this parameter changes the findings presented in this dissertation.

It would seem that the influence of context on lexical access would be beneficial to a processing system that works as quickly and accurately as ours does. Context would be able to guide access to lexical items which would allow us to process these items faster and without using a great deal of processing capacity or attentional resources. However, immediate contextual influence could also be seen as detrimental to processing. If semantic information influenced lexical access, many lexical competitors could become activated from the conceptual information and only through a slow, serial process could we distinguish the correct lexical item. This would not only slow our processing time but also increase the processing capacity or attentional resources we need, for example, to read a word. It might be more beneficial for context to play a later role in processing, one which helps to integrate selected lexical items with previous information after lexical access has occurred.

Further research should be carried out which directly manipulates various kinds of semantic contexts to determine if any semantic context influences lexical processing. As stated repeatedly throughout this paper, one must be careful to use a task which minimizes subject strategies so that the effects can be attributed to initial processing. The modified Stroop task seems to be a task which fulfills this criterion. However, this task may not be the most desirable given the fact that large priming effects may not be significant because of the difficulty of the task (which increases the "noise" in the data). Also, one must take care to ensure that the stimuli truly reflect
interlevel processing rather than intralevel processing; that is, one must control for associative relationships between the stimuli. For example, one could use the modified Stroop task and manipulate strength of biasing context on access to ambiguous words, controlling for the associations between words in the sentence and the target item as well as associations between the prime and target. By taking care to minimize the effects of controlled processing and word associations, there is the potential for a variety of research issues that could provide further evidence concerning the autonomous/interactive processing issue.
Footnotes

1. It should be noted that the associated word pairs may also be conceptually related. The critical difference between these two types of word pairs is whether the target is often generated as a free association response when the prime is read.

2. A more detailed derivation of the predictions from this model as to the types of priming effects one might expect for semantically related words will be discussed in a later section.

3. Priming in this task is measured as the amount of interference in naming the color a target word is printed in when this target is preceded by a critical (related) prime as compared to the same target preceded by a control prime.

4. Although she found evidence of priming for related, unassociated concepts it is not clear the effect was due to automatic rather than controlled processing. This issue is considered below.

5. The original idea for this dissertation was to use the cross-modal lexical decision task and sentence processing as a way to manipulate semantic processing of the prime. The initial pilot study using this task found no evidence of priming for either associated or related word pairs. A second pilot experiment which increased the number of related trials in the stimulus set (to 40%) demonstrated a marginally significant effect (with 36 subjects) of priming for both the associated word pairs and the related word pairs. However, there is no evidence concerning whether this effect was due to automatic or strategic processing. My own intuition suggests it is likely this effect came about because subjects were using strategies which made use of the relationship between the prime and target to help them make their lexical
decision. In fact, subjects might be more likely to use strategies given the
difficulty of this task.

6. Only concrete nouns are being considered in this discussion.

7. In the living judgment experiment, functionally related and associated
pairs were not included since making a living judgment to an action would be
confusing to the subject. All functional targets, including those in the
unrelated filler trials, were replaced with concrete nouns.

8. In the initial data analyses, outliers (defined as reaction times greater than
3 standard deviations above or below the mean) were removed. When this
was done, there were no significant effects for any word pairs in any of the
prime processing conditions. Also, when medians are used as the
dependent measure, there are no significant effects for any of the word pairs
in any of the prime processing conditions. These results suggested that the
outliers might actually contain critical data and, therefore, these reaction
times were put back into the analyses. The new analyses showed some
significant effects (e.g., categorically associated word pairs) in the semantic
prime processing conditions. Frequency counts were calculated for reaction
times that were 1.5 standard deviations above the mean for each of the word
pairs in each of the prime processing conditions. For the categorically
associated word pairs in the semantic prime processing conditions, 12.5% of
the reaction times were 1.5 standard deviations above the mean when the
target was preceded by a critical prime as compared to 3.5% of the reaction
times when the target was preceded by a control prime. There was also
significant priming for the forward associates across prime processing
conditions. For these word pairs, 9% of the reaction times were of the
reaction times were 1.5 standard deviations above the mean when the target was preceded by a critical prime as compared to 4% of the reaction times when the target was preceded by a control prime.
References


Appendix 1: Associated, Mediated and Related Word Pairs from the Animacy Judgment Task

<table>
<thead>
<tr>
<th>Mediated Prime</th>
<th>Mediated Target</th>
<th>Associated Prime</th>
<th>Associated Target</th>
<th>Related Prime</th>
<th>Related Target</th>
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</thead>
<tbody>
<tr>
<td>deer</td>
<td>vegetable</td>
<td>sofa</td>
<td>chair</td>
<td>table</td>
<td>bed</td>
</tr>
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<td>lawyer</td>
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<td>foot</td>
<td>train</td>
<td>canoe</td>
</tr>
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<td>army</td>
<td>navy</td>
<td>jeep</td>
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<td>gun</td>
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<td>mouse</td>
<td>butter</td>
<td>bread</td>
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<td>pan</td>
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<tr>
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<td>fox</td>
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<td>snake</td>
<td>flea</td>
<td>ant</td>
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<td>aunt</td>
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<td>daisy</td>
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<td>tiger</td>
<td>lion</td>
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<tr>
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<td>milk</td>
<td>sword</td>
<td>knife</td>
<td>floor</td>
<td>wall</td>
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<td>tree</td>
<td>syrup</td>
<td>ounce</td>
<td>pound</td>
<td>soup</td>
<td>juice</td>
</tr>
<tr>
<td>clam</td>
<td>pearl</td>
<td>cotton</td>
<td>wool</td>
<td>dog</td>
<td>lion</td>
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<tr>
<td>mane</td>
<td>tiger</td>
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<td>woman</td>
<td>bear</td>
<td>cow</td>
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<tr>
<td>drink</td>
<td>soap</td>
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<td>queen</td>
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<td>hat</td>
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<td>lemon</td>
<td>sweet</td>
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<td>dog</td>
<td>shark</td>
<td>trout</td>
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<tr>
<td>tea</td>
<td>bean</td>
<td>boy</td>
<td>girl</td>
<td>spider</td>
<td>ant</td>
</tr>
<tr>
<td>pants</td>
<td>collar</td>
<td>brush</td>
<td>comb</td>
<td>knife</td>
<td>hammer</td>
</tr>
<tr>
<td>winter</td>
<td>swim</td>
<td>nurse</td>
<td>doctor</td>
<td>magazine</td>
<td>poem</td>
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Appendix 2: Associated word pairs to be used in Experiment Two

<table>
<thead>
<tr>
<th>Animate Prime</th>
<th>Inanimate Prime</th>
<th>Animate Target</th>
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<td>bird</td>
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<tr>
<td>fish</td>
<td>stream</td>
<td>trout</td>
</tr>
<tr>
<td>animal</td>
<td>dam</td>
<td>beaver</td>
</tr>
<tr>
<td>cat</td>
<td>bark</td>
<td>dog</td>
</tr>
<tr>
<td>bug</td>
<td>hill</td>
<td>ant</td>
</tr>
<tr>
<td>bee</td>
<td>sting</td>
<td>wasp</td>
</tr>
<tr>
<td>nurse</td>
<td>medicine</td>
<td>doctor</td>
</tr>
<tr>
<td>student</td>
<td>school</td>
<td>teacher</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Inanimate Prime</th>
<th>Animate Prime</th>
<th>Inanimate Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>shirt</td>
<td>girl</td>
<td>blouse</td>
</tr>
<tr>
<td>cotton</td>
<td>lamb</td>
<td>wool</td>
</tr>
<tr>
<td>drill</td>
<td>dentist</td>
<td>teeth</td>
</tr>
<tr>
<td>auto</td>
<td>mechanic</td>
<td>car</td>
</tr>
<tr>
<td>spear</td>
<td>whale</td>
<td>harpoon</td>
</tr>
<tr>
<td>hatchet</td>
<td>indian</td>
<td>tomahawk</td>
</tr>
<tr>
<td>sea</td>
<td>mermaid</td>
<td>ocean</td>
</tr>
<tr>
<td>food</td>
<td>grocer</td>
<td>store</td>
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</table>
**Appendix 3: Critical Word Pairs: Modified Stroop Experiment**

<table>
<thead>
<tr>
<th>Categorically Related</th>
<th>Functionally Related</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Associated Related</strong></td>
<td><strong>Associated Related</strong></td>
</tr>
<tr>
<td>mother-father</td>
<td>shark-trout</td>
</tr>
<tr>
<td>stream-river</td>
<td>tulip-orchid</td>
</tr>
<tr>
<td>uncle-aunt</td>
<td>cobra-python</td>
</tr>
<tr>
<td>moon-sun</td>
<td>airplane-truck</td>
</tr>
<tr>
<td>man-woman</td>
<td>fox-rabbit</td>
</tr>
<tr>
<td>mountain-hill</td>
<td>robin-owl</td>
</tr>
<tr>
<td>boy-girl</td>
<td>elephant-deer</td>
</tr>
<tr>
<td>infant-child</td>
<td>elm-pine</td>
</tr>
<tr>
<td>queen-king</td>
<td>pig-goat</td>
</tr>
<tr>
<td>engine-motor</td>
<td>cannon-bomb</td>
</tr>
<tr>
<td>detective-police</td>
<td>flea-ant</td>
</tr>
<tr>
<td>road-street</td>
<td>sailboat-submarine</td>
</tr>
<tr>
<td>wolf-dog</td>
<td>cow-bear</td>
</tr>
<tr>
<td>carpet-rug</td>
<td>trumpet-drum</td>
</tr>
<tr>
<td>donkey-mule</td>
<td>giraffe-zebra</td>
</tr>
<tr>
<td>blanket-sheet</td>
<td>goldfish-perch</td>
</tr>
<tr>
<td>lizard-snake</td>
<td>oak-maple</td>
</tr>
<tr>
<td>brush-comb</td>
<td>violin-clarinet</td>
</tr>
<tr>
<td>mouse-rat</td>
<td>canary-finch</td>
</tr>
<tr>
<td>dime-nickel</td>
<td>pan-bowl</td>
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<tr>
<td>moth-gnat</td>
<td>wasp-roach</td>
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<tr>
<td>gloves-mittens</td>
<td>pistol-spear</td>
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<tr>
<td>sheep-lamb</td>
<td>whale-dolphin</td>
</tr>
<tr>
<td>tie-shirt</td>
<td>bicycle-bus</td>
</tr>
<tr>
<td>Size Related</td>
<td>Mediated</td>
</tr>
<tr>
<td>----------------------------</td>
<td>-------------------</td>
</tr>
<tr>
<td>walrus-policeman</td>
<td>lion-stripes</td>
</tr>
<tr>
<td>ladybug-squirrel</td>
<td>oyster-necklace</td>
</tr>
<tr>
<td>sycamore-skyscraper</td>
<td>deer-vegetable</td>
</tr>
<tr>
<td>minnow-bug</td>
<td>tooth-hair</td>
</tr>
<tr>
<td>couch-jeep</td>
<td>cat-cheese</td>
</tr>
<tr>
<td>book-shoe</td>
<td>beach-box</td>
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<tr>
<td>yacht-sink</td>
<td>tree-syrup</td>
</tr>
<tr>
<td>mug-earring</td>
<td>keg-wine</td>
</tr>
<tr>
<td>panther-daughter</td>
<td>nurse-lawyer</td>
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<tr>
<td>worm-pea</td>
<td>soap-drink</td>
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<tr>
<td>cougar-plumber</td>
<td>window-knob</td>
</tr>
<tr>
<td>frog-button</td>
<td>circle-dance</td>
</tr>
<tr>
<td>cabinet-harpoon</td>
<td>bull-milk</td>
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<tr>
<td>paperclip-nail</td>
<td>flower-thorn</td>
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<tr>
<td>canoe-office</td>
<td>lifeguard-sand</td>
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<tr>
<td>dart-radio</td>
<td>clam-pearl</td>
</tr>
<tr>
<td>princess-camel</td>
<td>moon-hot</td>
</tr>
<tr>
<td>guppy-rodent</td>
<td>tea-bean</td>
</tr>
<tr>
<td>chef-grandma</td>
<td>school-stop</td>
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<tr>
<td>gerbil-toad</td>
<td>pen-lead</td>
</tr>
<tr>
<td>pliers-kettle</td>
<td>pants-collar</td>
</tr>
<tr>
<td>jet-bank</td>
<td>bracelet-watch</td>
</tr>
<tr>
<td>card-can</td>
<td>ceiling-carpet</td>
</tr>
<tr>
<td>tanker-mall</td>
<td>phone-letter</td>
</tr>
</tbody>
</table>

*listed in forward direction
Appendix 4: Frequency of Difference Scores for Forward Associates in Experiment 3: Living Judgments
Appendix 4 (cont.): Frequency of Difference Scores for Forward Associates in Experiment 3: Size Judgments
Appendix 4 (cont.): Frequency of Difference Scores for Forward Associates in Experiment 3: Read Prime
Appendix 5
Critical Word Pairs used in Size Judgment Experiment

<table>
<thead>
<tr>
<th>PRIMES</th>
<th>TARGETS</th>
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<tbody>
<tr>
<td><strong>UNRELATED</strong></td>
<td><strong>RELATED</strong></td>
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<tr>
<td>pencil</td>
<td>chair</td>
</tr>
<tr>
<td>button</td>
<td>sofa</td>
</tr>
<tr>
<td>drum</td>
<td>flea</td>
</tr>
<tr>
<td>trumpet</td>
<td>tulip</td>
</tr>
<tr>
<td>daisy</td>
<td>cannon</td>
</tr>
<tr>
<td>orchid</td>
<td>spear</td>
</tr>
<tr>
<td>banana</td>
<td>tank</td>
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<tr>
<td>airplane</td>
<td>cherry</td>
</tr>
<tr>
<td>plum</td>
<td>car</td>
</tr>
<tr>
<td>bus</td>
<td>lemon</td>
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<td>carrot</td>
<td>train</td>
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<tr>
<td>truck</td>
<td>pea</td>
</tr>
<tr>
<td>potato</td>
<td>shotgun</td>
</tr>
<tr>
<td>bicycle</td>
<td>onion</td>
</tr>
<tr>
<td>pliers</td>
<td>taxi</td>
</tr>
<tr>
<td>jeep</td>
<td>chisel</td>
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<tr>
<td>paperclip</td>
<td>carriage</td>
</tr>
<tr>
<td>violin</td>
<td>spoon</td>
</tr>
<tr>
<td>pen</td>
<td>clarinet</td>
</tr>
<tr>
<td>needle</td>
<td>guitar</td>
</tr>
<tr>
<td>trombone</td>
<td>pin</td>
</tr>
<tr>
<td>disk</td>
<td>oboe</td>
</tr>
<tr>
<td>preacher</td>
<td>eye</td>
</tr>
<tr>
<td>wagon</td>
<td>vitamin</td>
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<td>mountain</td>
<td>nose</td>
</tr>
<tr>
<td>ship</td>
<td>key</td>
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<td>tractor</td>
<td>hand</td>
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<tr>
<td>wallet</td>
<td>synagogue</td>
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Appendix 6: Analysis by Items for All Experiments

Experiment One: Animacy Judgments

Associated \( t(19) = 3.26, p < .05 \)
Related \( t(19) = 1.85, p = .08 \)
Mediated \( t(19) < 1 \)

Experiment Two: Living Judgments

Associated \( t(31) = 2.01, p < .05 \)
Related \( t(19) = 2.46, p < .05 \)
Mediated \( t(19) = 1.36, p = .18 \)

Experiment Three: Modified Stroop Task

Nonsemantic Prime Processing

Categorically Related

Associated \( t(23) < 1 \)
Related \( t(23) < 1 \)

Functionally Related

Associated \( t(23) = 1.42, p = .14 \)
Related \( t(23) < 1 \)

Asymmetrical

Forward \( t(23) < 1 \)
Backward \( t(23) < 1 \)
Mediated \( t(23) < 1 \)

Size Related \( t(23) = 1.39, p = .18 \)

Semantic Prime Processing: Living Judgments

Categorically Related

Associated \( t(23) = 1.59, p = .12 \)
Related \( t(23) < 1 \)

Functionally Related

**Appendix 6 continued**

Associated \( t(23) < 1 \)
Related \( t(23) = 1.23, p = .22 \)

Asymmetrical

Forward \( t(23) = 1.89, p = .07 \)
Backward \( t(23) = < 1 \)

Mediated \( t(23) = 1.01, p = .31 \)

Size Related \( t(23) = 1.20, p = .24 \)

Semantic Prime Processing: Size Judgments

Categorically Related

Associated \( t(23) = 1.78, p = .08 \)
Related \( t(23) = 1.15, p = .26 \)

Functionally Related

Associated \( t(23) < 1 \)
Related \( t(23) < 1 \)

Asymmetrical

Forward \( t(23) < 1 \)
Backward \( t(23) < 1 \)

Mediated \( t(23) < 1 \)

Size Related \( t(23) = 1.03, p = .31 \)

Experiment Four: Living Judgments

Categorically Related

Associated \( t(23) = 3.24, p < .05 \)
Related $t(23) < 1$

Asymmetrical

Forward $t(23) < 1$
Backward $t(23) < 1$

Mediated $t(23) = 1.24$, $p = .16$

Appendix 6 continued

Size Related $t(23) < 1$

Experiment Five: Size Judgments

Same Category

Same Size $t(27) = 2.00$, $p < .05$
Different Size $t(27) < 1$
Unrelated Same Size $t(27) < 1$

Experiment Six: Modified Stroop Task - Nonsemantic Prime Processing II

Categorically Related

Associated $t(23) = 1.03$, $p = .31$
Related $t(23) < 1$