SEMANTIC MEMORY IN ALZHEIMER'S DISEASE

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ABSTRACT

Alzheimer's Disease is characterized by a general decline in cognitive functioning. Although phonology are relatively unaffected, patients with Alzheimer's Disease have been reported to have deficits of semantic memory. Thirteen patients with dementia, five of whom had a confirmed diagnosis of dementia, participated in the study. The purpose of this investigation was to replicate a study performed by Mark Byrd (1984), using Alzheimer's Disease patients. Subjects were presented with category-word decision pairs, for which the task was to decide if the word was an exemplar of the category, and category-letter decision pairs for which the task was to generate an exemplar of the category beginning with the letter. The dependent variable was reaction time.

Results indicated that Alzheimer's Disease patients and dementia patients had longer reaction times than a group of age-matched control subjects, and that the Alzheimer's Disease and dementia patients showed a pattern of responses similar to that of the control subjects. All groups showed longer reaction times for the generation trials than the decision trials. The results are consistent with the existence of a semantic memory deficit in Alzheimer's Disease, but other interpretations were discussed.
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CHAPTER 1
INTRODUCTION

1.1 Semantic Memory

In order to investigate the effects of Alzheimer's Disease on semantic memory, it is necessary to clearly state the nature of semantic memory. Masur (1986) defined semantic memory (SM) as "...that aspect of memory concerned with the representation and organization of word meanings." (p. 1305-B) While this definition is not incorrect, other authors have described SM in more detail.

Ober, Dronkers, Koss, Delis and Friedland (1986) defined SM as "...the associative network of permanent knowledge about the world which has been built up over one's lifetime." (p. 76) SM is more than memory for word meanings. It is the store of a person's world knowledge, which includes word meanings.

Perhaps the most beneficial way in which to define SM is to contrast it with episodic memory (EM). Bayles (1987) conceived of episodic memory and semantic memory as two components of long-term memory. Nebes, Martin and Horn (1984) described episodic memory as a record of an individual's experiences. In EM, episodes are encoded in relation to a temporal-spatial context. SM, on the other hand, is a context-free store of knowledge about concepts, their associations and organization. Nebes et al. illustrated the distinction between SM and EM as follows:

"...a person's recollection of seeing a canary in a shop window the preceding week, or of hearing the word CANARY among a list of 20 words given an hour earlier in a memory study, involves episodic memory. By contrast, the knowledge that a canary is a small yellow bird often kept as a pet, or that the word CANARY begins with the letter C and has three syllables, involves semantic memory...."1

Hannigan, Shelton, Franks and Bransford (1980) also contrasted EM and SM. They stated that EM and SM are two ways in which past experience can influence performance. Influences attributable to a person's having experienced an event, those which are tied to a particular context,
are episodic. Influences which are not attributable to a particular event are semantic. Hannigan et al. claimed that certain types of acts require different types of memory. Recall and recognition of previously presented material require episodic memory. Inferring and generalizing from presented material require semantic memory. Most tasks which are used to study memory require one or the other type of memory, but not both. A recall task may be used to test episodic memory, while a verification task may be used to test semantic memory.

The hypothesis of Hannigan et al. was that almost any cognitive act involves both semantic and episodic memory. Both semantic and episodic and semantic influences may affect the performance of that act. Semantic memory affects recall performance and episodic memory affects the performance of a verification task. Hannigan et al. found that both episodic and semantic memory influenced the identification of masked verbal stimuli.

Thus, although SM and EM are different aspects of long-term memory and although they can be investigated relatively separately, the performance of most cognitive acts (certainly the performance of complex cognitive acts such as creating and understanding discourse) involves the interaction of episodic and semantic memory.

Bayles (1987) defined semantic memory in greater detail. Following Tulving, she stated that SM is a subcomponent of procedural memory. Procedural memory involves the knowledge of how to do things, plans and skills. SM, on the other hand, involves factual knowledge of the world. Bayles also stated that the contents of SM are different from external sensory information about the world. Sensory information is transformed and coded in a way that is readable by SM processors.

"Semantic memory is that domain in the nervous system in which concepts are represented and inferential processing takes place.... Input from the perceptual modalities is accessed, actively cross-referenced, indexed, and sorted in SM.... it is a cognitive store in which knowledge is coded in an abstract way independently of the input modality. It is the functional system in which ideation and inferential processing consciously occur."2

Thus, semantic memory involves much more than the meanings of words. It is the storage system for abstract context-free mental representations. The highest-level, most abstract cognitive modality is stored in SM; conceptual knowledge.
1.2 Alzheimer’s Disease

Several years ago memory loss and senility were thought to be natural consequences of aging. Scientists, however, began to notice that some elderly people became senile while others retained all their mental faculties. In 1906 a German neurologist, Alois Alzheimer, observed neurofibrillary tangles in the brain of a 55-year-old demented woman. Because of the lack of any other brain pathology, he concluded that her dementia was due to these formations (Bayles, 1987; Semple, Smith and Swash, 1982).

At the time that Alzheimer published his findings there was much disagreement about his conclusions. However, it is now generally agreed that Alzheimer’s Disease (AD) is an identifiable disease syndrome, and that the physiological changes first noted by Alzheimer are considered to be the hallmarks of the disease.

The brains of AD patient atrophy and develop neurofibrillary tangles, neuritic plaques and areas of granulovacuolar degeneration. Bayles (1987) reviewed the research regarding the neuropathology of AD and summarized the information as follows. The total volume of the brain, including both grey and white matter, decreases. There is a loss of neurons in the frontal and temporal regions, and the number of dendritic branches per neuron decreases. This results in a decrease in the efficiency of the transfer of neuronal messages. Nebes and Madden (1988) studied the reaction times of AD patients and normal elderly subjects on a variety of tasks. They found that AD acts to slow most cognitive functions by a constant proportion. That is, the cognitive slowing associated with AD showed a pattern similar to the pattern associated with normal aging. However, there were some cognitive functions for which the performance of AD patients was disproportionately slow. Nebes and Madden suggested that:

"The dissimilarity of the effects that normal aging and AD have on the speed of cognitive performance suggests that AD is neither a component of normal human aging, nor a simple exaggeration of the processes that occur in normal aging."
Neurofibrillary tangles are the most common physiological change that occurs during AD. Bayles (1987) has described them in the following manner. Neurofibrillary tangles are filaments in the cell body which come together in a helical manner, running throughout the cytoplasm. They are thought to be caused by abnormal protein synthesis or a reaction to damage elsewhere in the nervous system. Neurofibrillary tangles are found in the hippocampus and the amygdaloid nucleus, as well as in the hypothalamus and throughout the neocortex. Because they are found in the brains of normal elderly subjects, there has been debate about the differentiation of normal aging and AD.

Bayles (1987) also summarized the information about neuritic plaques and granulovacuolar degeneration. Neuritic plaques are groups of degenerating neurons surrounding an amyloid core. They are found in the brain areas where neurofibrillary tangles are found. The centre of the plaques consist of proteins or protein antibodies. One theory regarding the cause of neuritic plaques states that plaques form when white blood cells ingest antigen-antibody complexes. Plaques occur in larger numbers in the brains of AD patients than normal elderly subjects.

Granulovacuolar degeneration refers to the presence of fluid filled spaces and granular degeneration in the brains of AD patients. These are also present in normal elderly brains, but not to the extent to which they are present in AD patients.

Bayles also described certain neurochemical changes associated with AD. The cholinergic system is deficient, the noradrenergic system is abnormal, and there is a reduction in the number of neuropeptides.

There are several theories about the cause of AD (Bayles, 1987). The infectious agent theory has received little support. The suggestion that AD may be caused by an unconventional virus has suffered from a lack of evidence regarding the transmissibility of AD. The aluminum toxicity theory has received more support. There have been reports of elevated levels of aluminum in the brains of AD patients at autopsy. The genetic transmission theory has also received support. Some investigators have found that family members of AD patients have a greater risk of developing the disease than individuals without a family history of AD. Despite these findings, there is no one theory which is generally accepted. The cause of AD remains unclear and much more research is needed.
Researchers have recently begun to discover physiologic characteristics associated with AD. Researchers have noted that patients suspected of having AD show abnormalities on the following measures: electroencephalogram, evoked potentials, computerized tomography, and positron emission tomography. So far these associations have proven to be unreliable. Thus, only at autopsy can AD be diagnosed accurately. At autopsy, neurofibrillary tangles, neuritic plaques and granulovacuolar degeneration can be detected.

The clinical diagnosis of AD is based on the presence of certain behavioural and cognitive characteristics, and on the absence of evidence suggesting other causes of dementia (e.g. multiple cerebral infarcts, Parkinson’s Disease, severe depression). The physiologic measures mentioned above are used mainly to rule out other possible causes of dementia. Hier, Hagenlocker and Shindler (1985) report that clinical diagnosis of AD is 82% accurate.

The most commonly reported symptom of AD is memory disorder (Bayles, 1987). Other common symptoms are disorientation, personality changes, and general cognitive decline including impaired concentration, difficulties with reasoning and judgement and an inability to abstract the central idea from a problem or discussion (Semple et al., 1982).

The onset of AD is insidious, thus it is difficult to pinpoint the earliest symptoms. Most patients exhibit disturbed mental function one to three years before they are brought in for diagnosis (Semple et al.). Even one to three years after the assumed onset of the disease, most patients are still in the early stages of AD.

1. Mild AD In the early stages of the disease, the following symptoms are present: impairment of recent and remote memory; personality changes such as irritability, hostility or apathy; impaired inferential ability; disorientation to place. The motor system is generally unimpaired, however (Bayles, 1987).

2. Moderate AD During the second stage of the disease, the following characteristics are present: global impairment of memory and learning; indifference or hostility; poor social judgement; severely impaired problem solving ability; misperception; more prominent spatial disorientation; motor system shows restless movements (Bayles, 1987).
3. Severe AD In the third stage of the disease, the patient's intellect is globally impaired, personality is disorganized, the patient may be mute or echolalic, and the motor system exhibits rigidity or flexion (Bayles, 1987).

Semple, Smith and Swash (1982) investigated the clinical features of a group of AD patients. They found that memory disorders were the most common feature, while many had language and communication deficits, disorientation, visual motor problems and personality deterioration.

Miller (1981) reviewed the literature regarding the nature of the cognitive deficit in senile dementia. Before discussing his review, however, mention should be made about the distinction between AD and dementia. The term dementia implies a cognitive deficit. Dementia has many causes, one of which is AD. Some other causes of dementia are Parkinson's Disease, Huntington's Disease, vascular dementia brought on by multiple cerebral infarcts, normal pressure hydrocephalus, hypothyroidism and intoxication. Although there are approximately fifty causes of dementia, some of which are treatable and some of which are not, AD is the most common (Bayles, 1987).

Because there are so many causes of dementia and because the cause of AD is unknown, the clinical diagnosis of AD is a diagnosis of exclusion. If the patient presents with the symptoms discussed above and all other causes of dementia have been ruled out, then one can conclude that the patient has a dementing disease which is probably AD. The diagnosis can only be confirmed at autopsy.

It is most difficult to diagnose AD in the early stages of the disease. Early diagnosis is desirable, however. Cognitive deficits and memory disturbances in particular are the earliest clinical symptoms of AD (Martin, Brouwers, Cox and Fedio, 1985). Thus, it is important to be aware of the cognitive deficits associated with dementia.

Miller (1981) summarized the general intellectual changes which occur in dementia. Because AD is a type of dementia, we can assume that these changes occur during the course of AD. Dementia patients show decreased mean IQ levels. It is generally found that Verbal IQ exceeds Performance IQ. There is debate as to whether the pattern of declining IQ is the same as that of normal aging subjects.

Miller also reviewed the evidence for perceptual abnormalities in dementia. There have been few studies in this area. One study revealed that about 4% of patients with cerebral atrophy
showed some abnormalities when asked to fixate on a particular object. Dementia patients have also shown some minor gnostic abnormalities, but no consistent pattern was found. Some visuospatial deficits have been reported. Dementia patients have difficulty solving mazes and have an impaired understanding of reflected space. They have been found to be distracted by auditory, not visual stimuli, however. Thus, there is some evidence of perceptual impairment in dementia, as well as general cognitive decline.

Miller reviewed the literature regarding the memory abilities of dementia patients. Many researchers have found dementia patients to have impaired short-term memory. Dementia patients have difficulty learning new material and are equally impaired regardless of whether the task involves recall or recognition. Based on evidence from dichotic listening tasks, Miller suggested that the difficulty lay in acquisition, as opposed to retention.

On dichotic listening tasks, subjects are asked to recall two lists of items which are presented to both ears simultaneously. The system used to recall items from the ear which is reported first must pass the information directly to the output system. The items from the ear which is reported second must be held temporarily until the first ear’s stimuli have been reported. This holding system is a short-term store. When compared with the performance of normal control subjects, dementia patients recalled items from the ear which was reported first, as well as the normal subjects. Dementia patients recalled items from the ear which was reported second with much reduced efficiency. This indicates a short-term memory deficit.

On a free recall task, dementia patients were impaired in their recall of words from both the beginning and the end of the list. Recall from the beginning of a list is assumed to reflect long-term memory while recall from the end of a list is assumed to reflect short-term memory. This provides further evidence to support the theory that dementia patients have a short-term memory deficit. Miller suggested that the long-term memory deficit indicated by these results was due to an interruption of the flow of words into long-term memory which in turn was caused by the short-term memory impairment.

To investigate this possibility, the rate of presentation of words was reduced. For normal subjects, reducing the rate of presentation allows short-term memory to cope with the flow of words into long-term memory, and performance on tests of long-term memory increases. The
performance of dementia patients did not increase as the rate of presentation was decreased. These results suggested that dementia patients had an impairment of long-term memory as well.

There are several theories regarding the nature of short-term memory deficit in dementia. It may be due to a disturbance at the input to the system, such as impaired attentional processes or disturbed iconic memory. The efficiency with which material entering short-term memory is coded may also account for the input disturbance. It was found that the acoustic similarity of stimuli had a less distracting effect on the recall of dementia patients as opposed to that of normal subjects. This indicates that dementia patients were less able to use acoustic coding in short-term memory.

The long-term memory abilities of dementia patients have received less attention. It has often been reported that memory for remote events is retained in dementia. Preserved recall of remote events would imply that the retrieval process of long-term memory must be intact. Objective investigations, however, indicate that recall of remote events is probably disturbed.

Miller summarized the results of a study in which dementia patients were presented a list of words three times and then administered a distracting task. Dementia patients performed poorly on the free recall and recognition tests. However, when cued with the initial letters of the words, the recall of the dement was indistinguishable from that of the controls. Because recall could be enhanced to normal levels, Miller concluded that acquisition was not impaired and that the problem must lay in retrieving information from long-term memory.

To explain the retrieval deficit, Miller suggested that new information entering long-term memory might be encoded inefficiently. Retrieval would then be enhanced if cues at the time of recall were similar to those at the time of encoding. However, the finding that dementia patients made the same types of errors on recognition tasks as normal control subjects offered no support for the inefficient encoding hypothesis.

Another possible explanation of the partial information effect is disinhibition. Successful performance on a memory task may depend, in part, upon the ability to inhibit the recall of incorrect words. Cues which supply partial information would limit the number of possible incorrect words, thus partially negating disinhibition.

On a free recall task, dementia patients produced more intrusions than normal control subjects, as predicted by the disinhibition hypothesis. On a recognition task, dementia patients became less
able to recognize the correct word as the number of alternatives was increased. This was also predicted by the disinhibition hypothesis. The long-term memory deficit of dementia patients may be due to an inability to inhibit incorrect responses rather than an inability to recall the correct response.

From his review, Miller concluded that dementia patients have deficits of both short-term memory and long-term memory, and that the difficulty probably lies in acquisition, retention and retrieval. Thus, dementia patients, and therefor AD patients, have a global deficit of episodic memory.

In conclusion, there are many cognitive deficits associated with AD, and these occur in step with the physical changes which occur in the brains of AD patients. According to Bayles (1987) AD patients are characterized by the following symptoms:

"...intellectual dysfunctions sufficient to interfere with social behaviour, absence of the characteristics of delirium, memory impairment indication of brain damage, and at least one of the following: personality change, impairment of abstract thinking, poor judgement, presence of instrumental disorder (aphasia, apraxia, or agnosia)." 4
2.1 Alzheimer’s Disease and Language

Recently researchers have begun to study the effect of Alzheimer’s Disease on speech and language with the goal of discovering more about the nature of AD, and of language organization in the brain.

It is generally agreed that language is affected in the early stages of AD while speech often remains unaffected until the disease has progressed significantly. Bayles (in Chapey, 1986) states that only in the late stages of dementia does the patient make errors in speech sounds and produce jargon words. Because the purpose of this study is to investigate the effects of AD on language, not speech, the literature reviewed in this chapter will be concerned with the effects of AD on the following three levels of language: the syntactic system, the lexicon, and the semantic system.

Most researchers agree that syntax is relatively spared in mild to moderate AD, while semantic memory is impaired even in mild AD. Schwartz, Marin and Saffran (1979) report a case study in which the patient demonstrated preserved syntax with profoundly impaired lexical function. The patient, WLP, a 62-year-old female, was seen over a 30 month period. On initial assessment, she demonstrated a WAIS performance score of 95, and showed no trouble manipulating objects or pantomiming their use, drawing or writing. She exhibited deficits in both verbal and nonverbal memory, had a limited vocabulary (PPVT age score=6 years), produced frequent circumlocutions, and exhibited poor confrontation naming ability. Despite these deficits, her articulation was clear. She was able to read aloud and repeat sentences of up to seven words in length without error. She was diagnosed as having a primary presenile dementia which was not classified as to type.

When presented with 70 pictures of common objects WLP could name only one. She overextended animal names. This brief description serves only to demonstrate WLP’s severe lexical impairment. These findings will be discussed in more detail later in this chapter.

Despite her deficits, WLP demonstrated intact syntactic production and comprehension abilities and was able to transform sentences spoken by the examiner into another sentence type; for
example, if the examiner made a statement, she could transform it into a question (e.g. ‘The boy is going.’ became ‘Is the boy going?’). She was also able to use syntactic information to assign thematic roles. A semantically reversible sentence was read. The task was to point to the picture which depicted the correct meaning of the sentence. The choices showed both possibilities of agent and object with active and passive sentences being used. WLP's performance was compared to that of three Broca’s aphasics. Broca’s aphasics are known to have impaired syntactic comprehension. She performed significantly better than the aphasics and did equally well on active and passive sentences. The aphasics had much more difficulty with the passive sentences. Schwartz et al. conclude that WLP used syntactic information to identify the referents even when the referents were those which she could not identify by name.

Further evidence of WLP’s preserved syntactic knowledge comes from a disambiguation task. Thirty pairs of homophones were embedded in 3 contexts and read aloud. The task was to transcribe the words orthographically. The contexts were: 1) semantic triad in which the target homophone was presented with two semantically related words (e.g. ocean lake /si/) 2) limited semantic context in which the homophone was presented with a paradigmatically related word (e.g. a /noz/ vs. he /noz/) 3) full sentence context in which the homophone was embedded within a disambiguating sentence. The full sentence context was four times as effective at eliciting the appropriate word as the semantic triad, but the limited syntactic context was virtually as effective as the full sentences. Thus, WLP could use syntactic but not semantic information to disambiguate spoken homophones.

Schwartz et al. conclude that syntactic and conceptual processing are dissociated in this dementia patient, syntax being spared and conceptual knowledge being impaired. The overall pattern of WLP’s language was one of preserved syntax and phonology in the face of semantic impairment.

Schwartz et al. note a case study reported by Whitaker (1976) in which another profoundly demented woman demonstrated a dissociation of syntax and semantics. This patient was echolalic and displayed no production or comprehension of propositional language. She was, however, able to spontaneously correct syntactically or phonologically anomalous input sentences. She could not correct semantically anomalous input.
Schwartz et al. suggest that the dissociation of syntax and semantics characterizes the primary degenerative dementias, one of which is Alzheimer's Disease. They suggest that the more automatic rule-governed aspects of language (syntax and phonology) can be isolated from those aspects requiring cognition (semantics). Finally, they note that syntactic disturbance has been reported in the late stages of dementia, but that this is not surprising given the heterogeneity of dementia patients and the variation in the distribution of the pathology.

Appel, Kertesz, and Fisman (1982) studied the language functioning of AD patients using the Western Aphasia Battery. They found that patients with mild AD demonstrated the least impairment on the fluency and articulation subtests and were most impaired on the naming and comprehension subtests. These findings also indicate preserved syntax in the face of impaired semantics.

Hier, Hagenlocker, and Shindler (1985) used several measures of receptive and expressive language to assess the language abilities of a group of AD patients ranging in severity from mild to severe. When compared with normal control subjects, the AD patients demonstrated decreased expressive and receptive vocabularies as well as decreased confrontation naming and word fluency abilities. They produced fewer total words and fewer unique words in a speech sample. The AD patients also reported fewer important facts in a speech sample than did the normal controls. These results indicate an impairment of the semantic system in AD.

In apparent contrast to the conclusions of Schwartz et al., Hier et al. found that their AD patients demonstrated poorer performance on the following measures of syntactic ability: logico-grammatical comprehension, MLU in a speech sample, number of subordinate clauses and prepositional phrases in a speech sample, mean clause length in a speech sample, and number of sentence fragments in a speech sample. The speech sample was a description of the cookie-theft picture from the Boston Diagnostic Aphasia Examination. Although these results may indicate that syntax is also impaired in AD, the difficulties in producing syntax were much less severe than those in accessing the semantic system.

Hier et al. compared the performance of AD patients of differing severity and found that as AD severity increases, speech becomes more verbose yet contains less information while syntactic
complexity is well maintained. Thus, the results indicate that AD is characterized by relatively preserved syntax in the face of impaired semantic abilities.

There is some evidence that the dissociation of syntax and semantics is not complete in AD. In a review of the literature, Obler (1983) suggests that AD does not effect specific linguistic categories (i.e. syntax vs. semantics), but that the linguistic interface with cognition -semantics- is disturbed. Since semantics can be expressed through the lexicon or through syntactic constructions, disruptions may appear in either area. As evidence for this view, Obler cites cases of dementia patients who, in a repetition task, spontaneously correct sentences with morphosyntactic errors (e.g. The boys is here.) but not sentences with logicosemantic errors (e.g. The boy comes yesterday.) or logicosyntactic errors (e.g. It is raining for I cannot go.). Thus, in those cases where semantics and syntax interact, AD patients may also demonstrate syntactic deficits.

The majority of researchers seem to agree that AD is associated with preserved syntactic abilities in the face of impaired semantic functioning, but that when syntax is influenced by semantic considerations (as in Obler's logicosemantic and logicosyntactic constructions) then syntactic impairment will be associated with the semantic impairment.

In this review of the literature comparing the performance of AD patients on syntactic and semantic measures, the term 'semantic' has been applied loosely. It has been used to refer to both conceptual and lexical knowledge. The term is often used indiscriminantly in the literature to indicate concepts or the words which represent them. Given that a lay definition of 'semantics' is 'meaning' or 'the meanings of words' it is not surprising that the term is applied so loosely. However, when a term is not well defined, it creates confusion. For the purposes of this study it is necessary to separate measures of lexical knowledge and conceptual knowledge which had previously been regarded as measures of semantic knowledge. Bayles (1987) refers to conceptual knowledge as the semantic memory (SM) and distinguishes it from the lexical store (or lexical knowledge). SM is a conceptual store. Concepts are stored in a system which is separate from the storage system of the words which represent them (the lexical store). Evidence to support the claim that concepts can be dissociated from the words that represent them will be presented later in this chapter.
In the previous discussion, the claim was made that syntax is preserved in AD while semantics is impaired. Given that the term 'semantics' was used to cover both lexical and semantic memory, we must then ask whether lexical or semantic memory (or both) are impaired in AD. If they are both impaired, to what extent is each impaired?

Let us again begin by discussing WLP, the patient of Schwartz, Marin, and Saffran (1979). It was noted earlier that when asked to name pictures of common objects, WLP could name only one out of seventy pictures. She was able, however, to demonstrate her knowledge of the pictured objects by gesturing their use. These results indicate that although WLP could not access the lexical entries for these objects from the lexical store, she had retained knowledge of the concepts. Thus, while her lexical memory appeared severely impaired, her semantic memory appeared much more intact.

To further investigate this apparent dissociation of words and concepts, Schwartz et al. presented WLP with each picture and five words: the target, two unrelated names, a phonological distractor, and a semantic distractor (a word from the same semantic category as the target). Her task was to choose the name of the pictured object after reading the five words aloud. The task was untimed.

The results indicate that WLP made errors on approximately 35% of the words. The majority of her errors involved the choice of the semantic distractor. Thus, her error rate was significantly lower than that on the naming task. She was inconsistent in her errors across two administrations of the name matching task, choosing the target one time and the semantic distracter the next time on a given trial. Schwartz et al. conclude that WLP had an impairment of semantic memory in that terms from the same semantic category no longer specified a particular referent, but were extended to a population of related referents.

The task was administered on three subsequent occasions spanning the 30-month period during which WLP was followed. While the percentage of total errors gradually increased over time, the number of errors resulting from the choice of the semantic distractor decreased. These results were claimed to be evidence for the hierarchical deterioration of semantic features which define referents, the more specific distinguishing features being lost before more general features.
Overall, Schwartz, Marin, and Saffran’s results seem to indicate that this dementia patient had a semantic memory deficit in addition to her lexical deficit. The naming task was a test of lexical memory and/or lexical access, not of semantic memory as defined by Bayles. We can make this claim because, although unable to generate the names of items, WLP clearly demonstrated her understanding of the concepts which the names represented. We can therefore conclude that WLP had a lexical deficit.

Did WLP have a deficit of semantic memory? The name matching task does not give us a clear answer to this question. In order to perform this task, the patient may adopt one of two strategies (see Figure 1). Using Strategy #1, the patient accesses the concept by means of the visual input (the picture), then maps the concept to the word which represents it, then matches the word to one of the choices. If the patient adopts this strategy, it may be assumed that errors are due to a breakdown at any step in the process. Errors may be due to a disrupted conceptual system or difficulty accessing the conceptual system, a semantic memory deficit. WLP’s ability to mime the use of the objects makes this explanation unlikely. Errors may also be due to an inability to map the concept to the word which represents it in lexical memory. Given WLP’s severe naming deficit, this explanation seems more plausible. The choice of the semantic distractor may indicate that lexical memory is organized similarly to semantic memory, by semantic features, for ease of mapping. Errors may also be due to an inability to map the correct lexical choice to the printed words. However, given WLP’s intact reading skills, this explanation is also unlikely.

Using Strategy #2, the patient accesses the name directly from the visual input, completely bypassing the conceptual system (see Figure 1). If the patient adopts this strategy, it may be assumed that errors are due to a perceptual deficit, a deficit of lexical memory, or difficulty mapping perceptual patterns to lexical memory. Since we have claimed, based on other evidence, that WLP had a deficit of lexical memory, and since her miming ability is evidence for an intact perceptual system, a deficit of lexical memory seems to be the most plausible explanation of her performance on the name matching task.

Thus, although it seems clear that WLP had a deficit in lexical memory, the coexistence of a deficit in semantic memory remains doubtful. It is difficult to design a task which tests semantic without also testing lexical memory.
Figure 1
Name Matching Task

Strategy #1
* ** + #
visual input---> SM---> LM---> name choice

Strategy #2
* #
visual input-------> LM---> name choice

key:
* perceptual error
** SM deficit
+ mapping from SM to LM disrupted
# LM deficit
Schwartz et al. noticed that on several occasions WLP overextended the label DOG to include CATS. Did this mean that the concept CAT was lost or that the label DOG now covered both the concepts CAT and DOG? To investigate this question, a task was administered in which WLP was shown pictures of various dogs cats and birds. She was presented with each picture one at a time and was shown two typed labels. The task was to move the picture to the appropriate label. All the instances of dogs were labelled correctly, while most instances of cats were also labelled DOG. All instances of birds were labelled correctly.

In another condition, WLP was shown three photographs: one sample and two choices. The task was to indicate which was the same type of animal as the sample. WLP was consistently correct when the sample was a cat. When the sample was a dog, she matched correctly only when the alternative was a bird and otherwise chose the cat. In this condition she overextended the category CAT to include dogs, which was the opposite of her performance in the written label task.

Schwartz et al. interpreted these results as indicating that the underlying category structure was disrupted, but that the category structure did not predict the pattern of naming errors.

The written label task, like the name matching task, could be accomplished by the two strategies mentioned above. It is difficult to decide whether WLP’s errors on this task were due to a deficit of semantic or lexical memory, or both.

In the picture-to-picture matching task, however, lexical memory is bypassed. The task can be accomplished by accessing the categories alone. Because WLP demonstrated deficits on this task, we can conclude that she had a semantic memory deficit as well as a lexical memory deficit. It seems that the lexical memory deficit was more severe than the semantic memory deficit. Given that the disrupted categories did not predict the pattern of naming errors, we can also conclude that WLP was unable to map the category to its label.

A final aspect of Schwartz et al’s study was the investigation of WLP’s reading ability. She demonstrated preserved ability to read aloud. There are two methods to attain the pronunciation of a written word. The first is to sound out the word using letter-sound correlations. The second is to associate the written word directly with a lexical entry, referred to as sight reading. The finding that WLP could read nonsense words fluently if they corresponded to normal spelling suggested
that she was able to use letter-sound correlations to attain the pronunciation. When her task was to match a spoken word to three possible spellings, one of which more closely approximated normal English spelling, WLP was able to match the majority of words correctly.

WLP was also able to read irregularly spelled words fluently. One task required her to read aloud pairs of words with similar spellings but different pronunciations (e.g. home, come). In this task, consistent application of spelling rules would result in incorrect pronunciations. If WLP correctly pronounced the words, then she must have been able to recognize them as words and access the pronunciation via the lexicon. That is, she must have been able to use the sight reading method. The result of this investigation was that WLP pronounced all the words correctly without hesitation.

Schwartz et al. concluded that WLP had intact phonological encoding abilities, suggesting that her naming difficulty must have arisen at a prephonological level. The phonological route to the lexicon seemed to be open while the conceptual route was not. Contrary to the conclusions based on the naming task, this would suggest that lexical memory was not impaired but that perhaps mapping from lexical memory to semantic memory was disrupted.

Bayles (1987) commented on WLP’s reading ability, suggesting that since WLP could read by sight, she must have been retrieving words based on memory of the visual configuration alone. WLP could read words which she could not understand. The ability to bypass the semantic system suggests the existence of a brain circuit which directly connects visual configurations and phonological codes. If dementia patients retain this circuit and if sight-reading is analogous to naming an object by matching its visual configuration to a word, then it is possible that dementia patients can name objects without activating semantic memory. Thus, Bayles concludes that naming tasks cannot be used as evidence regarding the state of the semantic memory of AD patients. Naming tasks test lexical, not semantic memory.

There have been several studies which indicate that AD patients have poor confrontation naming abilities. In a review of the research, Obler (1983) states that naming disturbances are present in virtually all cases of dementia, and that naming is impaired in the moderate stages of AD.
Appell, Kertesz and Fisman (1982) found that a group of AD patients were more impaired on the naming subtest of the Western Aphasia Battery than on any other subtest. Even mild AD patients showed a naming impairment. The results indicated that naming showed the greatest decline initially in AD, but that other language functions declined more rapidly with time.

Hier, Hagenlocker and Shindler (1985) found that dementia patients performed significantly less well than normal control subjects on a confrontation naming task. Martin and Fedio (1983) found that AD patients had a mean score more than three standard deviations below the mean score of normal subjects on the Boston Naming Test. An error analysis revealed that the AD patients produced more synonyms, descriptions and semantic field errors than perceptual errors. Martin and Fedio concluded that in AD:

"The ability to define a word using phrases or an appropriate synonym and knowledge of category membership were relatively more preserved than the ability to retrieve a specific referent." 1

The studies mentioned above investigated the overall pattern of language abilities and deficits in AD and found confrontation naming to be impaired. There has been some debate about the cause of the naming impairment. Is it due to a perceptual impairment or a semantic impairment? Bayles and Tomoeda (1983) investigated this question. Dementia patients of varying type and varying severity were asked to name twenty coloured pictures. Responses were classified according to the similarity to the target. The response could be unrelated, visually related, or linguistically related, which included phonemic and semantic similarities, to the target.

The results showed that only the moderate AD patients differed significantly from normal control subjects in their naming ability. For all groups the errors were more likely to be semantically associated than visually or phonemically associated. Of those responses that were visually similar, most were also semantically similar. The most common type of semantic error was within-class substitution. Another word from the same semantic category was chosen (e.g. truck for bus). As severity of dementia increased, extent of naming impairment and likelihood of unrelated errors also increased. Bayles and Tomoeda concluded that their results supported the hypothesis that naming errors in AD patients are due to a linguistic-cognitive impairment, not a
perceptual impairment. They suggested that the linguistic-cognitive impairment was a deficit of semantic memory which resulted from the erosion of the referential boundaries of words.

Later, Bayles (1987) reconsidered her conclusions. Confrontation naming is a test of lexical memory, not semantic memory. It is possible that the word form can be accessed without accessing the concept which it represents. The predominance of semantic errors made by AD patients may indicate that the lexicon is organized similarly to semantic memory. To summarize, confrontation naming is impaired in AD and the impairment worsens as the disease progresses. This indicates that lexical memory is impaired in AD, but the use of confrontation naming as evidence of a semantic memory impairment is equivocal.

Another task which has been used extensively in the study of AD patients language abilities is verbal fluency. Rosen (1980) defined verbal fluency as the ability to retrieve members belonging to a specified category within a limited time period. A subject can be asked to retrieve members of a semantic category or words beginning with a specified letter. In their studies of the overall language pattern in AD, Martin and Fedio (1983) and Hier, Hagenlocker and Shindler (1985) found that AD patients scored significantly lower than normal control subjects on word fluency tasks. Hier et al. used animal naming while Martin and Fedio used the category of items found in a supermarket (from the Mattis Dementia Rating Scale).

Martin and Fedio found that the normal control subjects not only produced more words than the AD patients, but also generated words from more categories and more words per category. The AD patients switched categories more often and produced names instead of specific items.

Rosen (1980) investigated verbal fluency of AD patients in more detail. An animal naming task and an initial-letter (CFL) task were used. Subjects were given sixty seconds for each category: animals, words starting with C, words starting with F, and words starting with L. Results indicated that normal control subjects retrieved more words than the AD patients on both tasks. Mild AD patients retrieved more words than moderate to severe AD patients. Overall, more animal names were given than C, F, or L words. Normal controls and mild AD patients produced more animal names than C, F, or L words while moderate to severe AD patients showed no difference between tasks. This may have been due to the limited number of words produced by the moderate to severe AD patients.
Different patterns of retrieval were found for the normal controls, mild AD patients and moderate to severe AD patients. The normal elderly retrieved the most words during the first fifteen-second interval than during the remaining three intervals. The performance of the normal elderly declined nonsignificantly over the next three intervals for the CFL words while performance declined significantly over the next three intervals for animal naming. Mild AD patients retrieved more words during the first interval with retrieval declining nonsignificantly over the remaining time for both tasks. The moderate to severe AD patients showed no significant change in performance throughout the entire time for both tasks.

Rosen concluded that verbal fluency is impaired in AD and performance declines as the disease progresses. The fact that both normal and mild AD patients produced more animal names than CFL words suggested to Rosen that the different categories are structured differently. Semantic categories have a core meaning composed of best exemplars. Therefore, animal names have many good exemplars while CFL words do not. Rosen suggested two retrieval strategies: 1) retrieve the best exemplars, 2) go to subsets of the category. For animal names, the best exemplars are retrieved quickly and then the subsets are entered. For CFL words, immediate entrance into the category does not produce many words because there are few best exemplars. The subsets are then entered.

Rosen found that for CFL words there were two subsets; semantic (e.g. animals that begin with C) and phonemic (e.g. words that begin with CI). The retrieval of more animal names by the normal controls and the mild AD patients may indicate the use of retrieval strategies such as the quicker recall of more numerous best exemplars. Rosen suggested that subset entrance was impaired in mild AD while retrieval of best exemplars was not, and that both of these strategies were impaired in moderate to severe AD. He interpreted these findings as evidence for an impairment of semantic memory in AD.

Ober, Dronkers, Koss, Delis and Friedland (1986) also investigated verbal fluency in AD patients. They used three different tasks: 1) a letter category task in which subjects generate words beginning with a certain letter, in this case F, A and S, 2) a semantic category task in which subjects generate words from a given semantic category, in this case animals and fruits, 3) a supermarket task in which subjects generate the names of items found in a supermarket. Ober et al.
expanded on the work of Rosen (1980) and Martin and Fedio (1983) by administering all three types of task to the same group of AD patients and by analyzing correct responses and error types.

The responses were scored in one of the following ways: 1) correct; 2) noncategory, when the response did not belong to the specified category; 3) morphological variant, when the response was morphologically similar to a word given earlier e.g. FOOT and FEET; 4) categorical variant, when the response was similar in category to a word given earlier e.g. BIRD and BLUEBIRD; 5) perseverations, when the response was a repetition of a previous response.

Subjects were divided into three groups: normal controls, mild AD patients and moderate to severe AD patients. Results indicated that all groups produced more correct semantic category items than letter category items during the first 15 seconds, but showed equal performance on the two tasks thereafter. As expected, normal controls produced the most correct responses, mild AD patients produced fewer and moderate to severe AD patients produced the least correct responses. The effect of time interval, in blocks of 15 seconds, was significant in all cases, subjects producing fewer correct responses over time.

Ober et al. analyzed the responses of the three groups according to category dominance and word frequency of the exemplars. There were no differences between the groups on these measures. Thus, differences in the performance of the groups were not due to differences in the accessibility of low dominance semantic category members or low frequency letter category members.

For the semantic category task, normal controls demonstrated the highest proportion of correct responses and the lowest proportion of errors while mild AD and moderate to severe AD patients did not differ significantly from each other in proportion of correct responses to errors.

For the letter category task, normal controls and mild AD patients were not significantly different from each other, both having a higher proportion of correct responses than moderate to severe AD patients. Moderate to severe AD patients demonstrated a higher proportion of noncategory and perseverative responses than mild AD patients and normal controls.

The supermarket task was administered only to the AD patients since it is part of the Mattis Dementia Rating Scale. Moderate to severe AD patients performed significantly poorer than mild AD patients on number of correct responses, number of subcategories, items per subcategory, and
pairwise clusters (the number of responses from the same category which are adjacent to one another in the response protocol). The moderate to severe AD group produced significantly more perseverations than the mild AD group.

Performance on the word fluency tasks was compared with results on a neuropsychological battery. Word fluency was significantly correlated with results on the Trail-Making, Digit-Symbol and Vocabulary subtests of the WAIS; the Visual Attention subtest of the Mattis Dementia Rating Scale; Naming and Comprehension subtests of the Boston Diagnostic Aphasia Examination; the Token Test; and Buschke's verbal learning via selective reminding test.

Ober et al. concluded that verbal fluency is impaired in AD and that the impairment increases with dementia severity, but that the impairment is not due to differences in category dominance or word frequency. The deficits in performance are due to a decrease in correct responses along with an increase in errors. There is a qualitative difference between the performance of mild AD patients and moderate to severe AD patients on the supermarket task in that the moderate to severe AD patients produce fewer items per subcategory. It was suggested that the results indicate a breakdown in the structure and/or processes of SM in AD which increases with the severity of the dementia. Ober et al. note, however, that the disruption may also be due in part to problems with attention, learning, naming and language comprehension which have been shown to be impaired in AD.

Thus, the consensus is that AD patients have difficulty with word fluency tasks and that this is due to a semantic memory deficit. Word fluency tasks which call for semantic categories require subjects to enter SM in order to produce correct responses. Subjects cannot bypass SM, going directly to LM, because they must enter the system through SM and use SM to generate subcategories, then map exemplars to forms in LM. Word fluency tasks test SM, LM, and the mapping from SM to LM. An impairment of word fluency in AD may be due to a SM deficit, a LM deficit or an inability to map concepts to the words which represent them.

The letter category word fluency task is somewhat different. Rosen (1980) found that the letter category task could be approached using two strategies, phonemic or semantic. If the phonemic strategy were used, subjects could bypass SM and perform a phonemic search of the lexicon (e.g. look for all words starting with /cl/). An impairment would then indicate a deficit of LM. If the
semantic strategy were used (e.g. look for all animals starting with /l/), could not bypass SM and an impairment would indicate a deficit of SM, LM, or the ability to map between them. Although the evidence from word fluency tasks has been interpreted as indicating a SM deficit in AD, the conclusions may not be warranted.

Another common finding is that AD patients have diminished vocabularies, both expressively and receptively, and that vocabulary declines during the course of the disease. Hier, Hagenlocker and Shindler (1985) found that, compared with normal control subjects, dementia patients had significantly lower expressive vocabularies as measured by the WAIS vocabulary subtest. This test requires subjects to provide definitions for words. Dementia patients also demonstrated significantly lower receptive vocabularies than normal controls, as measured by the Ammons and Ammons Quick Test. This test requires subjects to point to one of four pictures in response to a spoken word.

Martin and Fedio (1983) found that AD patients scored significantly lower than normal controls on both the vocabulary and similarities subtests of the WAIS, but that the scores were within the average range according to the WAIS norms.

In a review of the research regarding the vocabularies of AD patients, Bayles (1987) reported that moderate AD patients performed more poorly than normal controls on the WAIS vocabulary subtest. On the Peabody Picture Vocabulary Test (PPVT), a test of receptive vocabulary, mild AD patients performed significantly more poorly than normal controls.

Bayles stated that to respond correctly to an expressive vocabulary test, a subject must activate concepts because the examiner is asking for the conceptual representation of the word. A subject must access the lexical representation, then map it to the conceptual representation in order to produce a definition (see Fig. 2). An impairment of expressive vocabulary would indicate either a deficit of LM, SM, or the pathway between LM and SM, assuming that auditory perceptual skills are intact.

To respond correctly to a receptive vocabulary test, a subject may activate concepts via the lexical representation and then match the concept to the correct picture (path a) of Fig. 2). However, a subject may match the lexical representation directly to the visual configuration, in the reverse of process postulated for naming (path b) of Fig. 2). Since most tests of receptive
vocabulary increase in difficulty as the test progresses, it is unlikely that a direct mapping from visual memory to visual configuration would be possible for the more difficult abstract items. It is possible that AD patients use strategy b), thus correctly responding to the simpler items. This strategy may begin to fail as the items become more difficult and abstract. AD patients may then attempt to switch to strategy a), but because of a SM deficit are unable to use this strategy. Thus, they would not be able to respond correctly to the more difficult items.

In order to investigate this possibility, one would have to determine which items could be accessed directly from lexical memory and which could not. If results indicated that AD patients responded correctly to those items which could be accessed directly from lexical memory and not to those which could only be accessed through SM, one would have convincing proof of a SM deficit in AD patients.

An impairment of receptive and/or expressive vocabulary is evidence that there is a deficit of SM, LM or the ability to map between LM and SM. Thus, the research indicates that AD patients may have a semantic memory deficit.

Bayles (1987) noted that vocabulary measures such as the PPVT, which use line drawings, could be confounded by visual perceptual deficits. To investigate this possibility, she asked AD patients to orally define the words to which they responded incorrectly on the PPVT. Results showed that the patients could not define any of the words which they had missed. Thus, errors of receptive vocabulary were due to lack of knowledge of word meanings, not misperception.

As demonstrated by Schwartz, Marin and Saffran (1979), a subject’s ability to pantomime can reveal information about his conceptual knowledge without involving lexical memory. If AD patients show an impairment in their ability to pantomime, we can conclude that there is a SM deficit.

Bayles’ (1987) review of the literature revealed that while mild AD patients did not differ from normal controls in their ability to pantomime, moderate and severe AD patients showed a reduced ability to recognize or use pantomime. Because patients were able to imitate gestures, it was assumed that the impairment was not due to limb apraxia. A patient’s ability to name an object was not a predictor of his ability to pantomime the use of the object. We can conclude with Bayles that patients with AD have a deficit of semantic as well as lexical memory.
Figure 2
Vocabulary Tests

Expressive vocabulary

auditory input—>LM—>SM—>verbal output
(word) (definition)

Receptive vocabulary

a) auditory input—>LM—>SM—>choice of picture
(word)

b) auditory input—>LM—>choice of picture
(word)
Another task which has been used with AD patients is word association. It is assumed that if conceptual knowledge is intact the stimulus words will elicit strongly associated words, as defined by the norms. Gerwith, Shindler and Hier (1984) studied the responses of 22 AD patients to 16 words from the Palermo and Jenkins (1964) word association norms. The response latency was recorded and the responses were classified as popular or nonpopular. Popular was defined as one of the three most common responses in the normative sample. Responses were also classified as belonging to one of the five following groups: 1) paradigmatic-the response is semantically related to the stimulus item and is of the same grammatical class e.g. hot, cold 2) syntagmatic- the response is of a different grammatical class than the stimulus item and would occur sequentially within the same sentence e.g. sit, down 3) identity- the response is echolalic or contains a minor deviation from the stimulus e.g. man, men 4) idiosyncratic- the response bears no discernable relationship to the stimulus item e.g. hardly, yes 5) null- there is no response within 25 seconds of the stimulus presentation.

Results indicated that as dementia progressed, the number of popular responses decreased significantly. With increasing severity of dementia, the number of paradigmatic responses decreased and the number of idiosyncratic, identity and null responses increased, but there was no change in the number of syntagmatic responses. The response latency increased significantly with severity of dementia.

Gerwith et al. suggested that paradigmatic responses are generated by conserving the syntactic markers of a word while making a minor change in the semantic markers. A response would be of the same grammatical class as the stimulus while contrasting with respect to a single semantic marker e.g. hot, cold. The difficulty that AD patients experienced with paradigmatic responses was not due to a loss of syntactic markers. The normal control subjects produced the most paradigmatic responses when the stimulus item was a noun, the most syntagmatic responses when the stimulus was a verb, and the most null responses when the stimulus was an adverb. The AD patients produced the same pattern of responses, indicating that they were as sensitive to grammatical class as the normal subjects. The fall in paradigmatic responses may have been due to a loss of semantic markers. Along with the stability of syntagmatic responses, these results led Gerwith et al. to conclude that syntactic knowledge was preserved in AD while semantic knowledge was impaired.
To respond paradigmatically to a word association task, a subject must access the lexical representation of the stimulus word, map the lexical representation to the conceptual representation in SM, complete a feature analysis of the conceptual representation, find another conceptual representation which differs by only a few features, map the second conceptual representation to an item in LM, and produce the response (see Fig.3). Failure to produce a popular response may indicate a mild deterioration of conceptual knowledge in that common associations are not made, even though semantic analyses produce correct responses. Failure to produce a paradigmatic response may indicate a breakdown along any part of the path shown in Fig.3. Although appropriate concepts may have been selected, the corresponding item in LM may not have been accessed. Perhaps deterioration of the conceptual store has resulted in concepts no longer being related in the usual manner. The mechanism is not clear from the results. Word association research is another area in which results do not provide unequivocal evidence of a SM deficit in AD.

Martin and Fedio (1983) investigated the performance of AD patients on broad category judgement and a symbol referent test. The broad category judgement task required subjects to rate the pleasantness of 30 words on a 7-point rating scale. There were 10 pleasant, 10 neutral and 10 unpleasant words, as judged by normal individuals. Results showed that there was no significant difference in the number of words rated as pleasant, neutral and unpleasant by the AD patients and normal control subjects. Both groups rated the same words as pleasant, neutral and unpleasant. For the symbol referent test, subjects were presented with cards containing a word and four stylized line drawings. The task was to select the drawing which best represented the meaning of the word. The correct response was determined by the drawing chosen most often by a group of college students. The stimulus items included actions, objects, emotions and modifiers. Results indicated that the AD patients made significantly more errors than normal controls on actions, objects and modifiers, but not on emotions.

The authors concluded that AD results in a reduction in the availability of attributes that determine word meanings (AD patients performed more poorly on naming and word fluency than on broad category judgement). That is, word boundaries break down while broader categorical information is preserved. This may indicate an underlying deficit in the organization of SM.
Figure 3

Word Association Task

feature
analysis
input---->LM----->SM------------->SM----->LM----->output
(word 1) (word 1) (word 2) (word 2)
To perform the broad category judgement task, a subject must access the lexical representation of the word, map the lexical representation to the conceptual representation, analyze the general aspects of the concept, and make a judgement regarding the pleasantness of the concept. Since the AD patients were able to do this, we can assume that LM and the general aspects of SM are intact.

To perform the symbol referent task, a subject must access the lexical representation, map the lexical representation to the conceptual representation, analyze more specific aspects of the concept, and choose a suitable drawing. Errors may indicate an impairment of LM, SM or the ability to map from LM to SM. However, since the AD patients demonstrated intact LM by their performance on the broad category judgement task and demonstrated that the more general aspects of SM were intact, the errors on the symbol referent task must be due to difficulty with specific aspects of the concept or difficulty choosing a suitable drawing. The fact that AD patients were able to choose correctly for emotion words indicates that they were able to choose appropriate drawings and understood the task. Thus, the results of Martin and Fedio's (1983) study indicate that AD patients have a deficit of semantic memory. In particular, AD patients are unable to analyze the attributes which determine word meaning, while knowledge of broader categorical information is preserved.

Masur (1986) used a category exemplar task to examine the effects of AD on semantic memory. Subjects were to decide whether sentences consisting of exemplar-category relationships were true or false, and their reaction times were measured. Based on a probabilistic semantic model, predictions were made about the reaction times for the sentences. While the normal control subjects produced reaction times consistent with those predicted by the model, the AD patients produced anomalous patterns. The results were interpreted as indicating that even mild AD patients had a marked disruption of semantic memory.

To perform a sentence verification task of this type, a subject must access the lexical representations of both the category and the exemplar word, map them to their conceptual representations in SM, analyze the conceptual representations to decide if the exemplar is a member of the category, and respond by indicating whether the sentence is true or false. The results from this task do not provide unequivocal evidence for a SM deficit in AD because errors may result from a SM deficit, a LM deficit, or an inability to map between SM and LM.
Although many researchers agree that AD is associated with a SM deficit, some studies indicate that SM is preserved in AD. Nebes, Martin and Horn (1984) concluded that SM is spared in AD patients. They noted that most tasks used to investigate SM require attentional capacity and effortful processing. Subjects are required to make conscious decisions about the semantic features of stimuli. Nebes et al. suggested that tasks which are designed to assess SM should require automatic effortless processing, thereby placing fewer demands on attentional resources.

Three tasks designed to elicit automatic processing were administered to normal control subjects and patients with mild and moderate AD. For the semantic priming task, subjects were required to name visually presented words. Pairs of words were either semantically related or unrelated. After all the pairs had been presented, subjects' recall and recognition of the words were tested. This task was meant to measure the intactness of semantic associations. It was predicted that the amount of semantic priming would be equal for the normal controls and the AD patients.

Results from the priming task indicated that both the normal controls and the AD patients showed a positive priming effect. The response latency was significantly shorter when the target was preceded by a semantically related word. The normal subjects demonstrated shorter latencies than the AD patients and remembered more words than the AD patients on both the recall and recognition tasks.

The second task, approximation to English, required subjects to name letters presented one by one. Once the entire string of letters was presented, subjects were asked to recall the string in the correct order. The strings varied in their approximation to English spelling. The task was designed to measure a subject's ability to use his knowledge of English orthography to remember strings of letters. It was predicted that both normal controls and AD patients would better remember the strings which most closely approximated English spelling. Prior to performing the approximation to English task, subjects completed a standardized reading test. There was no significant difference between the mean scores of the AD patients and the normal control subjects. Although the control subjects and the AD patients were not matched for reading scores, they were matched for years of education. Nebes et al. did not report correlations between reading level and performance on the approximation to English and the approximation to text tasks.
Results from this task indicated that although the normal subjects recalled more letters than the AD patients, the increasing approximation to English improved the percentage recall of both groups equally.

The third task, approximation to text, was similar to the second. Subjects named a string of words presented one by one, and were then asked to recall them in order. The strings varied in their approximation to English word order. This task was designed to measure a subject's ability to use his knowledge of English syntax to remember strings of words. It was expected that the more closely the words reflected English word order the more easily they would be recalled by both normal subjects and AD patients.

Results from this task indicated that although normal control subjects recalled more words than the AD patients, increasing the approximation to text improved the percentage recall for both groups equally.

Nebes et al. suggested that the AD patients had deficits of episodic memory, as evidenced by their poor performance on recall and recognition tasks. Evidence for an episodic memory deficit was presented in Chapter 1.2. The AD patients also performed poorly on a task involving a conscious search of semantic memory, namely verbal fluency. However, on the three experimental tasks, which required minimal effortful processing, the AD patients performed as well as the normal control subjects. The fact that the two groups demonstrated the same semantic priming effect indicated that the structure of semantic memory was grossly intact in AD patients. The fact that the two groups demonstrated the same percentage improvement with increased approximation to English orthography indicated that AD patients were able to use their knowledge of English spelling to encode strings of letters into larger units. Thus, Nebes et al. concluded that at least some aspects of SM remain intact in AD.

Kahneman (1973) proposed a theory of attentional resources. He suggested that an individual has only a given amount of attentional resources. Each mental operation that is performed requires a certain amount of these resources. Some mental operations require few resources while others require large amounts of attentional resources. That is, they require effortful processing. The amount of attentional resource which is available at any one time is limited. This is evidenced by the fact that humans can perform only a limited number of operations at one time. When a subject
attempts to perform more than this number of tasks, his performance will suffer because the attentional resources needed to complete the task are not available. For example, recall of a list of words will be decreased if subjects are asked to perform mathematical operations during the interval between presentation and recall. The mathematical operations require a large amount of attentional resource and there is not enough resource available to rehearse the list of words.

Craik and Byrd (1982) suggested that older normal adults have a reduced amount of attentional resources. They presented evidence indicating that older subjects performed more poorly than young subjects on tasks requiring effortful processing. If older normal subjects have a reduced amount of attentional resource, then it is possible that AD patients have an even further reduced amount of attentional resource. Perhaps the effortful processing required to perform most of the tasks used to test semantic memory depletes the available resources, causing semantic memory to break down. However, when the processing is not effortful, the resources needed to maintain SM are available and SM remains intact. This would explain the discrepancy between the results of Nebes et al. and the results discussed previously in this chapter.

Martin, Brouwers, Cox and Fedio (1985) used recall and recognition tasks to investigate the SM of AD patients. Subjects were to recall a list of 8 words. They were given five recall trials then a recognition trial in which there were four choices: The target, a semantic distractor, a phonemic distractor, and an unrelated word. The same procedure was repeated six times over a three week period.

Results showed that AD patients recalled fewer words than normal control subjects, but demonstrated the same pattern of recall. The mean number of words recalled increased with each trial. The AD patients also demonstrated a serial position curve which was no different than that of normal controls. Both primacy and recency effects were apparent. On the recognition task, the AD patients recognized fewer words than the normal controls. The AD patients chose the semantic distractor significantly more often than the phonemic distractor or the unrelated word. If the target was not recognized, the AD patients were most likely to choose a semantically related word. Martin et al. concluded that although the AD patients had a reduced ability to learn word lists, their pattern of performance did not differ from that of normal control subjects. It was suggested
that the reduced recall of the AD patients was due to an incomplete semantic analysis of verbal material during learning.

The second experiment of Martin et al. (1985) was designed to investigate the effects of semantic encoding on recall. Subjects were required to recall four lists of nine words each. There were four possible encoding conditions: 1) free encoding - the subject was given no special instructions 2) rhyme - the subject was asked to say a word which rhymes with the target 3) where - the subject was asked to state where the object could be found 4) praxic - the subject was asked to pantomime the use of the object. Subjects were asked for immediate recall of the lists. For those items which were not recalled, the subject was cued with his own responses.

Results indicated that although AD patients recalled fewer words than the normal control subjects, they exhibited the same pattern of recall. Semantic encoding (the where and praxic conditions) was superior to phonemic encoding (the rhyme condition) in prompting correct recall. Martin et al. concluded that the memory abilities of AD patients are quantitatively, not qualitatively different from those of normal subjects.

If AD patients had SM deficits, then semantic encoding would not aid recall. Since semantic encoding did aid recall, we must conclude that AD patients do not have SM deficits.

Thus, it seems that when AD patients are required to use SM to help them perform a task, they are able to do so; when asked to make a conscious search of SM, they are unable to do so. This adds further support to the speculation that effortful processing causes a breakdown of SM in AD patients.

In her 1987 review of the literature, Bayles suggests that priming may be the best paradigm for testing SM because SM is activated without effortful processing. The results are equivocal, however. While some researchers have found equivalent amounts of priming in AD patients and normal controls, others have failed to find a semantic priming effect and some researchers have reported a negative priming effect for AD patients. The AD patients had longer response latencies when the target was preceded by a semantically related word.

Bayles suggested that the SM of AD patients is disrupted, but that the disruption occurs gradually. While in mild AD the associative links between concepts in SM may be weakened but
not broken, by severe AD the inability to use objects or even to imitate their use indicates a severe deficit of conceptual knowledge.

Further evidence of a SM deficit in AD comes from a study by Mitchell, Hunt and Schmitt (1986). They investigated a phenomenon called the generation effect in AD patients. The generation effect refers to the finding that internally generated information is better remembered than externally provided information. Another phenomenon, called reality monitoring, refers to the fact that subjects can be extremely accurate at identifying the source of the information, whether it was externally provided or internally generated. Internally generated and externally provided information are treated differently psychologically. It has been proposed that the advantage of internally generated information depends on the activation of SM, because nonsense syllables which are internally generated do not elicit the generation effect.

Mitchell et al. hypothesized that if the generation effect is produced by activating SM and if AD patients have a disruption of SM, then AD patients will fail to produce the generation effect. Several tasks were administered to the subjects. The generation task consisted of three sets of 20 sentences of the form SUBJECT VERB OBJECT (SVO). The SUBJECT and VERB were always provided while the OBJECT position was either blank or supplied and underlined. Subjects read the sentence aloud and either read the OBJECT or generated an OBJECT. Subjects were then administered the Mini Mental Status Exam. Next, Subjects were asked to name as many U.S. presidents as they could in two minutes. This served as a distractor and a test of semantic memory. Subjects were then given the SUBJECT from each SVO sentence and asked to recall the OBJECT from that sentence, a cued recall task. The reality monitoring task was the final task. Subjects were given the correct SO pairs and were asked to judge whether they had read or generated the OBJECT.

Results from the cued recall task indicated that while the generation effect was robust for the older normal subjects, the AD patients showed no benefit from generational processing. For the reality monitoring task both younger and older normal subjects showed the reality monitoring effect, but the AD patients could not identify the information which they had generated at a level greater than chance. The fact that the AD patients performed significantly more poorly than the
normal controls on the task which required them to name US presidents was interpreted as evidence of the AD patients’ SM difficulties.

Mitchell et al. concluded that because the AD patients demonstrated neither the generation effect nor reality monitoring, SM must be disrupted in AD. They note that the tasks which were administered (excluding the presidents task) did not require effortful processing. Mitchell et al. noted several sources of evidence to support the claim that AD patients demonstrated impaired activation of and retrieval from SM: 1) although the words generated by the AD patients did not differ significantly from those generated by the normal subjects, the AD patients often needed up to 30 seconds to generate a word 2) the AD patients had much difficulty recalling names of presidents 3) although the AD patients generated suitable words in the generation task, these words were not processed in the beneficial manner that normally produces the generation effect in episodic recall.

Mitchell et al. proposed the following to explain their results. When a subject generates information, he first activates the semantic representation then accesses the lexical representation. When information is externally presented, the subject first activates the lexical representation then the semantic representation. Cued recall involves the activation of semantic memory, then lexical memory, and thus is more similar to the generation input. Therefore, recall for internally generated information is better than for externally presented information. Mitchell et al. suggested that the failure of AD patients to produce the generation effect may be due to a difficulty of the lexical decoding of a semantic representation. That is, the deficit may lay in the ability to translate a semantic representation into a lexical representation.

In this chapter findings have been discussed which indicate that patients with Alzheimer’s Disease have deficits of lexical memory, semantic memory and the ability to map between lexical and semantic memory. The status of semantic memory in AD patients remains an issue of debate. Some researchers have found it to be impaired while others have found it to be spared. We have identified some variables which have important effects on the results and their interpretation: the severity of dementia, the type of task used and what it is testing, and the amount of effortful processing required to perform the task. The state of semantic memory in Alzheimer’s Disease patients remains unclear. The problem to be investigated is whether AD patients have a semantic
memory deficit. In order to investigate this problem, the variables of dementia severity, task type, and effortful processing must be controlled.

2.2 Aging and Semantic Memory

There is an extensive research literature concerning the effects of aging on memory. The majority of the research has examined episodic memory abilities of older adults. Craik and Byrd (1982) reviewed this literature, and concluded that older normal subjects have a deficit of episodic memory in that they fail to carry out deeper inferential processing. When asked to recall word lists under various conditions, older subjects consistently performed more poorly than younger subjects.

In tests of memory, results are scored according to the number of items recalled or recognized correctly. Another frequently used measure is reaction time. However, to interpret the results of reaction time studies with older subjects correctly, one must take into account the general behavioural slowing which occurs with age. If older subjects respond more slowly than younger subjects, is it because of a memory deficit or behavioural slowing?

Birren, Woods, and Williams (1980) reviewed the research regarding behavioural slowing with age. The essence of their review was that there is a general decline in speed of behaviour with age, and that the slowness is evident not only in simple motor responses and sensory phenomena, but also in more complex behaviours such as memory and performance on tests of general intelligence.

Birren et al. reported that in simple reaction tests, older subjects typically respond 13-20% slower than younger subjects. This is perhaps the most replicated finding of behavioural change with age. However, Birren et al. found little evidence to support the attribution of behavioural slowing to slower neural conduction velocity.

The fact that older subjects show slower reaction times during complex cognitive tasks indicates that slowing is not limited to simple movements. Birren et al. discussed some of the early research on intellectual changes across adulthood. Although these studies showed that intellectual abilities declined with age, it has proven impossible to eliminate the confounding effect of cohort on the intellectual performance of older adults. One generally accepted finding in this area of
research is that abilities which are the first to show decline with age are those which require speed: spatial visualization, inductive reasoning, and word fluency.

In order to avoid cohort effects, some researchers have used an information processing approach to investigate skills across adulthood. This approach divides cognitive processes into a sequence of steps, beginning with stimulus acquisition and ending with a response. The processing time required at each stage can be measured. Age differences have been found for all of the five following steps: peripheral feature analysis, central feature analysis, sensory store, short-term memory, and long-term memory.

Birren et al. reported the results of a study in which backward masking of visual stimuli was used to test peripheral processing. Older subjects showed significantly slower peripheral processing by their need for a longer interstimulus interval to escape masking. Central processing, which occurs subsequent to peripheral processing, has also been investigated using a masking paradigm. Substantial age differences were found in processing speed for central processing as well.

The next stage of information processing is the sensory store, also known as iconic memory. Iconic memory consists of an image of the stimulus which is holistic and not yet represented as a symbolic memory. Birren et al. reported the results of several studies which indicated age-related differences in iconic memory. Certain aspects of iconic memory are selected to be transferred to the next stage of information processing, i.e. short-term memory. Birren et al. found no evidence to indicate a reduction in the capacity of short-term memory with age, although there appears to be a reduction in the speed at which items in short-term memory are scanned. Scanning of short-term memory is the sequential review of items in short-term memory. When young subjects are required to determine whether an item has been presented among a list of items, their response latencies increase with the number of items in the list, assuming that the number does not exceed the capacity of short-term memory. The latency is presumed to be a measure of short-term memory scanning speed. Several studies have indicated that for a given set size, the response latencies of older subjects are longer than those of younger subjects (Birren et al., 1980). These results indicate a slowing of the scanning rate in short-term memory with age.

Birren et al. did not review literature regarding age differences in long-term memory, but they noted that several studies have found a correlation between memory abilities and speed of
behaviour. For example, the Weschler Memory Scale showed no correlation with digit writing speed for young subjects, while the two measures were significantly correlated for older subjects.

Although behavioural slowing occurs with age, Birren et al. noted that environmental factors also have an effect on speed of behaviour. Patients with hypertension, heart disease, and cerebrovascular disease respond more slowly than patients without vascular problems. Birren et al. suggested that the behavioural slowing seen in healthy older adults may be due to minor cerebrovascular problems, since the relationship between age and atherosclerosis is well-known. Epileptic and brain-damaged subjects also showed slower response times than age-matched control subjects. One study found a significant interaction of the effects of age and brain damage on simple reaction time. Birren et al. pointed that reaction time tests have been found to be very sensitive to both diffuse and focal brain damage.

Based on these results, we can predict that dementia patients would show increased response latencies as compared to older normal subjects, and that reaction time measures may be sensitive to the presence of AD. Lawson and Barker (1968) have shown reaction time to be a more sensitive measure of dementia than number of correct responses in a naming task. Lawson and Barker assessed 100 dementia patients (etiology of dementia was not reported) and 40 normal control subjects using a naming task. For half of the items, the use of the object was demonstrated and subjects were allowed to manipulate the object. The remaining items were not demonstrated. Reaction times were recorded using a stop watch. If an item had not been named 50 seconds after presentation, the trial was discontinued and scored as a failure.

Results indicated that low-frequency words required longer reaction times for dementia patients and control subjects, and that dementia patients showed longer reaction times than control subjects for both low and high frequency words. The word frequency effect was more pronounced for dementia patients than normal subjects. Demonstrating the use of the object decreased the reaction times for dementia patients but had no effect on the reaction times of the normal subjects.

Lawson analyzed the results from the reaction time measure and the pass/fail measure. The number of true and false positives (i.e. whether the task correctly identified the dementia patients) were calculated for both measures, and receiver-operator curves were created. Results from this analysis indicated that use of the reaction time measure achieved a more accurate separation of
groups than the pass/fail measure. Lawson and Barker concluded that the use of reaction time measures was advantageous in distinguishing dementia patients from normal age-matched adults. They also concluded that the use of less common objects increases the efficiency of the test, while demonstrating the use of test items decreases the efficiency of the test.

Lawson and Barker’s results can be interpreted as evidence for increased behavioural slowing caused by diffuse brain damage associated with dementia. Birren et al. reported that Parkinson’s Disease, schizophrenia and depression were also associated with a loss of speed. Birren et al. reported further evidence to support the theory that environmental factors interact with general behavioural slowing. Several studies have indicated that the slowness of older persons may be attributable in part to a lack of physical fitness. Some researchers have suggested that physical activity increases the arousal of the central nervous system, thus increasing responsiveness.

Birren et al. suggested several causes of behavioural slowing with age. 1) Older subjects may be less inclined to respond quickly because of the fear of making a mistake. 2) Older subjects’ lower capacity to attend to stimuli may cause slowing of behaviour or slowness of behaviour may cause lower attention. 3) There may be more than one cause of behavioural slowing:

"Perhaps one should envisage a primary ontogenic slowing in a subcortical structure that can be influenced by additional processes, such as learned cautiousness, or localized tissue damage in a wide range of structures."6

Birren et al. also found evidence of neurobiological causes of behavioural slowing with age: 1) With age, there is a loss of extrapyramidal cells in humans. 2) There is a decrease in the overall number of neurons with age, although no uniform pattern has been observed. 3) Reduced cell counts in the locus ceruleus have been reported. Interestingly, deficits in this area of the brain have been implicated in AD as well (Bayles, 1987). 4) A reduction in the number of synapses with age has been reported. This indicates that the number of connections with other cells has been reduced. Reductions in the number of intercellular connections in the brains of AD patients have also been reported. 5) Neurotransmitters have been found in reduced numbers in the brains of aging subjects, as well as AD patients. Morphological changes, reduction of neuronal connectivity, and reduced
amounts of neurotransmitters can be associated with a slowness of neural events and with memory changes. The similarity of these results with those from AD patients deserves further investigation.

Birren et al. concluded that there is a general loss of speed of behaviour with age. This slowing is reflected in a number of behaviours, ranging from simple motor responses to complex cognitive operations. Birren et al. suggested that the loss of speed is a reflection of a general mediating process in the central nervous system. Behavioural slowing has been implicated in the episodic memory deficits of older subjects.

Because the purpose of this study is the investigation of semantic memory in AD patients, it is necessary to review the research which has investigated the semantic memory abilities of older normal subjects. There is some evidence to indicate that older subjects exhibit slowing of semantic memory as well as episodic memory. For tasks in which the older subjects are required to make a motor response, the investigators must control for slower motor response time and sensory processing time in order to accurately measure any age differences in memory.

Bowles and Poon (1981) used several methods to control for motor response time in a group of older subjects. The purpose of the study was to investigate the effect of aging on speed of lexical access, using a lexical decision task. Bowles and Poon noted that an age-related slowing in response time during a lexical decision task could be due to sensorimotor and/or cognitive processing. They used three methods to separate the sensorimotor and cognitive components: The subtraction method, the analysis of covariance, and the additive-factor method.

In the subtraction method, latencies for an appropriate sensorimotor control task are subtracted from the total latencies, supposedly revealing the latencies for the cognitive task. The success of this method depends on the control task duplicating the experimental task in all but one processing stage. A two-choice reaction time task was used as a control for the lexical decision task. The reaction time task involved the information processing stages of sensory processing, decision, response selection, and motor response. The lexical decision task was assumed to include these four stages plus a lexical access stage. When latencies for the control task are subtracted, the remaining latencies should reflect lexical access time.

In the analysis of covariance method, the portion of the error variance due to the covariate is statistically removed. The covariate in this study was sensorimotor processing, as measured by the
choice-reaction task. If a significant age effect is found by analyzing the covariance, it is attributed
to processing other than the sensorimotor processing represented in the covariate task. If no effect
is found, the age difference is attributed to sensorimotor processing.

In the additive-factor method, the reaction time is assumed to be the sum of all the times for
the component stages which make up total processing. If a variable affects the total reaction time,
it must affect one or more of the component processes. If two independent variables affect the
same stage of processing, they are assumed to interact. If they affect different processing stages,
their affects would be additive and there would be no interaction. Bowles and Poon varied the
word-frequency of the stimuli. This variable is known to affect reaction time, with high frequency
words resulting in faster reaction times than low frequency words. It was assumed that if age and
word frequency interacted, then both variables affected the same processing stage, namely lexical
access. If age and word frequency did not interact, then it would be concluded that age did not
affect lexical access time.

Subjects were required to decide whether two strings of letters were both English words by
lifting a finger off one of two buttons. High and low frequency words were presented randomly in
pairs of two words per trial. In the choice-reaction task, subjects were required to lift one finger
off a button in response to the words UPPER or LOWER.

Results indicated that age did not significantly affect accuracy, but there was a significant age
difference in reaction time. Analysis based on the subtraction method indicated that there was a
slowing of lexical access associated with aging. However, Bowles and Poon noted that the control
task, choice-reaction time, was probably not an accurate replication of the sensorimotor, decision,
and response selection stages involved in lexical decision. They suggested that it is possible that
the insertion of a new stage effects the processing time of the other stages. The finding of an age
difference in lexical access using this method, then, is not valid.

The analysis of covariance indicated no effect of age on lexical access time. The variance
associated with the choice-reaction time task accounted for the variance in the lexical decision task.
There were problems with this analysis as well. An assumption of the analysis of covariance is
that the two variables are independent. Bowles and Poon reported that some of the variance
associated with choice reaction time was shared with the age variable. Because the two variables
were not independent, the failure to find an age deficit in lexical access time using this method is not a valid result.

The additive-factor analysis indicated no effect of age on lexical access time. There was no age by word-frequency interaction, indicating that the two variables affected different processing stages. Because word-frequency has been shown to affect lexical access, age difference must affect a processing stage other than lexical access.

Bowles and Poon concluded that age had no effect on speed of lexical access, and that speed differences in lexical decision were due to age-related slowing at other processing stages. These results are opposed to those of many researchers who have found that older subjects have word-finding difficulties and perform more poorly than young subjects on tests of naming. It was stated in Chapter 2.1 that lexical decision tasks and naming tasks test lexical access and/or lexical memory.

Obler and Albert reviewed the literature regarding the lexical abilities of older subjects. They found that the number of correct responses on the Boston Naming Test increased between the ages of 30 and 50, held steady among 60-year-olds, and decreased among 70-year-olds. Institutionalized elderly subjects made significantly more errors than those who were not institutionalized. Interestingly, institutionalized elderly made more errors of misperception and exhibited more circumlocution, while noninstitutionalized elderly made more semantic association errors. Two types of errors increased with age: comments on the task and circumlocutions which described the item. There was no consistent pattern of response to semantic and phonemic cues across age. Thus, it seems that naming ability decreases with age. An action naming test developed by Obler and Albert, indicated that the pattern of results across ages was the same for verbs as it was for nouns.

Obler and Albert also reviewed older subjects’ definitional abilities. They noted that the vocabulary subtest of the WAIS, which requires subjects to provide definitions for stimulus words, is scaled for age. For example, a score of 43 for a 70-year-old is equivalent to a score of 50 for a 30-year-old. This suggested to Obler and Albert that small, but reliable age differences in definitional abilities exist. After some investigation, however, Obler and Albert that these differences are due to scoring criteria. The criterion for a good definition, according to the WAIS scoring procedures, is a one-word synonym. However, multiword responses increased with age. If
full credit is given for correct multiword definitions, older subjects do not differ from young subjects in their ability to define words. Although naming ability appears to decline with age, one aspect of semantic memory, definitional ability, appears to remain intact.

Bowles and Poon (1985) investigated the effects of aging on the retrieval of words from semantic memory. They used a lexical decision task and a word retrieval task. Based on their earlier (1981) work, they predicted that older subjects would perform as well as young subjects on the lexical decision task. The purpose of the study was to investigate the claim made by many older subjects that they are unable to find the desired words when speaking, despite the fact that vocabulary tests have indicated that there is no age difference in accessing the semantic network via the lexical network.

Bowles and Poon hypothesized that older people have a problem accessing the lexical network via the semantic network. That is, they may be unable to map from SM to LM. To investigate this hypothesis, Bowles and Poon used a word retrieval paradigm. Subjects were presented with the definition of a target word and were required to produce the target word that was defined. They predicted that there would be an age difference in success at word retrieval. Priming was used in both the word retrieval and lexical decision tasks.

Results indicated that there was no significant difference between the young and older subjects in accuracy and response latency for the lexical decision task. Neither was there a difference in the size of the priming effect due to semantically related primes. For the word retrieval task, an age-related deficit was found. The older subjects were significantly slower to respond than the young subjects in every priming condition.

Bowles and Poon suggested that older subjects had difficulty mapping from the conceptually organized semantic network to the orthographically and phonetically organized lexical network in the absence of orthographic/phonetic information. The importance of orthographic information was evidenced by the fact that older subjects showed much better performance on the word retrieval task when the prime was orthographically related to the target. Bowles and Poon concluded that the older subjects' difficulty in word retrieval indicated a breakdown in the connection from the semantic to the lexical networks, while both semantic and lexical memory remain intact.
Burke and Yee (1984) also found the semantic memory of older subjects to be intact. They administered a lexical decision task which was primed by semantically related sentences. Immediately after reading a sentence, subjects were required to decide whether a string of letters was a word in English. The target words were either unrelated to the sentence, related to the episode described in the sentence as a whole, instruments implied by the action described in the sentence, or related to only one word in the sentence.

Results indicated that there were significant main effects for age and sentence-target condition. The related response time was faster than unrelated response time only for the instrument condition. There were no age-related differences in accuracy. Burke and Yee also investigated the subjects’ memory for sentence primes. On a recognition test, older subjects made significantly more errors than younger subjects.

Burke and Yee concluded that their results indicated no age-related changes in semantic processing, but that there were clear age differences in retention of sentences. Their results highlight the importance of separating comprehension and retention processes in semantic memory testing. They suggested that the conflicting results regarding the status of semantic memory in older subjects may be explained by the amount of effortful processing required by the tasks used. Tasks which require retention also require effortful processing, and on these tasks age-related deficits in semantic processing have been found. These conclusions parallel those regarding the semantic memory deficit in AD patients.

Walsh and Baldwin (1977) used a linguistic abstraction paradigm to investigate age differences in semantic processing. Subjects were presented a set of sentences, each representing a partial meaning of a complete idea. After reading each sentence, subjects were asked an elliptical question about the information contained in the sentence. After the set of sentences were presented, subjects were administered a recognition test in which they judged whether a sentence had been presented previously. Studies have indicate that subjects abstract information from separate, related sentences and retain an integrated representation of the idea.

Results indicated no significant age-related differences in the accuracy of acquisition of information. Both young and older subjects understood the sentences equally well. There was no significant difference in recognition of sentences. Both groups retained equivalent amounts of
information regarding the surface structure form of the sentences. The results suggest that both groups integrated the linguistic ideas to the same degree. Walsh and Baldwin concluded that ecologically valid semantic memory functions may not decline with age.

Lorsbach and Simpson (1984) found evidence for age differences in semantic memory. They used a probe-recognition task to investigate the hypothesis that presentation rate and task complexity have different effects on the memory skills of young and older adults. In the probe-recognition task, subjects were presented with a series of 10-word lists. The exposure time for each word varied from 350 to 1400 milliseconds. Following each list, a cue and a probe word were presented. The cue indicated to the subject whether he was to judge if the probe word was identical to a word presented in the list, was a homonym or a synonym of a word in the list. Lorsbach and Simpson predicted that if complex semantic analyses require more processing time and if older subjects have slower processing times, then older subjects should perform significantly poorer than on synonym recognition at shorter presentation rates.

Accuracy results indicated that identical and homonym probes differed significantly from synonym probes, but not from each other. There was a small age effect, but an insignificant presentation effect. Although accuracy was unaffected by age, response time was. Older subjects required significantly more time to respond to synonym probes, but presentation rate did not affect young and older subjects differentially. The results did not support the speed-loss hypothesis, but did support the hypothesis that older subjects are slower than young subjects in gaining access to semantic information.

These results do not indicate that the structure of semantic memory is deficient in older adults, but that access to SM requires more processing time. The probe-recognition task requires effortful processing. Thus, it appears that older adults only show SM deficits when effortful processing is involved. This lends support to Craik and Byrd’s (1982) theory that aging produces a reduction in attentional resources.

Craik and Byrd (1982) suggested that:

"...decreased availability of attentional resources in older people reduces the amount of spontaneously initiated deep, elaborate, and inferential processing that is carried out and this reduction in turn is associated with lower levels
of retention. We do not wish to imply that no semantic processing is carried out: rather, it seems that the semantic processing achieved is more general in character."

They have supported this theory by citing evidence which shows that on a recognition task, older subjects and subjects under divided attention conditions make the same types of errors. Specifically, they make more false alarm responses to synonyms of target words. Older subjects, amnesic patients, and subjects under divided attention conditions all make more intrusions from previous lists into their free recall of current lists. It is assumed that subjects under divided attention conditions have a reduction in the amount of attentional resource available for the performance of the target task. The fact that older subjects respond similarly to subjects under conditions of divided attention indicates that older subjects may also have a reduced amount of attentional resource available.

Further evidence to support Craik and Byrd's theory comes from the finding that automatic aspects of information processing appear to be intact in older subjects, while effortful, conscious processes are impaired. This conclusion is indicated by the literature reviewed in this section and by the literature regarding AD and semantic memory (see Section 2.1 of this chapter).

Based on this theory, Byrd (1984) predicted that older subjects would show poorer performance than young subjects on a test of semantic memory which required them to make a conscious effortful search of semantic memory. Byrd carried out two experiments to test his prediction. In the first experiment, subjects were presented a category name, followed after 3 seconds by either a letter or a category exemplar. When provided with a category name plus an exemplar, the subject's task was to decide if the exemplar was a member of the category (decision task). When provided with a category name plus a letter, the task was to generate an exemplar of the category that began with the given letter (generation task). Half of the subjects were presented with a random mixture of generation and decision trials (mixed trials condition), while the remaining subjects were presented with blocks of generation and decision trials (blocked trials condition). Byrd was interested in the effect of blocking because other investigators had found that knowledge of the question format for the generation trials allowed subjects to begin a search of SM as soon as the category name was presented. This allowed a reduction in the time necessary to find a correct
answer. Byrd predicted that older subjects would benefit from this condition to a greater extent than young subjects.

Results indicated that older subjects showed longer response latencies than young subjects for both conditions. Both groups had longer response latencies in the mixed trials condition than in the blocked trials condition. Both groups of subjects took longer to respond to low dominance than high dominance words. Both groups showed longer response latencies for the generation than the decision task. There was a significant interaction between age, condition and task, with young subjects producing faster responses on the generation task in the blocked trials condition. In contrast to Byrd's prediction, young subjects benefitted more from the blocked trials condition of the generation task. To explain this finding, Byrd noted that his subjects were informed of the nature of the blocked trials and were encouraged to use this information. Perhaps the young subjects were better able than the older subjects to use this information to initiate a search of SM.

Byrd suggested that the differential performance on the two tasks as a function of age was due to an interaction between task demands and processing abilities. He suggested that the decision task involved more automatic, less effortful processing than the generation task because the given information in the decision task directs the search of semantic memory. The decision task involves task-driven processing, while the generation task involves subject-driven processing. In the generation task, the information is not enough to activate automatic processing, and the semantic memory structures must be consciously analyzed. If older subjects have less available attentional resource, then they would perform more poorly on the generation task than on the decision task.

Byrd's second experiment was designed to:

"...examine the use of information that is semantically related to the questions in order to determine if both groups are capable of facilitating automatic information processing to the same degree."

Subjects were presented with category-word pairs as in the decision task of Experiment 1, except that the members of the pairs were presented simultaneously. The pairs were presented with zero, one, or two intervening items between two pairs of the same category (0,1, or 2 item lag). Byrd predicted that no age differences in the size of priming would be observed because older
individuals should be able to make use of automatic processing strategies as well as young individuals.

Results indicated that while older subjects showed longer response latencies than young subjects, the two groups responded equally to the priming. Both groups responded faster in the 0 lag condition. Byrd concluded that although there was an age decrement in the ability to activate SM, there was no decrement in the ability to facilitate automatized information retrieval processes. His experiments demonstrated the usefulness of the effortful/automatic processing dichotomy when interpreting results regarding age differences in SM.
CHAPTER 3
OBJECTIVES

3.1 Original Objectives

The purpose of the present study is to investigate the semantic memory of a group of patients with the diagnosis of probable Alzheimer's Disease, by replicating the first experiment of Byrd's (1984) research. The aim of this study is to determine whether AD patients exhibit a deficit of semantic memory. In the discussion in Chapter 2, it was concluded that AD patients appear to exhibit a deficit of SM when performing tasks which require effortful processing. When the task involves automatic processing, however, AD patients appear to have intact SM abilities. It has been suggested that normal older subjects have reduced attentional resources in comparison to young subjects, and that perhaps AD patients have a further reduction of attentional resources.

Given Byrd's suggestion that the generation task involves more effortful processing that the decision task, it is predicted that the AD patients will perform more poorly on the generation task than on the decision task. Following from the suggestion that AD patients have a reduced capacity for effortful processing, it is predicted that the AD patients will perform more poorly than a group of normal elderly subjects on the generation task.

The locus of the verbal memory deficit was discussed in Chapter 2. There is evidence that AD patients have a deficit of lexical as well as semantic memory. There is some evidence that AD patients have difficulty accessing LM via SM or SM via LM. One of the important variables in memory research is the type of memory which a task requires. Do the generation and decision tasks test SM, LM, or the ability to map between them?

It is suggested that, to perform the generation task a subject must access the lexical representation of the category name, map the lexical representation to the conceptual representation in SM, analyze the conceptual representation searching for members of the category, then map the conceptual representation of each category member to its lexical representation checking for a
member which begins with the specified letter, then choose the correct lexical form and respond verbally (see Fig.4).

It is suggested that, to perform the decision task a subject must access the lexical representation of the category name, map the lexical representation to its conceptual representation in SM, then access the lexical representation of the exemplar, map it to its conceptual representation in SM, compare the two conceptual representations to determine if the exemplar is a member of the category, and respond verbally (see Fig.4). Lexical access to the exemplar word is assumed to occur after the conceptual representation of the category has been accessed because the category name is presented for 3 seconds prior to presentation of the exemplar. However, given the extremely long response latencies of some of the AD patients, and given the theory that lexical access is impaired in AD, we cannot assume that 3 seconds is sufficient time to allow all subjects access to SM. Therefore, for some subjects, access to the conceptual representations of the category and exemplar may occur simultaneously.

In contrast to a naming task, which can be performed by matching lexical representations directly to visual information thereby bypassing SM altogether, the generation and decision tasks involve activation of SM. If AD patients have a deficit of LM only, they will perform better on the decision task than the generation task because both lexical forms are provided in the decision task. On the generation task, however, only one form is provided. The subject must generate the lexical form of the exemplar. If AD patients have a deficit of SM only, they will perform equally poorly on the generation and decision tasks because SM must be accessed for both the category and the exemplar in each task.

If AD patients have a deficit in the ability to access LM via SM, they will perform more poorly on the generation task than on the decision task because the generation task provides less lexical information for the subjects to use as a cue in accessing LM.

If AD patients have reduced attentional resources, resulting in a deficit of semantic memory, then they will demonstrate longer response latencies than normal older subjects on the generation task. They will demonstrate better performance on the decision task than on the generation task. The hypothesis for the purposes of this study is: that patients with AD will demonstrate a pattern of performance which is not different from that of a group of normal older adults.
Figure 4

Experimental Tasks

**Generation Task**

![Diagram](image)

**Decision Task**

![Diagram](image)
3.2 Revised Objectives

During the course of work on this experiment, some unforeseen problems arose. In dealing with these problems, the original aims of the study were revised.

1) The first problem involved the difficulty of finding subjects. The clinical diagnosis of AD is a long and complicated process. Many patients are referred to an Alzheimer's Disease clinic because other sources, family physicians and specialists, have been unable to discover the cause of the patient's memory problem. Since the process of assessing a patient is so arduous, only a small number of patients are seen over a short period of time. Of the 13 subjects who were interviewed for this study, only 7 were diagnosed as having Alzheimer's Disease. Of these 7 subjects, the data from two subjects could not be used. The remaining 6 of the 13 subjects exhibited dementia, but the etiology was unknown. Because of the small number of subjects, rigorous statistical analyses could not be applied.

The subjects were divided into three groups: 1. subjects in the pilot experiment, 2. the AD patients, and 3. the dementia patients. The following chapters will deal with these groups separately.

2) The second problem became apparent when the first few subjects were interviewed. These subjects responded inappropriately to the task by making irrelevant comments, commenting about the task, or by producing circumlocutions. They frequently asked how to respond to the task, or indicated by their comments that they did not understand the nature of the task. After these subjects were seen, the instructions were modified and more examples added.

3) The third problem also became apparent with the pilot subjects. The pilot subjects often appeared unable to respond to the trials without help from the experimenter. The experimenter provided prompts designed to elicit a response. Because it seemed likely that several subjects would require prompting and because the use of a prompt to elicit a response affects reaction time, the method of prompting was standardized. For the remaining subjects, a standard set of prompts were used, and a record was made of each trial for which a prompt was used. Reaction time data from prompted trials were excluded from the analyses.
4) Despite the size of stimuli, some of the pilot subjects had difficulty reading the words. In order to carry out the experiment, the experimenter read the words aloud to subjects as they appeared on the computer screen. Because of the small number of subjects, it was desirable not to exclude subjects on the basis of vision. Therefore, when it appeared that the subject was having difficulty reading the stimuli, the experimenter offered to read them aloud.

5) Many of the subjects presented with conditions which would complicate the diagnosis of AD. However, because of the small number of subjects available, subjects with complicating conditions were not excluded.

6) Because of the small number of subjects available it was not possible to investigate the effect of severity of AD, although some general comments will be made.

The purpose of this study is to investigate the effects of AD on semantic memory. However, because of the small number of subjects, rigorous statistical analyses of the many factors influencing semantic memory performance will not be possible. The predictions made in Section 3.1 cannot be tested with any accuracy, although some tentative conclusions may be drawn.
4.1 Subjects

4.11 Pilot Experiment

Two male and one female subject participated in the pilot experiment. They ranged in age from 63 to 77 years (mean= 71.7 years). These subjects were drawn from a population of patients who were assessed at the University of British Columbia (UBC) Health Sciences Centre Hospital (HSCH) Alzheimer’s Clinic (10). Subjects in both the pilot experiment and the main study participated during their initial assessment at the Alzheimer’s Clinic. Thus, diagnosis was unknown at the time that each subject participated. Two subjects in the pilot experiment received diagnoses of AD, although they presented with conditions which complicated the diagnosis. The third subject received a diagnosis of Parkinson’s Disease with associated dementia (see Appendix 1A for more detailed information regarding the pilot subjects).

4.12 Experimental Subjects

Five patients with a diagnosis of AD participated in the main study, one male and four females. They ranged in age from 64 to 73 years (mean= 69.4 years). The subjects had a mean education level of 11.9 years, with a range of 10 to 13.5 years. One patient was diagnosed as moderately impaired while the other four patients exhibited mild AD. Three patients presented with conditions which complicated the diagnosis of AD (see Appendix 1B for information about individual subjects).

These patients were also drawn from the UBC HSCH Alzheimer’s Clinic and participated as part of their initial assessment. As with the subjects who participated in the pilot experiment, the diagnoses were made following the subjects’ participation in the study.
The group of patients who were drawn from the UBC HSCH Alzheimer’s Clinic included the pilot subjects, the AD patients and the dementia patients. Because subjects were seen during initial assessment and because it was not possible to determine the total number of subjects prior to running the experiment, subjects were assigned to the blocked and mixed trials conditions alternately in consecutive order. That is, subject #1 was assigned to the blocked trials condition, subject #2 was assigned to the mixed trials condition and so on. This procedure resulted in the assignment of four AD patients to the mixed trials condition and one to the blocked trials condition.

A group of 20 normal older individuals, 10 male and 10 female, served as control subjects (11). The control subjects ranged in age from 64 to 83 years (mean = 71.2 years) and had an average of 13.2 years of education (range= 6 to 20 years). Half were assigned to the blocked trials condition and half to the mixed trials condition.

All subjects were administered a short version of the Mill Hill Vocabulary Test. The control subjects displayed slightly higher vocabulary scores (mean= 16.5) than the AD patients (mean= 14.0). this may have been attributable to the control subjects’ higher mean level of education.

4.13 Dementia Patients

Of the remaining five subjects, three received a diagnosis of dementia for which the etiology was unknown, one received a diagnosis of circumscribed memory deficit specific to the retrieval of new information, and one had not received a diagnosis. She was referred to the UBC HSCH Alzheimer’s Clinic on the basis of the following symptoms: memory disturbance, personality disturbance, and increased dependence on her spouse. Three of the dementia patients were drawn from the UBC HSCH Alzheimer’s Clinic and participated in the experiment as part of their initial assessment. Subjects #12 and #13 were inpatients at Valleyview Hospital (12). All of the dementia patients presented with symptoms which would complicate a diagnosis of etiology (see Appendix 1C for more detailed information about the dementia patients).

The dementia subjects ranged in age from 61 to 82 years (mean= 72.6 years)and had an average of 8.4 years of education (range= 6 to 11 years). This group demonstrated lower
vocabulary scores (mean = 9.2) than the AD patients and the control subjects. Four dementia subjects were assigned to the blocked trials condition and one to the mixed trials condition.

4.2 Stimuli

The stimulus materials used in this investigation are similar to those used in Byrd's (1984) experiments. Twelve categories were chosen from the Battig and Montague (1969) category norms (see Appendix 2). Two high dominance and two low dominance exemplars were chosen from each category. Those exemplars chosen by 50% or greater of the subjects in the Battig and Montague norms were considered to be high dominance exemplars. Equal numbers of high and low dominance exemplars were chosen in order to control for the effect of category dominance on reaction time. For each category, the first letter of one high and one low dominance exemplar were used to create generation pairs. The remaining words were used in full to create decision pairs. Thus, 24 category-letter generation pairs and 24 category-word decision pairs were constructed. In addition, 24 incorrect category-word decision pairs were constructed from the original 12 categories, to act as distracters in the decision task (see Appendix 2 for a list of the stimulus items).

Six category-word decision pairs and three category-letter generation pairs were presented to the subjects as examples. The experimenter demonstrated the first few examples and then guided the subject through the remaining examples, explaining the response required. Ten category-word decision pairs and ten category-letter generation pairs served as practice trials.

There were two conditions: blocked trials and mixed trials. In the blocked trials condition, blocks of 6 category-letter generation pairs or 12 category-word decision pairs were presented alternately. There were 4 blocks of generation trials and 4 blocks of decision trials. In the mixed trials condition, there were 9 pairs per block, each containing a random mixture of generation and decision trials. The order of trials in each block was randomly assigned for each subject (see Appendix 3).
4.3 Procedure

Each subject was seen for one 1-hour session. Subjects were informed that the purpose of the study was to investigate the ability to retrieve words from memory. A standard set of instructions were read (see Appendix 4). Subjects were told to answer each question as quickly as possible, but to try to answer correctly. During the administration of the example trials, subjects were instructed as to the proper type of response and were prompted often. Subjects in the blocked condition were informed of the nature of the blocked trials and encouraged to use that information.

A computer program written in BASIC (9) allowed stimuli to be presented on the screen of a Zenith 158 personal computer with NEC Multisync colour monitor, which was controlled by the experimenter. Words were approximately one half inch high, and the subject was seated two to three feet from the screen. As noted in the previous chapter, for those patients who could not read the stimuli, the experimenter read the words aloud. While this may have affected reaction time, none of the AD group required this modification.

On each trial, the category name appeared first. The category name (e.g. Fruit) remained on the screen for 3 seconds. Then either a letter or an exemplar appeared on the screen to the right of the category name. The appearance of the letter or exemplar was accompanied by a short beep. When a category-letter pair appeared on the screen, the subject’s task was to produce an exemplar of the category beginning with that letter. When a category-word pair appeared on the screen, the subject’s task was to decide if the word was an exemplar of the category, and respond verbally ‘YES’ or ‘NO’. The pair remained on the screen until the subject responded.

When the subject responded, the examiner pressed a key on the computer which terminated the computer’s timer and automatically recorded the reaction time. The examiner then coded the response as correct or incorrect, in the case of decision trials, or recorded the exemplar produced in generation trials. Byrd used a voice-activated timer to record response latency. This was felt to be inappropriate for AD patients because they show a tendency to comment on the task or rehearse responses aloud before producing a correct response. Although the experimenter’s response time is also included in the reaction time measure, it remained fairly constant across trials.
There was a break of two minutes between each block of trials. During this time, the experimenter conversed with subjects in an attempt to help them feel more comfortable.

Prompts, in the form of questions, were administered when the subject responded to the stimulus items but not in the manner required. For example, when presented with the stimulus VEGETABLE: CHERRY, a subject might respond, "Well, there’s vegetables and there’s cherries." Prompts were also administered when the subject indicated that he/she did not know how to respond. For example, a subject might say, "I don’t know what you want me to do." Prompts were also administered when the subject was silent for several seconds. This criterion, however, could not be applied strictly because of the different response strategies of the subjects. While some subjects were silent only when they needed help, other subjects remained silent until they responded correctly, even if they took over 30 seconds to respond.

For the decision task, subjects were prompted with the following question:

Is there a CATEGORY called EXEMPLAR?

e.g. Is there a fruit called apple?

For the generation task, the following prompt was used:

Tell me a CATEGORY starting with LETTER.

e.g. Tell me a fruit starting with A.

Following the experimental task, subjects were administered a short vocabulary test. Twenty items of graded difficulty were taken from the Mill Hill Vocabulary Test. Subjects saw one test item at a time. Testing was discontinued after three consecutive incorrect responses were made. The maximum score attainable was 20.
5.1 Pilot Experiment

Results of the pilot study indicated a need for changes in the methodology of the experiment. These have been discussed in Chapter 3. The pilot subjects appeared to have much more difficulty completing the task than normal older adults. Byrd (1984) noted that errors, omissions and anticipatory responses accounted for 6.9% of the generation trials and 3.3% of the decision trials. Subjects #1 and #2 had no difficulty completing the decision task; they both responded correctly to every trial. On the generation task, however, subject #1 made errors on 25.0% of the trials and subject #2 erred on 21.0% of the trials. Both subjects required prompting to complete the tasks, a problem not encountered by Byrd with his older subjects.

Reaction time data from subjects 1 and 2 could not be analyzed because no record of prompted trials was kept, making it impossible to distinguish valid and invalid reaction times.

Subject #3 had greater difficulty completing the tasks. During a one-hour session, he was only able to complete two practice lists and three experimental lists. There are eight experimental lists for each condition. Subject #3 required one or more prompts for most trials. On only five of 32 decision trials did he respond appropriately without prompting. Of these, four of the five responses were correct, and all were ‘YES’ responses. Given his tendency to perseverate on ‘YES’, the five trials cannot be assumed to represent an understanding of the task.

Subject #3 required prompting for each generation trial. With prompting, only three of 16 generation trials were responded to correctly. While some errors were purely phonological in nature (e.g. Tree:F produced the response ‘FREE’), others seemed to represent an inability to focus attention on both the category and the letter simultaneously. For example, in response to the stimulus Bird:C, subject #3 responded ‘CAT’. When the experimenter prompted him to think of a bird beginning with C, he responded ‘ROBIN’.
The results from the pilot experiment indicated the importance of considering the number and type of errors made by subjects, as well as the need to use standard prompts, excluding prompted trials from analyses of reaction times.

5.2 Main Experiment

Overall, the AD patients appeared to have less difficulty completing the tasks than the pilot subjects did. The AD patients had a mean of 10.8% errors on the generation task and 4.2% on the decision task. These error rates were slightly higher than those reported by Byrd for the older normal subjects. The AD patients also required prompting. Trials during which prompts were supplied were excluded from analyses of reaction times.

Table I represents the reaction time data and the percent errors for the AD patients in both conditions for each task. For each subject, the mean response latency for the generation task is longer than the mean latency for the decision task. The standard deviation values for each subject in the generation task are larger than those in the decision task, with the exception of subject #6. This indicates that there was a larger amount of variability in the reaction times for the generation task than for the decision task. The range of reaction times for each subject in the generation task is larger than the range in the decision task, also indicating a greater degree of variability in the reaction times for generation trials. Again, subject #6 is an exception.

The data from subject #6 seem inconsistent with the pattern of results seen for the other AD patients. This inconsistency can be explained by the fact that subject 6 had so few trials for which reaction time was a valid measure. She required prompting on all but eight of 24 decision trails. One of the eight unprompted trials resulted in an abnormally long reaction time. This long reaction time affected variability to a greater extent than would be expected if there were a larger number of reaction times in the sample.

Subject #8 was diagnosed as having moderate AD, while the other AD patients were diagnosed as mild. Her mean response latencies were greater than those of the mild AD patients for both the generation and decision tasks (disregarding the decision task data from subject #6).
Table I

AD Patients Data

<table>
<thead>
<tr>
<th>Subject #</th>
<th>Condition</th>
<th>Errors (%)</th>
<th>Reaction Time (msec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Mixed</td>
<td>4.2</td>
<td>Mean: 6060</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>SD: 4112</td>
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<td></td>
<td></td>
<td></td>
<td>Range: 1695-15,757</td>
</tr>
<tr>
<td>6</td>
<td>Mixed</td>
<td>8.3</td>
<td>Mean: 5640</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>SD: 3256</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Range: 2310-11,149</td>
</tr>
<tr>
<td>7</td>
<td>Blocked</td>
<td>8.3</td>
<td>Mean: 5771</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>SD: 3256</td>
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<td></td>
<td></td>
<td></td>
<td>Range: 1700-15,220</td>
</tr>
<tr>
<td>8</td>
<td>Mixed</td>
<td>16.7</td>
<td>Mean: 10,901</td>
</tr>
<tr>
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<td></td>
<td></td>
<td>SD: 8869</td>
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<td></td>
<td></td>
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<tr>
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Decision Task

<table>
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<th>Condition</th>
<th>Errors (%)</th>
<th>Reaction Time (msec)</th>
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<td></td>
<td></td>
<td>Range: 992-3679</td>
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<tr>
<td>6</td>
<td>Mixed</td>
<td>8.3</td>
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<td></td>
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<td></td>
<td></td>
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<td></td>
<td></td>
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<td></td>
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<td>Mixed</td>
<td>4.2</td>
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<td></td>
<td></td>
<td></td>
<td>SD: 220</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Range: 1259-2080</td>
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Subject #7 was assigned to the blocked trials condition while the other patients were assigned to the mixed trials condition. Inspection of Table I reveals the pattern of results for subject #7 to be the same as those for subjects in the mixed trials condition. From inspection of Figures 5 and 6, in which the reaction times of subjects 4, 6, 8, and 10 have been averaged, it appears that the blocked trials condition had the effect of decreasing response latency for both the generation and decision tasks. However, because the data for the blocked trials condition are based on the results from only one subject, the difference may not be reliable. Figures 5 and 6 serve only to illustrate the similarity of the pattern of results for the AD patients and the control subjects.

The control subjects showed longer response latencies for the generation task than the decision task, with blocking reducing the response latencies on both tasks. Blocking showed a greater effect for the generation than the decision task. The mean response latencies for the control subjects were as follows:

- Generation task, mixed trials: 2174 msec
- Generation task, blocked trials: 1766 msec
- Decision task, mixed trials: 1095 msec
- Decision task, blocked trials: 988 msec.

Comparing these results with those in Table I, it appears that each AD patient demonstrated longer response latencies than the mean response latencies of the control subjects on the generation and decision tasks regardless of condition.

The majority of errors made by the AD patients were semantic in nature. Semantic errors were those in which the subject produced a word beginning with the correct letter, but not belonging to the specified category, e.g. a response to Flower:P was ‘PLUM’. Other semantic errors were more subtle, in that the generated word was semantically related to the category, if not a member of the category. For example, a common response to Metal:N was ‘NAILS’. Phonological errors were those in which the subject produced a word which belonged to the correct category, but did not begin with the specified letter. Phonological errors were rare. Another common error was the inability to produce a response. Subjects were encouraged to try to produce a response in order to avoid overuse of the null response. There were a small number of idiosyncratic errors which seemed to result from spelling difficulties. For example, one subject responded to
Four-footed Animal: R with ‘ORANGUTAN’, which she pronounced ‘rangutan’. Other than this type of error, the initial letter was usually correct.

5.3 Dementia Patients

Reaction time and error rate data from the dementia patients are presented in Table II. The dementia patients appeared to have more difficulty completing the generation task than the AD patients. The dementia patients erred on an average of 25.0% of the generation trials. Subject #13 had the highest percentage of errors (62.5%). On the decision task, however, the dementia patients performed as well as the AD patients.

The dementia patients showed the same pattern of results as the AD patients. The mean response latency of each dementia patient was greater for the generation task than the decision task. The dementia patients also showed greater variability in response latencies for the generation task, as indicated by the larger ranges and standard deviations.

Subject #12 was assigned to the mixed trials condition, while the other dementia patients were assigned to the blocked trials condition. Although his mean response latencies were greater than those of the subjects in the mixed trials condition for both tasks, the severity of his dementia may have confounded the results. Subject #12 was diagnosed as having moderate dementia, subject #15 had a diagnosis of mild dementia, and the remaining subjects had no diagnosis of severity. It is possible that the subjects in the blocked condition were all mildly demented, and the observed difference between conditions may have been due to a difference in severity.

Subject #9 was diagnosed as having a circumscribed memory deficit. Strictly speaking, he was not demented. He was included in this group of subjects for convenience. Given that subject 9 did not have dementia, he would be expected to perform better than a group of dementia subjects on a test of memory, but given that he showed a memory deficit, he would be expected to perform more poorly than a group of age-matched control subjects. As expected, his mean reaction times on both tasks were shorter than those of the dementia patients, but longer than those of the control subjects.
Figure 5
Mean Reaction Times for AD Patients and Control Subjects - Generation Task

Reaction Time (msec)

Group

Control Subjects
AD Patients

- Blocked
- Mixed
Figure 6
Mean Reaction Times for AD Patients and Control Subjects - Decision Task

Reaction Time (msec)

Control Subjects  AD Patients

Group

- Blocked
- Mixed
Table II

Dementia Patients Data

Generation Task

<table>
<thead>
<tr>
<th>Subject #</th>
<th>Condition</th>
<th>Errors (%)</th>
<th>Reaction Time (msec)</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Mean</td>
</tr>
<tr>
<td>5</td>
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<td>6172</td>
</tr>
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<td>9</td>
<td>Blocked</td>
<td>8.3</td>
<td>3373</td>
</tr>
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<td>Blocked</td>
<td>29.2</td>
<td>5448</td>
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</tr>
<tr>
<td>13</td>
<td>Blocked</td>
<td>62.5</td>
<td>4951</td>
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Decision Task

<table>
<thead>
<tr>
<th>Subject #</th>
<th>Condition</th>
<th>Errors (%)</th>
<th>Reaction Time (msec)</th>
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<td></td>
<td></td>
<td></td>
<td>Mean</td>
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<td>3385</td>
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<tr>
<td>13</td>
<td>Blocked</td>
<td>4.2</td>
<td>2746</td>
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</table>
The pattern of errors made by the dementia subjects was also similar to that of the AD patients. The majority of errors were semantic errors or null responses. In general, the initial letter was retained correctly. There were some examples of phonological errors in the responses of the dementia patients; in response to Metal: N one subject said 'STEEL'.

Subject #13, who produced the greatest percentage of errors, produced mostly semantic errors in which the initial letter was correct, but the word had no recognizable semantic relationship to the category. For example, in response to Colour: R she said 'RUTH' and in response to Fish: H she said 'HACK'.
CHAPTER 6
DISCUSSION

In general, the predictions made in Chapter 3 were upheld by the results of this investigation. The first prediction was that AD patients would perform more poorly on the generation task than on the decision task because of the reduced attentional resources supposedly available to them, and the greater degree of effortful processing required by the generation task. The AD patients did perform more poorly on the generation task as indicated by the results from both the reaction time and error rate measures. These results suggest that effortful processing is more impaired in AD than automatic processing.

The second prediction was that AD patients would perform more poorly than normal older subjects on the generation task. AD patients showed longer response latencies and more errors than the control subjects on the generation task. Although AD patients also performed more poorly than the control subjects on the decision task, the difference between groups was much smaller than for the generation task. This result provides further support for the notion that AD results in a reduction of attentional resources. On the task which requires more effortful processing, the AD patients showed much greater impairment. AD patients appear to have intact automatic processing abilities, as studies such Nebes, Martin and Horn's (1984) have also shown.

The third prediction involved the locus of the verbal memory deficit in AD. If AD patients had a deficit of SM, as Bayles (1987) suggested, they were expected to perform equally well on the generation and decision tasks. The AD patients did not perform equally well on both tasks, therefore, they must not have a deficit of SM only. The results are compatible with a deficit of LM, the mapping between LM and SM, or a deficit of SM in conjunction with these two.

The pattern of results are consistent with an interpretation based on the interaction between SM and effortful processing. When the task involves effortful processing, as in the generation task, AD patients perform more poorly than normal age-matched subjects. When the task involves automatic processing, as in the decision task. AD Patients perform similarly to normal control subjects.
Most of the errors made by the AD patients were semantic in nature. This may indicate a SM deficit. If SM is disturbed, subjects will generate exemplars from the wrong categories, thus producing errors. However, SM may be intact. If subjects generate exemplars from the correct category, but unable to access LM via SM, semantic errors will be produced. Given the LM deficit demonstrated by AD patients on naming tasks (Bayles and Tomoeda, 1983), A deficit of LM would also produce semantically related errors.

The results of this study did not provide evidence for a semantic memory deficit in AD, although they are consistent with its existence. The hypothesis of this study was rejected. AD patients (and dementia patients) performed differently from normal age-matched control subjects, indicating that the generation and decision tasks may be useful diagnostic tools for identifying dementia patients. It is difficult to tell if the tasks used in this investigation would differentiate AD patients from dementia patients of different etiologies, since most of the patients in the dementia group were not diagnosed as to etiology. The generation task may be better suited to identifying dementia patients because it involves effortful processing, which these patients seem to have more difficulty with.

It is suggested that future research involve larger numbers of AD patients, in order to investigate the effects of the mixed and blocked trials conditions and the effects of severity. The small number of subjects involved in this study limits the conclusions which can be drawn. The results of this investigation must remain cursory. One conclusion which can be drawn with a fair amount of certainty is that the group of subjects suspected of suffering from Alzheimer's Disease is not homogeneous.


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10. Special thanks to Dr. L. Beattie, Medical Director, Robyn Lawrence, Clinic Coordinator, and all the staff at the Alzheimer’s Clinic for providing subjects.

11. Special thanks to Kathy Fuller for collecting data from the control subjects.

12. Special thanks to Dr. S. Holliday, Dr. Lishman, and the clinical research staff of Valleyview Hospital.
Bibliography


## Appendix 1

### Subject Information

### 1A Pilot Subjects

<table>
<thead>
<tr>
<th>Subject Number</th>
<th>Diagnosis</th>
<th>Severity</th>
<th>Complicating Conditions</th>
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<tbody>
<tr>
<td>1</td>
<td>AD</td>
<td>Moderate</td>
<td>Nutritional status</td>
</tr>
<tr>
<td>2</td>
<td>AD</td>
<td>Mild</td>
<td>Possible lacunar infarct</td>
</tr>
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<td>3</td>
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### 1B AD Patients

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<td></td>
<td></td>
<td>Possible MID</td>
</tr>
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<td>6</td>
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<td>Mild</td>
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</tr>
<tr>
<td>7</td>
<td>AD</td>
<td>Mild</td>
<td>--</td>
</tr>
<tr>
<td>8</td>
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<td>Moderate</td>
<td>Depression</td>
</tr>
<tr>
<td>10</td>
<td>AD</td>
<td>Mild</td>
<td>Epilepsy</td>
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### 1C Dementia Patients

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<td>Dementia, etiology unknown</td>
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<td>Depression, Non-fluent aphasia</td>
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<td>9</td>
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<td>Depression</td>
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<td>11</td>
<td>Unknown</td>
<td>Unknown</td>
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</tr>
<tr>
<td>12</td>
<td>Dementia, etiology unknown</td>
<td>Moderate</td>
<td>Alcohol abuse</td>
</tr>
<tr>
<td>13</td>
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<td>Unknown</td>
<td>Depression</td>
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# Appendix 2

## Stimulus Pairs

<table>
<thead>
<tr>
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<th>Correct Decision Exemplar</th>
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<th>Generation Letter</th>
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<tr>
<td>Colour</td>
<td>Blue</td>
<td>Soccer</td>
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<tr>
<td></td>
<td>Lavender</td>
<td>Wrestling</td>
<td>T</td>
</tr>
<tr>
<td>Fruit</td>
<td>Apple</td>
<td>Copper</td>
<td>O</td>
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<td>Walnut</td>
<td>L</td>
</tr>
<tr>
<td>Sport</td>
<td>Football</td>
<td>Corn</td>
<td>B</td>
</tr>
<tr>
<td></td>
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<td>Pink</td>
<td>R</td>
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<tr>
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<td>Hockey</td>
<td>V</td>
</tr>
<tr>
<td></td>
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<td>Celery</td>
<td>O</td>
</tr>
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<td>Sparrow</td>
<td>Guitar</td>
<td>R</td>
</tr>
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<td>Mouse</td>
<td>P</td>
</tr>
<tr>
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<td>Ball</td>
<td>Banana</td>
<td>D</td>
</tr>
<tr>
<td></td>
<td>Yoyo</td>
<td>Mercury</td>
<td>J</td>
</tr>
<tr>
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<td>Carrot</td>
<td>Milk</td>
<td>P</td>
</tr>
<tr>
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<td>S</td>
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<tr>
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<td>Trout</td>
<td>Donkey</td>
<td>S</td>
</tr>
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<td>Eagle</td>
<td>H</td>
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<tr>
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<td>Iron</td>
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<td>S</td>
</tr>
<tr>
<td></td>
<td>Platinum</td>
<td>Carnation</td>
<td>N</td>
</tr>
<tr>
<td>Four-footed Animal</td>
<td>Dog</td>
<td>Birch</td>
<td>C</td>
</tr>
<tr>
<td></td>
<td>Beaver</td>
<td>Tuna</td>
<td>R</td>
</tr>
</tbody>
</table>
Appendix 3

Trial Lists

Mixed Trials Condition

Practice List C

Fruit, Banana  
Sport, Tennis  
Bird, Lion  
Four-footed Animal, Lettuce  
Vegetable, Pig  
Colour, Y  
Musical Instrument, T  
Fruit, P  
Bird, C  
Metal, G

Practice List D

Tree, Pine  
Flower, Bass  
Fish, Brass  
Sport, Golf  
Metal, Aluminum  
Four-footed Animal, B  
Vegetable, C  
Flower, P  
Tree, F  
Toy, T

List 11

Metal, N  
Fish, Trout  
Vegetable, Zebra  
Toy, Ball  
Vegetable, P  
Tree, Tomato  
Colour, Soccer  
Bird, P  
Flower, Tulip

List 12

Fruit, Mango  
Colour, T  
Fish, Donkey  
Four-footed Animal, Tuna  
Vegetable, Milk  
Bird, Chicken  
Fruit, O  
Metal, S  
Metal, Iron
List 13
Fruit, Apple
Colour, Blue
Toy, Yoyo
Fish, H
Bird, R
Tree, Lily
Fish, Eagle
Tree, W
Four-footed Animal, Beaver

List 14
Four-footed Animal, C
Colour, Wrestling
Metal, Carnation
Vegetable, Cabbage
Flower, R
Sport, B
Fruit, L
Colour, Lavender
Metal, Platinum

List 15
Fish, Minnow
Tree, Oak
Musical Instrument, Piano
Four-footed Animal, R
Sport, Pink
Bird, Guitar
Toy, Banana
Colour, R
Flower, D

List 16
Fish, S
Four-footed Animal, Birch
Fruit, Copper
Sport, Volleyball
Musical Instrument, O
Toy, D
Tree, M
Tree, Poplar
Bird, Sparrow
List 17

Flower, Lilac
Four-footed Animal, Dog
Fruit, Walnut
Sport, Corn
Musical Instrument, Celery
Toy, J
Musical Instrument, V
Sport, Football
Vegetable, S

List 18

Musical Instrument, Harmonica
Vegetable, Carrot
Musical Instrument, Hockey
Bird, Mouse
Toy, Mercury
Flower, Potato
Flower, Drum
Metal, Spruce
Sport, R

Blocked Trials Condition

Practice List A

Fruit, Banana
Sport, Tennis
Bird, Lion
Four-Footed Animal, Lettuce
Vegetable, Pig
Tree, Pine
Flower, Bass
Fish, Brass
Sport, Golf
Metal, Aluminum

Practice List B

Colour, Y
Musical Instrument, T
Fruit, P
Bird, C
Metal, G
Four-footed Animal, B
Vegetable, C
Flower, P
Tree, F
Toy, T
List 1
Toy, Yoyo
Flower, Lilac
Fish, Trout
Sport, Football
Four-footed Animal, Dog
Fruit, Apple
Vegetable, Milk
Tree, Tomato
Fruit, Copper
Metal, Spruce
Musical Instrument, Hockey
Colour, Soccer

List 2
Colour, R
Sport, R
Musical Instrument, V
Toy, D
Tree, W
Metal, S

List 3
Colour, Wrestling
Sport, Corn
Bird, Guitar
Toy, Banana
Flower, Drum
Fish, Donkey
Colour, Blue
Fruit, Mango
Bird, Sparrow
Vegetable, Cabbage
Tree, Oak
Metal, Platinum

List 4
Colour, T
Fruit, O
Fruit, L
Bird, R
Fish, H
Four-footed Animal, C
List 5

Four-footed Animal, Beaver  
Metal, Iron  
Colour, Lavender  
Musical Instrument, Piano  
Flower, Tulip  
Fish, Minnow  
Four-footed Animal, Birch  
Metal, Carnation  
Tree, Lily  
Toy, Mercury  
Bird, Mouse  
Fruit, Walnut

List 6

Sport, B  
Toy, J  
Flower, R  
Metal, N  
Vegetable, P  
Fish, S

List 7

Sport, Volleyball  
Musical Instrument, Harmonica  
Bird, Chicken  
Toy, Ball  
Sport, Pink  
Musical Instrument, Celery  
Vegetable, Zebra  
Vegetable, Carrot  
Tree, Poplar  
Flower, Potato  
Fish, Eagle  
Four-footed Animal, Tuna

List 8

Musical Instrument, O  
Bird, P  
Four-footed Animal, R  
Tree, M  
Flower, D  
Vegetable, S
The following instructions were read to each subject by the experimenter:

The purpose of this study is to investigate memory for words in Alzheimer’s Disease. We do not know if you have Alzheimer’s Disease yet. I want to see if the questions that I will be asking can help us tell which patients have Alzheimer’s Disease and which do not.

This will take about an hour to complete. Some of the questions will be hard, but that is necessary so that I can find what kind of problems you are having. I want you to try and answer as quickly as possible, but try to give the correct answer as well.

This study is to investigate memory for words. I want to see how quickly you can retrieve words from memory. You will see a word on the screen for a few seconds. Sometimes you will see another word with it (the example Colour: Green was shown to the subject). When you see two words together, tell me yes or no, for example, is there a colour called green?

Sometimes you will see a word and a letter (the example Bird: B was shown to the subject). When you see this, tell me, for example, a bird that starts with B.

We will practice some words on paper, then we will do two practice lists on the computer and eight more lists on the computer. You will have a two-minute break between each list. Do you have any questions?

The following instructions were read only to subjects in the blocked trials condition:

Each group of questions will be of the same type, and you can use this to help you answer. For example, one group will be two words, like this (the example Colour: Green was shown). The next group will be a word followed by a letter, like this (the example Bird: B was shown). Remember, in one group they are all the same type of answer.