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ON THE DIRECT ACCESS TO SEMANTIC MEMORY: DIFFERENCES BETWEEN WORDS AND MEANINGS

The Ohio State University

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ON THE DIRECT ACCESS TO SEMANTIC MEMORY:
DIFFERENCES BETWEEN WORDS AND MEANINGS

Presented in Partial Fulfillment of the Requirements for
the Degree Doctor of Philosophy in the Graduate School of
The Ohio State University

By
Marilyn Turner Lyga

****

The Ohio State University
1982

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# VITA

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<td>Born Roanoke, Virginia</td>
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<td>1976</td>
<td>B.S. Virginia Polytechnic Institute and State University Blacksburg, Virginia</td>
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<td>1981-1982</td>
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## Publications


Turner, M., Balascio, B., "The effect of a shift to increment or decrement reward conditions on rats trained with unpredictable stimulus features", Presented at the Southeastern Psychological Association in March, 1976.
Areas of Study

Experimental Psychology
Dr. Neal Johnson

Counseling Psychology
Dr. Don Dell
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INTRODUCTION

When a person hears a word such as "orange", a multitude of information comes to mind almost immediately. The person may form an image of the citrus fruit by that name, remember an object of that color, or a miriad of other associations. This process of word understanding has interested psychologists for years. How is it that an individual is able to retrieve such a vast amount of information about a word almost effortlessly? In psychological terms, this can be restated as: what is the organization of semantic memory, and how is a person able to use this stored information?

Semantic versus Lexical Memory

A classic study designed to investigate the structure of semantic memory was performed by Brown and McNeil (1966). They were interested in a phenomenon they termed tip-of-the-tongue, which occurs to everyone when they can almost, but not quite, remember a word. They gave subjects definitions of words, and asked them to
name the word that was being defined. When the subject felt s/he was in the TOT state, meaning that s/he knew the definition, but couldn't quite recall the word name, Brown and McNeill found that the subject was able to report some characteristics of that word. People usually knew how many syllables were in the word, the initial letter, or where the accent occurred. Brown and McNeill proposed that when a word is stored in memory, both its meaning and its sound are stored along with it. In addition, they suggested that each word had associations to other words that were similar in meaning. Each word, along with its collection of information, was related to other words through a large set of interconnecting associations.

Loftus and Cole (1974) also found evidence supporting the hypothesis that word meanings and physical attributions are interconnected by associations. They presented subjects with a category name, an adjective, and a letter, and asked them to name the word that corresponded to these three clues. (For example: animal-small-m; with the answer being mouse.) They varied the presentation sequence of these clues such that subjects received category-adjective-letter combinations some of the time, and category-letter-adjective sequences other times. They found that when subjects received the
letter before the adjective, they were slower at knowing what word was being clued than when they received the adjective before the letter.

Loftus and Cole (1974) and later Collins and Loftus (1975) explained these findings by proposing a model in which conceptual information about a word is located separately from the name of the word itself. The names of words are stored in a lexical network called a dictionary, which is organized on the basis of phonemic and orthographic similarity. Along with each word name, is also stored those attributes that Brown and McNeill's (1966) subjects could remember about the word name, such as initial letter, how many syllables are in the word, and where the accent occurs. In addition, the name also contains an address telling where semantic information can be found within the semantic network.

The semantic network, on the other hand, is organized on the basis of semantic similarity. The more properties two concepts have in common, the shorter the semantic distance between the two concepts, and the more links they have in common with one another. These links differ in accessibility based on use. In other words, commonly used links may be stronger than lesser used links. For example, the robin and bird link would be strong-
er than the chicken-bird link, because we tend to use robin as an example of bird more often than we use chicken. Processing occurs by a spread of activation originating from each concept within the input stimuli, in a decreasing gradient throughout the network system, much like the waves a stone makes when thrown into the middle of a puddle. However, there is more activation of strong paths than weak ones, as explained earlier. Activation decreases with time and/or intervening activity, while rehearsal can prolong activation. In addition, each nodal intersection requires some threshold for firing. Activation from different sources can summate, and so fire a particular node that perhaps would not have been fired from one source alone.

Therefore, the Loftus and Cole (1974) experimental results can be explained by using this semantic network vs. lexical network distinction. When the noun is followed by the adjective and then by the letter, the subject can enter an appropriate cluster within the semantic network (because of the noun and adjective information) and then go to the lexical network's cluster of names of those instances to find the one with the appropriate letter. When the letter comes before the adjective, however, the subject could either wait for the adjective, or
else start in the semantic network (because of the noun information) then go to the lexical network to retrieve a large cluster of names, and then go back to the semantic network to verify which one matches the adjective. Both strategies could explain why the noun-letter-adjective condition was slower than the noun-adjective-letter condition.

In summary, then, one recent model for the organization of semantic memory proposes that word information is divided into two systems. One system, the lexical network, contains the word name, phonemic and orthographic information, as well as an address to the appropriate concept in the other system - the semantic network. The semantic network is organized on the basis of semantic similarity, such that each conceptual node contains a variety of conceptual information as well as links to other semantically related nodes. Those nodes that are used frequently, or contain overlapping information are closer together (figuratively speaking) than those nodes that do not.

The proposal that memory is divided into two networks, the lexical network and the semantic network, gives rise to a number of experimental questions. Is there some sort of mediated processing prior to lexical
access? Next, are the lexical and semantic systems dependent on one another? In other words, can there be semantic information available about a word without the word's name, and conversely, can the word's name be available without any kind of conceptual information? Related to this issue, is the question: which kind of information is available first? Does word processing require that the name of the word be available before any semantic information is available, or is there some semantic information available without the name? These topics will be discussed in the next few sections, and relevant data will be presented.

The Lexical Network

The traditional view of word processing assumes that word naming and semantic interpretation of that identification are the results of preliminary stages of processing. Initially, the visual representation of the word occurs and is briefly maintained in the form of an icon (Neisser, 1967). It was thought that this initial representation was literal and that the item could not be identified until later stages of processing occurred (Sperling, 1960). At this stage, a subject could only detect whether or not the representation was present, but could not identify the representation.
The next level of analysis was thought to involve the conversion of the image retained in the icon into a phonological representation. At this point, the word would be named (Gough, 1972). According to the traditional models of word processing, semantic interpretations only occur after the word is named (or encoded phonologically), and so semantic interpretations of a word would be the end of a string of different stages of analysis.

An example of the traditional model of word processing is the levels of processing model by Craik and Lockhart (1972). According to this model, there exists a series of analyzers that function on a continuum, and that process words according to the needs of the task. Structural analysis occurs in the first part of the continuum, while semantic analysis occurs last and only after all the other processes are finished. Therefore if the task demands only structural information about a word, then only structural analysis occurs. If, on the other hand, semantic information is required by the task, then analysis must include all levels prior to semantic analysis.

This model is consistent with studies of incidental learning by Craik and Tulving (1975). Subjects were
asked to read individual words, and then respond to a question regarding that word that could be answered either based on the word's structure (Is the word a capital letter?), phonemic processes (Does the word rhyme with ___?), or semantic processes (Does the word belong to the category ___? or Does the word fit into the following sentence?). After all the words were read and questions were answered, a recognition test was given for the words. It was found that memory for words that had to be semantically processed in order to answer the question was better than memory for words which required a more preliminary analysis, indicating to Craik and Tulving that the preliminary analysis had preceded the semantic analysis.

Other research using tasks similar to reading have indicated that people do use some of the preliminary stages of analysis discussed by the traditional models, at least in some circumstances. For example, one early study by Conrad (1964) showed that when subjects are required to report the letters contained in a briefly exposed display, the errors they made were usually ones acoustically similar to the actual letters. Another study by Corcoran and Weening (1968) found that when subjects were asked to proof-read prose passages, they could
detect the omission of pronounced letters easier than un-
pronounced letters. Recently, a study by Navon and
Shimron (1981) examined the naming of Hebrew words in
which vocalic information is usually presented by vowel
signs written below the letters. Hebrew speakers were
asked to name the Hebrew words by their letters only, dis-
regarding vowel signs. Naming was equally fast for words
with no vowel signs, words with incorrect vowel signs
which preserved the correct vowel sound, and words with
correct vowel signs. Naming was slowed by vowel markers
that were incompatible with the word sound, indicating to
Navon and Shimron that phonemic coding is part of word
processing.

One problem with all of these studies, however, is
that the task involved may somehow require the use of pho-
nemic encoding and so encourage regression to a stage
that is not normally used. In other words, phonemic en-
coding might be an optional stage of processing that is
used only when the task is such that a phonemic code
would facilitate performance.

Rubenstein, Lewis, and Rubenstein (1971) also were
interested in the role of the phonemic code in word pro-
cessing. The procedure they used to investigate this is
known as lexical decision. Most studies using this task
present letter strings to the subject, and require
him/her to decide whether or not the letter string is a
word. Reaction times and error rates are usually the
dependent measures.

Rubenstein et al theorized that during a lexical
decision task, the letter string is always converted to
its phonological representation. If gross illegalities
are found during this conversion, then processing stops.
If the phonological code is made, however, the subject
then compares the phonological representation of the
letter string with a set of phonological representations
stored in lexical memory and the order of comparison is
based on word frequency. If a match is found between the
phonological representation and a code in lexical memory,
the search process stops and a spelling check occurs.
This spelling check is necessary to detect any words that
sound like English words but have illegal spellings.

In their study, Rubenstein et al presented pro-
nounceable nonwords (i.e. gorch), pseudohomophones which
were made to sound like real English words (i.e. brane),
homophonic English words (i.e. sale), and nonhomophonic
words (i.e. desk) to subjects who were required to make a
lexical decision. They reasoned that if the subject rou-
tinely encoded all of the letter strings phonemically, as
their model predicts, then their performance should be influenced by the phonological properties of the letter string.

Rubenstein et al found that subject's negative responses were slowest for pseudohomophones (brane), as would be predicted from their model. They argued that this could occur because initially subjects encode all letter strings phonemically. Then, since these pseudohomophones sound like English words, they access a lexical representation. It is only when the spelling check occurs that the participant discovers that the letter string is actually a non-word.

A similar explanation can be used for the finding that positive response times were suppressed for homophonetic English words (sale). Again, the subject would make a phonemic representation, access a lexical representative, and then check the spelling. Some of the time, however, the spelling would not match (as in sale-sail), and so performances would therefore be slowed by these unsuccessful checks.

One problem with the Rubenstein, Lewis and Rubenstein (1971) study was that they confounded graphemic properties of letter strings (how much they look like English words) with phonetic properties (how
much they sound like English words). It could be argued that the reason performance to a word like brane was depressed, was because brane looked more like an English word than did a word such as gorch. Subjects could have been making their decisions based on the visual properties of the letter strings without using a phonemic encoding step.

Meyer, Schvanevelt, and Ruddy (1974) did a study that effectively eliminated this problem. Again the task was lexical decision, but this time the stimulus list consisted of letter-string pairs. Sometimes yes-item word pairs were graphemically and phonetically similar (such as bribe-tribe), while sometimes they were graphemically similar but phonetically dissimilar (freak-break). In addition, they included some word pairs that were semantically similar as well. If phonetic encoding is used, then performance on phonetically dissimilar pairs (freak-break) should be depressed, since one of the pairs might be pronounced as the other and therefore would not be a word. (For example: freak might be pronounced as break). If on the other hand, phonetic encoding is not used, then the two types of word pairs should be the same.
Meyer, Schvanevelt, and Ruddy's (1974) results indicated to them that subjects did use phonemic encoding to accomplish this task. Subjects' performance on word pairs that were graphemically similar but phonetically dissimilar was significantly inhibited, while performance on word pairs that were phonetically similar was slightly facilitated over that of controls. They also found that when the word pairs were semantically related, performance was increased.

It could be argued, however, that the Meyer, Schvanevelt, and Ruddy (1974) experimental task actually required the use of a phonemic encoding step that might not be used otherwise. As part of their experimental procedure, they included pronounceable nonword (or pseudoword) pairs as the "no" items. One argument might be, then, that subjects may have had difficulty in determining whether the nonwords were actually no items or were rare English words, and this may have caused them to use phonemic encoding as an extra step.

Shulman and Davison (1977), in fact, found that the lexical decision performance facilitation that occurred when two words were semantically related, could be manipulated by the type of foils used in the task. When they used nonwords, pseudowords, and related words in their
task, semantic facilitation decreased. They explained their results by stating that orthographic, phonemic, and semantic coding occurred in parallel with randomly determined completion times (but with semantic encoding usually taking longer). If phonemic or orthographic information is sufficient to resolve response uncertainty, then processing is terminated, while if semantic information is needed, then processing is extended. Therefore, the decrease in semantic facilitation occurred because of a shift in the optional processing mode used by the subject.

Shulman, Hornak, and Sanders (1978) hypothesized that the Meyer, Schvanevelt, and Rudy (1974) experimental results may have been influenced by the no items. They felt that a change in the nonword context from which the word pairs were to be discriminated would reduce the effects of phonetic similarity demonstrated by Meyer et al (1974) using pronounceable nonwords. Therefore, they performed the same experiment using orthographically and phonetically illegal letter strings as foils. If response latencies for word pairs that were phonetically related were equivalent to other word pairs, then it would imply that phonemic encoding is not used. If on the other hand phonemic encoding is used, then response
latencies for words that were phonetically similar would be facilitated.

They found that response times to words such as bribe and tribe were equivalent to words such as freak and break, and both were faster than the controls (couch-break), indicating that phonemic encoding was not used. They felt that their results indicated that phonemic coding is a storage aid to short-term-memory, and not a requirement for lexical access. Lexical access, then, may occur directly from a graphemic code, and so phonemic encoding could be viewed as an optional process that can be used if warranted by the task.

Clinical reports of certain brain-damaged patients provide corroborative evidence that phonemic encoding is not necessary for lexical access to take place. These patients suffer from an aphasic syndrome known as phonemic dyslexia that is caused by damage to the parietal lobe of the left cerebral hemisphere. When these patients are asked to read individual words out loud, their performance shows several interesting errors. First, nouns and adjectives are usually read correctly, while function words and abstract words are not even attempted. Next, some words evoke paralexic errors, in
which another word is substituted for the stimulus word that either matches it visually (origin-organ) derivationally (courage-courageous), or semantically (dream-sleep). Patients are also not able to read pronounceable nonwords (such as dake), but can repeat any of these if presented aurally (Marshall and Newcombe, 1973; Shallice and Warrington, 1975; Patterson and Marcel, 1977).

Marshall and Newcombe (1973) and Shallice and Warrington (1975), have interpreted these errors to indicate the operation of a direct encoding route, since the grapheme-phoneme route is inoperative. What this means, then, is that these patients are able to read words without encoding them phonemically. That is, they are able to access the lexicon without a phonemic encoding step. The fact that they make paralexic errors that are semantically based also indicates that this lexical access may not be precise, suggesting that the patient may have semantic information without a correct lexical identification.

This explanation was evaluated by a series of experiments done by Patterson and Marcel (1977). They compared the performances of both normal participants and phonemic dyslexic patients on several tasks involving
orthographically regular nonwords (such as widge, jub). In the first experiment, both groups were asked to read a series of these orthographically regular nonwords. While normal participants could do this without error, phonemic dyslexic patients could perform only when these words were presented aurally.

The second experiment asked subjects to make lexical decisions (Is this letter string a word?) on a group containing nonwords that sounded like real words (example: brane). Previous research had indicated that normal subjects were slower in responding to these type of stimuli because they tried to encode the nonword phonemically (Meyer, Schvanevelt, and Ruddy, 1974). Patterson and Marcel found that while the normal group was slower in responding to letter-strings containing homophonic nonwords, the phonemic dyslexic patients were not. What this indicates is that the normal subjects were hampered in their performance because they encoded the nonword strings phonetically which then made them equivalent to English words. The phonemic dyslexic patients, on the other hand, did not phonemically encode the nonword strings, and so were not hampered in their performance.

The data on the normal subjects in these experiments seems to agree with the previously discussed research
(Rubenstein, Lewis, and Rubenstein, 1971; Conrad, 1964; Concoran and Weening, 1968; and Meyer, Schvanevelt and Ruddy, 1974) that suggested that lexical access is mediated by phonological encoding. However, it must be remembered that other research has shown that the task involved here may have forced the normal subjects to use phonological encoding (Shulman, Hornak, and Sanders, 1978). In addition, the results of the phonemic dyslexic patients imply that graphemic-phonetic conversion is not the only means of accessing the lexicon. Since these patients are able to complete the task, and indeed are able to read some types of words, then there must be some sort of alternate route. Data from Shulman, Hornak, and Sanders (1978) would suggest that this type of encoding might come directly from the visual display. It seems feasible to conclude, then, that graphemic-phonetic mediation of lexical access is something that normal subjects are able to do if the task demands that kind of information, but that alternate direct routes to lexical access do occur.

The Semantic Network

A similar question to that asked about the lexical network can be asked about the semantic system as well. That is, is the semantic access for a word direct, or is
there some kind of mediation. Related to this question, is the role of the lexical system. Can there be semantic information available about a word without the word's name also being available, or does access to the semantic system depend on first accessing the lexical system?

Brown and McNeill's (1966) data hinted at some answers to these questions. They found that while subjects knew that the definition given in the stimulus presentation was a familiar word, subjects were unable to name the word and could only give certain physical characteristics of the word. This might suggest that the subject had access to conceptual information about a word without access to the word's name. On the other hand, mere recognition of a word's definition could be a different process than that of actually retrieving the semantic information attached to that word. For this reason, other studies must be examined before making any final judgements on the issue of mediation of semantic access.

Picture and Word Processing

One body of literature in which mediation of semantic access of words has been discussed has been the literature dealing with the processing of pictures and words. Pictures and words have been studied separately
and together in an effort to discover more about the ways the semantic memory and the lexical memory are related. Of course there are differences in the way pictures and words are processed, but picture processing may provide valuable clues to the nature of semantic and lexical memory. Research done during the last decade comparing the processing of pictures and words has shown a superiority of pictures in the time subjects take to make both semantic category and physical size judgements (Pellegrin, Rosinski, Chiesi, and Siegel, 1977; Potter and Paulconer, 1975; Rosch, 1975). In addition, a number of studies have shown a consistent superiority of pictorial relative to verbal input on a variety of standard long-term retention tasks (Paivio, 1971).

There are several ways of interpreting this data. Paivio (1971, 1975) has argued in favor of a dual model in which there is separate but interconnected verbal and nonverbal symbolic systems. Pictures have access to the nonverbal symbolic system while words have direct access to the verbal symbolic system. These two systems are interconnected, but transfer from the nonverbal to the verbal symbolic system is more rapid than the transfer from the verbal to the nonverbal systems. Because of the ease of access to the two long-term memory
representations for pictures, long-term retention of pictures is superior to that of concrete words, which in turn is superior to that of abstract words.

Another way of interpreting this data relies on a model known as the single-unit model. In such a system, there are multiple access routes, of which only one involves verbal or linguistic processing which leads to a single abstract permanent knowledge system. In other words, pictures and words access a common memory store, but pictures access this common memory store more directly than words, which are mediated by lexical processing.

Differentiating between these two theories has been difficult. Paivio (1974) used decision latency time to illustrate his contention that pictures and words access different memory systems. He presented picture pairs and word pairs to subjects, who were required to select the item from the pair which had the largest real world referent. (For example: mouse vs. elephant). Paivio found that decision times for picture pairs were faster than for word pairs, and argued that this was consistent with a dual memory system. Since the nonverbal memory system is organized in terms of perceptual attributes, the size judgement is mediated by information from the
nonverbal system. Therefore, the decision times for word pairs were slower because of the necessary time required to transfer information from the verbal to the nonverbal symbolic system.

This argument also can be used to predict and explain another set of results. In some of the pairs the larger real world referent (for example: elephant) was presented so that it was physically smaller than the conceptually smaller referent (e.g. mouse). According to Paivio, this should cause problems for the pictures because the presented stimuli would interfere with the stimuli generated in memory. Word pairs should be less affected since verbal memory is not organized on the basis of perceptual attributes. As predicted, reaction times were slower for the incongruent pairs than for the congruent pairs, and this difference was more pronounced for pictures than for words.

The unitary memory model also can offer an explanation of this data, however. Instead of relying on two different memory systems (the dual memory model), with the judgement for the word pairs being contingent upon accessing both the nonverbal and verbal memory systems, the unitary model assumes that the extra processing time for word pairs occurs because of a mediation step that is
necessary prior to accessing semantic memory. That is, the difference in processing times between picture pairs and word pairs is due to an acoustic-phonemic decoding process necessary for words prior to the access of semantic memory. This decoding process would not be affected by print size or differences in print size for the word pairs.

To explain why subjects responded to picture pairs faster than word pairs, the unitary model assumes that the word pairs would have to go through a mediation step prior to access of semantic memory, while picture pairs would not. In addition, since this decoding process is unaffected by print size, then the incongruency between the print size and the actual real world referent (e.g. printing elephant in small letters and mouse in large letters) would affect word pairs less than picture pairs. It seems then, that the unitary model can offer an explanation for data that Paivio (1974) interpreted as being supportive of a dual memory model.

As was stated earlier, it has been difficult for researchers to differentiate between the dual memory and unitary memory models of picture and word processing. A number of more recent studies, however, do seem to suggest that pictures and words access a common memory
system, and these studies are the most the germane ones to the present issue, in that the crucial question is whether access to the semantic system is mediated by the lexical system.

Sperber, McCauley, Ragain and Weil (1979) asked subjects to identify stimuli (label pictures or read words) as rapidly as possible. These stimuli occurred in pairs (a prime followed by a target) with no mention being made of any relationship between the stimulus pairs. In experiments one and two, subjects were required to name picture pairs or read word pairs. Half of the time these pairs were semantically related, and half of the time they were semantically unrelated. It was found that naming a picture prime semantically related to a target picture facilitates the naming of the target picture, and similar results were found with word pairs, which replicates and extends the Meyer, Schvaneveldt and Ruddy (1974) study. In addition, picture-picture priming was superior to word-word priming. A third experiment was then performed that compared pairs of words, pairs of pictures, and mixed picture-word or word-picture pairs. Priming effects for picture-picture pairs was still larger than those for
word-word pairs, but priming on mixed pairs was no greater than that on word-word pairs.

Sperber et al felt that these experiments demonstrated that both pictures and words accessed semantic memory. They explained the picture priming facilitation by saying that the pictures provided an additional relationship between primes and targets not present for the word-word pairs or the word-picture pairs. That is, pictures of objects belonging to the same category have more visual features in common than do words.

Other researchers have found that while pictures and words do seem to access the same semantic system, this access takes longer for words than pictures. Dhawan and Pellegrino (1977) used an interference procedure originally employed by Kintsch and Buschke (1969). In this procedure lists of 15 items were presented to the subject, followed by a probe item selected from the list. The subject's task was to remember and respond with the item from the list that had followed the probe. Dhawan and Pellegrino included a distractor item in the lists which was either acoustically or semantically related to the probe. They found that word stimuli showed acoustic interference for items at the end of the
list and semantic interference for items earlier in the list, replicating Kintsch and Bushke's (1969) results. For the picture stimuli, however, subjects showed large semantic interference at all list positions, with very little acoustic interference.

Dhawan and Pellegrino felt their data indicated that words take longer to reach semantic as opposed to acoustic levels of processing, while pictures seem to be rapidly coded at a semantic level followed by possible coding at an acoustic level. This supports the notion that word access to semantic memory is mediated by some sort of processing akin to the lexical processing as discussed in an earlier section. This study, however, falls prey to the same criticisms leveled at those studies that purported to demonstrate that word naming was preceded by a phonemic encoding step. In other words, since it has been demonstrated (Shulman, Hornak and Sanders, 1978) that normal subjects do not need to use a phonemic encoding step, then it could follow that this experimental task actually induced the subjects to use a phonemic encoding step that would not otherwise be used.

On the other hand, evidence from developmental studies seem to support Dhawan and Pellegrino's (1977) model of picture vs. word processing. Rosinski
Pellegrin, and Siegel (1977) have shown that the superiority of pictorial processing speed declines with age, although it still remains significantly above word processing even for adult college students. They gave second, fifth-grade and college students a task in which pairs of pictures or words were presented for same-different category judgements, and found that verbal access time decreased with increasing experience. They concluded that as subjects received more reading experience, they spent less time in mediation steps prior to accessing the semantic memory.

As discussed earlier Sperber, McCauley, Ragain and Weil (1979), found that pictures in general are not more effective primes than words, but they suggested that pictures in the same semantic category shared more visual features than do word pairs. Rosinski, Pellegrin, and Siegel's (1977) results could be explained by assuming that word pairs from the same semantic category come to develop some kind of association when they are experienced again and again by a reader. In other words, it may not be that with experience readers spend less time in mediation steps as Rosinski et al claim, but that semantically related words come to share more and more features with one another.
Nelson, Reed, and McEvoy (1977) have proposed a model that attempts to describe exactly how the processing of pictures and words differs by again using a mediation step. They assume that both sensory and semantic codes can be activated for pictures and words, but that the relative order of access to phonemic information is different for these two types of representations. That is, name codes are accessed differently for pictures than for words. For pictures, the naming process is indirect, with a label being available only after semantic processing. Words, on the other hand, access a name code directly and semantic processing only occurs after the word is named. In terms discussed earlier, Nelson et al. are saying that access to the semantic network comes after access to the lexical network when words are the stimuli, but prior to access to the lexical network when pictures are used.

McCauley, Parmelee, Sperber, and Carr (1980) have recently obtained evidence that at least with pictures, the Nelson, Reed, and McEvoy (1977) model may be correct. They presented subjects with target pictures that they had to label, which were preceded by either semantically related or unrelated priming pictures. The exposure durations of the priming pictures were varied around a
threshold value, established separately for each subject, that prevented identification of the picture primes. McCauley et al found that semantic priming effects were obtained with primes at exposure durations that were too brief for conscious identification. Based on the evidence, they proposed that extracting the meaning from a picture and consciously identifying it could be two separate processes. In other words, meaning can be extracted for a picture before information sufficient for explicit identification has accrued.

One problem with many of the studies described thus far, is that when the experimental task requires word naming, it is difficult if not impossible to assess the extent to which any semantic processing occurs prior to the access of that name code. It has already been demonstrated that semantic information is available about a picture prior to conscious identification. It has yet to be demonstrated that this same process does not occur with words. In addition, a more active form of processing may have occurred in these previously described studies that could be different from the rather automatic kind of analysis that occurs when a person is reading a text. Therefore another type of experimental paradigm has emerged in which the task hopefully requires a more
automatic type of processing. In this procedure some processing of the word is inevitable and so the nature of the word influences performance, but the response itself is not based on the word. This method is known as the picture-word interference paradigm, and is analogous to the Stroop (1935) color-word interference task.

In this task a word is superimposed on a line drawing of an object and is displayed to the subject, whose task is to ignore the word and name the picture as rapidly as possible. Lupker (1979) found that subjects take 70-90 msec longer to name the picture when a word is superimposed on it, than when the picture is presented alone. He also found that when the superimposed word is a member of the picture's semantic category, picture-naming latency is further prolonged by 24-30 msec.

The fact that the semantic relationship influences this task suggests that just as in normal reading, some semantic information about the word is becoming available automatically and is somehow disrupting the picture-naming task. Lupker (1979) examined this phenomenon in detail and came up with a number of findings. In Experiments 1 and 2, he compared picture-word pairs that were either from the same
semantic category (mouse-dog), a frequent associate (mouse-cheese), an unrelated word (mouse-hand), a pronounceable nonword (mouse-lorim), or the picture alone (mouse). He found that highly associated words not belonging to the picture's semantic category caused no more interference than unrelated words. In addition, frequent associates of the same semantic category (hand-foot) caused no more interference than infrequent associates of the same semantic category (hand-ankle).

What these first two experiments seemed to suggest was that either word-association strength was not a good indicator of semantic distance, or else within-category semantic distance was not important in a picture-word interference task. Therefore he did a third experiment where he compared "typical" members of a category with "atypical" category members, and found that "arm" superimposed on a picture of a foot caused no more interference than "lip" superimposed on a picture of a foot. Lupker concluded that much of the semantic information automatically available from words must be information common to most members of the word's semantic category.

This conclusion was reinforced by a series of studies done by Lupker, Katz and Cartman (1979). In Experiment 1, subjects had to identify whether a picture
was of a dog. Superimposed on the pictures was either an identical word "dog", a word from the same semantic category "cat", an unrelated word "table", or no word. They found that words from the same category interfered with the task. In a second experiment, they reversed the procedure, this time the task being to identify whether the word was a dog with the picture being of a dog, being from the same semantic category (cat), or else unrelated (table). This time they found that there was no interference from the pictures in the word naming process.

Lupker et al interpreted these findings to indicate that semantic information automatically supplied by pictures is quite specific to the concept pictured, while semantic information automatically supplied by words seems to be the kind of information which is common to more members of the word's semantic category. They also felt that the kind of semantic information available to pictures and words are different. While pictures and words access the same semantic memory, they access this from different directions. Words initially access orthographic and phonetic information before accessing semantic information, while pictures directly access semantic information.
This explanation has recently received further support from a series of experiments done by Smith and McGee (1980). They were interested in investigating the time course of picture-word processing in the picture-word interference task. They hypothesized that pictures have faster access to semantic information, and slower access to lexical entries (which include name codes, spelling codes, and articulatory codes). Words, on the other hand, have faster access to articulatory codes, but slower access to semantic information. Remember, this is the theory already advanced by Nelson, Reed, and McEvoy (1977) which was used to explain a variety of data comparing the processing of pictures and words.

In Experiment 1, subjects were required to determine whether an item was a member of a particular category, or they were asked to just name the item. The stimuli were pictures with superimposed words, and subjects were required to either categorize/name the picture, or categorize/name the word.

Smith and McGee found that having a superimposed word disrupted picture naming, while having a superimposed picture did not disrupt word naming. This replicates and extends previous findings, and supports
nicely their hypothesis that words have faster access to lexical information than do pictures. That is, since a word is named faster than a picture is named, then having a superimposed word on a picture naming task interferes with picture naming. However, having a picture superimposed on a word naming task does not interfere with word naming, because the word reaches this name code so quickly (i.e. before the picture name is available to interference).

However, this pattern of results was reversed when the task was changed to categorizing the words and pictures. The categorization of words was more significantly disrupted by the presence of a picture, than was the categorization of a picture disrupted by the presence of a word. Again this goes nicely with their hypothesis. Since categorization involves accessing the semantic network, it follows that the word categorization task would be disrupted by the presence of a picture, since pictures access this memory faster than words. This also explains why the presence of a word did not disrupt the picture categorization task to the same extent. That is, the picture already was categorized before the meaning of the word became available.
This explanation was tested further by Experiments 2 and 3. Smith and McGee used Craik and Lockhart's (1972) model of memory which says that the more extensive the processing of an item the better it is remembered. Smith and McGee used this model to suggest that words which are categorized should be remembered better than words which are merely named, since the semantic network needed in the categorization task is accessed after the lexical network which is needed in the naming task. This pattern should be reversed for pictures, however. Pictures which are named should be remembered better than pictures which are categorized, since pictures access the semantic network before the lexical network. The results from this experiment supported their prediction, providing more evidence that words access semantic information only after the word is named.

However, the same criticisms could be used for the studies using the picture-word interference paradigm that were leveled against studies comparing the naming latency of pictures vs. words. That is, by the procedures used here it would be impossible to assess the extent to which any semantic attributes about a word were available prior to the time that word was named. We know, now, a little more about how the time course of picture and word
processing compare. To say, however, that because word categorization occurs more slowly than word naming, and picture naming occurs more slowly than picture categorization, is not to say that there are no semantic attributes are available about a word prior to word naming.

Therefore, the question posed at the beginning of this section was whether a word directly accesses the semantic system or whether the lexical system is a necessary mediating step. Data from a variety of sources have been reviewed here, and seem to suggest that word processing does require a lexical "look-up" before the semantic system can be tapped. These studies are not without problems, however, and so a definitive answer is still unavailable.

In some ways, then, one could say there are three models of word processing. The first is the traditional model in which semantic information becomes available about a word only after phonemic and lexical analysis. The second is that meaning is stored with the word, so that the lexical entry and meaning become available simultaneously. The third model is like the second to the extent that lexical and semantic memory are assumed
to be distinct, but the third view does not require meaning to be accessed via the lexical memory.

Semantic Processing Without Naming

There is another body of data published recently indicating that some semantic information may be available about a word much sooner than was previously expected. In other words, there is data to suggest that some semantic processing of written words occurs independently of the ability to name them. Putting this in terms already discussed, some information from the semantic network may be accessed prior to the time naming information from the lexical network is available.

Some initial evidence of this rather startling hypothesis comes from physiological studies. Albert, Yamadori, Gardner, and Howes (1973) have described a brain injured patient who had fluent, spontaneous speech, but was unable to read aloud written words (with the exception of 10% of the short, high frequency words and single letters) and said that he had no knowledge of the meaning or identity of the other words. However, this patient was able to pick from a set of words, the one that was related to a given semantic category. For example, when given the category landscape, he was able to pick the correct target mountain out of a set of
words that contained president, general, church, constitution, mountain, hydrant. He was unable to name the word mountain, yet obviously was picking up some semantic information, indicating a case where some semantic information was available but a name code was not.

There also is evidence from normal subjects that suggests that people may have some semantic information available about a word, even when that word cannot be named. One early investigation into this issue was described by Wickens (1972). In an unpublished study, Wickens, Shearer, and Eggemeier asked subjects to judge whether a fully-seen word had some semantic similarity to a tachistoscopically exposed "unseen" word. They presented the first word of a word pair at either 50, 60, 70, or 80 msec. exposures, followed by a broken-letter mask (for 1.5 sec.) and the second target word (for 5 sec.). Half of the time the masked word shared some semantic attribute with the target word, and half the time it did not.

Wickens, Shearer, and Eggemeier found above chance responding for some of the word pair semantic attribute dimensions at the 60 and 80 msec durations. Unfortunately, it is hard to assess how these results fit
in with the question of words having direct unmediated semantic access, because Wickens et al did not provide a test to measure directly the subjects' awareness of the masked word. That is, we have no way of judging whether the masked word was truly "unseen," just not nameable, or briefly read and not remembered.

Wickens (1972), citing his previous research, came up with the theoretical perspective that various attributes of words do not come into being simultaneously, but accumulate across time. While he stressed the tentative nature of conclusions based on the Wickens, Shearer, and Eggemeier study, he stated that this research may indicate that certain attributes of a word could occur prior to naming, while others occur simultaneously with naming, or even wait upon it. His analogy was that of a wave, with a leading edge of semantic attributes, a crest representing word naming, and a trailing edge of semantic attributes accessed only after word naming occurs.

Following Wickens (1972), a number of investigators studied the influence an "unattended" word has on the processing of words, sentences, or even paragraphs. Again, unfortunately, none of these investigators provided a test to measure the subject's awareness of the
attended material. Still, a number of interesting phenomena were studied.

Bradshaw (1974) presented subjects with a tachistoscopic display consisting of three items; a centrally located homograph (ex: palm), located between two peripherally presented words, of which one was a disambiguating word (ex: either hand or tree), and the other was a consonant string. The subjects viewed the display for 125 msec after which they were required to name the central homograph, the disambiguating whomograph. What Bradshaw concluded from his experiment was that the meaning of individual printed words may be perceived even though these words are unattended.

Underwood (1981), however, wondered whether the results that Bradshaw (1974) reported could have another explanation. That is, the peripherally presented disambiguating "unattended" word could have influenced the centrally presented homograph because it appeared in isolation, and so actually received attention. He had subjects give category names to target words at the same time as masked unattended words appeared to the right of fixation. He found that even when unattended words were embedded in a set of four letter-strings printed vertically, they still influence processing of the
attended word. However, four letter-strings containing several related unattended words affected the target word no more than one unattended word did.

MacKay (1973) also has studied the perception of unattended words and their effect on sentences. In his study, subjects were presented with ambiguous sentences (example: They threw stones toward the bank yesterday.) in a dichotic listening task, and were instructed to shadow the sentences. In the unattended channel, disambiguating words were presented (such as money, or river), which were designed to bias the interpretations of the ambiguous sentence one way or the other. After the subject shadowed all sentences, they performed a recognition trial, in which they were asked to pick sentences that most closely matched the ones that they had heard. For example, if the sentence They threw stones toward the bank yesterday was one of the lines presented dichotically, then the subject would have to pick from They threw stones toward the side of the river yesterday, They threw stones toward the savings and loan association yesterday, or They threw stones toward the bank yesterday. MacKay found that while subjects were not able to report the unattended words, their answers to the recognition trials were biased, indicating
that these unattended words had some influence. He did not do any kind of testing to measure the extent to which the unattended words were perceived, however, so it is not known whether these words were truly not perceived, or whether they just decayed very rapidly from short-term memory.

Willows and MacKinnon (1973) have investigated the effectiveness of unattended sentences on prose passages. Sixth grade boys were asked to read aloud stories (printed in red ink) that also had lines that were to be ignored printed in black ink between the attended lines of the story. (Color of ink was counterbalanced.) A second group of subjects read control passages without the unattended lines. After each story, participants were asked multiple-choice questions about the reading material. Willows and MacKinnon found that while subjects in the experimental group were not able to recall the irrelevant lines, their answers to the multiple-choice questions contained false information that had been contained in the irrelevant sentences, indicating that their answers were influenced by the unattended material.

Willows and MacKinnon (1973) study suffers from the same problem that MacKay's (1973), Underwood's (1981),
Bradshaw's (1974) and Wicken's (1972) studies did. That is, there was no task designed to measure the perception of the "unattended" material, making it impossible to know how much the material was perceived. There is good evidence that unattended material can influence conscious processing, but these studies do not indicate whether the unattended material was only partially perceived, or totally perceived and forgotten rapidly. That is, it would seem desirable to have not only an index of whether subjects can remember or report the displayed word, but also whether they can even detect simple physical characteristics of the stimulus itself.

The first series of studies that has attempted to determine the extent to which physical characteristics of the unattended word was perceived, are those studies done by Marcel (in press), Marcel and Patterson (1978), Marcel (1978), Allport (1977), and Fowler, Wolford, Slade and Tassinary (1980). These studies suggest that subjects may have useable amounts of semantic information available about a word when they do not even have a conscious awareness that the word was actually presented to them. These results are counterintuitive, and go against the traditional theories of word processing. Therefore because the implications of this series of
studies are major, and the results are unexpected, they will be described in detail.

In Marcel's initial investigations (Marcel, in press) a procedure was used in which it was determined (for each subject separately) the longest SOA at which the subject could not tell whether a word or a blank card had been presented prior to a pattern mask. In other words, Marcel used the SOA at which subjects were not able to make presence/absence judgements about a word. Then using this masked word as a prime, he had subjects choose which of two words presented after the mask was most closely associated with the masked word in meaning or physical properties. As SOA for the masked word was further decreased, Marcel found that judgements of physical properties usually dropped to chance before meaning judgements did. Subjects, then, were providing meaning information at SOAs at which they could not provide information on physical characteristics, and providing information on physical characteristics and meaning at SOAs at which they could not make presence/absence judgements.

Marcel and Patterson (1978) did a similar experiment in which they again determined separately for each subject, the SOAs at which the subject was unable to
report whether any word had been presented at all. Under these viewing conditions, participants were able to decide which of the two subsequently presented words was a synonym of the word they "didn't see." However, Marcel (in press) discovered that the design of these experiments was less than optimal because subjects objected to performing a task which required them to make comparisons to a word they did not see. Marcel (in press) stated that some of the data from some subjects had to be discarded because "the subjects had used strategies that precluded any real assessment of the availability of the various kinds of information they were asked to provide." How many subjects were discarded, or exactly what criteria was used is not known. Therefore, Marcel and Patterson (1978) and Marcel (in press), developed a procedure that used the masked word as a prime for making lexical decisions.

In these studies, semantically related primes were found to facilitate lexical decisions to subsequently presented targets. In fact, this priming was found to be of equal magnitude when compared to experiments in which the priming event was presented under normal viewing conditions. It is this complete dissociation between the ability to make presence/absence judgements about the
masked word, and the masked word's ability to prime that provides compelling support for the conclusion that perception may occur in the absence of awareness. Or to put it in terms already used, what these studies appear to indicate, is that words may access the semantic network without accessing the lexical network.

Allport (1977) also has provided evidence for semantic access without corresponding lexical access. He presented four word arrays to subjects who were required, in one condition, to list any words or letters they might see, and in the other condition, to report the one word out of the array that matched a prespecified category (which was, in this case, animals). The arrays were presented under conditions of masking such that, on the average, only one word out of the array could be reported. He found that subjects could selectively report words belonging to a particular category out of this array of briefly presented words.

In a second experiment, Allport had subjects write down as many letters as they could from a word presented briefly between two bars, followed by a pattern mask. On some trials, a second word appeared above the first word, and data from a control condition indicated the subjects were unable to see the second word. When this second
word was unrelated to the target word, accuracy for reporting letters from the target word was depressed over that occurring when the target word was presented alone. When the second word was related to the target words, this depressed effect was elevated, but not quite to the level of a target word alone. Allport felt that this experiment, coupled with the one discussed earlier, indicated that words can gain access to the semantic system without being consciously perceived.

Recently Marcel (1980) has asked questions about the nature of the semantic activation that occurs before word naming. He proposed that all meanings of a word are accessed in the first preconscious stage, regardless of context, and that specific meanings are available only at the conscious stage (lexical access). He presented subjects with three letter-strings, and required that they make a lexical decision about the first (LS1), and third (LS3) string. On critical trials, LS2 was a polysemous word (for example: palm), and LS3 was related to one of its meanings (for example: wrist). LS1 was either related to the same meaning (e.g. hand), related to a different meaning (e.g. tree), or unrelated (e.g. clock). LS2 was pattern masked, left unmasked, or energy masked.
Marcel found that when subjects were aware of LS2, (LS2 unmasked), decision latency time to LS3 was only facilitated in the biased condition (hand), which Marcel felt indicated that prior context determined which meaning had been chosen for LS2. When LS2 was pattern masked, however, there was semantic facilitation in both the biased condition (hand) and the unbiased condition (tree), which Marcel felt indicated that when LS2 was below awareness, both meanings were chosen. Therefore, Marcel felt that preconscious semantic processing is not determined by context, and all meanings of a word are accessed. Conscious perception of a word, however, is another matter, since context does play a role and only one meaning of a word is chosen.

While the studies cited above are fascinating, they are not without problems. Fowler, Wolford, Slade, and Tassinary (1980) have recently attempted to replicate these procedures. They tried to reproduce Marcel's (in press) early studies which demonstrated better-than-chance judgments about semantic properties of words below detection. That is, in a procedure similar to Marcel's (in press) procedure, they asked subjects to judge whether a word was semantically similar, phonetically similar, or graphically similar to a masked
word (below detection). They replicated Marcel's results, finding that subjects could make these kind of judgements.

However, in a subsequent experiment, they found that these same results could even be obtained when there was no word prior to the mask. Fowler et al explained these findings by saying that subjects may have been asking themselves which word had more words either semantically, graphically, or phonetically similar to it. That is, subjects were making their responses on the basis of frequency. In a subsequent experiment, however, Fowler et al did replicate Marcel's demonstration that masked words (that were not detectable) facilitated the lexical decisions of words that were semantically related to them.

Merikle (1981) also found problems with the procedures used by Marcel, Allport, and Fowler. He stated that the validity of the arguments Marcel and others make is dependent on the adequacy of the procedures used to determine the thresholds for discriminated verbal reports. He felt that these measures are totally inadequate. First, he examined Fowler's et al (1981) procedure, and found that the SOA between the word/blank and the pattern mask was initially
set at 50 msec, and then decreased whenever a subject made three or more correct responses within a block of five trials. That is, every time the subject responded correctly on three out of five consecutive trials, the SOA between the word/blank and the pattern mask was decreased 5-10 msec. The highest SOA at which detection performance fell below .7 was used for all subsequent trials, but no post test was done to ensure that subject's responding remained below the .7 criterion.

The problem with this procedure, is that the criterion for the establishment of the SOA is based on the responses to only five trials; clearly not enough to establish a reliable estimate of the response probabilities. Merikle felt that given the small number of trials used to establish the SOA, a large difference in percent correct performance on these trials would not be meaningful. In addition, since no post-testing was done, it is difficult to assess exactly how much the subject's were seeing during the experiment. Merikle believed then, that Fowler's conclusions were not warranted without more controlled procedures for establishing the "detection" SOA.

Merikle (1981) also found fault with Marcel's method. On close examination of the few sketchy accounts
of the procedure (Marcel, 1980; Marcel and Patterson (1978), Merkle found discrepancies in the criterion Marcel uses for establishing the "threshold" SOA. Marcel typically uses a decreasing sequence of SOAs over an unspecified number of trials to determine: 1. An SOA where subjects "could no longer make presence/absence judgements above chance" (Marcel, 1980), or 2. an SOA where subjects "could no longer perform above 60% correct." In some cases Marcel lowered SOA 5 msec below the threshold level, while in other studies he did not. Merkle complained that since Marcel does not report the number of trials used to determine threshold, nor the response distributions at threshold, it is impossible to evaluate his data properly. Obviously, then, more controlled studies must be done in order to satisfy Merkle's criticisms. How this can be done will be discussed later.

**Lexical versus Semantic Memory Revisited**

In the past few sections, the traditional model of word processing was presented and examined. Remember that in this model a word is initially encoded in a literal form (the icon), then assigned a phonological code, and then assigned a meaning. The lexical network is thought to be the representation of graphemic,
phonetic and phonemic knowledge about words, while the semantic network has been thought to be the representation of word meaning. Therefore, this traditional model of word processing not only assumes a distinction between lexical and semantic access, but also assumes lexical access prior to semantic access and that the lexical representation is used for semantic access.

Also in the past few sections, data has been reviewed which seriously calls into question this traditional model. Data using normal subjects (Shulman, Hornak, and Sanders, 1978), as well as various physiological studies (Marshall and Newcombe, 1973; Shallice and Warrington, 1975; and Patterson and Marcel 1977), have disputed the notion that a word has to be phonemically encoded before it can be named. In addition, while the picture-word studies seemed to indicate that the name of a word occurs before semantic information about that word was available (in contrast to pictures), these studies did not test for the amount of semantic information that could have been available about a word prior to that naming phenomenon. Evidence from the laboratories of Marcel, Allport and Fowler have indicated that more semantic information might be available about a word prior to conscious awareness
(naming) than was ever thought possible. These studies, however, do have some methodological flaws that could lead to alternate explanations (Merikle, 1981). Obviously more work needs to be done before this issue can be settled appropriately.

As described earlier, there are three models of word processing were described. The first is the traditional model, while the second model maintains that meaning is stored with the word so that the lexical entry and meaning become available simultaneously, and the third is that there is a distinction between semantic and lexical memory, but that lexical access is not necessary for semantic information to become available. Of these three models, the model which seems to handle the above data most satisfactorily is the third one, in which semantic information can become available without, necessarily, lexical access having to occur.

In the next section, an interesting sideline to the whole issue of word processing will be discussed, and a number of questions raised. That is, what is the differential contribution of the different hemispheres of the brain? What is the evidence for the traditional view of word processing in the right and left hemispheres? Could there be differences in the way words are processed
across hemispheres? While answers to these questions are not clear, clinical evidence and experimental studies using normal participants provide some tintillating beginnings.

**Hemispheric Language Processing**

In 1836, Dax, an obscure country doctor, delivered a paper to the French medical society that clearly linked aphasia, or the loss of speech, with damage to the left hemisphere. It was not until the work of Broca, however, that it became popular to assume that different functions occur in each of the two hemispheres of the brain, and the era of cerebral localization of function was begun (Springer and Deutsch, 1981). Broca's work has been replicated and extended to the point that it is now generally believed that many functions related to verbal behavior are localized in the left hemisphere. Lesions to the left posterior temporal lobe impair a person's ability to comprehend verbal information (either written or spoken). In addition, lesions to the mesial temporal lobe and hippocampus cause memory loss for verbal material, while lesions of the left frontal lobe cause
the inability to order verbal stimuli in time (Milner, 1971).

In his review of the literature, Moscovitch (1973) reported that these findings, plus the research of numerous other surgeons, led to the prevailing opinion that right-handed people without a family history of left-handedness had verbal functions represented exclusively in the left hemisphere. The ability of some patients to recover language function after left hemisphere damage was traditionally thought to be due to other tissue in the left hemisphere taking over language function, rather than to the right hemisphere's contribution.

There have been some clinical data to dispute the claim that all language functions are localized in the left hemisphere. This data comes primarily from three sources: evidence from patients who have sustained lesions in the right or left hemisphere, patients who have undergone the removal of the left hemisphere, and patients who have undergone the surgical separation of the left hemisphere from the right.

Before discussing these clinical studies, a word of caution should be given. Clinical studies are notorious for grouping patients with widely different life
histories, ages, and premorbid abilities into the same homogeneous group on the basis of a similar lesion or illness. Oftentimes the treatment done on the patient differs greatly from others within this homogeneous group, while in addition, many of the findings stem from observational data, since well-controlled studies are usually not done on these clinical populations. Finally, many of the conclusions based on these studies come from observations on a small number of patients. Given these limitations, however, the results from these studies are interesting, and will be briefly described.

Clinical Studies

In his review of the literature, Searleman (1977) has stated that although it has been known since the 19th century that damage to the left hemisphere produces difficulties in language, there is controversy about the cause of language recovery in patients who have suffered this type of damage. He reports a variety of studies indicating that although abnormal electroencephalogram readings over the left hemisphere does not necessarily lessen the prognosis of recovery of speech in aphasics, abnormal readings over the right hemisphere does. Patients who have recovered from aphasia caused by left hemisphere damage will become aphasic again if the right
hemisphere is injured. It seems, then, that recovery of aphasia is linked to right hemisphere function.

In addition, it recently has become apparent that damage to the right hemisphere also may disrupt language, but in a milder fashion. Searleman (1977) again cites a study by Einenson (1962) which found that patients with right hemisphere lesions performed worse on standardized vocabulary and sentence completion subtests taken from the Stanford-Binet Intelligence Scale. Searleman also cites evidence that patients with right hemisphere lesions have a general tendency to perseverate (repeating syllables) in both speaking and writing. In addition, patients with damage to the right hemisphere are unable to write well known phrases, while they are able to create and write well-organized prose. On the other hand, when damage occurs in the left hemisphere, the patient is able to write well-known phrases, but is unable to create and write prose. Searleman (1977) concludes that these studies indicate some rudimentary language functioning in the right hemisphere.

Other clinical evidence for the right hemisphere linguistic functioning comes from the examination of patients who have had the cortex from one of their hemispheres removed. This operation is usually performed
only to treat otherwise fatal tumors, or infantile hemiplegia. Language skills of the patients are analyzed pre and post-operatively to assess the contribution the removed hemisphere makes to language function.

Again, there must be a word of caution before describing these studies. There is the possibility that some language capabilities could have been taken over by the opposite hemisphere as a result of the disease, and so analysis of the language capabilities of these patients could be biased. However, these studies do tend to provide corroborative evidence for right hemisphere linguistic capabilities and should be considered along with other clinical data.

Hemispherectomies performed during the first few years of life typically result in normal language development for the majority of the patients. This illustrates the remarkable plasticity of the immature hemispheres, and has led some researchers to speculate that the two hemispheres are "equipotential" at birth, and that bilateralism occurs later on in a child's life (Searleman, 1977).

The effect of hemispherectomies in adults, however, is a different story. Following left hemisphere removal, patients are able to utter only expletives and other
automatic phrases. However, Gott (1973) has described evidence that although these patients have lost most of the ability to speak and write, they did show a significant amount of verbal comprehension. She also found that patients were able to sing entire songs, and could express themselves better through song than through ordinary speech. What these studies seem to indicate is that while right hemisphere speech production may be limited to a few automatic phrases and expletives, speech comprehension remains fairly proficient. Therefore, one difference between the right and left hemisphere's linguistic capacity lies in speech production. Further studies must be examined before deciding how the right and left hemispheres differ in speech comprehension.

The third source for clinical data regarding the linguistic capabilities of the right hemisphere comes from patients who have undergone surgery to section the forebrain commissures (particularly the corpus callosum) as an alternative method for treating uncontrollable epileptic seizures when traditional methods of treatment have proved ineffective. The cutting of the corpus callosum is done to prevent the spread of an epileptic seizure from one hemisphere to the other. It also
prevents information from being passed from one hemisphere to the other, and so provides a unique opportunity to examine the differences in language processing between the left and right hemispheres.

The first testing of patients who had undergone this procedure was done by Akelaitis (1944). In a series of studies done on twenty-four subjects, of whom nine had their corpus callosums sectioned completely and fifteen had partial sections done, he found no disturbance of verbal function on either side. Both hands could write and read material presented exclusively to one eye or the other, and all other types of functioning seemed to be normal. Based on these findings, Akelaitis felt that the corpus callosum was not an important structure for integrating information from the right and left hemispheres as had been suggested. These findings also caused Lashly (1950) to quip that the only function of the corpus callosum, might be to hold the two halves of the brain together.

However, in the mid 1950's Sperry (1956, 1958) found that when he sectioned not only the corpus callosum but also the optic chiasm in cats (the part of the optic nerve that crosses so that each hemisphere receives information from both eyes), he did get evidence that the
corpus callosum serves to transfer information from one hemisphere to the other. He had a cat learn a discrimination task with one eye covered, and found that when the other eye was covered, the cat had to learn the discrimination task all over again.

This result suggests that information being received by one hemisphere did not transfer across the hemispheres, indicating that the corpus callosum may be instrumental in transferring information. Since then, approximately 10 patients have undergone this split brain procedure, although only five have been examined at length. These five patients have been studied using a new technique which makes use of the fact that in humans, each peripheral visual half-field projects directly to the opposite hemisphere. When material is shown only to that half-field (accomplished by having that subject fixate a central dot and then presenting stimuli in their peripheral vision) it registers only on the opposite hemisphere. This special testing must be done to insure that only one hemisphere receives the information.

In his review of the split-brain literature, Gazzaniga (1970) states that in the beginning the most prominent feature of patients who had undergone this technique was that when a word was flashed to their right
visual field, or an object was placed in their right hand, both of which were cases in which the stimulus was projected only to the left hemisphere, the patient could verbally identify the stimulus effortlessly. In contrast, when the word was flashed to the left visual field or if the object was placed in the left hand, the patient would not identify it and would either guess incorrectly, or else deny that anything had happened. Based on these early findings, it was proposed that the right hemisphere was completely incapable of comprehending verbal material.

However, it was soon learned that speech production and speech comprehension were two different things. Gazzaniga (1970) stated that when he asked the subject to point to a picture of the stimulus or to blindly retrieve it with his left hand, s/he was quite able to comply. For example, if the word cigarette was flashed to the subject's left visual field, s/he would be able to point to a picture of a cigarette, or else retrieve a cigarette with his/her left hand. This illustrates that the patients were able to understand simple English words presented to their left visual field (or right hemisphere).
Gazzaniga and Hillyard (1971) later tested patients, in order to analyze further the language capacity of the right hemisphere. They asked subjects to identify pictures presented to their left visual field by choosing the correct answer from two alternatives. For example: when presented with a picture of a girl kissing a boy, subjects were unable to tell which alternative was correct—*the girl kisses the boy*, or the *boy kisses the girl*—regardless of whether the questions were phrased in active or passive forms. In addition, subjects also were unable to distinguish future tense from present. This was tested by presented subjects with a picture of a girl drinking a glass of water, and asking whether the picture was of *the girl is drinking* or the *girl will drink*. Finally, subjects were unable to distinguish singular from plural nouns, again tested using the pictures. That is, subjects were unable to differentiate whether the picture was of *The dog jumps over the fence*, or the *dogs jump over the fence*. Subjects were able to distinguish affirmatives from negatives, illustrated by distinguishing whether a picture of a girl sitting was of *a girl sitting*, from *a girl is not sitting*. Therefore Gazzaniga felt that the right hemisphere was only able to recognize concrete
nouns and adjectives, and could only make distinctions between affirmative and negative sentences.

Gazzaniga (1970) summarized what he felt to be right hemisphere linguistic capabilities by saying that the right hemisphere was mainly skilled at attaching noun labels to pictures and objects. Through a series of studies, Gazzaniga found that commissurotomized subjects did not respond to verbal commands presented to their right hemisphere, did not comprehend the semantic aspects of verbs, and did not relate subjects to objects via a verb. He also cautioned future researchers about being overly optimistic about linguistic capabilities of the right hemisphere because of a danger he uncovered when doing this research.

Gazzaniga (1970) describes a study in which he instructed a commissurotomized patient to orally report whether a red or green light flashed in his left or right visual field. The left hemisphere (right visual field) responding was correct, while the right hemisphere (left visual field) was at chance. However, with more trials, the subject began to perform more accurately to the lights flashed to his left visual field. At first this appeared to indicate that with practice, the right hemisphere can produce speech in response to a simple
task. However, on closer examination, it was found that the subject would sometimes respond incorrectly, then shake his head and correct himself. What the subject was doing, Gazzaniga decided, was using his body to allow his right hemisphere (which had received the stimuli, but could not make the response) to correct the incorrect responses made by his left hemisphere (which had not received the stimuli but could make the responses). Gazzaniga labeled this phenomenon "cross-cuing," and stated that any new discoveries about right hemisphere linguistic capabilities done with commisurotomized patients should be examined suspiciously.

Gazzaniga's (1970) conclusions about the nature of right hemisphere linguistic capabilities have been attacked by researchers using different tasks. Levy (1970) found that when she asked commisurotomized patients to pick up an object associated with a verb with their left hand, they were able to comply, indicating that they were comprehending the meanings of verbs on some level.

Zaidel (1973) also proposed commisurotomized patients have more linguistic capacity in their right hemisphere than Gazzaniga found. He developed a new technique in which he outfitted patients with contact
lenses designed to project a stimulus onto the right or left visual field much longer than was previously possible using conventional techniques. He presented subjects with line drawings (in their right or left visual field) that they had to match with spoken labels.

The results of his experiments led Zaidel to conclude that the right hemisphere could comprehend a variety of syntactic structures (including verbs), and also could comprehend abstract words. These results are controversial, however, because he did not control for potential cross-cuing. In addition, some researchers (Searleman, 1977) feel that his contact-lense technique has yet to be shown to be totally valid.

On examination, the split-brain studies seem to indicate that the right hemisphere has more linguistic capability than was previously considered, but these studies are not without fault. As in any clinical study, the numbers of commissurotomized patients is small, with only five patients having been tested for linguistic capacity, to date. In addition, the premorbid characteristics of the patients vary. In some cases this has had impact on the kinds of linguistic capabilities shown by the right hemisphere, with different patients showing widely differing abilities. Gazzaniga (1967)
found that in one patient he tested, right hemisphere linguistic capacity was indistinguishable from left hemisphere, with the exception of speech production. This particular patient, however, had had severe seizures in his left hemisphere from the time he was two years old, indicating that linguistic function could have been duplicated in the right hemisphere.

This same problem holds for studies based on hemispherectomized patients. Again, because of their disease the right hemisphere may have taken over some linguistic processing and so show more linguistic capacity than would ordinarily occur. Therefore, any right hemisphere linguistic capacity shown in clinical cases must be duplicated using normal subjects. Studies using normal subjects will be considered next.

**Experimental Studies**

Moscovitch (1973) has been one investigator who has tried to evaluate the right hemisphere linguistic potential in normal subjects. He used a procedure whereby subjects were first presented with a set of letters (binaurally) that they were to memorize, and then a probe letter was flashed to either the left or right visual field. The subject's task was to respond as quickly as possible with their left hand. By using this
procedure and forcing the subject to respond with a
movement that had to be initiated by the right
hemisphere, Moscovitch hoped to show whether or not the
right hemisphere's linguistic abilities were just slower
than the left hemisphere's, or if information projected
to the right hemisphere had to be transferred over the
corpus callosum and processed in the left hemisphere.
That is, if the right hemisphere would process the
stimuli, then reaction times should be quicker to stimuli
flashed to the left visual field (right hemisphere),
because the left hand (right hemisphere) responded. If
the right hemisphere could not process the stimuli, then
reaction times to material flashed to the right visual
field should be faster, because material flashed to the
left visual field would have to pass over the corpus
callosum twice—once transferred to be processed in the
left hemisphere, and then once again transferred to be
outputted from the right hemisphere. The results of
these experiments led Moscovitch to conclude that the
right hemisphere in normals was unable to process verbal
stimuli, in contrast to Gazzaniga's (1970) results with
commisurotomized patients.

Moscovitch (1973, 1976) suggested that the reason
that the discrepant results occur between his findings
and those of Gazzaniga's (1970), was because the left hemisphere suppresses the right hemisphere's language skills. In his model that he termed the model of functional localization, he said that the right hemisphere of the intact brain possesses the same linguistic skill as that of the split-brain patient, but that the person is only able to demonstrate this capacity when s/he is freed from the inhibiting aspects of the left hemisphere—either by commissurotomy or by hemispherectomy. In these patients, there are no longer any inhibitory effects from the left hemisphere, and so the right hemisphere is relatively unhampered in its linguistic pursuit.

A few other investigators have attempted to replicate the split-brain findings of Gazzaniga (1970) using normal subjects. In these studies, the basic procedure has been to present words in the left and right visual half-fields (so that they project directly to the left or right hemisphere) and compare the accuracy of identification of words in the two visual fields. Investigators using this technique have assumed that a difference in accuracy between the visual half-fields reflects the predominance of one hemisphere over the other on the task used.
Ellis and Shepherd (1974) presented concrete and abstract word pairs simultaneously to the left and right visual fields. They found that words projected to the right visual field (left hemisphere) were identified (i.e. named) more accurately than words projected to the left visual field (right hemisphere). They also reported that there was a greater visual field asymmetry in favor of the right visual field, for abstract nouns than for concrete nouns. That is, there was a greater difference between the right and left visual field's ability to identify abstract nouns than there was to identify concrete nouns. Ellis and Shepherd concluded that at least some concrete words must be recognized by the right hemisphere, replicating Gazzaniga's (1970) finding with commisurotomized patients.

Attempts to reproduce the Ellis and Shepherd (1974) results have met with mixed success. Hines (1976) used the Ellis and Shepherd procedure, and tested both abstract and concrete nouns and verbs. They found a greater visual field asymmetry in favor of the right visual field for the naming of abstract nouns than for naming concrete nouns, replicating exactly the Ellis and Shepherd (1974) results, and also found a right visual field superiority for the reporting of both concrete and
abstract verbs. Both of these results coincide with Gazzaniga's (1970) findings.

Orenstein and Meighan (1976), however, were unable to replicate these findings. Again using the same technique that Ellis and Shepherd used, they presented concrete and abstract word pairs to subjects who were instructed to name the words. They found that words presented to the left visual field were recognized more easily than words presented to the right visual field which is in direct contrast to the Hines (1976) and the Ellis and Shepherd (1974) results. The difference between abstract and concrete nouns was not significant. They interpreted these findings, however, not in terms of right hemisphere superiority in recognizing concrete nouns, but in terms of the motor responses acquired while learning to read. That is, subjects may have been paying more attention to the material on the left side of the screen, and indeed tended to report the material on that side of the screen first.

Day (1977) also has investigated the right hemisphere linguistic capacity in normal subjects. He presented subjects with either abstract or concrete words in their right or left visual field along with non-words. The subjects had to determine whether the string of
letters they saw was a word or not. In addition, Day compared the subject's ability to perform this task with both his/her right and left hands, using the Moscovitch (1973) procedure described earlier. Remember, according to this procedure, if only the left hemisphere can perform a linguistic task, then information from the left visual field must be transferred to the left hemisphere for analysis. Reaction times; then, should favor the right visual field by a constant amount regardless of the hand that is used to respond. If the right hemisphere can also perform the task, (but perhaps have slower processing), then the visual field reaction time difference should be significantly smaller, if not reversed when the left hand (right hemisphere) responds. By comparing visual field differences in reaction time for left and right hand responding, Day hoped to determine whether the left visual field stimuli were analyzed within the right hemisphere or transferred to the left hemisphere for analysis.

Day (1977) found in his first experiment that there was no significant difference between responding to right or left visual field stimuli, or between responding using the right or left hand. This indicates that both hemispheres were equally efficient in processing concrete
nouns in the lexical decision task. The reaction time data also showed a right visual field (left hemisphere) advantage for processing abstract words. When the reaction time of the difference between the right and left hand responding was compared by right and left visual fields, it was found that the right visual field superiority was equal for the two hands. Day felt this indicated that the information about abstract words was transferred to the left hemisphere, rather than just being a matter of the right hemisphere being slower in processing the information.

In his experiments 2 and 3, Day (1977) investigated the Gazzaniga (1970) finding that the right hemisphere is able to recognize semantic associations between object nouns and to use this information to perform simple tasks. Day presented subjects with a superordinate category word (foveally) followed by either a positive or negative category instance in either the right or the left visual field. Day (1977) found that subjects were able to recognize accurately instances of categories in either their right or left visual fields, indicating that the right hemisphere is able to detect semantic relationships between concrete nouns and their superordinate categories.
In a later study, Day (1979) also replicated another Gazzaniga (1970) finding by again using normal subjects. In a procedure similar to the one described above (Day, 1977, experiment 1), Day presented subjects with high and low imagery nouns, adjectives, and verbs, and found no difference in subject's responding to right and left visual field presentations of high imagery nouns and adjectives, but a significant right visual field (left hemisphere) advantage for subject's responses to low imagery nouns and adjectives, and to both high and low imagery verbs. He interpreted these findings to mean that the right hemisphere's internal identification system is facilitated by an internal imagery-based coding system.

Day's (1977) study has been repeated by Shanon (1979). Again Shanon measured subjects' reactions times for deciding whether abstract or concrete English nouns and verbs were words or not (lexical decision task). He presented these letter strings to either the subject's right or left visual field, but did not measure differences between right and left hand responding. While Shanon (1979) found trends in the direction of Day's findings, he found no significant difference between the subject's responses to right or left visual
presentations of either abstract or concrete nouns or verbs. However, Shanon's experiment, used one quarter the number of words as did Day's experiment, and Shanon used fewer subjects, so while Shanon's study is interesting, more research has to be done before right hemisphere processing of abstract words is believed.

Another way in which right and left hemispheric processing of language has been studied has been by analyzing subjects' responses to written Japanese. Japanese may be written using any of three different orthographic systems. Kanji is ideographic, so that single characters or groups of characters represent individual words. There is no systematic relationship between the orthographic form of a word and its phonetic character. In the other two systems of writing, Hiragana and Katakana (both known as Kana), each element represents a syllable, and there is a close relationship between the written and pronounced form of a word.

Clinical data indicates that these two systems may be processed in different areas of the brain. Right hemisphere damage seems to produce deficits in the reading and writing of Kanji (the ideographic system), while left hemisphere damage seems to produce deficits in
the reading and writing of Kana (the phonetic writing system) (Sasanuma and Fujimura, 1972).

Normal subjects also show right versus left hemisphere differences in the processing of Kanji and Kana. Sasanuma et al (1977) found that subjects were able to identify Kana words (phonetically based) presented to the right visual field (left hemisphere) better than Kana words presented to the left visual field. While the difference was insignificant, there were trends that Kanji was identified better when presented to the left visual field (right hemisphere) than when presented to the right visual field. However, the Kanji used in the Sasanuma study were all nouns, and studies described earlier (Day, 1977; Gazzaniga, 1970) indicate that the right hemisphere can only process high imagery nouns and adjectives.

Elman, Takahashi, and Tohasku (1981) therefore have investigated right hemisphere responding to abstract Kanji words. They presented subjects with abstract and concrete Kanji words in either the right or left visual field, and found that while there was no difference in the identification of concrete Kanji nouns in the right and left visual fields, there was a distinct right visual field (left hemisphere) advantage for the identification
of abstract Kanji words. This result, therefore, corroborates data by Day (1977), Ellis and Shepherd (1974), and Hines (1976), and seems again to state that the right hemisphere's linguistic capabilities are limited to concrete (high imageable) nouns and adjectives.

**Summary**

Results from clinical studies, and experimental results from normal subjects seem to indicate a few basic facts about right hemisphere linguistic capabilities. There seems to be quite a lot of evidence that the right hemisphere can process highly-imageable concrete nouns and adjectives (Gazzaniga, 1970; Ellis and Shepherd, 1974; Hines, 1976; Day, 1977; Elman et al., 1981). There also are indicators that point to the right hemisphere's capability of making semantic associations (Day, 1979; Gazzaniga, 1970; and Levy, 1970). With a few exceptions, most researchers have also found that the right hemisphere is not capable of analyzing abstract words (Day, 1977; Elman et al., 1981; Ellis and Shepherd, 1974; Hines, 1976). These results, then, seem to paint a picture of right hemisphere linguistic capabilities that are much more primitive that the left
hemisphere's capacities. Day (1979) in fact, hypothesized that the right hemisphere's linguistic system may be based on an imagery system, which raises interesting questions regarding the differences in word comprehension between the left and right hemispheres. These differences, along with their implications for the study of semantic and lexical memory, will be examined further in the next section.

Statement of the Problem

Lupker and Sanders (1980) have studied right and left hemisphere differences in word processing, using the standard picture-word interference task described earlier and they varied the type of words presented to the subject. The category-one words were semantically related to the pictures, the category-two words were unrelated to the pictures, the category-three letter-strings were pronounceable nonwords superimposed on the pictures, while category four items were consonent strings superimposed on the pictures.

Therefore, in addition to having the words vary in semantic relatedness to the pictures, Lupker and Sanders also varied the words in terms of a phonetic continuum. Words in condition one were basically equivalent to words in condition two, except that they should provide extra
interfering semantic information. Category three letter-strings should be roughly equivalent to category two words in terms of pronounceability, except that they should provide no semantic information at all, while category four letter-strings should provide neither semantic nor phonetic information.

Lupker and Sanders presented the picture-word interference task to both the left visual field and the right visual field, and after subjects performed the picture-naming task for all the items, they were given a surprise free recall test of all the words they had seen. The investigators expected subjects to show differences in their ability to recall based on whether the words had received semantic analysis, phonetic analysis, or both (Craik and Lockhart, 1972). Words that receive semantic processing should be recalled better than words which receive only phonetic processing, (Craik and Tulving, 1975).

In terms of picture-word interference, the results from the right visual field (left hemisphere) were quite straightforward. Consonant strings, which provided only a minimal amount of phonetic information, evoked only a minimal interference effect, when subjects were asked to name the pictures. Pronounceable nonwords and unrelated
words, both of which would provide phonetic information, produced roughly equal amounts of interference in picture naming, and significantly more interference than the consonant strings, while the semantically related words produced the greatest amount of interference. Therefore, for the right visual field (left hemisphere), both phonetic and semantic factors were important determiners of the amount of interference observed, and Lupker and Sanders (1980) concluded that left hemisphere processing of words is similar to that observed for centrally presented word processing.

The results for the left visual field presented an entirely different picture. All the conditions, from the consonant strings to the semantically related words, produced a roughly equivalent amount of interference when compared to the picture alone condition.

Data from the free recall task, however, allow for an explanation of the performance to left visual field stimuli. Overall, the words presented in the right visual field were recalled better than words which had been presented in the left visual field. In addition, words that appeared superimposed on same semantic category pictures were recalled better than unrelated words. However, the difference between the same semantic
category picture-word pairs and unrelated picture-word pairs was equivalent for the two hemispheres, indicating a clear effect of semantic factors on the recall of material presented to the left visual field (right hemisphere).

Lupker and Sanders interpreted these findings as follows: when the picture-word stimuli were presented in the left visual field (right hemisphere), automatic phonetic processing did not occur and the word's name never became available. For that reason, there was no difference in the interference effect between the different categories of words when the subjects attempted to name the picture. That is, words and letter strings providing differing amounts of phonetic information failed to produce differing amounts of interference on the picture-naming task. On the other hand, Lupker and Sanders did argue for the automatic processing of the semantic information in this task based on the free recall data. This data showed superior recall of words semantically related to the pictures when compared to the recall of words unrelated to the pictures, and this superior performance was equal for material presented to both visual fields.
Lupker and Sanders suggested that picture naming latencies were slowed for material presented to the left visual field because of the right hemisphere's unique method of processing the task. They proposed that the right hemisphere has a tendency to analyze stimuli in a holistic fashion. In this case, that would mean analyzing the pictures along with the words creating an amalgamation of letters and features. The right hemisphere must then either work to break apart the cluster, or else process the entire thing as a unit until a picture identification can be made. In either case, this would slow down processing when compared to naming a picture alone.

Lupker and Sanders (1981) concluded their study by stating that the left and right hemispheres process words differently. In both central and right visual field presentations, both phonetic and semantic information becomes available about a word almost automatically. In left visual field presentations (right hemisphere), however, phonetic information is not important, while there is evidence that semantic information does influence performance. To state this conclusion in terms used throughout this presentation, Lupker and Sanders (1980) have found evidence for the traditional
model of word processing being important when the left hemisphere is processing the words, (i.e. lexical access [word naming] is important to semantic access), but when the right hemisphere engages in word processing, semantic information can be available without word naming, (i.e. semantic information is available without lexical access).

This hypothesis about right hemisphere word processing also finds support from other studies discussed earlier. The data from the phonemic dyslexic patients (Marshall and Newcombe, 1973; Shallice and Warrington, 1975) indicated the existence of a direct encoding route whereby patients were able to read words without encoding them phonemically. These results also suggest the existence of semantic analysis without a lexical access. Interestingly enough, these patients had lesions in their left hemisphere, again indicating that this process might be a right hemisphere phenomenon. Clinical evidence from Japanese speaking people also gives credence to this idea. Right hemisphere damage seems to produce deficits in the reading and writing of Kanji, the ideographic Japanese writing system which does not correspond to the word's phonetic characters, while left hemisphere damage typically produces deficits in the
reading and writing of Kana, the phonetic writing system (Sansanuma and Fujimura, 1972).

In the context of these considerations, it would seem important to find corroborative evidence that the right hemisphere truly does differ from the left hemisphere in terms of word processing. A paradigm has been developed within which this kind of question could be answered. It may be recalled that Marcel and Patterson (1978), Marcel (1978), and Fowler, Wolford, Slade and Tassinary (1980) all used a procedure in which subjects showed evidence of semantic processing of words without even being aware of the word's existence. In their procedure, they obtained for each subject separately, an SOA at which a word, followed by a pattern mask, could not be detected as distinct from a blank card followed by the same pattern mask. Subjects then were presented with a word at this threshold SOA, followed by another letter string (a word or nonword) to which they had to make a lexical decision. Priming words semantically related to the letter strings that were presented at the predetermined sub-threshold SOA did facilitate reaction times to the subsequently presented letter strings in this task, indicating that even when the word was not nameable, or even perceivable, it still
influenced the processing of a semantically related target word that was presented immediately after it.

If one used this procedure, it would be possible to determine if word processing in the right hemisphere occurs without benefit of lexical access (or word naming). Similarly, it also would be possible to determine if semantic information is available prior to lexical access during left hemisphere word processing, or if left hemisphere word processing requires lexical access before semantic information is available.

There are some cautions to remember, however before using a procedure of this type. Merikle (1981) has criticized these paradigms on grounds that the measures to determine how much the subjects were actually seeing were inadequate. Therefore, any new study must contain controls to measure the extent to which subjects can actually see words that are not "nameable".

In regard to these considerations, then, the purpose of these experiments is two-fold. First, the relationship between lexical and semantic memory will be examined by analyzing word processing in the right and left hemispheres. This will be studied by using a procedure which allows for the semantic information in a word to be used when the word's name is unavailable. It
is important to note, however, that the focus of this work is on the distinction between lexical and semantic memory, and not on differential hemispheric functioning. Second, this paradigm will contain appropriate controls to answer Merikle's (1981) criticisms, and measure the extent to which subjects actually can see the words that are not nameable and encode semantic information from them.
EXPERIMENT 1

The present experiment was based on a study reported recently by Johnson and Huber (1981), using a procedure much like that of Marcel (1980). They used a paradigm in which subjects were asked to determine whether two simultaneously displayed items were both words when the items were presented under viewing conditions such that subjects could neither report the words nor even detect whether the items on the two lines were typed in the same case. The subjects then were asked to make lexical decisions about word pairs that varied in terms of their relationship to one another. They selected word pairs that shared an underlying meaning (semantically related), word pairs that shared an overlap in environment such as time or place (a contiguity-based relationship), and word pairs that were not related in any way (unrelated).

Johnson and Huber hypothesized that contiguity-based relationships (such as women-dress or table-food) would exist only among lexical representations. That is, they hypothesized that word-pair relationships or associations based primarily on overlap in time or space, rather than same category membership would have their primary impact within lexical memory. Word-pair relationships based
primarily on a commonality of meaning (such as woman-lady or table-desk) were assumed to have their impact upon semantic memory.

They found that when the viewing conditions were such that the subject could clearly identify both members of the word pairs, both types of relationships facilitated performance over unrelated word pairs. On the other hand, when the displays were degraded as described above, semantically-based relationships facilitated performance, while performance on items that shared a contiguity-based relationship were not significantly different from the unrelated controls. They interpreted these findings as illustrating an instance of semantic access without accompanying lexical access.

In the present experiment, the relationship between semantic and lexical memory was investigated further by comparing the word-processing capabilities of the right and the left hemisphere. The task used was the Johnson and Huber (1981) experimental procedure modified in order to compare responses to material presented in the right or left visual field. That is, subjects were presented with pairs of letter-strings and were asked to make lexical-decisions about these stimuli. The letter
strings were presented to the right and left visual fields, as well as to the center, at speeds such that subjects were unable to determine whether the items were printed in the same case.

If right hemisphere word processing does not involve word naming, as has been hypothesized earlier, then data similar to the Johnson and Huber (1981) results using the degraded stimuli should be obtained in this situation. That is, performance on the semantically-related word pairs presented in the left-visual field should be facilitated over that of the contiguity-based or unrelated word pairs. On the other hand, since this procedure prevents word naming, material presented to the right visual field (left hemisphere) may be processed differently. If the left hemisphere requires lexical access as part of its word processing, then left hemisphere performance on both the contiguity-based word pairs and the semantically related word pairs will be depressed.

The present experiment also will include an important procedure to answer Merikle's (1981) objections to this type of research. As described earlier, Merikle felt that the type of procedure used to determine the threshold SOA was unreliable. So much so, in fact, that
he was not sure how much the subjects actually were seeing in these types of paradigms. In this experiment, however, subjects were given the procedure to determine a threshold at the beginning and at the end of the experiment. Those subjects who showed above chance performance on the final task were not used in the main analysis. This is a particularly important control in that this type of research is controversial and counter-intuitive, and Merikle's (1981) criticisms have been particularly damaging.

This experiment, then, has two important goals. The first is to show that subjects do have semantic information available without lexical access (word naming) in a procedure that carefully controls the method used to determine a threshold SOA. The second goal is to use the relationship of the items in the task, along with the visual field of presentation (hemisphere) to obtain information on the distinction between semantic and lexical memory. That is, under what conditions is lexical access necessary in order for semantic access to occur, and under what conditions is it not?

Therefore a number of specific comparisons will be of interest. First, subjects' responses to the lexical decision task (foveal presentation) will be
compared to their responding to the case decision task, and to the performance that would be expected by chance. Next, the subjects' performances to the lexical decision task (peripheral presentations) will be compared to chance, and then responses to left visual field stimuli will be contrasted with responses to right visual field stimuli. Finally, responses to each of the stimulus types (semantically-related, contiguity-based, and unrelated) will be analyzed, comparing responses to right visual field stimuli with responses to left visual field stimuli for each stimulus type.
Subjects. Fifty-six Ohio State University undergraduate volunteers received course credit in Introductory Psychology for participating in this experiment. Each participant was tested individually in a session lasting approximately 45 minutes. All subjects were strongly right-handed with laterality quotients of +80 or higher on the Edinburgh Inventory (Oldfield, 1971). In addition, all reported that English was their first language, all had 20/20 corrected vision, and no subject had ever been in this type of experiment before. Participants were assigned to one of the two possible target presentation of the three different counterbalancing arrangements of the displays.

Stimuli. The displays for the experiment consisted of two types: those used for the case-decision, and those used for the lexical decision. These will be discussed separately.

Those displays used for the lexical-decision task consisted of two rows of upper-case letters, one typed immediately above the other using IBM gothic type on a 5" by 8" white card. The words varied in size from three
letters to nine letters, which means a variation in visual angle from .45 degrees to 1.34 degrees. The words were either centered in the visual field or else they were displaced 1.5 degrees from the center.

Word pairs were selected using the Russel and Jenkins (1954) Kent-Rosanoff word-association norms. For any one Kent-Rosanoff stimulus word, two of its response items were selected to pair with the stimulus word on display cards. The two response items were chosen such that they would be approximately equal in frequency as responses to the stimulus. One was a member of the same semantic category as the stimulus (i.e. woman-lady), while the other response item was not from the same semantic class (such as woman-dress). Semantic class membership was based on the agreement of two judges.

Thirty-six such triplets were selected. Three different experimental displays were constructed from these words to provide counterbalancing, such that each possible word pair was represented on the right side, the left side, and the center of the card. Within each display group, a subject saw 12 semantically related word pairs, 12 contiguity-based word pairs, and 12 unrelated word pairs on each of the right, center, and left side of the card. The thirty-six word pairs that were used for
the unrelated word set, had no associative relationships
to one another, and were chosen from those items that
were used as response items for the stimulus word in the
Kent-Rosanoff word association norms.

These 108 word pairs served as the "yes" items in
the task. "No" items were constructed by scrambling the
letters from one or both members of each of the word
pairs taken from another experimental display group.
That is, 54 word-nonword pairs and 54 nonword-nonword
pairs were created from semantically-related,
contiguity-based and unrelated word pairs from another
experimental display deck. Again, these were displayed
on the right, left, or center of the card, making a total
of 108 stimuli. Each of the 216 "yes" and "no" displays
were preceded and followed by a pattern mask, on which a
transparent orange central fixation point was
superimposed.

The word pairs used in the case-decision part of the
experiment also were typed in gothic type on 5" by 8"
white cards, and centered on the card. The words were
normal high frequency English nouns which varied in
length from 3 letters to 9 letters, which means a
variation in visual angle from .45 degrees to 1.34
degrees, with a vertical displacement of .9 degrees.
Again, each display was preceded and followed by a pattern mask, on which a transparent orange central fixation point was superimposed.

**Equipment.** The display apparatus was a Scientific Prototype two-channel tachistoscope (Model 800E). Rate of presentation was approximately one stimulus card every three seconds.

**Procedure.** At the beginning of the experiment, all subjects were given the case-decision task, in which they had to determine whether two words were both typed in capital letters (Yes items) or whether at least one of the words was typed in lower case letters (No items). These words were presented on the center of the card, preceded and followed by a pattern mask which included a transparent orange central fixation point. Participants were told to fixate on the orange fixation point when they heard the experimenter say "ready." Immediately after the word "ready," the experimenter presented the display words, and subjects responded orally with their answers.

Subjects first viewed five practice trials at 200 msec, to make certain they understood the instructions. Then a beginning display duration of 100 msec. was used. Each time the participant responded correctly on at least
four out of five display trials, the display duration was lowered, until the subject was responding at chance. Chance responding level was taken as responding correctly on no more than 55% of 24 stimuli. The display duration reached during this part of the experiment was then used on all subsequent parts. Next, half of the subjects received an additional 48 case-decision stimuli, while the other half of the subjects received these stimuli at the end of the experiment.

After subjects participated in either the case-decision threshold task, or both the case-decision threshold task and the case-decision experimental task, subjects participated in the lexical-decision task. Again they were told to fixate on the central fixation dot when the experimenter said "ready." Their job was to respond "yes" if both words presented on the right, left, or center of the card were normal English words, and to respond "no" if at least one word was a nonword. After subjects responded, they were asked to attempt to name any English words they saw. Accuracy on the lexical decision task and word naming were the dependent measures. Subjects viewed a total of 216 of these stimuli, with the pattern mask (including the accompanying orange fixation dot) preceding and following
each display presentation, and remaining in view until the next presentation. The rate of presentation was approximately one stimulus every three seconds.

Following the lexical-decision task, all subjects again received a case-decision task. Those subjects who had received the 48 case-decision display items after their threshold had been determined, received another 24 items. Those subjects who had not yet received their 48 case-decision display items, received these. Subjects who were correct on more than 55% of these last case-decision items were not included in the main analysis.
RESULTS

Out of the 56 subjects who participated in this experiment, the performances from only 24 were used in the main analysis. Out of the other 32 participants, 20 scored above the 55% correct cut-off value for the last case-decision task, while the remaining 12 were excluded because of inattention mid-way through the experiment. It was obvious to the experimenter when a subject was inattentive, because s/he sighed frequently, said they were "bored" with the experiment, frequently asked to see a trial again because s/he was not looking through the monitor, and asked several times how many more trials were to be presented. The testing of these subjects were terminated early.

The first analysis compared the subject's responses to the case-decision task with their responses to foveal presentations of the lexical-decision task. It was found that performance (measured by percentage correct) was significantly better for the lexical decision task (with a mean of 53% correct), than for the case-decision task (with a mean of 47% correct), $F(1,23) = 8.277$, $p < .01$. 
Table 1

Overall Percentage Correct Scores for Performance to the Lexical Decision Task

<table>
<thead>
<tr>
<th>Visual Field</th>
<th>Left</th>
<th>Right</th>
</tr>
</thead>
<tbody>
<tr>
<td>Response Type</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>No</td>
<td>Mean</td>
</tr>
<tr>
<td>Type of Relationship</td>
<td>63</td>
<td>42</td>
</tr>
<tr>
<td></td>
<td>56</td>
<td>45</td>
</tr>
<tr>
<td></td>
<td>55</td>
<td>40</td>
</tr>
</tbody>
</table>
Accuracy on the foveal presentations of the lexical-decision task also was significantly better than that which would be expected by chance, $t(23) = 2.14$, $p < .05$.

The overall analysis of the lexical decision task compared the relationship of the items to the visual field of presentation and to response type. Table 1 presents the mean percentage correct scores for each field of presentation and type of relationship.

It was found that the kind of relationship (unrelated, semantically-related, or contiguity-based items) did not significantly affect performance, $F(2,46) = .07, p > 1$; nor did it interact with visual field, $F(2,46) = 1.73, p > .10$, or response type, $F(2,46) = 1.29, p > .10$. In addition, neither the visual field of the stimulus presentation nor the response type influenced performance, $F(1,23) = .19, p > 1$, and $F(1,23) = .07, p > 1$, respectively. In fact, the only reliable effect obtained for the lexical-decision task analysis was the interaction between visual field and response type, $F(1,23) = 21.3, p < .01$. The mean percentage correct scores for this analysis are presented in Table 2.
Table 2

Percentage Correct Scores for Response Type by Visual Field, Collapsing Across the Type of Relationship of the Stimuli.

<table>
<thead>
<tr>
<th>Response Type</th>
<th>Visual Field</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Left</td>
<td>Right</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>59.2</td>
<td>43.4</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>41.5</td>
<td>58.5</td>
<td></td>
</tr>
</tbody>
</table>
As can be seen from Table 2, the subjects seem to be answering "yes" correctly in the left visual field and "no" incorrectly, and answering "no" correctly in the right visual field and "yes" incorrectly. In other words, they answered "yes" whenever the stimuli appeared in the left visual field, and "no" whenever the stimuli appeared in the right visual field.

Finally, an additional analysis compared the subjects' performances to stimuli presented in the right and left visual field with the performances that would be expected by chance. It was found that performance to stimuli presented in the right visual field did not differ from chance, $t(23) = .79, p > .10$; nor did performances to left visual field stimuli differ from chance $t(23) = .43, p > .10$. In fact, overall responding to both left and right visual field stimuli did not differ from chance $t(23) = 1.22, p > .10$. 
DISCUSSION

Obviously, the results from this first experiment were disappointing, in that subjects' performance can be explained by response bias. In other words, subjects seemed consistently to say "yes" to items presented to the left visual field, and "no" to items presented to the right visual field. Overall performance to material presented to the right and left visual fields was not significantly different from chance, making such performance uninterpretable.

However, when subjects were questioned about their strategy in performing this experiment, several said that they had been responding to the relative visual clarity of the stimuli in the lexical decision task, since they were actually unable to see the words. In fact, the best subject out of the twenty-four included in the main analysis, was able to name correctly only one word out of the stimuli presented during the lexical-decision task. One possible explanation for the subjects' response bias may have been that they were indeed responding on the basis of the clearest visual information.

Research on right and left hemisphere differences has indicated that the right hemisphere is more adept at
processing pattern information (see Gazzaniga, 1970 for summary). It is possible that subjects, in lieu of any verbal information, simply responded to the image that was most readily processed. Therefore it makes sense that subjects answered yes to material presented to the left visual field (right hemisphere), and no to material presented to the right visual field (left hemisphere).

One reason why subjects responded in such a fashion on the lexical-decision task may have been that the material in the left and right visual fields was presented at speeds far below their threshold SOA. It will be recalled that the criteria for the threshold SOA used for the lexical-decision task was set by having subjects respond to material presented foveally. Material of this type presented foveally is seen more clearly than material presented in peripheral vision. Therefore, one reason subjects responded as they did may have been that they did not have enough visual information to complete the task. This is also a possible explanation for the extreme fatigue and boredom evidenced by the subjects.
EXPERIMENT 2

Experiment 2 followed essentially the same procedure as Experiment 1, with a few changes. First, the case-decision task was altered such that the word pairs appeared in the right and left fields, as well as in the center. The threshold SOA was then set as the display duration that yielded chance performance to material presented in the right and left visual field, with responses to items presented in the center being excluded.

Items in the center of the screen were only included so that one-third of the time, the subjects were presented with stimuli at the point of fixation. Young and Ellis (1981) have recently stated that a procedure like this is necessary to insure that subjects will continue to fixate on a central fixation point instead of moving their eyes to see the stimuli presented to the right or left periphery. Again, responses to items presented in the center of the subjects' visual field were not included in the main analysis for either the case-decision task or the lexical-decision task.

The second modification in the Experiment 1 procedure involved asking subjects to rate how confident they were of their answers to the lexical-decision task,
on a scale of one to five. That procedure was done so that the data could be analyzed using a nonparametric signal detection measure (Ag). The Ag measure provides a way of detecting the subjects' discrimination of a signal from background noise. It is independent of the subjects' expectations, and so only reflects his/her sensitivity to the difference between signal and noise regardless of his/her response bias.

Experiment 2, then, had the same goals as Experiment 1, but made some minor modifications in the procedure. It will be recalled that the first goal was to show that subjects do have semantic information available without lexical access (word naming) in a procedure designed to answer Merkle's (1981) criticisms of this type of research. The second goal was to investigate the distinction between semantic and lexical memory and how they interact. That is, does the relationship between semantic and lexical memory differ across hemispheres, or is word processing in the right hemisphere equivalent to word processing in the left? Again, however, the focus is not on the difference between the hemispheres in their functioning, but rather on the distinction between lexical and semantic memory.
Therefore, a number of comparisons will be of interest. First, subjects' responses to the lexical decision task (using only responding to peripheral presentations) will be compared to the performances that would be expected by chance. Next, the subjects' performances to each stimulus type (semantically-related, contiguity-based, unrelated) will be compared to chance, and then the combined response scores to the semantically-related and the contiguity-based items will be contrasted with scores for the unrelated items. Finally, responses to each of the stimulus types will be analyzed, comparing responses to right visual field stimuli with responses to left visual field stimuli for each stimulus type. Analysis beyond these planned comparisons will be conducted using posthoc procedures.
Subjects. Eighty-nine Ohio State University undergraduate volunteers received course credit in Introductory Psychology for participating in this experiment. Each participant was tested individually in a session lasting approximately 45 minutes. Again, each participant met the same requirements as had been used in Experiment 1. That is, they were strongly right-handed with laterality quotients of +80 or higher on the Edinburgh Inventory (Oldfield, 1971), had English as their first language, and had 20/20 corrected vision. No subject had ever been in this type of experiment before. Participants were assigned to one of the two possible target presentations of the three different counterbalancing arrangements of the displays.

Stimuli. The displays for Experiment 2 consisted of two types: those used for the case-decision, and those used for the lexical-decision. The displays used for the lexical-decision task consisted of the lexical-decision material from Experiment 1. Displays used for the case-decision task also consisted of the words from Experiment 1, with some minor modifications.

The word pairs used in the case-decision part of the experiment were typed in gothic type on 5" by 8" white
cards, and centered, or displaced 1.5 degrees to the right or left of the center as described before. As stated earlier, the words were normal high frequency English nouns which varied in length from three letters to nine letters, which means a variation in visual angle from .45 degrees to 1.34 degrees, with a vertical displacement of .9 degrees. Each display was preceded and followed by a pattern mask, on which a transparent orange central fixation point was superimposed.

**Equipment.** The display apparatus was a Scientific Prototype two-channel tachistoscope (Model 800E).

**Procedure.** The procedure for Experiment 2 was essentially the same as that used in Experiment 1. That is, at the beginning of the experiment, all subjects were given the case-decision task, in which they had to determine whether two words were both typed in capital letters (Yes items), or whether at least one of the words was typed in small letters (No items). Each time the participant responded correctly on more than four out of the five display trials, the display duration was lowered, until the subject was responding at chance. Chance responding level was taken as responding correctly on no more than 56% of the stimuli printed on the right or left side of the card, with answers to the central display items being excluded. The display duration
reached during this part of the experiment was then used on all subsequent parts. Next, half of the subjects received an additional 48 case-decision stimuli, while the other half of the subjects received these stimuli at the end of the experiment.

After subjects participated in either the case-decision threshold task, or both the case-decision threshold task and the case-decision experimental task, subjects participated in the lexical-decision task. Their job was to respond "yes" if both words, presented on the right, left, or center of the screen, were normal English words, and to respond "no" if at least one item was a nonword. After subjects responded "yes" or "no", they were instructed to give a numerical rating of how confident they were of their answers. A scale of one through five was used, with one meaning "not confident", and five meaning "sure". These two measures formed the dependent variables.

As in Experiment 1, following the lexical-decision task, all subjects again received a case-decision task. Those subjects who had received the 48 case-decision display items after their threshold had been determined, received another 24 items, while those subjects who had not yet received their 48 case-decision display items, received these. Subjects who answered correctly more
than 56% of these last case-decision items (counting only responses to items on the right or left side of the card) were not included in the main analysis.
Results

Out of the 89 subjects used in this experiment, only 36 were used in the main analysis. Of the other 53 participants, 38 scored above the 56% correct cut-off value for the last case-decision task, while the remaining 15 were excluded because of inattention, mid-way through the experiment. The criteria for exclusion mid-way through the experiment was the same as it had been for Experiment 1.

The results from the 36 subjects used in the main analysis were analyzed using a nonparametric signal detection measure (Ag). Ag scores were determined separately for each subject, based on their performance on the lexical-decision task. Using data from the subjects' responses to stimuli presented in both the right and left visual fields, a mean Ag score of 51.50 was obtained. This Ag score was significantly different from chance (50), $t(35) = 2.46$, $p < .02$.

The overall analysis of the lexical decision task compared the relationship of the items to the visual field of presentation and the mean Ag scores for this overall analysis are presented in Table 3.
Table 3

Overall Ag scores for the Lexical Decision Task

<table>
<thead>
<tr>
<th>Type of Relationship</th>
<th>Visual Field</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Semantically-related</td>
<td>Left</td>
<td>51.1</td>
<td>Right</td>
</tr>
<tr>
<td>Contiguity-based</td>
<td>Left</td>
<td>56.1</td>
<td>Right</td>
</tr>
<tr>
<td>Unrelated items</td>
<td>Left</td>
<td>48.8</td>
<td>Right</td>
</tr>
</tbody>
</table>
The interaction of visual field of presentation and the type of relationship between the stimulus items was significant, $F(2,70) = 3.68, p < .05$. However, there was no main effect for type of relationship or visual field of presentation, $F < 1$ in each case.

Since the unrelated items did not differ across visual field of presentation, $t(35) = 1.19, p > .10$, the interaction of the semantically related and the contiguity-based items with the visual field of presentation was analyzed. While the interaction was significant, $F(1,35) = 6.64, p < .05$, there was no main effect of type of relationship, $F(2,70) = 1.36, p > .05$.

Next, the above interaction was explored by making a comparison between the visual fields of presentation and the semantically related and the contiguity-based items separately. It was found that responding to left visual field semantically-related stimuli did not differ from responding to right visual field semantically-related stimuli, $t(35) = 1.24, p > .10$, but responding to left visual field contiguity-based items did differ from performance to right visual field contiguity-based items, $t(35) = 2.49, p < .05$. 
The overall combined Ag scores of the contiguity-based items and the semantically related items together was significantly different from that which would be expected by chance, \( t(35) = 4.93, p < .01 \). In addition, the overall Ag score for the semantically-related items was significantly different from chance \( t(35) = 2.51, p < .05 \), and also the mean Ag scores for the contiguity-related items was significantly different from chance, \( t(35) = 2.43, p < .05 \).

The combined Ag score of the semantically-related and the contiguity-based items also was significantly different from the mean Ag score of the unrelated items, \( t(35) = 1.71, p < .05 \) (one-tailed). As will be discussed later, this finding, along with other results, suggests that meaning did affect the subjects' performances when the stimuli were presented at the below-threshold duration.

The combined Ag score of the semantically-related and the contiguity-based items also were compared to the unrelated items across each visual field of presentation. It was found that for the left-visual field, accuracy in responding to the semantically-related and the contiguity-based items was significantly different from responding to the unrelated items, \( t(35) = 2.89 \),
p < .05, but that was not true for responding to items in the right visual field, t(35) = .50, p > .10. Therefore, while there did appear to be a reliable effect of associative relationship in the right hemisphere, the effect in the left hemisphere was unreliable.

Although the subjects' responses to the foveal lexical-decision displays were not included in the main analysis, they were analyzed separately and it was found that the relationship among the items in the stimuli did affect performance, F(2,70) = 3.28, p < .05. The mean Ag scores are presented in Table 4.

The responses to semantically-related items were not different from responses to contiguity-based items, t(35) = .04, p > .10, replicating the Johnson and Huber (1981) results with items above the threshold SOA, but the combined Ag scores of performances to semantically-related and contiguity-based items were significantly different from responses to unrelated items, t(35) = 2.6, p < .02.

An analysis also was done for those thirty-eight subjects who were discarded because they responded better than 56% correct on the last case-decision task. It was thought that their sensitivity to the stimuli would increase with increasing percentage correct scores.
Table 4

Ag Scores for Word Pairs Presented Foveally

<table>
<thead>
<tr>
<th>Category</th>
<th>Ag Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Semantically related</td>
<td>62.4</td>
</tr>
<tr>
<td>Contiguity-based</td>
<td>61.7</td>
</tr>
<tr>
<td>Unrelated items</td>
<td>56.1</td>
</tr>
</tbody>
</table>
That is, it was thought that the better they could see the items presented during the lexical-decision task (based on their final responses on the case-decision task), the better their Ag scores to the lexical-decision task. All subjects in this group, however, still performed the lexical-decision task at a duration of less than 90 msec, and no one scored more than 87% correct on the final case-decision task, with the average being 64% correct.

A product-moment correlation between final performance on the case-decision task and overall Ag score yielded $r = -.15$ for stimuli presented to the right visual field, which accounts for less than 2% of the variance; and a correlation of $-.01$ for stimuli presented to the left visual field, which accounts for less than .1% of the variance. The overall mean Ag score of the subjects, summed across visual field of presentation and type of relationship between the stimulus items was 50.24, which was not reliably different from chance, $t(37) = .39$, $p > .10$. 
DISCUSSION

The results from Experiment 2 yielded several important and interesting findings. First, it indicated that in a situation where subjects were unable to detect whether lower case letters appeared in at least one of two lines of type, they were able to determine if the letter strings were both normal English words. While the subjects in Experiment 2 were not asked to name the words, the results of Experiment 1 (which employed essentially the same procedure) indicated that at best subjects could report only one word out of the 216 displays (mode and median being zero). This means that the subjects had virtually no information about the name of the word (lexical access), or visual characteristics, yet they were able to report whether or not the letter-strings were English words.

Previous research (Marcel, 1980; Marcel and Patterson, 1978; Fowler et al., 1981) also had given data which indicated that subjects were able to perform tasks which required semantic memory access without being aware of the word's name. However, Merikle (1981) had objected to the procedures used in these studies. These experiments typically used some sort of threshold
determining task at the beginning of the experiment to set a stimulus display duration which would preclude access to the lexical memory. Unfortunately early research had not provided enough trials to set an adequate measure of the subjects' responses to this threshold determining task. In addition, these earlier studies had not provided any kind of check at the end of the experiment to ensure that subjects' responses remained at the predetermined threshold level. The threshold, then, may not have been set adequately at the beginning of the experiment, or else the subjects may have become better at viewing briefly presented stimuli with practice. These earlier studies had no way of testing for either possibility.

In this experiment, this situation was corrected by the use of the same task at the end of the experiment that had been used to set the threshold SOA. Subjects whose performance increased above the 56% correct criteria, were excluded from the main analysis.

Therefore, the first major result of Experiment 2 was to show that in a paradigm that corrected the procedural problems Merikle (1981) had discussed, there is evidence that subjects are able to determine if letter-strings are words when they have no knowledge of
the case in which the words are typed. That result provides evidence to suggest that subjects did have direct semantic access without accompanying lexical access.

The next important result of Experiment 2, was that responses based on the associated or related items were more accurate than were responses to the unrelated items. That result indicated that the relatedness of the word pairs significantly affected performance.

Recently Miller (1979) provided data indicating that subjects were able to make accurate lexical decisions on letter-strings presented at brief SOAs (to prevent naming) only when the foil items (or "no" items) were orthographically irregular letter strings, and that they were not able to make accurate lexical decisions when the foil items were orthographically regular. Miller argued that subjects in experiments such as Experiment 1 and 2 made these lexical decisions based on orthographic information rather than semantic information, and that could mean that semantic access was not occurring.

However, the results from Experiment 2 indicated that subjects' accuracy in responding to the unrelated items was significantly poorer than responding to the semantically-related and the contiguity-based items.
These results, then, would indicate that subjects' decisions were influenced by the relationship between the items, and so would suggest some access to semantic memory.

Results from Experiment 2 also indicated that the semantically-related, the contiguity-based, and the unrelated items interacted with visual field of stimulus presentation. It was found that the semantically-related items and unrelated items did not differ across visual field of presentation but the contiguity-based items did differ across visual fields, with performance to the left visual field material (right hemisphere) being superior to performance to the right visual field material (left hemisphere).

This result is different from what was predicted. It will be recalled that Johnson and Huber (1981) had hypothesized that contiguity-based relationships (such as woman-dress) would only exist among lexical representations. That is, they hypothesized that word pairs based on real world associations (composed of an overlap in time or space rather than same category membership) would be analyzed in lexical memory. Word pairs composed of an overlap in meaning (such as woman-lady) could exist within semantic memory.
Johnson and Huber found evidence suggesting that when both semantic and lexical memories are accessed, both types of associations facilitated the subjects' performances, but when the task was presented at viewing speeds that precluded lexical access only the semantically related word pairs facilitated performance.

It was predicted, then, that right hemisphere word processing would not involve lexical access, and so the accuracy of the responses to same-category items presented in the left-visual field would be greater than responses to the contiguity-based or the unrelated items. Predictions regarding responding to right-visual field stimuli were less certain. If left hemisphere word processing did require lexical-access, then performance on the semantically-related and the contiguity-based word pairs would be depressed. If some word processing could occur in the left hemisphere without lexical-access, then performance to semantically-related items should be facilitated over performance to the contiguity-based or the unrelated items.

As predicted, the Experiment 2 results indicated that response accuracy to semantically-related stimuli did not differ across the hemispheres. However, the results also indicated that response accuracy to left-visual
field contiguity-based items was superior to that for the right-visual field contiguity-based items. This result was unexpected, particularly in light of the Johnson and Huber (1981) results, which found no difference between contiguity-based and unrelated items when viewing speeds were below the threshold SOA.

In light of these considerations, an alternative model of word processing might be formulated. First lexical representations seem to be most characteristic of the left hemisphere. It may be recalled that when patients undergo the removal of their left hemispheres, they can neither name nor write words, yet they can comprehend simple instructions (Gott, 1973). In addition, while patients who have undergone the section of their corpus callosum are unable to name words presented in their left visual field (right hemisphere), they are able to understand the meanings of these words. Word naming, then, does appear to be a left hemisphere phenomenon.

Second, it was found in Experiment 2 that accuracy of responding to semantically-related items was above chance, but did not differ with regard to the visual field of presentation. Since it was assumed that the semantically-related items would have their primary
impact upon semantic memory, this suggests that semantic memory may not be lateralized. In addition, it may be recalled that patients with damage to the right hemisphere are able to write, speak, and read (Searleman, 1977). Furthermore, as noted above, while patients with their left hemispheres removed do experience difficulty in language production, they do show evidence of some speech comprehension (Gott, 1973). These considerations, then, suggest that semantic memory may not be lateralized.

Finally, in addition to semantic and lexical encoding, a third method of word encoding may occur. Springer and Deutsch (1981) have cited growing evidence that the right hemisphere uses a holistic manner of dealing with information, and also is superior at tasks which require visuo-spatial analysis. Levy and Trevarthen (1976) found that when a commissurotomized patient was given instructions to match pairs of stimuli on the basis of overall appearance or function, the patient matched stimuli appearing in the left visual field (right hemisphere) on the basis of overall appearance, and stimuli appearing in the right visual field (left hemisphere) on the basis of function. In addition, Day (1979) has hypothesized that right
hemisphere language processing may be based on an imageable system, and that coincides with Gazzaniga's (1970) report of superior performance to pictorial material presented in the left visual field (right hemisphere) of commissurotomized patients. These considerations, then, suggest that there may be another form of word encoding based on an imageable system, which is lateralized in the right hemisphere. This form of encoding would represent stimuli holistically, and imaginally, and it would be expected that responses to stimuli that can be represented pictorially should be facilitated when those stimuli are presented to the right hemisphere. In addition, while it is assumed that the contiguity-based relationships employed in Experiment 2 would yield greatest facilitation within lexical memory, and the semantic relationships would have their greatest facilitation effect within semantic memory, relationships indexed by the subject's ability to form integrated imageable representations that include both items should be represented within the imageable system.

In summary, this model proposes that lexical memory is lateralized in the left hemisphere, that semantic memory is not lateralized and that the imageable system is
lateralized in the right hemisphere. In addition, it is assumed that relationships among items can exist in each of these systems, and when a representation is accessed, the activation spreads to other items that share a system-specific relationship.

The results of the present experiment can be explained in terms of this model. The relevant results can be summarized quite briefly. While the subjects' performance was at chance for the stimuli containing unrelated word pairs, the items representing a contiguity-based relationship and those representing a semantic-based relationship both yielded performance reliably above that level. In addition, while there was no overall difference in performance on items representing the two types of relationships, there was a reliable interaction between the type of relationship and visual field, with performance on contiguity-based items presented to the left visual field being reliably better than performance to both the contiguity-based items presented in the right visual field and to the semantically-related items presented in the left visual field.

First, the unrelated word pairs did not share any kind of relationship, and so it was expected that
accuracy of performance on these items would be low relative to the related word pairs, with performance not influenced by visual field, and the data seem in accord with these expectations. The semantically-related word pairs, on the other hand, did share a relationship based on an overlap in meaning, and so they would receive the greatest facilitation within semantic memory. It would be expected that subjects should do relatively well on the semantically-related word pairs, but again, performance should not be influenced by visual field because semantic memory is assumed to be nonlateralized, and the pattern of data also seem to fit these expectations.

The situations with regard to the contiguity-based items, however, is more complex. These items shared a relationship based on an environmental overlap in time or space, and it was expected that such a relationship would be represented in lexical memory, and lexical memory is assumed to be lateralized in the left hemisphere. Therefore, performance on these items should have been facilitated when presented to the right visual field (left hemisphere). However, since the Experiment 2 exposure durations were deliberately set to prevent lexical access, it was expected that accuracy of
responding to the contiguity-based items presented in the right visual field (left hemisphere) would be relatively low, and that result was obtained.

If right hemisphere word processing does not include a lexicon, but instead does involve a holistic imaginal system (in addition to semantic memory), then processing of items that generate an integrated image should be facilitated. In addition, just as the present data indicate is the case for semantic memory, the McCauley, Parmelee, Sperber, and Carr (1980) study would suggest that imaginal-pictorial information can be encoded under conditions where items cannot be named.

Now, in terms of the contiguity-based items, it may be the case that in addition to indexing lexical relationships, the measures used for selecting these items also indexed an imaginal relationship, and did so to a greater extent than did the procedures used for selecting the unrelated items or the items that share an overlap in meaning. That is, the contiguity-based items are environmentally related to the extent that they have shared an overlap in time or space, and so may not only have indexed a lexical relationship, but also have indexed an imaginal relationship. For example, a word pair such as woman-dress could easily elicit an image
of a woman wearing a dress, in which both items retain a distinct representation, yet are integrated into a combined image. While such an image could be elicited by two unrelated items (such as woman-table), this relationship would not be a high frequency one, and so might not occur as readily within the imaginal system. Word pairs which have an overlapping meaning (such as woman-lady) also could generate an image quite readily, but this image might not consist of two distinct representations, but instead consist of only one (that of a female). (Note, the subjects' task was to make a positive responses only when two words were presented.)

Therefore, the above considerations could account for the Experiment 2 data with regard to the contiguity-based items. First, accuracy of responding to contiguity-based items presented in the left visual field (right hemisphere) was facilitated over that of contiguity-based items presented in the right visual field (left hemisphere), and that should have occurred if those items did not yield a facilitation within lexical memory, but did yield such a facilitation within the imaginal system. Second, although one also might expect a facilitation for the semantically-related items when presented in the left visual field (i.e. that memory also is asumed to be
represented in the right hemisphere), the fact that a single meaning was activated may have confused the subjects. It will be recalled that the lexical-decision task required subjects to make a positive response only when both letter strings were English words, and although the overall level of activation may have been higher for two semantically-related items than for two unrelated items, yielding some facilitation, the fact that there was only one active representation rather than two distinct representations may have detracted from performance.

Therefore, this model assumes that there are three systems involved in this task. In addition to the traditional notions of semantic and lexical representations, it has been hypothesized that there also exists an imaginal system and that procedures used to select materials that represent contiguity-based relationships may not only index relationships within lexical memory, but also index relationships within the imaginal system as well. Experiment 3, then, will investigate the types of relationships that exist among the word pairs used in Experiment 2.

An analysis also was made of the performances of those subjects who were discarded because they scored
more than 56% correct on the final case-decision task. It was found that added visual information (as determined by their score on the final task) did not aid in lexical decisions. In fact, their total score on the lexical decision task was not different from chance.

It is difficult to determine what actually happened with these subjects. It could have been the case that when subjects learned that the final case decision was the last task, they increased their attention to the task. If this explanation were true, it seems logical that there should be no correlation between amount seen on the final case-decision task, and the ability to perform the lexical-decision task.

On the other hand, it also might have been the case that subjects did have more visual information to perform the lexical-decision task, but not enough to be sure of their answers. This partial visual information might actually have been interfering with the subjects' responses. In other words, occasionally subjects may have seen enough to identify one of the words (which would not be enough to complete the task), or pick up random letters. This information could have biased them to say "yes" or "no" depending on their individual response bias, which would then reduce their Ag scores.
A similar explanation would be that again subjects did have visual information available to them to identify some of the words, or pick up random letters. However, it could be the case that such visual information would bias them to try to use lexical information to make their decisions, instead of making use of available semantic information. There was a slight, though non-significant, negative correlation between Ag scores and percent correct on the final case-decision task, which does give some credence to this interpretation.

Finally, it must be said, that the paradigm used in this study does have some problems. Subjects did not enjoy participating in this research. While it is frustrating to try to report on objects that are degraded (as in this study) and appear foveally, it is almost unbearable to try to report on degraded objects in peripheral vision and a number of subjects had to be discarded because of extreme inattention. The subjects who actually did participate in this experiment complained about the experiment, and stated that it had been extremely frustrating and boring. This problem is similar to the problem that Marcel (in press) reported in his early studies. It may be recalled that in his paradigm, subjects were asked to determine whether or not
words presented below awareness were synonyms of words that subjects could see and name. He also had to discard an unknown number of subjects. Marcel eventually abandoned this procedure in favor of the one he described in his 1978 study with Patterson.

The difficulty, then, is that the subjects' boredom and inattention may introduce a great deal of random error into the experiment, and the problem is compounded by the fact that the absolute magnitude of the effects are quite small. This difficulty made analysis of within group differences difficult. However, while the paradigm used in Experiment 2 does seem to have problems, several interesting results were obtained.

In summary, the two goals for Experiment 2 have been satisfied to a large extent. It may be recalled that one goal for this study was to provide evidence that direct semantic access can occur without accompanying lexical access, using a procedure that controls for Merikle's (1981) criticisms of this type of paradigm. In addition, it was shown that subjects were responding to the task based on semantic information, eliminating the argument that subjects could have performed the task by using only orthographic information. Therefore, the first goal of this study was met.
The results also provide evidence regarding the second goal, although the data were not entirely in the hypothesized direction. First, the fact that the subjects' performance was influenced by semantic relationships, when the items themselves were not nameable, and the visual information was so impoverished that they could not make case detections, argues for the distinction between a lexicon and semantic memory, because the two types of representations seem to be available at different points in time. In addition, although the overall pattern of the data is not consistent with the original model of hemispheric functioning within which the lexical versus semantic memory distinction was being examined, an alternative model that also assumes a lexicon separate from semantic memory, but includes an imaginal representation as well, does seem able to handle the data quite well. However, for that model to do so required the assumption that subjects could form an integrated image of the contiguity-based items more readily than they could for either the unrelated items or the semantically related items.
EXPERIMENT 3

Experiment 3 was designed to test the critical assumption used in the model to explain Experiment 2 that subjects could form an integrated image of the contiguity-based items used in Experiments 1 and 2 more readily than they could form such an image for either the unrelated items or the semantically related items. Subjects were asked to determine how easily and quickly both members of a word pair could be integrated into a combined and meaningful image. Ratings of the contiguity-based, the semantically-related, and the unrelated items were compared, with the expectation being that the subjects would rate the contiguity-based items as being more picturable than either the semantically-related or the unrelated items.

Subjects also were asked to rate the closeness of the association between the word pairs. Since the semantically-related and the contiguity-based word pairs were chosen such that they had the same word association index, (using the Russel and Jenkins (1954) Kent-Rosanoff word-association norms), it was expected that ratings for the relatedness of the items would be the same for the
semantically-related and the contiguity-based word pairs, and greater for these than for the unrelated items.

After judging the closeness of the relationship between the members of the word pairs, subjects were asked to determine if the word pairs were based on same category membership, based on an overlap in time or place (contiguity-based membership), or else unrelated. This judgement provided a check on the categorization of word pairs used in Experiments 1 and 2.

Finally, a separate group of subjects was asked to judge how quickly all of the word (printed separately) used in Experiments 1 and 2 could arouse a mental image. This last rating task provided a check to make sure that the words used for the contiguity-based items were not different in this imagery rating than the words used for the semantically-related and the unrelated word pairs.

METHOD

Subjects. A total of 51 subjects participated in this experiment. Of these, 36 subjects rated word pairs used in Experiments 1 and 2 for picturableness, relatedness, and category membership, while 15 rated all of the words (printed separately) used in Experiments 1 and 2 for
imagery. Participants included undergraduate volunteers who participated in the experiment as part of a course option, as well as friends, relatives, and acquaintances of the experimenter, and all subjects had English as their primary language. Subjects were tested individually or in groups, with the picturableness and relatedness tasks taking approximately 30 minutes, and the imagery task taking approximately 10 minutes.

Stimuli. The stimuli for Experiment 3 consisted of the semantically-related, contiguity-based, and unrelated word pairs used as stimuli for Experiments 1 and 2, and they were typed in a column on regular typing paper, followed by the numbers 1 to 7 (for the picturableness ratings) or by the numbers from 1 to 7 and the labels meaning-based, experience-based, (a new label for the contiguity-based items), or unrelated (for the categorization judgment task). Words used for the imagery-rating task were typed in a column on regular typing paper followed by the numbers from 1 to 7.

Procedure. The 36 participants in the picturableness and relatedness tasks were asked to make three kinds of judgements about the word pairs. The first judgement was to rate the picturableness of the word pairs on a scale of 1 to 7. The second judgement involved rating the
relatedness of the words on a scale of 1 to 7, followed by a judgement as to whether each word pair was best categorized as meaning based, experience based, or unrelated. Subjects received one of 12 randomizations of the word pairs, and half of the subjects received the picturableness rating task first followed by the relatedness rating task, while the other half received the opposite ordering.

The instructions for each task were adapted from Paivio, Yuile and Madigan's (1968) instructions. The instructions for the three tasks will read as follows:

**Instructions for the Picturableness of the Word Pairs**

Nouns differ in their capacity to arouse mental images or pictures of things or events. Some words conjure up a sensory experience, such as a mental picture or sound, very quickly and easily, whereas others may do so only with difficulty (i.e. after a long delay) or not at all.

In this experiment, you will be asked to rate (on a scale from one to seven), how quickly and easily a pair of words conjure up a single, unified picture that makes sense in terms of everyday experience. In other words,
how quickly and easily are you able to combine the two members of the word pair into a unified and meaningful picture in which the two members interact with one another in a normal manner.

For example: the word pair cigarette-match could easily conjure up a combined picture of a match lighting a cigarette. This is a good example of a unified picture, (and so would have a high imagery rating), in that it makes sense in terms of everyday experiences. That is, we often see cigarettes being lighted by matches. The critical thing to note in this example is that the two members of the word pair are interacting to make a single picture.

Similarly, the word pair table-chair can quickly and easily conjure up a combined picture that is often experienced in everyday life. We often see chairs set at tables, and it is common for tables and chairs to interact in this fashion.

It would take more time, however, to conjure up a single unified picture of a cigarette-doorknob. Obviously, it is easy to conjure up a picture of a doorknob and a cigarette together, but it is not easy to think of a case in which a cigarette and a doornob could interact in a way that is experienced often in everyday
life. One could conjure up a rather bizarre image of a cigarette being balanced on a doorknob or else a doorknob merely laying next to a cigarette, but again, such a picture is not often experienced in everyday life, and makes no more sense than any other items laying next to a doorknob, such as an apple or a sword or any other word we might want to name. Therefore, because it is difficult to conjure up a meaningful, unified, and familiar picture of these two words quickly, they would have a low imagery rating.

Do not be fooled into saying that two items make a unified picture merely because they are closely associated with one another. For example: the words carpet-rug might be closely associated with one another, but it is difficult to conjure up quickly a picture of a carpet interacting with a rug in some meaningful fashion that is experienced often in everyday life. One might do so if one were given enough time, but again, the key factor is that the two word concepts interact to form a unified image that is frequently experienced in the environment. Similarly, the word pair citizen-state, while closely associated would not make a high imagery word pair, because it is difficult to
create a unified picture in which the meanings of citizen and state interact in some manner.

Therefore, any word pair which, in your estimation, arouses a single meaningful picture in which the two items interact and form a meaningful relationship with one another, should be given a high imagery rating. Any word pair that arouses a unified picture with difficulty or not at all (or else arouses a bizarre picture that does not make sense in terms of everyday life), should be given a low imagery rating. Your ratings will be made on a seven-point scale, where one is the low imagery end of the scale, and seven is the high imagery end of the scale. Make your ratings by putting a circle around the number from 1 to 7 that best indicates your judgement of the ease or difficulty with which the word pairs arouse a unified picture.

In summary, then high imagery ratings should be given to words for which a unified, meaningful picture can be created quickly, in which both elements interact in a way that is experienced in everyday life. Word pairs that do not conjure up such an image, or else conjure up one slowly and with difficulty, should be given a low imagery rating. Words pairs that are intermediate in ease or difficulty of picturableness, of
course, should be rated appropriately between the two extremes. Feel free to use the entire range of numbers from 1 to 7. At the same time, don't be concerned about how often you use a particular number as long as it is your true judgement. Work fairly quickly, but do not be careless in your ratings. If necessary, refer back to these instructions when rating the words on the following pages.

Instructions for Degree of Relatedness

For this part of the experiment, you will be asked to determine how closely the two members of the word pairs relate to one another, and then judge the kind of relationship that they share. That is, for each word pair, you will determine how much one word reminds you of the other, and give a rating of your judgement on a scale of 1-7. After giving a numerical rating for the word pair, you will circle one of three categories (to be described later) that describes the type of relationship that exists between the two words.

When judging the degree of relatedness, keep in mind the following example: the word pair robin-bird would be more closely related than the word pair
chicken-bird, for although a chicken is also a bird, we tend to think of robins more often when we think of birds, and tend to think of chickens as something we eat. Similarly, the word pair black-white is more closely associated than the word pair black-yellow, since we experience the words black and white together more often than we experience the words black and yellow. Word pairs such as robin-bird or black-white would be highly related, and so should be given a score near the 7 end of the scale. Word pairs such as black-yellow, or chicken-bird, would not be as highly related, and so should be given a lower number on the scale.

Word pairs intermediate in their relationship, should be given a number intermediate between 1 and 7. Make your ratings by putting a circle around the number from 1 to 7 that best indicates your judgement as to the degree of relatedness of the word pairs. Remember, 1 is for word pairs that are related to a low degree, and 7 is for word pairs that are related to a high degree. You may make use of all the numbers, and it does not matter how often you use a number as long as it is a true indication of your judgement.

After making a numerical judgement of the relatedness of the word pair, then circle one of the
three categories describing the relationship between the members of the word pair. The first type of relationship is meaning based. Two words can be related because they have a common meaning (for example: Big and Large), or the items designated by the words could be similar in some way such as lemon and lime, or coffee and tea. Even apple and banana share some common meaning, because they are both fruits.

Another way words can be related is that they have been experienced together in the environment, even though they may not have any common or overlapping meaning. This second category is called an experienced based relationship. For example, paper does not share a meaning with pencil (as pen shares a meaning with pencil), but because we have experienced paper and pencil together we think of them as related or associated together. Similarly, the words canary-cage do not have a common meaning, yet they are related because they are experienced together in the environment. That is, canaries are often in cages, but the meaning of canary and the meaning of cage are quite different and not related. We might call this an experience based relationship rather than a meaning-based relationship.
Finally, the word pairs *apple-dress* would be classified as an *unrelated* word pair. Apples and dresses do not have similar meaning, nor are they often experienced in the environment together. For this reason, then, they would be classified as an *unrelated* word pair.

Therefore, for each words pair, determine how closely the two words are related. After circling the number from 1 to 7 which best describes this judgement, then determine whether the word pair is related or unrelated. If it is unrelated, then circle *unrelated*. If it is related, then determine whether the relationship is based on a *meaning based* or *experience based* relationship and circle the appropriate category. Work quickly, but be careful about your ratings. If necessary, refer back to these instructions when rating the words on the following pages.

The 15 participants in the word-imagery task received one of 5 randomizations of the words used in Experiments 1 and 2. They were asked to judge how quickly and easily each word created a mental image, and to rate this judgement on a scale from 1 to 7. The
instructions for this task were copied from Paivio, Yuile, and Madigan's (1968) instructions.
RESULTS

The results for the picturableness and relatedness rating tasks are summarized in Table 5, and these data were analyzed separately from the results for the word-imagery rating task, and will be considered first. Separate analysis were done for each task, using both subjects and items as the sampling unit.

The analysis of the picturableness rating task using subjects as the sampling unit, showed a significant main effect of type of word pair, $F(2,70) = 145.5, \ p < .001$, but no significant effect for either the order of task presentation, $F < 1$, or the interaction, $F < 1$. In addition it was found that the picturableness ratings for the semantically-related items were significantly less than the ratings for the contiguity-based items (with mean scores of 4.01 and 5.7), $F(1,35) = 52.6, \ p < .001$, or the contiguity-based items (5.7), $F(1,35) = 283, \ p < .001$. 
TABLE 5

Overall mean scores (based on a scale from 1 to 7) for the picturableness ratings and the relatedness ratings for word pairs used in Experiments One and Two

When Presented First

<table>
<thead>
<tr>
<th>Type of Relationship</th>
<th>Picturableness Ratings</th>
<th>Relatedness Ratings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Semantically-related</td>
<td>3.94</td>
<td>5.51</td>
</tr>
<tr>
<td>Contiguity-based</td>
<td>5.78</td>
<td>5.29</td>
</tr>
<tr>
<td>Unrelated</td>
<td>2.56</td>
<td>1.39</td>
</tr>
</tbody>
</table>

When Presented Second

<table>
<thead>
<tr>
<th>Type of Relationship</th>
<th>Picturableness Ratings</th>
<th>Relatedness Ratings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Semantically-related</td>
<td>4.09</td>
<td>5.43</td>
</tr>
<tr>
<td>Contiguity-based</td>
<td>5.62</td>
<td>5.94</td>
</tr>
<tr>
<td>Unrelated</td>
<td>2.40</td>
<td>1.94</td>
</tr>
</tbody>
</table>
The same pattern of data emerged for the picturableness rating task when items were used as the sampling unit. That is, there was a significant main effect for picturableness, $F(2,105) = 100.7$, $p < .001$, and the picturableness ratings for the semantically-related items were significantly less than the ratings for the contiguity-based word pairs, $F(1,70) = 51.5$, $p < .001$. In addition, the picturableness ratings for the unrelated items were significantly less than ratings for the semantically-related items $F(1,70) = 42.5$, $p < .001$, and the contiguity-based items, $F(1,70) = 238$, $p < .001$.

Ratings for the judged degree of relationship between the words of the word pairs showed a different pattern of data. Using subjects as the sampling unit, it was found that there was a significant main effect for both types of word pair, $F(2,70) = 406.5$, $p < .001$, and the presentation order $F(1,34) = 6.81$, $p < .05$, as well as an interaction between type of word pair and the task presentation order, $F(2,68) = 3.37$, $p < .05$. 
### TABLE 6

Category judgements expressed in terms of percentage

<table>
<thead>
<tr>
<th>Type of Relationship</th>
<th>Category judgements</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Meaning Based</td>
<td>Experience Based</td>
<td>Unrelated Based</td>
</tr>
<tr>
<td>Semantically-Related</td>
<td>65.5</td>
<td>29.5</td>
<td>5</td>
</tr>
<tr>
<td>Contiguity-based</td>
<td>17.2</td>
<td>79.8</td>
<td>3</td>
</tr>
<tr>
<td>Unrelated</td>
<td>3</td>
<td>5</td>
<td>82</td>
</tr>
</tbody>
</table>
However, in contrast to the results for the picturableness ratings, the analysis of the related ratings collapsed across orders of presentation, showed that the difference between the ratings for the semantically-related items (mean scores of 5.47) and the contiguity-based items (5.62) was not reliable, $F < 1$. The interaction between these ratings and the presentation order was significant, $F(1,34) = 10.06, p < .05$.

Further analysis indicated that when the picturableness rating task occurred first, the subjects judged the relatedness of the contiguity-based items as significantly greater than that for the semantically-related items (with means of 5.94 and 5.43), $t(35) = 2.95, p < .05$, while when the relatedness task occurred first, this trend was reversed (with means of 5.29 and 5.51), $t(35) = 2.06, p < .05$. The relatedness ratings for the unrelated items (mean of 1.67) were significantly less than the ratings for the semantically-related items (mean of 5.47), $F(1,35) = 385.3, p < .001$ and the contiguity-based items (mean of 5.62), $F(1,35) = 778.1, p < .001$.

Again an analysis that used items as the sampling unit showed the same pattern of data. First, there was
an overall significant effect of the type of relationship on the ratings for relatedness, $F(2,105) = 488.53$, $p < .05$, but there was no overall difference between relatedness ratings for the semantically-related items and the ratings for the contiguity-based items, $F < 1$. In addition, the relatedness ratings for the unrelated items were significantly less than the ratings for the semantically-related items, $F(1,70) = 712$, $p < .001$, and the contiguity-based items $F(1,70) = 891$, $p < .001$.

The results for the categorization task were scored in terms of the percentage of time the subjects' categorization of the word pairs agreed with the way the experimenter categorized the word pairs, and these data are presented in Table 6 along with the percentage of times the subjects categorized each word pair differently from the experimenter's categorization. The analysis of the agreement scores using subjects as the sampling unit showed a significant main effect of the type of word pair $F(2,70) = 15.0$, $p < .01$, but no significant effect for order of task presentation, $F < 1$, or the interaction $F < 1$. Separate analyses indicated that the agreement scores for the contiguity-based items were not significantly different from those for the
unrelated items (with mean scores of 79.8 and 82.0), \( F < 1 \), but that the agreement scores for the semantically-related items (with mean scores of 65.5) were significantly less than the agreement scores for the contiguity-based items (79.8), \( F(1,35) = 14.9, p < .01 \), or the unrelated items (82.0), \( F(1,35) = 28.8, p < .01 \).

The analysis of the categorization task using items as the sampling unit showed the same pattern of data and indicated that there was a significant main effect of the type of word pair on the agreement scores of the subjects, \( F(2,105) = 11.7, p < .01 \). In addition, while the agreement scores for the contiguity-based items were not reliably different from the scores for the unrelated items, \( F < 1 \), the scores for the semantically-related items were significantly less than the agreement scores for either the contiguity-based items \( F(1,70) = 13.5, p < .05 \), or the unrelated items, \( F(1,70) = 16.6, p < .05 \).

Product-moment correlations were computed separately for each type of word pair comparing ratings for the picturableness of the items (when the picturableness rating task was presented first) to the relatedness of the items (when the relatedness rating task was presented first). These data are presented in Table 7 (word
pairs are the sampling unit). The correlation between the picturableness ratings and the relatedness ratings was .14 for the semantically-related items, which was not reliable, .58 for the contiguity-based items, and .60 for the unrelated items, both of which were reliable. In addition, a confidence interval was constructed around the contiguity-based product-moment correlation using Fisher's $r$ to $z$ transformation, and it was found that the correlation for the unrelated items was not different from the contiguity-based items but that the correlation for the semantically-related items was significantly lower (at the .05 level) than that for the contiguity-based items. In general, then, the degree of relationship between the items was related to their picturableness for the contiguity-based and unrelated items, but not for semantically related items.

Product-moment correlations also were computed separately for each type of word pair comparing the relatedness ratings for the items, to the subjects' categorization of the items (i.e. the agreement scores), and those data are presented in Table 7. It was found that the relatedness ratings correlated significantly with the category agreement scores for the semantically-related items ($r = .54$), but the correlation was not
reliable for the contiguity-based items \( (r = .11) \), and was reliably negative for the unrelated items \( (r = .91) \). Overall, then, relatedness had a reliable influence on the subjects' categorization of the semantically-related items, but did not influence subjects' ability to judge the category of the contiguity-based items. Relatedness did impact the subjects' categorization of the unrelated items to the extent that when subjects saw a relationship between the words of the unrelated word pairs they did not categorize these items as unrelated.

Product-moment correlations also were computed separately for each type of word pair comparing the picturableness ratings to the agreement scores for the category judgement task, and these data appear in Table 7. The results indicate an unreliable negative correlation for the semantically-related items \( (r = -.27) \), a significant positive correlation for the contiguity-based items \( (r = .56) \), and a significant negative correlation for the unrelated items \( (r = -.67) \). Using Fisher's \( r \) to \( z \) transformation and constructing confidence intervals around the correlation for the semantically-related items, it was found that the correlation for the semantically-related items was significantly different from both the contiguity-based items and
the unrelated items. In general, then, picturableness is related to the subject's ability to make category decisions for the contiguity-based items and unrelated items, while it does not seem to influence subjects' categorizations for the semantically-related items.

Finally, an analysis using subjects as a sampling unit for the single word imagery ratings indicated that words used for the semantically-related items were judged to be more imageable than words used for the contiguity-based word pairs, $t(14) = 6.58, p < .01$. However, an analysis using items as the sampling unit indicated that semantically-related words were not different than contiguity-based items, $t(14) = 1.36, p > .05$. 
TABLE 7

Correlational Data

<table>
<thead>
<tr>
<th>Type of Relationship</th>
<th>Picturable and Relatedness</th>
<th>Relatedness and Category Judgement</th>
<th>Picturable and Category Judgement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Semantically-related</td>
<td>$r = .14$</td>
<td>$r = .54$</td>
<td>$r = -.27$</td>
</tr>
<tr>
<td>Contiguity-based</td>
<td>$r = .58$</td>
<td>$r = .11$</td>
<td>$r = .56$</td>
</tr>
<tr>
<td>Unrelated</td>
<td>$r = .60$</td>
<td>$r = -.91$</td>
<td>$r = -.67$</td>
</tr>
</tbody>
</table>
DISCUSSION

Experiment 3 was designed to test the assumption made in Experiment 2 that subjects could form an integrated image of the contiguity-based items used in Experiments 1 and 2 more readily than they could form such an image for either the unrelated items or the semantically-related items. It may be recalled that this crucial assumption was made in order to apply a proposed model of word processing to explain the data from Experiment 2. According to that model, it was assumed that there exists an imagery-based system which is laterlized in the right hemisphere, and within which stimuli are represented holistically and imaginally. Since the contiguity-based items showed a facilitation in the left visual field (right hemisphere), it was hypothesized that these items could be represented pictorially or imaginally more easily than either the semantically-related or the unrelated items.

First, subjects showed a marked tendency to agree with the preexperimental categorizations of the word pairs, but to a slightly less extent for the semantically-related word pairs than for either the contiguity-based
word pairs or the unrelated items. This lower score may have occurred because some of the semantically-related items had both a semantic and a contiguity-based relationship. For example, items such as crackers-cheese, while semantically-related, was experienced together in the environment, and so a subject might categorize these word pairs as experience-based items. The data indicated that the correlation between judged picturableness and the category agreement scores for the semantically-related items, while not reliable, was in the negative direction, showing that those semantically-related items that were judged to be picturable, tended to be categorized differently by the subject than by the experimenter.

In addition, subjects did not view the relatedness of the semantically-related word pairs as being greater or less than the relatedness of the contiguity-based word pairs, but did judge the relatedness for both these types of word pairs as being greater than that for the unrelated items. This result was as expected, since the semantically-related and the contiguity-based word pairs were chosen such that they had the same word association index (using the Russel and Jenkins (1954) Kent-Rosanoff Word-association norms).
However, the crucial question of the experiment was whether subjects could form an integrated image of the contiguity-based items more readily than they could form such an image for the semantically-related items or the unrelated items. The results indicated that subjects viewed the contiguity-based items as more picturable than either the semantically-related items or the unrelated items, showing that word pairs based on an overlap in time or space (environmental relationship) were judged to conjure up an image more readily than word pairs overlapping in meaning, even though both types of items were judged to be equally related. In addition, picturableness was correlated with relatedness for the contiguity-based pairs, but it was significantly less correlated with relatedness for the semantically-related pairs, indicating that for the semantically-related items, relatedness is not as strongly associated to picturableness.

Judged picturableness also was associated with judged relatedness for the unrelated items, and that would be expected because any relationship a subject saw between the words of the unrelated word pairs would have to be based on the subjects' individual
experience. Consistent with that expectation, when the unrelated items were judged to be picturable, they tended also to be categorized as experience-based items, with the correlational data indicating that judged picturableness of the unrelated items was reliably correlated with the tendency to categorize these items as experience-based. When these items were not picturable, they were judged to be not related as well, and were categorized as unrelated items.

Therefore, the pattern of data from Experiment 3 indicates that while the semantically-related and contiguity-based items were equally related, the contiguity-based items were judged to conjure up a combined image more readily than the semantically-related items. This provides support for the crucial assumption made in Experiment 2 regarding the relative picturableness of the contiguity-based items, and is consistent with the model presented in Experiment 2 which called for an imagery based system in addition to semantic and lexical memories. Additionally, while subjects tended to agree with the preexperimental categorizations of the word pairs, the categorization of the contiguity-
based and unrelated items tended to be most influenced by the picturableness of the word pairs, while the categorization of the semantically-related items tended to be most influenced by the relatedness of the word pairs. This provides further evidence that items containing an overlap in meaning do not necessarily conjure up an integrated image readily.
CONCLUSIONS

In conclusion, the results of these three experiments yielded several potentially important findings about lexical and semantic memory. First, the fact that subjects' lexical decisions regarding word pairs were influenced by the relationship between the word pairs, when the visual information was so impoverished that they could not make case detections, argues for the distinction between a lexicon and semantic memory. That is, the two types of representations seem to be available at different points in time.

In addition, the evidence for direct semantic access without accompanying lexical access occurred in a paradigm that carefully determined the SOA for the lexical-decision task, as well as provided a check at the end of the experiment on the visual information available to the subject. These procedures ensured that subjects were still unable to determine the case of the word pairs at the end of the testing session, satisfying some of the criticisms of this type of research.

This series of experiments also provided evidence for a view of hemispheric functioning within which the lexical versus semantic memory distinction was examined,
but the evidence was not entirely in the hypothesized direction. That is, it was expected and found that responding to semantically-related items occurred in the absence of name information in both hemispheres indicating that direct semantic access can occur in both hemispheres. In addition, it was not expected that responding to contiguity based word pairs would be facilitated in either hemisphere, since it was hypothesized that lexical memory would be lateralized in the left hemisphere, and the degraded visual information would prohibit lexical access. This result was obtained when subjects responded to contiguity-based items presented in the right visual field (left hemisphere), but responding to contiguity-based items presented in the left visual field (right hemisphere) was unexpectedly facilitated.

An alternative model of word processing then was proposed that also assumed a lexicon separate from semantic memory, but included an imaginal representation as well, which was assumed to be lateralized in the right hemisphere. Based on prior data, it was assumed that the imaginal system would represent stimuli holistically and imaginally, and that responses to stimuli that could be represented pictorially should be facilitated when those stimuli are presented in the left visual field (right hemisphere).
It was hypothesized that the contiguity-based relationships employed in Experiments 1 and 2 may have indexed such an imaginal relationship in addition to a lexical relationship, and this crucial assumption was tested in Experiment 3. It was found that while the semantically-related and contiguity-based word pairs were judged to be equally related, the contiguity-based word pairs were judged to conjure up a combined image more readily than either the semantically-related items or the unrelated items.

Therefore, the current series of experiments provided evidence that there may be three systems for representing word information within memory. Words can be represented semantically, which is not lateralized; lexically, which is lateralized within the left hemisphere; and imaginally, which is lateralized in the right hemisphere. The data also suggested that direct access can occur to both the semantic and imaginal systems, but that access to the lexicon may occur somewhat later in processing, in contrast to the traditional theories of word processing.
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