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AUTOMATIC AND CONTROLLED INFORMATION PROCESSING IN ALZHEIMER'S DISEASE

by

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Abstract

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This research investigation explored the cognitive processing operations of 18 healthy elderly (HE) subjects and 12 Alzheimer's Disease (AD) subjects in the mild clinical stage of the disease in their performance on a semantic priming task involving semantic lexical activations of both automatic and controlled processing natures.

Relatively little conclusive evidence has been documented regarding the relative roles of attention and memory processing in the lexical-semantic impairment of Alzheimer's Disease. A lexical decision processing task was implemented to investigate the effects of normal aging and neuropathological damage of Alzheimer's Disease on subjects' semantic priming abilities. The research design was based on the growing body of literature reporting successful procedural use of priming techniques with HE and AD subjects, as well as the fact that temporal boundaries reflecting attention-dependent and non-attention dependent processing have been suggested, particularly with healthy young populations. Findings of this investigation revealed that healthy elderly subjects demonstrate priming of a facilitative

nature, at both automatic and controlled temporal processing boundaries, whereas AD subjects demonstrated priming due to inhibition at long controlled temporal processing boundaries. Implications of these findings relative to normal age-related changes in language function and progressive lexical semantic impairment in AD are addressed.

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Chapter 1 - INTRODUCTION

Normal language processing involves the ability to integrate information from a variety of complex sources, including lexical, semantic, structural and pragmatic information. Further, these sources rely on the underpinning of normal storage and attention mechanisms, as well as other general cognitive processes for intact language.

The information processing approach to the study of language, focusing on the interaction of information types and processing time, has played a significant role toward developing normal psycholinguistic processing models. Research in neuropsychology and speech-language pathology has assisted in providing evidence to advance general theories of normal information processing, specifically, by examining how information is processed when various putative information sources are disrupted in cognitively and/or linguistically impaired neurological populations.

Alzheimer's disease or dementia of the Alzheimer type (DAT), is of particular interest in this regard because the unique pattern of language and cognitive breakdown associated with the clinical progression of the disease involves the apparent slowing of mental operations, as well as a concomitant dissociation between linguistic and nonlinguistic abilities. Thus, this unique cognitive profile offers a rich research opportunity to examine the interaction between various aspects of language functioning.

The exact appearance of the language and cognitive declines in Alzheimer's disease is not uniform across all cases of the disease, and varies significantly during progression of the disease. While these patients present language and other nonlinguistic cognitive impairments such as attention and memory deficits, the underlying nature of the relationships of these impairments remains unclear. Thus, psycholinguistic questions of the following nature still require answering. Do these patients have an adequate store but poor retrieval mechanisms? Is there a major functional disorganization of stored knowledge which underlies impaired retrieval of information? Are both the storage and processing of information adequate, yet a generalized slowing in processing information exists which causes information processing failures? These are only a few of the questions currently facing investigators in their progressive attempts to describe the linguistic and nonlinguistic impairments associated with the neurological changes in Alzheimer's disease. If we are to understand the clinical nature of this disease, questions of this nature must be addressed.

The central hypothesis of this investigation is that the specific lexical semantic impairment seen in the initial stages of Alzheimer's Disease is characterized by inefficient temporal processing, which by itself, is a function of a more generalized breakdown of attention-dependent processing. Specifically, it was initially hypothesized that while "automatic" or non-attentional dependent processing would be intact, so-called "controlled" or attention-dependent processing would be impaired in mild stages of Alzheimer's disease. Thus, this investigation proposed to examine the relationship between lexical semantic activation and cognitive slowing in subjects in the mild stages of Alzheimer's Disease (AD), and then compare their abilities to those of the healthy older adults. Although the current literature describes other significant areas of linguistic change associated with AD, the intimate, though potentially dissociable, language and attention deficit question is particularly ripe for investigation. There is a growing body of research evidence in this area which will be described in the following section. The present investigation will build on these previous research findings in the attempt to clarify the role of automatic and controlled lexical semantic information processing in the mild stages of Alzheimer's Disease via lexical semantic priming techniques.

A. Purpose of the Study

This section will summarize the key areas which make this study important and timely in the attempt to directly analyze cognitive slowing and semantic priming in Alzheimer's disease.

The chief purpose of the research investigations is to respond to the basic issue of temporal processing of lexical-semantic information in Alzheimer's disease, and to specifically shed light on this aspect of the linguistic status of Alzheimer's patients using healthy elderly persons as a control. As indicated by Ober, Shenaut, Jagust and Stillman (1991), "No study in semantic priming in Alzheimer's Disease...has adopted experimental procedures that convincingly eliminate controlled, attentional processing...all of the findings from previous studies may reflect a significant contribution of controlled processing and should not be used as the basis for conclusions concerning automatic priming in Alzheimer's disease."

Therefore, the notion of what aspect of priming behavior may or may not be intact in AD has not been resolved in the literature. This is especially important in that impaired or aberrant priming may be a hallmark of Alzheimer's Disease in its early stages. If so, this finding could have diagnostic importance, as well as research significance. Another aspect of this question is that it is not semantic load per se, but primary deficits in attention which contribute to lexical-semantic decline in AD. Therefore, it is important to isolate time conditions, keeping semantic load constant to examine this factor, which this experiment does.

A further question which has arisen in the literature is whether AD represents exaggerated cognitive slowing, similar to, but greater than that associated with normal aging. If this is true, response times should be greater, yet the quality of response in terms of priming effects, should not differ between the AD and HE groups. This question was also addressed in the present study.

Finally, the present study also sought to address the question of whether one or both types of processing (i.e., automatic versus controlled) was impaired in AD, and to examine any inter-relationships which may exist between these two operations. This study analyzes subjects' response behavior to answer this question, and to obtain data regarding what was the underlying nature of the lexical-semantic impairment in AD subjects , and how it compared to normal aging subjects. The following set of hypotheses were generated relative to this set of investigations. If it is true that automatic lexical operations are intact in mild AD subjects, they should perform normally at ISI's of 500 msec or less. They will exhibit impaired priming when controlled processing is involved at ISI's of greater than 500 msec. Underlying these predictions are the assertions that automatic operations are those which can be shown to be facilitated even when little or no opportunity to benefit from increased processing time or contextual information exists. Likewise, attention-dependent facilitation increases as expectation builds up through controlled memory processes involving recognition of relationships in the experimental set. However, due to constraints of human memory, although there may be time benefits gained by attending to memory representations of related words, there are likewise time costs in response time when recognizing unrelated words, such as occurs in attention-dependent processing (Tweedy, Lapinski and Schvaneveldt, 1977). Therefore, if AD subjects demonstrate a delay in processing in the unrelated compared to the neutral condition, it may be presumed that subjects are drawing attention from the expected to the unexpected target by means of effortful processing. This then leads to the conclusion that the facilitation obtained under these conditions is due to controlled as opposed to automatic processing. Therefore, in the short ISI, the prediction for normal subjects would be facilitation without inhibition, and facilitation with inhibition in the long ISI. The AD subjects' prediction, however, is one of impaired priming at automatic and controlled levels.

While it is important to note that the healthy elderly performance on tasks involving these types of lexical activations remains unknown, it is the present investigator's assumption that HE will perform similar to healthy young subjects in terms of overall pattern. However, longer response times were anticipated from HE subjects. The results of a pilot investigation using with this stimuli set with 9 healthy young adults enrolled in the psychology department of a local community college, revealed general priming patterns which appeared to conform to expected facilitation and inhibition effects in the two ISI conditions as described in the literature.

In terms of the normal elderly controls, if they indeed follow healthy young adult subjects' patterns, it was predicted that in the short ISI condition when targets were preceded by related primes, subjects would respond fastest, whereas subjects' response times when targets were preceded by neutral or unrelated primes, would not differ significantly from each other. In the longer ISI, it was predicted that subjects' response times for targets preceded by related primes would be shortest, but that subjects' response times when targets were preceded by unrelated primes would be slower than response times when targets were preceded by neutral primes, if controlled operations were intact. If the hypothesis regarding AD was correct, the AD subjects would perform normally on the short ISI task, but show aberrant patterns on the long ISI. In order to maximize this possibility, factors controlling for the influence of attention-dependent types of processing, (i.e., strategizing which may take place by anticipating relationships) were accounted for in this experiment. In other words, lists were constructed so that a 50% probability existing that items would be semantically related. As a whole, these manipulations represented an attempt to some of those control variables previously unaccounted for by previous investigations.

Chapter 2 - REVIEW OF LITERATURE

This section first reviews what is known regarding the neuroanatomical and neurophysiological concomitants of Alzheimer's Disease, and secondly, describes the language and other nonlinguistic cognitive impairments associated with the disease. This is then followed by a discussion regarding normal linguistic processing. The last section reviews findings from the lexical semantic priming literature relative to cognitive slowing in normal and AD populations.

A. Neuroanatomical and Neurophysiological Concomitants of Alzheimer's Disease

Both neuroanatomical and neurophysiological changes are associated with Alzheimer's disease. Progressive gyral atrophy of the temporal, frontal and parietal regions, and histologic changes involving cortical neurons are characteristics of Alzheimer's disease, (Brody, 1970; Kemper, 1984; Berg,1985). Specifically, there is a marked decrease in cerebral weight with the loss of neurons and myelin, ventricular dilation, and amyloid accumulation, as well as a predominance of senile plaques, neurofibrillary tangles and granulovacuolar degeneration, as compared to the brains of normal aging adults.

Neurochemically, the most significant deficiency associated with the disease is a marked cholinergic deficit involving the synthesis and transmission of a major neurotransmitter to the cortex, namely acetylcholine, (McGeer, McGeer, Kamo, Tago and Harrop, 1986). This deficiency is related, in turn, to a significant reduction in the enzymes responsible for its synthesis. The origin of the cholinergic neurons is primarily in the nucleus basalis and its cortical projections. With Alzheimer's Disease, a severe loss of neurons occurs in this region, with significant associated clinical effects of memory and other cognitive functions, (Coyle, Price and DeLong, 1983; Bondareff, 1986).

In terms of neuro-laboratory studies, electroencephalographic studies have not aided in the clinical diagnosis of AD, especially in initial stages of the disease. In general, EEG findings reveal a progressive nonspecific slowing in brain wave activity with an eventual diffuse overall slow wave pattern in final stages of AD. Similarly, computerized tomography provides only a gross correlation to the presence and severity of AD, since the noted cerebral atrophy is also found with other, non-dementing and benign neurological conditions, such as normal aging in some cases. However, of significance, regional cerebral blood flow studies and cerebral glucose metabolism scans tend to be positive, showing reduced cerebral blood flow and metabolism in parietal and frontal regions, (Cummings, 1982).

What remains critical, however, in the study of Alzheimer's disease is that while cortical cell loss and neurochemical changes brain have been established, the correlation between these brain changes and observed clinical changes in language and other nonlinguistic cognitive areas is still unclear due to the variability of AD patient profiles, and the fact that medical diagnosis cannot be confirmed until autopsy. With recent correlational studies using highly sophisticated brain x-rays, such as PET scans (positron emission tomography), the promise of identifying brain changes in vivo during disease progression may be realized.

Various underlying etiologies of AD have been implicated, including aluminum and drug toxicity, a slow latent virus, nutritional deficiency, and a genetic predisposition. At present, it appears that there may be subtypes of the disease associated with different etiologies and transmission, thus the reason for the different clinical profiles among AD patients. These include subtypes which have been associated with trisomy 21, and other subtypes which have different onsets and symptom presentation, (Katzman, Terry, DeTeresa, Brown, Davies, Fuld, Renbing and Peck, 1988). However, the important point to be made is that changes in brain anatomy in Alzheimer's disease involve cortical areas (ie. mid-frontal and superior temporal areas, especially of the left hemisphere) that are known to support normal language functions. Furthermore, there is a reduction of important neurochemicals that underlie the ability to form memory traces. Taken together, these result in loss of cortical function which may in fact directly compromise memory and language abilities of AD persons.

B. Language and Other Cognitive Deficits in Alzheimer's Disease

According to recent investigators such as Marshall (1993), various language deficits are seen as a primary characteristic of Alzheimer's Disease, commonly appearing as early as the beginning stages of the disease, and progressively increasing in moderate and severe clinical stages. Typically, patients in the earliest stages may exhibit word finding difficulty, an inability to maintain conversational topics, and a mild impairment in the ability to comprehend lengthy and more syntactically complex information. In mild and moderate stages, these patients more typically exhibit preserved phonological, morphological and syntactic abilities in the face of a lexical semantic naming impairment.

Furthermore, persons in the moderate clinical stage of this disease may exhibit an impairment in discourse, such that they are unable to maintain conversational rules of dialogue, i.e., turn-taking, inference drawing and other implicit rules of interactive language behavior. The anomic aspect increases in severity and nature as the disease progresses, with the patient demonstrating both a growing paucity in the number of vocabulary items elicited upon examination, and a decline in the variety of and sophistication of items within their semantic lexical repertoire. In the advanced stages of the disease, there is a muteness with global communication impairment affecting all aspects of language functioning.

In Alzheimer's Disease, there is a wide body of literature describing its lexical semantic impairment component, (Appell, Kertesz and Fisman, 1982). Initially, the lexical semantic dysfunction takes the form of word-finding difficulty, characterized by circumlocutions and the use of indefinite or vague terms. Moreover, while the lexical-semantic impairment may take the form of a loss of specific labeling or naming skills, preservation of supraordinate categorization remains, (Martin, Brouwers, Cox and Fedio, 1985). Persons in the moderate stages of AD may begin producing paraphasic responses along with reduced verbal fluency skills, such as on confrontational and generative naming tasks, (Martin and Fedio, 1983). AD subjects' performance on naming tasks is typically characterized by a quantitative decrease in overall responses, fewer subcategory labels, and fewer within-category items as compared to normals. Although responsive naming performance may be superior to confrontation naming ability, subjects have difficulty with sentence completion naming tasks and automatic seriation tasks. Furthermore, their poor recall of learned verbal information is associated with a decrement in learning of new verbal information, such as word lists. Their ability to respond to semantic cuing and related strategies for verbal recall is limited even in early stages, and further declines as the disease progresses, (Kempler,1991).

The overall word-finding difficulty of Alzheimer's disease has been closely examined to determine specific underlying causation of the impairment, with as yet inconclusive results. In all cases, however, the pattern which emerges is that the anomic symptoms associated with AD tend to exceed in severity beyond those subtle changes in naming ability that have been documented with the normal elderly population, (Nebes, 1989).

Efforts to characterize the AD language impairment have drawn on aphasia research. While on the surface similarities have been drawn between the language impairments of persons with dementia and aphasia, (e.g., mild AD changes to anomic aphasia, moderate to Wernicke's aphasia, and severe to transcortical aphasia), the underlying nature of the language impairment in Alzheimer's disease is viewed as different than the language impairment seen in aphasic patients with focal brain lesions, (Bayles and Kaszniak, 1987). As compared to the various types of aphasia, a marked dissociation between impaired semantic-lexical and relatively intact syntactic abilities is typically noted for mild and moderate stages of the disease. As indicated in the introduction, various claims exist regarding the underlying nature of this lexical-semantic deficit (Kempler, 1991). This study in part has aimed at responding to these theories, because of the compelling fact that the lexical semantic impairment of AD is the most striking, yet probably least understood of the disease's clinical aspects.

The notion that lexical-semantic operations are impaired due to the disorganization of stored information, ie., a widening of semantic boundaries for stored lexical-semantic information, has been put forth. This claim is supported by research findings which indicate that subjects can identify, but not hierarchically indicate semantic saliency of related items (Grober, Buschke, Kawas and Fuld, 1985). Another claim is that AD subjects may suffer loss of conceptual representations, and therefore are unable to distinguish items which share defining semantic features (Martin et al, 1985). Beyond the claims of disorganization and loss of the lexical semantic store is an additional proposition that lexical-semantic disorganization may occur in initial disease stages, but that in the later stages of the disease, the lexical information becomes lost. As the disease progresses, all aspects of lexical-semantic functioning decline, including retrieval, organization, and integrity of the semantic fields themselves (Nebes, 1992).

Marshall (1993) presented an interesting analysis of the two ends of this controversy regarding underlying process failures as represented by the cumulative work of Bayles and Nebes, two independent investigators whose findings will be cited in the present investigation. Marsh (1993) presents the viewpoint of Bayles, who argues that the cognitive underpinnings for language are lost in AD, and contrasts it with the viewpoint of Nebes which argues that processing abilities for the access and manipulation of language are impaired. Importantly, for the present study, is that the "automatic" language functions are perceived as less vulnerable to the disease effects than are the "effortful" conscious level language functions, (Hasher and Zacks, 1979). Nevertheless, these contradictory viewpoints call for research clarification.

In terms of the cognitive literature, Alzheimer's disease is characterized by progressive cognitive declines. According to the most widely used clinical criteria for AD as developed by NINCDS-ADRDA, (McKhann, Drachman, Folstein, Katzman, Price and Standlan, 1984), an individual must demonstrate deficient performance in two or more of the following cognitive areas to be diagnosed as having "probable" clinical Alzheimer's Disease: memory, language, motor skills, and perception.

In the preponderance of prior research studies using clinical populations of probable AD subjects, subjects tend to be in various stages of AD, rather than just one stage, most typically in the mild-moderate stage, when subjects can still perform experimental tasks. However, Reisberg, Ferris, Deleon and Crook (1982) described the clinical symptoms associated with AD from the early to late stages of the disease. They described seven major stages, with primary symptomatology:

* In stage 1, there are no subjective complaints of memory deficit, and no evidence of memory deficit upon interview.

* In stage 2, subjective complaints of memory deficit arise, and there is appropriate concern with respect to symptomatology. There remains no objective evidence of memory deficit on clinical interview.

* In stage 3, earliest manifestations of clear-cut deficits are seen. However, objective evidence of memory deficit is obtained only through intensive interview. Social and job performance begins to decline. Denial and anxiety may be present.

* In stage 4, clear-cut deficits are apparent on careful interview. Frequently, deficits will be manifested in knowledge of current events, deficit in memory of one's own personal history, concentration deficit

on serial subtractions, and decrease in ability to travel, handle finances, and similar functions. There is an inability to perform complex tasks. Denial is present, with a flattening of affect and withdrawal from challenging situations.

* In stage 5, patients can no longer survive without assistance. The patient is unable to recall relevant aspects of their current lives, and exhibit disorientation to time or place.

* In stage 6, the patient may occasionally forget the name of the person upon which they are entirely dependent, and will be largely unaware of all recent events and experiences in their lives. The person may retain some knowledge of their surroundings. However, they will require some assistance with basic activities of daily living.
  Diurnal rhythm is usually disturbed. Personality and emotional changes occur, including delusions, obsessiveness, agitation, and cognitive abulia.

* In the final stage, 7, all verbal and psychomotor ability is lost. The person will suffer incontinence. Generalized and cortical neurologic signs will be present. (pages 1136-1139)

As compared to the other cognitive deficits, much attention has been directed to the specific nature of the memory changes in Alzheimer's disease. In particular, a semantic memory impairment is suspected to underlie the early memory dysfunction in AD. However, because of task demands, memory and processing performance can be examined only in persons presenting in mild or moderate stages of the disease. The technique of semantic priming, which will be discussed in detail later has been especially useful in testing lexical-semantic processing on conscious and presumably unconscious levels. Although there are discrepant findings reported concerning AD subjects' performance on these tasks, and controversy concerning the theoretical explanations for their performance, information exists on healthy old and young populations on such tasks with which to contrast AD performance patterns (Stern, Prather, Swinney and Zurif, 1991). Research findings relative to such normal adult populations, as well as available data on AD subject groups, will be reviewed in subsequent sections as a background to the present study.

The central question of how cognitive functioning in general is affected by Alzheimer's Disease continues to be debated. As indicated by Au, Albert and Obler (1989), it remains unclear in AD how nonlinguistic cognitive areas may contribute to specific impairments, such as the lexical-semantic impairment. One theory, the multiple cognitive deficits theory, holds that multiple deficits of language, attention and memory may underlie the lexical-semantic impairment in AD (Ober, Dronkers, Koss, Delis and Friedland, 1986). An important factor to consider relative to this general question of cognitive functioning in the AD population, is the effect of cognitive load on processing information. Alzheimer's subjects' performance is notably affected by the nature of test materials and task demands, both on priming and nonpriming tasks, as well as on general clinical cognitive tasks, (Jorm, 1986). AD subjects are poor at organizing a structured approach to a task, such as evoking a strategy, and may not benefit from applied strategies, such as cuing, especially at the moderate stages and beyond. They are deficient in semantic tasks involving low cloze value items which do not offer much semantic information, i.e., finishing a sentence with an unexpected last word as well as in open-ended cognitive tasks in general. The latter would be exemplified by inferential thinking as reflected in hearing a story and being unable to think of an appropriate title describing the gist of a story. Collectively, these tasks can be said to call upon effortful conscious level processing or attention-dependent operations which require manipulation of information. Therefore, based on these findings, it has been suggested that persons with Alzheimer's disease basically suffer from a more generalized cognitive processing deficit, which equally affects processing of both linguistic and nonlinguistic information. Jorm (1986) has summarized these behaviors and consolidated an argument that AD patients suffer from a disruption of "controlled" cognitive processing, whereas "automatic" cognitive operations remain unimpaired at initial disease stages of AD.

Jorm's position regarding this primary breakdown is given support by the findings from the investigation by Nebes, Boller and Holland (1986). These colleagues have examined various types of semantic priming and other off-line tasks in numerous studies to conclude that lexical-semantic memory information may be intact in the AD population, but that it cannot be adequately used by AD subjects when the task involves substantial attentional demands. Further, Nebes and his colleagues claim that the use of lexical-semantic memory information remains intact when automatic or non-effortful processing is involved. Findings from Hartman's (1987) investigation using also a semantic priming task and neuropsychological batteries further support the claim that if access and use of lexical-semantic information occurs through automatic processing channels, the Alzheimer patient will perform normally. Thus, the present investigation aims to explore whether persons with AD are unable to consciously or effortfully manipulate linguistic lexical semantic information.

C. Effects of Normal Aging on Language and Cognitive Functioning

Various investigations of the language changes in the normal aging population have been undertaken (Bayles and Kaszniak, 1987). As judged by tasks such as sentence comprehension, sentence completion, sentence disambiguation, nonverbal picture matching and overall formal intelligence performance, findings reveal that propositional knowledge is well preserved until very late in life. According to Bayles and Kaszniak (1987), no loss of syntactic or phonologic language functions have been associated with the normal aging process. Moreover, vocabulary abilities may continue developing throughout life. It can therefore be suggested that, for the most part, the mild changes reported in the naming and discourse abilities of the healthy elderly population are most probably not of the same origin as those observed in the initial stages of persons with AD, although surface clinical manifestations of the naming changes may be similar.

A factor which does characterize the cognitive performance of the older adult population, is the need for sufficient time to adequately process information, whether it be verbal or nonverbal (Bayles and Kaszniak, 1987). This factor may confound the task results on experimental investigations. It is reliably demonstrated by researchers that advancing normal age affects processing time involved in lexical-semantic performance of the healthy elderly. This general slowing of processing information i.e., "cognitive slowing," has been demonstrated in the normal aging population on tasks involving motor and cognitive functions (Bayles and Kaszniak, 1987). When the experimental measure is one of response time per se, a significant age effect is usually obtained. However, when the experimental measure is one of accuracy without time constraints, there are no age effects generally. Therefore, the normal older adult does not exhibit difficulty with task comprehension given enough time to perform the task. This is not the typical picture in AD. Again, the work of Bayles and her colleagues (1987) indicates that the language of the normal older adult population is compromised most by the failure of peripheral sensory processes such as audition, and vision. The specific performance of the normal older adult population on experimental semantic priming tasks is described separately in the following section, as it directly pertains to the present investigation.

D. Distinction of Automatic Versus Controlled Processing

The model of normal language functioning which serves as the underpinning of the present investigation is drawn upon the concept of mental modularity, (Fodor, 1983). Modularity theory proposes the existence of distinct language modules consisting of mandatory perceptual processing as well as more general, integrative cognitive functions. For the purpose of the present investigation, automatic and controlled cognitive processes will be described in terms of these distinctions. Automatic processing operations are those mandatory (non-volitional) processes which place little demand on attention, are inflexible in nature, and are not under the active control of the individual. Controlled or attention-dependent processing operations which are more central in nature (conceptual and consciously executed for the most part), often involve slower and more effortful processing on the individual's part, according to the theory (Hasher and Zacks, 1979).

These authors explained the differences between automatic and controlled processing operations by indicating that automatic operations are those that do not require an intentional or self-directed use of information, nor do they make substantial demands on attentional resources, with the opposite true of controlled processing. One of the relevant aspects of this automatic/controlled processing distinction is the fact that defined time parameters have been established for each of these processes in terms of priming behavior. Findings of Neely's research (1977) with adults possessing normal language functioning revealed that separate examination of the time course of automatic and controlled processes is possible. Using a priming paradigm, he concluded that semantic lexical processing which takes place within the range of 250-400 msec of interstimulus interval processing (ISI) time may be attributed to "automatic" mechanisms, and that processing with interstimulus intervals longer than 400 msec involves "controlled" processing. Experimental paradigms which examine lexical decision and access response times often draw on Neely's finding in an effort to establish the characteristics of the internal lexicon. Research in this area has given rise to various theoretical constructs regarding how the mind organizes and categorizes lexical-semantic information, and will be discussed as they apply in this study.

Currently, priming is one of the most intensively studied aspect of memory, and has been useful in identifying processing breakdowns in populations known to suffer a memory loss (Squires, Knowlton and Musen, 1993). In its various experimental manipulations, different types and strengths of priming effects can be obtained. This has been especially useful in examining lexical semantic memory, and the automatic/controlled continuum. Further collaboration of the viability of this approach comes from PET scan studies of brain function revealing direct evidence for areas of activation during priming (Squires et al, 1993). Thus, the priming paradigm was selected for this investigation since it provides an explicit criteria for distinguishing automatic from attention dependent processes.

As per Squire and his colleagues, priming is defined as the facilitation of a mental process (eg. lexical search) by prior information. There are three types of standard priming paradigms in the literature. The first is repetition priming, where brief exposure to an identical prime will facilitate faster target recognition time. Second, semantic or associative priming occurs when the prime and the target share semantic features, or are associatively linked, thus facilitating faster response time in naming or lexical decision tasks. Third, form priming occurs when familiarity of the written form of a word facilitates faster response time in naming or decision tasks of words with similar orthographic form.

The "facilitation effect" is the millisecond response time advantage obtained. These response times are also generally measured in comparison of the response times to other unrelated and semantically "neutral" items, which comprise the "inhibition" effect and baseline, respectively, ie. nurse-doctor would be a related word pair, giving rise to facilitation of retrieval of the second item in the pair, fruit-doctor is an unrelated pair which should give rise to an increase in response time for retrieval of the second item, and word-doctor have a presumably neutral relationship which should neither facilitate nor inhibit response time.

When the task requires subjects to pronounce words, the facilitation effect is typically measured by the analysis of reading latency for the second of two words. In lexical decision paradigms, the facilitation effect is measured by analysis of how long it takes to recognize and decide that the second member of a word pair is a legitimate word. The explanation for these effects is often attributed to the notion of spreading activation, (Collins and Loftus, 1975). This theory holds that response times to words will decrease when these words are preceded by exposure to semantically related words (the prime). It is thought that exposure to the word prime activates its own internal representation as well as that of those words that are either closely semantically or associatively related to the prime via a "spreading" of activation. Therefore, decision time for the target word "doctor" is faster than that for "butter" when each is preceded by the priming word "nurse."

Posner and Snyder (1975) distinguished priming relative to automatic versus controlled processing. Automatic priming is characterized as a rapid process which takes place without the subject's conscious processing. Thus, response times are facilitated or more rapid to the related items. No difference in response times occurs when neutral prime or unrelated items precede the word. On the other hand, priming activity which is related to controlled processing takes longer to invoke and depends on conscious expectation based on observed associations in the stimuli items, and hence, strategizing by the subject. Thus, facilitation in the related condition, and inhibition in the unrelated condition, both occur. Neely (1977) developed a paradigm to distinguish these processes. By manipulating conditions of prime-target relation, subject expectancy (by special instructions to the subjects), and processing time between prime and target, he was able to provide evidence for the automatic/controlled processing dichotomy.

Since 1977, further research has indicated that these effects depend on task demand, nature of stimuli, and other significant methodological differences (Neely, 1991). This author has provided a synthesis of semantic priming findings and theories reviewing all the major phenomena seen in this paradigm, by which these studies are analyzed. A brief account of this information follows. The majority of work in the area of priming has been done with normal healthy young individuals, such as Neely's own Yale University population.

E. Theories of Lexical Decision

Three major theoretical models have been put forth to account for semantic priming effects. These include automatic spreading activation, expectancy and post-lexical priming mechanism theories. Within various tasks, these explanations have met with varying degrees of support relative to the available for research. One of the primary methodological factors affecting experimental outcomes is task demand. The major types of priming tasks are: lexical decision, ie. the subject makes a determination regarding whether a target is a legitimate word by pressing a yes/no response pad and pronunciation tasks, ie. the subject actually says the target word. These tasks place very different demands on the cognitive and semantic systems, and as such are conducive to different types of priming. The lexical decision task is consider more conducive to controlled processing since a target must be identified and a decision regarding word appropriateness be made. This would seem to evoke lexical search and retrieval processing. On the other hand, the literature indicates that naming is a more direct process, and may be more conducive to automatic processing. However, of main importance here is that these constructs are not mutually exclusive, and that ISI is considered the prime pivotal methodological factor in manipulating automatic versus controlled processing. Therefore, in the present investigation, both a short and a long ISI are used with a lexical decision task to determine automatic and controlled processing boundaries when this task is used.

F. Priming Research on Normal Older Adults

Since lexical decision is used in the present study, discussion will focus more on findings relative to this type of task. According to Neely (1977, 1991), the lexical decision task generally yields a larger advantage in terms of priming effect than the pronunciation task, namely an average of 32 msec response time advantage, as compared to 17 msec advantage, respectively. Further, an average of +51 msec advantage has been demonstrated in the facilitated condition, and a -16 msec cost (or inhibition) in the unrelated condition by healthy young subjects.

However, because of the possibility of normal aging effects on processing time of older subjects on lexical decision tasks, it is important to first examine what findings exist for the healthy elderly population before one turns to the Alzheimer's disease case. Stern, Prather, Swinney and Zurif (1991) questioned whether there was a slowing of automatic lexical access with increased normal age. These colleagues determined that it is a central process which draws on attentional resources that contributes to "cognitive slowing" in normal aging. Further, it is the intentionally accessed information ie. attention dependent controlled processing which is vulnerable to normal aging effects. In their experimental design, Stern and her colleagues contrasted the performance of healthy young versus healthy elderly subjects on an automatic priming lexical decision task. The study used a continuous list paradigm in presenting the stimuli. This design was developed by these authors who considered the task to be automatic in nature, because there was no consistent interval between words in which subjects could infer the relationships contained in the stimuli, thereby leading to expectation-based strategy. They reported a rise time for facilitation which was similar for the two populations where a decrease in response time to targets preceded by related primes occurred for both groups at the locus of 500 msec ISI, when ISI's from 300-1500 were examined. Young normal subjects exhibited a significant +18 msec advantage, and the elderly normal subjects exhibited a +35 msec advantage, indicating normal automatic facilitation for both groups.

Balota, Black and Cheney (1992) also examined the basic model of automatic and attentional priming in younger and older normal adults. They compared the results of prime-target relatedness, expectancy buildup, and ISI in a pronunciation task, designed to minimize any post-lexical checking processes, a process which can takes place after a word is accessed. Across their experiments, there was evidence of an interaction between relatedness, expectancy and ISI. This is an important finding in that it contrasts with the finding of Stern et al, (1991) which suggests a more linear relationship between age and priming effects related directly to longer response times. However, importantly, since the methodology between these two studies varied greatly, it is not scientifically reliable to directly compare the results of these studies.

G. Priming Research in Cognitively Impaired AD Subjects

Information regarding AD subjects' performance on semantic priming tasks of this nature is relatively sparse, yielding conflicting results. (See Table 1 for a summary of the cogent findings.)

TABLE 1

AN OVERVIEW OF SEMANTIC PRIMING AND ALZHEIMER'S DISEASE

STUDY	RESULT	NEUTRAL PRIME	ISI
Nebes, Martin, Horn (1984) Naming task	DAT s's P.E. equal to nls.	none	unk.
Nebes, Boller, Holland (1986) Sentence Priming task	P.E. obtained (fac. and inh. eff.)	yes	unk.
Hartman (1987) Naming task	P.E. obtained (fac. eff.,no inh.eff.)	yes	500ms
Ober and Shenaut (1988) Lexical Decision task	No P.E.	no	1000ms
Albert and Milberg (1989) Lexical Decision task	6 s's positive P.E.; 4 s's-"neg."priming- faster in unrel. cond.	no	500 ms
Chertkow et al (1989) Lexical Decision task	Greater than nl. P.E. ("hyper-priming")	no	500 ms
Nebes, Brady, Huff (1989) Naming and Lexical Decision task	Greater than nl. P.E.	no	750 ms
Balota and Duchek (1991) Naming task	Greater than nl. P.E.	no	500 ms
Ober et al (1991) Naming and Lexical Decision task	Nl. automatic P.E.	no	250 ms
Carozza (1995) Lexical Decision task	DAT S's priming differs from nl.	yes	500 and 1500ms

Nebes, Martin and Horn (1984) were among the first to research the premise that if the semantic association network was impaired in AD, subjects would not demonstrate the prime effect. Their subjects consisted of mildly to moderately impaired AD victims, with a mean MMS of 19. Results revealed their AD subjects were slower than their normal elderly subjects to prime, but that overall magnitude of the priming effect was the same for both groups. From this finding, they interpreted that structure of lexical memory store was intact in AD. However, it should be noted that the general ability to prime was assumed as associated with automatic operations in this study. Therefore, these authors concluded that the loss of semantic function in AD most likely results from linguistic processing which demands conscious attention, as opposed to a lack of store. Applying Neely's (1977) construct, it would have been necessary to apply a neutral prime condition to see whether these researchers' findings were indeed purely facilitative in nature. Since this was not done in the Nebes et al (1984) study, the automatic versus controlled distinction could not be made.

In 1986, Nebes, Boller and Holland used incomplete sentences as primes in the related, unrelated and neutral conditions. In this study, both facilitation and inhibition effects in AD subjects were demonstrated. In fact, AD subjects showed greater than normal inhibition effects as compared to normal subjects, which was interpreted by these investigators as evidence that AD subjects adequately access and use lexical semantic information even when it requires attentional conscious level processing. In 1991, Nebes and Brady presented a review of the results of a review of various response-time tasks using AD patients reported in the literature. Overall, these authors concluded that RT increased along with increases in clinical dementia severity, indicating that AD produces a generalized slowing of all cognitive processing.

Hartman's investigation (1987) was designed as an attempt to respond to Nebes' conclusions. Her AD subjects ranged from 10-30 on their MiniMental State scores, although their subject group mean of 19.5 was similar to that of Nebes' subjects, overall in the moderate ranges. Using single word primes, results revealed facilitation but no inhibition effects. Hartman's results therefore suggested only purely automatic operations as being intact in AD. Thus far from these previous investigations, it appeared that the relationship between semantic priming and attentional processing in AD remained unanswered. However, numerous other researchers have continued to study this area in search of an explanation for the underlying lexical semantic deficit seen in AD.

Ober has been one of the most prolific authors in this area. Ober et al (1986) measured lexical retrieval from semantic memory for mild to moderately impaired AD subjects. Her findings suggested a coincidental progressive breakdown in both lexical semantic memory and other types of attentional memory processing in AD. In another investigation, Ober and Shenaut (1988) studied semantic priming with 9 subjects who were in the mild to moderate in stages of Alzheimer's Disease. While these subjects failed to show facilitation effects, they did demonstrate less errors in the related condition versus unrelated condition. As indicated by Ober (1988), AD appears to alter the effect of the related context in lexical decision-making, which is significant in that this alteration has not been reported for any other clinical population. This suggests that impaired priming may be a possible clinical benchmark of AD. By way of explanation, Ober's investigations suggest that the impaired priming in AD may result from increased susceptibility to "lateral" inhibition in the semantic network, and drew the comparison to the phenomena which occurs in related prime inhibition or difficulty with suppression of stimulation of threshold activation. Finally, Ober and her colleagues (1988) postulated that there may be different neuro-architecture for the processing of facilitation and inhibition with different types of connections taking place between nodes, such that certain nodes may be responsible for facilitation and others for inhibition.

A later investigation by Ober (1991), of 20 AD subjects with a mean MMS of 19 to studied the effect of category relations on automatic priming. In this study, a short ISI of 250 msec was used. No significant group difference was found in the effect of priming relative to factors in the prime-target relationship, suggesting intact automatic priming.

In a later review of 14 semantic priming experiments with AD subjects, Ober indicated that discrepant findings relative to priming behavior of AD subjects is likely due to methodological differences (In communication, 1992). Hyperpriming by AD subjects and increased RT's tended to be reported in experiments in which the designs did not effectively eliminate controlled processing circumstances. On the other hand, response time and priming effect differences were less when the tasks were more clearly defined in terms of automatic processing. Ober's conclusion based on this review was that for the most part, AD subjects appear able to use word relations strategies effectively, with resulting increases in response times and increased inhibition.

By contrast, Chertkow, Bub and Seidenberg (1989) used a lexical decision task with 6 AD subjects who presented with a mean MMS of 17.5. They reported that their

AD subjects were correct 96.5% of the time on the task, showing greater semantic priming effects relative to the controls. However, priming was greater for semantically degraded items than those which were judged intact on off-line tasks. Semantic degradation was determined by evaluating subjects's competence with semantic material in non-priming language tasks using comparable stimuli. In light of the overwhelming amount of contradictory data in this area, these authors considered these unexpected results as indication that a re-evaluation of the concepts of the mental lexicon relative to semantic memory structure and their alteration in AD was necessary. This conclusion reinforces the fact that issues regarding the underlying nature of the lexical semantic deficit in AD continue to be debated.

In summary, the majority of priming studies in Alzheimer's disease collectively report greater than normal priming, (Nebes, 1984, 1986; Margolin, 1987; Hartman, 1987,1991; and Chertkow, 1989). By contrast, Nebes (1984) reported semantic priming performance in AD subjects as equal to that of his normal older subjects, with differences in methodology possibly accounting for many of these discrepant findings in the various studies reported. Albert and Milberg (1989) and Ober and Shenaut (1988) respectively reported two studies of lexical decision which found no significant priming effects for AD subjects. However, a decrease in subjects' error rate was noted in the related prime conditions, signifying some level of intactness of semantic lexical information, (Albert and Milberg, 1989; and Ober and Shenaut. 1988). These two studies had in common medium to long ISI's ranging from 600 to 2000 msec. Another variable known to affect priming is expectation, based on the proportion of semantically related items in the stimuli set, which varied from 25 to 50 % in these same studies. Other methodological considerations that may have affected priming outcome of various studies include word frequency and list construction, which were not necessarily comparable across studies, thus making comparison difficult.

In spite of these confounds of methodology and interpretation, semantic priming studies in AD collectively have concluded that automatic semantic facilitation appears intact in Alzheimer's disease. This finding has been considered as evidence that fundamental semantic information and its organizational relationships are preserved for immediate access, at least in early disease stages. Since word finding and, hence, naming problems are significant hallmarks of this and other neurological conditions, the implication of this assertion can be seen to be far-reaching from a diagnostic standpoint.

The overriding question in the literature regarding the basis of the language deficit seen in AD, particularly the naming deficit, however, surrounds the notion that conscious retrieval or controlled processing may in fact underlie the naming impairment. A factor which needs to be examined further in this regard is the role of that attention plays in language access and retrieval. In spite of claims to the contrary, this theoretical question remains. This is especially true in regard to the nature of the cognitive operations contributing to the automatic facilitation effects reported in the literature, (i.e., in terms of the potential relative contributions of attentional mechanisms, which may not be fully accounted for). Normal or greater than normal priming has been offered as evidence that automatic operations may be intact, while using experimental paradigms which do not completely control for the influence of controlled operations at work, such as timing, proportion of related items in list construction and the nature of the category or associational relationships utilized. This would pertain primarily to the earlier studies in this area.

By the same token, impairments in priming (less than normal, or greater than normal, "hyper-priming") have been explained by investigators as a disruption in automatic operations in those designs with methodological differences. In terms of the two major interpretable effects possible in priming experiments, facilitative effects have been consistently obtained with Alzheimer's Disease subjects by Nebes et al, (1984, 1986). Nebes and his colleagues offer this as evidence of integrity of semantic fields in AD, and tested under conditions presumed to represent both attention dependent and non-attention dependent processing. However, two other studies have failed to report a facilitation effect, or alternatively, report hyper-priming (i.e., greater than normal) or negative priming (i.e., priming in the unrelated condition), (Ober and Shenaut, 1988; Chertkow et al, 1989). Explanations put forth by these researchers for these findings have referred to the disruption of semantic fields, or a hypersensitivity and loss of threshold discrimination for closely related items. Other explanations offered relate to the inconsistent nature of performance by Alzheimer's disease subjects, and the possibility that partial degradation of certain items within semantic fields may have occurred. As a group, however, when contrasted with other demented subjects (e.g., Korsakoff's disease), Alzheimer's patients exhibit impaired priming while other demented groups do not (Shimamura, Salmon, Squires and Butters, 1987), suggesting that some form of lexical activation impairment may be characteristic of persons with AD.

Based on the above reports, there have been suggestions in the literature that semantic retrieval of an automatic nature is intact in AD, but retrieval associated with active and directed search or conscious attention is not. As indicated by Ober and Shenaut (1988), the abnormalities in semantic priming may only become apparent on response time tasks which require more extended processing, the more extended phase being a better vehicle for detection of deficits in semantic memory of a search/retrieval nature. However, the literature continues to reflect conflicting data with regard to the attention-dependent inhibition effect in this population. Attempts to explain for such differences in outcome between studies have taken into account the effect of textual material and presentation style, in an effort to explain decline in performance when responses require active search, and when stimuli consists of items with little or no semantic predictability. It is possible that these experimental tasks call upon different types of processing, one being related to the ability to build appropriate expectation regarding target relatedness, or alternatively, that facilitory, as well as inhibitory connections may exist between related items.

This line of reasoning is relevant in that it suggests that Alzheimer's subjects' priming behavior should be studied with regard to the effect of the amount and type of information load on processing. Nebes and Madden (1988) have suggested that Alzheimer's Disease produces a disproportionate reduction in the speed with which patients can carry out extended cognitive operations, especially lexical search. It is therefore the relative role of attention which must be clarified before we are truly able to ascribe semantic erosion, degradation or intactness to this population.

In this vein, it is of significance to note the evidence that exists when target stimuli are highly constrained semantically. In other words, the Alzheimer's disease patient performs best on priming tasks, presumably due to the integrity of information processing for highly automated associations. However, performance breakdown occurs with more complex tasks, suggesting that conceptual information, although seemingly intact, is vulnerable to attentional and cognitive demands.

Semantic context, therefore, appears to facilitate the ability of Alzheimer's disease patients to perform certain semantic processing tasks, according to many researchers. Given high semantic constraint, these patients have demonstrated normal priming on reading and lexical decision tasks, which implicates effortful processing. However, it is conjecture by the present researcher that it is not a simple state of a dichotomous relationship between attention-dependent and non-attention dependent failures that exists in these patients, but a probable interaction of processing time and lexical-semantic information which occurs.

In the face of the above factors which have not been systematically dealt with to date in the priming literature as it pertains to Alzheimer's Disease, significant controversy remains. Although a substantial body of research is growing in this area, there are still relatively few studies of on-line lexical access in this population. The information which is available is difficult to interpret reliably because of methodological differences, especially with reference to the controlled processes.

The response behavior of other brain-damaged subjects on priming tasks may shed a revealing light on this question. It is relevant to discuss the findings (Prather, Zurif, Stern and Rosen, unpublished manuscript, 1982) of a Broca's aphasic. This case is of interest because these researchers raise the issue of "slowed automatic lexical access." The subject, having been exposed to ISI's ranging from 500 to 1800 msec, exhibited semantic priming at only the 1500 msec interval. This finding suggests that patterns of slowed automatic semantic priming may be characteristic of certain neurological disease states, warranting further research.

The role of attentional effects in linguistic processing performance warrants major consideration if our understanding of these brain-damaged subjects is to be made clear. Specifically, the claims that AD subjects are at risk for any attention-mediated language task versus the claim that AD subjects can perform controlled or attention dependent tasks providing the semantic stimuli are highly constrained must be first clarified. Thus, it is essential that the time course of information interaction in these patients be better understood. This study, therefore, proposed to examine priming behavior relative to a given set of experimental manipulations aimed at clarifying these points for the normal older adult and Alzheimer's Disease populations.

Chapter 3 - METHOD

A. Subjects

Eighteen individuals who were diagnosed at the Alzheimer's Disease and Research Center of New York University Medical Center as meeting the criteria for probable Alzheimer's Disease as determined by NINCDS-ADRDA criteria, (McKhann, Drachman, Folstein, Katzman, Price and Standlan, 1984) served as the experimental subjects. Subjects had normal functional normal vision without corrective lenses, and functional levels of hearing acuity for conversational purposes. Medical history, neurological examination, radiographic studies and laboratory tests indicated no other significant medical, psychiatric or neurological conditions to account for subjects' memory losses. All experimental subjects had a score of 4 on the Global Deterioration Scale, (Reisberg, Ferris, Deleon, and Crook, 1982), corresponding to the mild clinical stage of dementia. Subjects' mean score on the Mini Mental State Examination, (Folstein, Folstein and McHugh, 1975) was 23.4, within a range of 18-28. Mean age of the AD subjects was 73.0, with a range of 57-86 years. Mean education of subjects was 14.8 years.

The control subjects consisted of 18 healthy elderly adults, who were still alert and active in the community, presented with no known chronic medical conditions, and who were identified by the Center as normal controls for research purposes. Control subjects were matched by age and education levels to the experimental subjects; mean age was 71.8 (range = 61-85), and mean number of years of education was 15.5 years. Mean socio-economic levels were equivalent between experimental and control subjects, both at the uppermost level, 1.23, according to the Hollingshead Index of Social Position

(Hollingshead 1958). See Tables 2 a,b and c for complete demographic characteristics of subjects.

TABLE 2a

Summary of Demographic Characteristics of AD and HE Subject Groups by Gender, Mean Age, Educational Level, Cognitive Level and Social Class

	AD SUBJECT GROUP	CONTROL SUBJECT GROUP
Number	12	18
Males	5	11
Females	7	7
Mean Age	73.0	71.8
Mean Education	14.8	15.5
MMS	23.4	30.0
Mean Social Status*	1.2	1.2

(* Hollingshead Index of Social Position, 1958)

Table 2b

Individual Subject Characteristics for AD Group

	Initials	Sex	C.A.	Yrs./Ed.	Mean Soc. Status	MMS
1.	W.W.	M	74	16	1	22
2.	V.B.	F	69	14	1	22
3.	C.S.	M	78	12	1	25
4.	M.A.	F	76	16	1	18
5.	Y.B.	F	73	12	3	22
6.	B.B.	F	86	16	1	21
7.	P.S.	M	81	16	1	25
8.	S.M.	F	57	16	1	28
9.	M.F.	F	68	16	1	27
10.	J.E.	F	67	12	2	22
11.	F.N.	M	68	16	1	24
12.	E.C.	M	77	16	1	26

Note: For the nonword condition, subjects # 2 and 7 were excluded from analysis.

Table 2c

Individual Subject Characteristics for HE Group

	Initials	Sex	C.A.	Yrs./Ed.	Mean Soc. Status	MMS
1.	W.M.	M	80	16	2	30
2.	S.S.	F	69	16	1	30
3.	C.B.	F	73	12	3	30
4.	C.S.	F	68	12	1	30
5.	D.K.	F	71	14	1	30
6.	I.G.	M	75	14	1	30
7.	W.M.	M	61	16	1	30
8.	A.W.	F	63	12	1	30
9.	C.M.	M	71	16	1	30
10.	V.F.	M	67	16	1	30
11.	N.T.	M	78	16	1	30
12.	E.C.	F	72	12	2	30
13.	D.G.	M	75	20	1	30
14.	L.R.	M	68	12	1	30
15.	M.T.	F	85	16	1	30
16.	N.W.	M	76	17	1	30
17.	L.A.	M	71	16	1	30
18.	H.T.	M	71	16	1	30

All subjects were native English speakers or highly dominant English speakers, (having emigrated to the U.S. in early childhood). Consent to participate in this study was obtained for all subjects, and is on file at the Center. While initially there were 18 subjects in group, 6 of the 18 AD subjects upon preliminary analysis of the data had to be eliminated from the final analysis for reasons which will be explained in the Results Section of this investigation. No normals subjects were eliminated.

B. Task and Procedures

A lexical decision task was used to examine priming effects. Counterbalanced sets of stimuli for each ISI condition (i.e., 500 msec and 1500 msec) were established, and subjects were randomly assigned to receive a stimuli set, such that 6 subjects each received one of three potential sets for the two ISI each timing conditions. The stimuli appeared in sequential fashion on the computer screen according to the preset timing condition. Subjects were instructed to determine whether the presented item was a legitimate English word or not, and to indicate their response by pressing a yes/no button on a response pad. The prime was presented in lower case letters, with the target stimulus presented in upper case letters. The subjects were instructed to respond to all items. They were able to respond either during the actual target presentation or the interstimulus period. In both ISI conditions, the target word remained onscreen for 500 msecs. Each subject received two ISI conditions, with the 500 ISI condition always presented prior to the 1500 msec ISI condition. This was implemented to control for the influence of controlled processing due to increased response time and its possible impact on the short ISI condition. Displays were presented at a comfortable viewing distance on a video monitor of a Commodore 64 computer set-up containing an internal clock accurate to milliseconds.

A software system developed at the Psycholinguistics and Cognition Laboratory of the Graduate Center of the City University of New York, was modified by the present experimenter to contain both stimuli and timing features for these experimental conditions. A subject response board was interfaced with the computer with a yes/no button system. Subjects were seated in front of the monitor and instructed to respond to the single word presented in the center of the screen by indicating "yes" if the target was an acceptable real word, and "no" if it was a nonword. Stimuli remained onscreen for the assigned interval regardless a subject's response. Inter-trial interval (ITI) of 2000 msecs was presented in both conditions. Subjects were instructed to keep their hand on the response board at all times. Response times were recorded by the computer. A set of practice items commensurate with list construction was administered at the beginning of each testing session. A rest period was given between the two experimental conditions.

Data were collected for analysis by means of software which was developed by Dr. David Swinney and incorporated in the C-64 Psycholinguistic Research Lab Program, Version 1.2. Mean response times to words preceded by related, unrelated and control primes as a function of ISI were calculated and priming, facilitation and inhibition effects were measured. Priming effect was calculated as the difference in the related over the unrelated conditions. Facilitation was calculated as the difference between related and neutral conditions. Inhibition effects were calculated as the difference between the unrelated versus the neutral conditions.

C. Stimuli

The experimental stimuli, consisting of semantically and associatively related prime-target pairs e.g., "carpet"-"rug" as well targets with neutral and unrelated primes, eg., "word"-"rug"; "tower"-"rug", respectively. These stimuli were in part adapted from those used by Hartman (1987) in her priming study of Alzheimer's Disease subjects. (See Appendix A and B for overall task design outline and stimuli set.)

The 500 msec and 1500 msec ISI conditions each contained 36 experimental word items: 12 related pairs, 12 neutral pairs and 12 unrelated pairs. There were also 12 non-experimental related filler pairs included for purposes of establishing a relatedness proportion of 50% in the word conditions. There was an equal number of 48 nonword targets (word-nonword pairs), which were constant throughout the lists. All items were 3 to 8 letters in length, and contained no more than 3 syllables. Word stimuli consisted of medium to high frequency English words (Kucera and Francis, 1976). Nonword targets were pronounceable letter sequences with the same letter and syllable lengths as word targets.

In the prime-target sets, the second word in each pair was the target; and the first word was the prime for the neutral, related and unrelated conditions. The related stimulus pairs were drawn from word association and category norms, (Battig and Montague, 1969;

Hunt and Hodge, 1971; Postman, 1970; Shapiro and Palermo, 1970). The unrelated pairs were formed by matching each target with an unrelated word matched for overall length and frequency. Neutral pairs were formed by combining the word "word" with targets from rotated lists. It should be noted that the word "word" was used as the neutral prime, drawing on the work of de Groot, Thomassen and Hudson (1982) regarding the importance of an appropriate neutral prime in measuring priming effects.

Word sequences were developed incorporating the experimental targets and their primes, fillers and word-nonword pairs in equal distribution. The lists for the 500 msec ISI and the 1500 msec ISI conditions were counterbalanced. Item pairs were randomized and 3 trial sets for each ISI condition were developed. Trial sets were constructed so that a subject saw a given target only once in either the Related, Unrelated or Neutral Condition. The location of targets was organized such that all prime types, fillers and nonword targets were rotated throughout the lists in a consistent fashion.

Each subject was presented with two experimental conditions: one consisting of an ISI of 500, and the other of an ISI of 1500, with a total of 192 trials, (96 trials for each ISI condition). The first ISI boundary was interpreted by the present author as representing nonattention-dependent processing, and the second ISI was interpreted as representing attention-dependent processing.

Chapter 4-RESULTS

This section contains a description of the overall characteristics of the HE and AD subject groups, subject response patterns and then the comparative analysis between these two subject groups.

A. Preliminary Data Analysis

In order to establish that all subjects were responding to the lexical decision task, it was necessary to first examine the error patterns that the subjects were making on the raw data set. Of the originally planned 18 AD subjects, 6 were found to be unable to respond successfully to the task, primarily due to operational designs employed in the study in terms of time allotted to respond, and certain mechanical constraints of the computer program which will be described. Initially, there were high error rates and/or overt failures by subjects to respond at all to the stimuli that significantly outnumbered analyzable data in certain of the cases. This was determined by two independent reviewers who examined the individual subject responses across the word and nonword conditions for both ISI conditions for all subjects. Those subjects who exhibited consistent response bias (i.e., indiscriminately responding "yes" to all targets) were eliminated. However, in those few instances where subjects withheld responses to non-words as a clear pattern in a subject's response data, it was considered as a GO/NO GO lexical decision. Thus, the data were for these subjects were included in the final analysis.

A second factor emerged with the analysis of the raw data where many AD subjects responded late to the stimuli. There were several components to this pattern. One was the task demand that asked subjects to respond to both the prime and the target, such that slower subjects' responses might overlap to the next presentation, especially in the shorter ISI condition when maximal response interval was 1000 msec per trial. A third compounding factor was the mechanical structure by which the computer recorded responses, so that only one response was recorded per trial. Therefore, if a subject held his/her finger down too long on the response pad, his/her subsequent response was not recorded accurately. In consultation with Dr. Dianne Bradley of the Linguistics Department of the CUNY Graduate Center and Dr. Swinney of the Speech and Hearing Sciences Department of the CUNY Graduate Center, these data were re-analyzed with consideration of the epoch structure between trials. It was determined that there was a calculable 32 msec down time between trials that could be added to the total response time in certain cases to recover many of these "time-out" or "non-responses". Further, a situation arose when the subject responded just at the end of the target presentation during the ISI period. This latter instance would appear as if a subject had "no response" to a particular item, yet actually responded during the intertrial interval. This pattern was uncovered by Dr. Bradley whose experience with these types of tasks and machinery enabled us to reconfigure the subjects' response in order to recalculate response times. Additionally, although of less importance, some subjects appeared to experience response pressure, particularly in the short ISI when stimuli are presented especially rapidly. These subjects produced unrealistically rapid response times (in the range of 150 msec) which were attributed to anticipatory response behavior. A final possible confounding factor was considered post hoc. This was the fact that non-word responses in general might be expected to be slower, and more adequate response time needed to be allotted, especially for the AD subjects. Each subject's protocol was reviewed to determine whether this type of response behavior was present. A follow-up investigation of this data may in fact yield revealing data.

Using the procedures described above, almost all of the previously non-recorded subject data was recovered. Thus, for the final AD subject group, the "non-response" pattern was virtually eliminated. In the 500 msec ISI, there was ultimately an average of 4.8% residual responses to words or non-words that were questionable in the AD data, and even less (1.3%) in the 1500 msec ISI condition, during which the subjects presumably had more time to consider their choice. This compared very favorably to the HE protocol, in which the average percent of true non-responses was 4.6% for word decisions and 1.9% for non-word decisions regardless of ISI. This overall preliminary analysis yielded 12 AD subjects and 18 HE subjects whose results comprise the data base for the final statistical analysis of this investigation.

The healthy elderly subjects met original criteria for percent correct in all tasks. However, due to the pattern of "non-response" encountered within the AD subject group described above, an analysis was undertaken to compare Mini-Mental-State (MMS) scores between the 12 subjects who were included and those 6 who were excluded from the final data analysis to determine if dementia severity might be a factor. This proved not to be the case. For the AD subjects whose data were used, the mean MMS was 23.5, whereas for those whose data were unusable, the mean MMS was 23.3.

B. Subject Groups' Overall Response Times and Error Rates for Word and Nonword Data

In terms of overall response time (RT) characteristics, the mean word RT for HE clients was 673.44 msec with a standard deviation of 95.86. While the mean RT for AD clients (727.67 msec) was significantly slower than HE subjects, there was large variability in RT, with a standard deviation of 205.23 (see Table 3a). However, in mean word error analysis, where errors were either actual errors or true non-responses, a highly significant difference was found between the subject groups. As illustrated in Table 3b, the mean percent error rate for the HE group was 3.5 % with a SD of 2.5, and the mean percent error rate made by the AD group was significantly higher ($p < .001$) (i.e., 9.5 % with a SD of 4.8).

TABLE 3a

Comparison of Mean Response Times (ms) to Words By HE and AD Subjects

	HE (18) Ss	AD (12) Ss	
	683	802	
	607	720	
	683	504	
	830	878	
	674	552	
	849	615	
	544	1282	
	752	756	
	787	650	
	622	699	
	678	568	
	523	694	
	629		
	622		
	595		
	556		
	762		
	726		
GROUP MEAN	**673.44**	**727.67**	
GROUP SD	**95.86**	**205.23**	**F(1,28) = 0.92**

TABLE 3b

Comparison of Mean Percent Error in Word Responses By HE and AD Subjects

	HE (18) Ss	AD (12) Ss	
	7.3	11.5	
	2.1	6.3	
	6.3	6.3	
	2.1	11.5	
	2.1	8.3	
	4.2	6.3	
	2.1	20.8	
	7.3	15.6	
	9.4	4.2	
	4.2	6.3	
	0.0	11.5	
	1.0	6.3	
	3.1		
	1.0		
	3.1		
	2.1		
	3.1		
	3.1		
GROUP MEAN	**3.533**	**9.575**	
GROUP SD	**2.517**	**4.839**	**$F(1,28) = 20.15, p<.001$**

With the nonword data, which will be discussed below in greater depth, similar patterns were found, as illustrated in Table 4a. Overall nonword response times were slower than those for the overall word data, with the HE group mean nonword RT at 898 msec and the AD group mean nonword RT at 1016 msec, again yielding a nonsignificant difference between groups. However, as illustrated in Table 4b, the mean nonword error percentages were significantly different (p. < .025) for the two subject groups, 10.3% for the HE group and 16.5% for the AD group.

TABLE 4a

Comparison of Mean Response Times (ms) to Nonwords By HE and AD Subjects

	HE (18) Ss	AD (10) Ss	
	946	913	
	790	670	
	888	1362	
	1238	742	
	919	1680	
	1012	740	
	691	1391	
	1031	939	
	1020	761	
	820	965	
	772		
	745		
	844		
	835		
	947		
	805		
	937		
	929		
GROUP MEAN	**898.28**	**1016.30**	
Group SD	**129.32**	**342.60**	**F(1,26) = 1.74, p>.10**

TABLE 4b

Comparison of Mean Percent of Error in Nonword Responses By HE and AD Subjects

	HE (18) Ss	AD (10) Ss
	7.3	7.3
	10.4	25.0
	14.6	13.5
	5.2	10.4
	4.2	39.6
	11.5	14.6
	10.4	17.7
	15.6	10.4
	9.4	19.8
	8.3	6.3
	11.5	
	12.5	
	9.4	
	6.3	
	11.5	
	13.5	
	12.5	
	11.5	
GROUP MEAN	**10.311**	**16.460**
GROUP SD	**3.126**	**9.966** **$F(1,26) = 5.96$, $p < .025$**

C. Response Times by Prime Type for AD and HE Subject Groups

The following results pertain to the specific word data relative to prime type RT's for subject groups. An overall analysis of both reaction time and error rate data was made by prime type. In no instance was there any significant main effect or interactions indicated by the error rate data. Hence, the subject and item analysis solely reflects the response time data. Firstly, the word data analysis included correct responses to word items with the following cutoffs applied. Incorrect responses were replaced by a value equal to the subject's mean RT. Absolute cutoffs were applied to these data such that data were excluded from analysis if values were less than 200 msec or greater than 2000 msec. This was done since such data points would be outside normal range of expectations established for this study. In the case of nonword analyses, a 3000 msec cutoff was applied. Relative cutoffs were set subject by subject, with outliers of reaction times more than two standard deviations above or below a subject's mean reaction time omitted from analysis. Values beyond these cutoffs were not excluded from analysis, but were replaced by the designated cutoff value to limit the effect of outliers.

Both sets of data (HE and AD) were analyzed by means of two analyses of variance, subject and item analyses, across the factors of Subject group (3) X ISI (2) X Prime type (3), and Item group (3) X ISI (2) X Prime Type (3).

In the overall subject analysis, the repeated measures variables were ISI and prime type. In the overall item analysis, only prime type was a repeated measures variable.

D. Results of Healthy Elderly Subjects' Lexical Decision Task

Table 5 summarizes both the healthy elderly and Alzheimer's Disease subject groups'reaction time data as a function of prime type and ISI. Results of the healthy elderly will be discussed first below.

TABLE 5

Mean Reaction Time (ms) to Word Targets as a Function of Prime Type and ISI for Healthy Elderly and AD Subject Groups

SUBJECT GROUP		PRIME TYPE		
(HE)	ISI	Related	Neutral	Unrelated
	500	623	650	664
	1500	656	698	698
(AD)	ISI	Related	Neutral	Unrelated
	500	692	707	710
	1500	652	682	734

As illustrated in Tables 6 and 7, a three way analysis of variance of the HE RT data revealed the presence of a main effect for prime type in both ISI conditions; $F1(2,30) = 9.82$, $p<.001$, $F2(2,132) = 8.11$, $p<.001$. No main effect of ISI or interaction was present. (In these following tables, Factor A=Variance Term, B=ISI Conditions, C=Prime Type Conditions, and S=Error Term.)

TABLE 6

Three - way analysis of variance of response time by healthy elderly subject group.

The overall response times of the healthy elderly subjects was analyzed by combining the two ISI conditions for each of the three prime types.

SOURCE	SS	df	MSS	F	P
A	1011923.17	2	50961.58	1.04	0.379
S	738188.92	15	49212.59		
B	40329.34	1	40329.34	2.12	0.166
AB	39449.24	2	19724.62	1.04	0.379
S*B	285415.58	15	19027.71		
C	35609.39	2	17804.69	9.82	.524E-03
AC	5891.11	4	1472.78	.81	0.527
S*C	54395.83	30	1813.19		
BC	1153.46	2	576.73	.64	0.534
ABC	23999.04	4	5999.76	6.67	.580E-03
S*BC	27001.83	30	900.06		

TABLE 7

Three-way analysis of variance of healthy elderly group's response time by stimuli items.

The overall response times of healthy elderly subjects by item was analyzed combining the two ISI conditions for each of the three prime types.

SOURCE	SS	df	MSS	F	P
A	7056.23	2	3528.12	.38	0.684
B	81666.67	1	81666.67	8.85	0.00409
AB	40638.69	2	20319.35	2.20	0.119
S	609047.28	66	9227.99		
C	80436.68	2	40218.34	8.11	.475E-03
AC	226728.55	4	56682.14	11.44	.596E-07
BC	3346.58	2	1673.29	.34	0.714
ABC	81871.31	4	20467.83	4.13	0.00348
S*C	654257.56	132	4956.50		

The next subanalysis concerned the relative difference between the mean RT in the related condition compared to the unrelated condition. As illustrated in Tables 8 and 9, results indicated a reliable difference between these two semantic conditions in both ISI's; $F1(1,15) = 14.69$, $p < .005$, $F2(1,66) = 12.89$, $p < .001$, main effect with no interaction.

TABLE 8

Three-way analysis of variance of the healthy elderly subjects' response times in two ISI conditions and two related vs. unrelated prime type conditions.

SOURCE	SS	df	MSS	F	P
A	49965.78	2	24982.89	.70	0.512
S	535102.79	15	35673.52		
B	20842.01	1	20842.01	1.39	0.257
AB	14253.78	2	7126.89	.47	0.631
S*B	225326.46	15	15021.76		
C	31208.35	1	31208.35	14.69	0.00163-04
AC	1586.78	2	793.39	.37	0.695
S*C	31863.12	15	2124.21		
BC	.68	1	.68	.00	1.000
ABC	15582.11	2	7791.06	9.37	0.00229
S*BC	12468.46	15	831.23		

TABLE 9

Three-way analysis of variance of the healthy elderly subjects' response times by item in two ISI conditions and two related vs. unrelated prime type conditions.

SOURCE	SS	df	MSS	F	P
A	26356.10	2	13178.05	1.69	0.192
B	41107.56	1	41107.56	5.28	0.0247
AB	16707.13	2	8353.56	1.07	0.348
S	513420.88	66	7779.10		
C	6679.17	1	6679.17	12.89	.630E-03
AC	88582.93	2	44291.47	8.55	.500E-03
BC	540.56	1	540.56	.10	0.748
ABC	36752.79	2	18376.40	3.55	0.0344
S*C	341998.04	66	5181.79		

The next analysis determined whether facilitation or inhibition effects contributed to the differences obtained. As illustrated in Tables 10 and 11, results indicated the presence of a facilitation effect by comparing the related versus neutral response times, $F1(1,15) = 10.80$, $p<.005$, $F2(1,66) = 11.52$, $p<.025$, for both ISI's.

TABLE 10

Three-way analysis of variance of healthy elderly subjects' response times in 2 ISI conditions and two related vs. neutral prime type conditions.

SOURCE	SS	df	MSS	F	P
A	67393.08	2	33696.54	.99	0.396
S	512441.54	15	34162.77		
B	30053.35	1	30053.35	2.66	0.124
AB	55431.69	2	27715.85	2.45	0.120
S*B	169388.71	15	11292.58		
C	21252.35	1	21252.35	10.80	0.00500
AC	5781.03	2	2890.51	1.47	0.262
S*C	29526.37	15	1968.42		
BC	889.01	1	889.01	.74	0.403
ABC	6563.86	2	3281.93	2.73	0.0976
S*BC	18039.87	15	1202.66		

TABLE 11

Three-way analysis of variance of healthy elderly subjects' response time by item in two ISI conditions and two related vs. neutral prime type conditions.

SOURCE	SS	df	MSS	F	P
A	48423.26	2	24211.63	3.55	0.0345
B	67730.06	1	67730.06	9.92	0.00246
AB	63619.54	2	31809.77	4.66	0.0128
S	450766.46	66	6829.79		
C	53091.84	1	53092.84	11.52	0.00117
AC	107937.26	2	53968.63	11.71	.444E-04
BC	1173.06	1	1173.06	.25	0.616
ABC	56247.88	2	28123.94	6.10	0.00370
S*C	304184.46	66	4608.86		

In comparing neutral versus unrelated conditions, no inhibition effect was found for either ISI. Although this is seemingly in contrast with a set of expectations which might have predicted inhibition in the longer ISI condition, this issue shall be examined in the Discussion section of this paper. Both subject and item analyses yielded no significant difference between the neutral and unrelated conditions. The overall conclusion which can be drawn from these data is that priming of a facilitative nature occurs to an equal extent in both timing conditions for the healthy elderly subject group.

E. Alzheimer's Disease Subjects' Results on Lexical Decision Task

Overall RT summary for the AD subject group appears in Table 5. In contrast to the HE subject group, analysis of the data for the AD subject group revealed the presence of an interaction between prime type and ISI in the overall analysis, $F1(2,18) = 3.63$, $p < .05$, $F2(2,132) = 3.52, p < .05$. (See Tables 12,13)

TABLE 12

Three-way analysis of variance of AD response times by subjects.

The overall response times of AD subjects was analyzed combining two ISI conditions for each of the three prime types.

SOURCE	SS	df	MSS	F	P
A	201776.86	2	100888.43	.53	0.604
S	1699747.96	9	188860.88		
B	3348.35	1	3348.35	.48	0.506
AB	12167.36	2	6083.35	.87	0.451
S*B	62880.13	9	6986.68		
C	29859.03	2	14929.51	3.73	0.0441
AC	11309.39	4	2827.35	.71	0.0598
S*C	72038.92	18	4002.16		
BC	13542.36	2	6771.18	3.63	0.0472
ABC	20633.06	4	5158.26	2.77	0.0592
S*BC	33537.25	18	1863.18		

TABLE 13

Three-way analysis of variance of AD group response times by items.

The overall response times of the AD subjects by item was analyzed for two ISI conditions and three prime types.

SOURCE	SS	df	MSS	F	P
A	66716.26	2	33358.13	1.94	0.151
B	31.89	1	31.89	.00	1.000
AB	88118.48	2	44059.24	2.57	0.0843
S	1132415.92	66	17157.82		
C	112938.45	2	56469.23	3.94	0.0218
AC	293088.30	4	73272.07	5.11	.732E-03
BC	100886.68	2	50443.34	3.52	0.0324
ABC	65855.07	4	16463.77	1.15	0.337
S*C	189631.50	13	14330.54		

Since the interaction of prime type and ISI was significant for the AD subject group, several subanalyses were performed. As seen in Tables 14 and 15, comparison of the difference between reaction times in the related and unrelated conditions over both ISI's (18 at 500 ISI versus 82 at 1500 ISI) revealed a significant interaction ($p < .05$) between the two values.

TABLE 14

Three-way analysis of variance of AD subject group's response times by two ISI conditions and two related vs. unrelated prime type conditions.

SOURCE	SS	df	MSS	F	P
A	153306.13	2	76653.03	.62	0.559
S	1111796.94	9	123532.99		
B	825.02	1	825.02	.12	0.734
AB	11800.54	2	5900.27	.88	0.449
S*B	60540.69	9	6726.74		
C	29750.52	1	29750.52	6.13	0.0353
AC	4562.54	2	2281.27	.47	0.640
S*C	43714.19	9	4857.13		
BC	12513.02	1	12513.02	15.72	0.00328
S*BC	7165.94	9	796.22		

TABLE 15

Three-way analysis of variance of AD subjects' response times by items for two ISI conditions and two related vs. unrelated prime type conditions.

SOURCE	SS	df	MSS	F	P
A	33258.72	2	16629.36	1.25	0.294
B	17008.51	1	17008.51	1.28	0.263
AB	97509.72	2	48754.86	3.66	0.0311
S	879678.21	66	13328.46		
C	106765.56	1	106765.56	10.26	0.00210
AC	184128.50	2	92064.25	8.84	.395E-03
BC	46189.17	1	46189.17	4.44	0.0390
ABC	49818.39	2	24909.19	2.39	0.0992
S*C	686982.88	66	10408.83		

A secondary analysis to determine the presence of a priming effect revealed no significant differences among prime types in the 500 msec condition. However, a highly significant degree difference between prime types was obtained in the 1500 msec ISI condition, $F1(1,9)=9.75$, $p=<.025$, $F2(1,33)=26.50$, $p=<.001$, main effect. (See Tables 16,17 for subject-based and item-based analyses)

TABLE 16

Two-way analysis of variance of AD subject group's response times in one ISI condition (1500 ms) and two related vs. unrelated prime type conditions.

SOURCE	SS	df	MSS	F	P
A	94647.58	2	47323.79	1.03	0.394
S	411925.88	9	45769.54		
C	40426.04	1	40426.04	9.75	0.0123
AC	17608.08	2	8804.04	2.12	0.176
S*C	37314.38	9	4146.04		

TABLE 17

Two-way analysis of variance of AD subject group's response times by item for one ISI condition (1500 ms) and two related vs. unrelated prime type conditions

SOURCE	SS	df	MSS	F	P
A	117958.11	2	58979.06	4.78	0.0150
S	40729.17	33	12337.15		
C	146701.39	1	146701.39	26.50	.119E-04
AC	193460.11	2	96730.06	17.47	.668E-05
S*C	182692.50	33	5536.14		

Since no priming effect was obtained in the shorter ISI condition, no further analysis was appropriate. However, in the case of the 1500 msec ISI Condition, it was necessary to determine if the priming effect was obtained due to facilitation or inhibition effects. The results of this analysis as indicated in Tables 18 and 19, revealed no significant effects of facilitation (i.e., Related versus Neutral Condition). In the case of inhibition (i.e., Neutral versus Unrelated Condition), a highly significant difference was identified, in both subject, $F1(1,9)=9.36$, $p=<.025$, and item analysis, $F2(1,33)=9.46$, $p=<.005$.

TABLE 18

Two-way analysis of variance of AD subjects' response time in one ISI condition (1500 ms) and two neutral vs. unrelated prime type conditions.

SOURCE	SS	df	MSS	F	P
A	133351.75	2	66675.88	1.25	0.332
S	480771.25	9	53419.03		
C	16016.67	1	16016.67	9.36	0.0136
AC	12092.58	2	6046.29	3.53	0.0737
S*C	15405.75	9	1711.75		

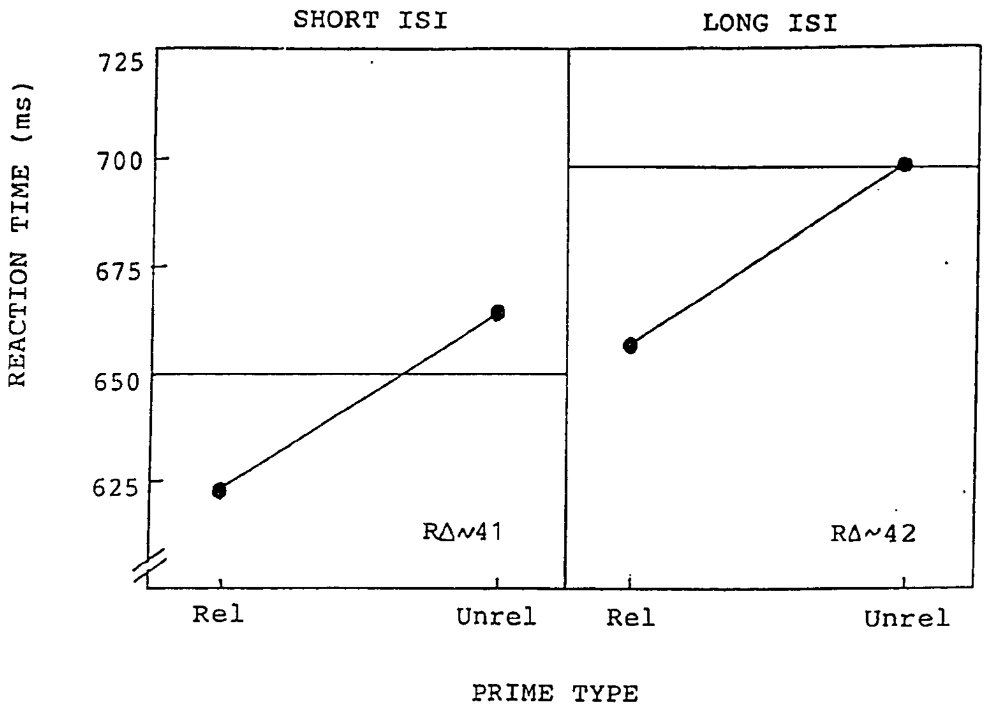
TABLE 19

Two-way analysis of variance of AD subjects' response time by item in one ISI condition (1500 ms) and two neutral vs. unrelated prime type conditions.

SOURCE	SS	df	MSS	F	P
A	277259.69	2	138629.85	9.62	.509E-03
S	47509.08	33	14403.31		
C	82147.56	1	82147.56	9.46	0.00419
AC	122644.69	2	61322.35	7.06	0.00279
S*C	286432.75	33	8679.78		

In summary, these data support the conclusion that when priming did occur with the AD subject group, it only occurred in the long ISI condition, and was driven by inhibition and not by facilitation. Figure 1 illustrates this comparison. Finally, a non-repeated, one-way analysis of variance was conducted (unequal n). As stated previously, there was no reliable difference in mean word RT between HE and AD groups. However, there was a highly significant difference in mean word percent error, which included both non-responses and incorrect responses.

HE
DATA



AD
DATA

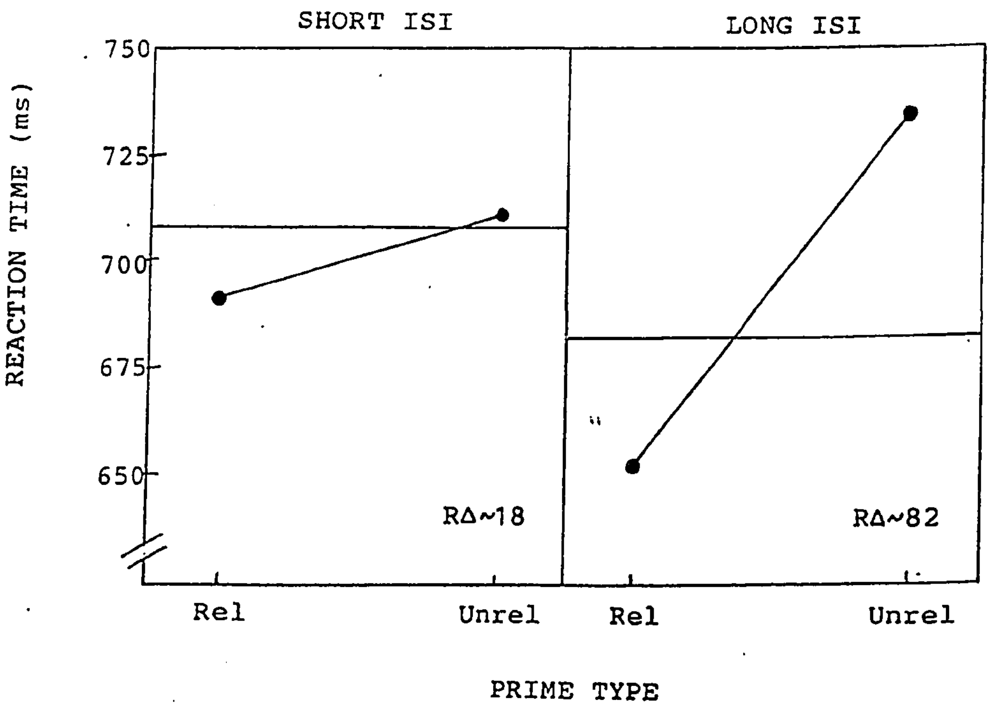


Fig. 1 Comparison of Mean RT's by ISI for HE and AD Subjects

F. Results of HE and AD Groups on Nonwords

The intention of this study was to focus on the performance of the two subject groups (HE, AD) relative to priming effects of different semantic classes of words. However, the nonword stimuli used for the lexical decision portion of the task led to certain interesting observations. The most significant aspect of the nonword data is the fact that AD and HE subject groups responded remarkably alike when discriminating nonwords versus real words. Except for the fact that the AD subject group's RT was slower than the normal group, both groups' overall patterns were virtually identical. This was not the case for AD and HE groups' identification of words when preceded by the related, unrelated and neutral real word primes. Thus, this illustrates that semantic information was used differently by the two subject groups.

At this point, the findings relative to nonword response patterns among subject groups are discussed. The nonword data were analyzed according to order of presentation, where the data was divided into equal quartiles, (i.e., first, second, third and fourth quartile) since no prime type variable existed. Some interesting patterns of similarity between the HE and AD subject groups' performance emerged. These findings have relevance both for the present experiment, as well as future investigations in this area. There is a lack of information in the research literature describing the actual nonword response patterns of AD subjects, however, reliable nonword resultant patterns are obviously critical in lexical decision experiments in order to determine if subjects are performing the task as it is intended. What is especially interesting in the present data is the tendency for HE and AD subject groups to treat nonwords in a similar manner. Figure 2a,b illustrates reaction times and error rate patterns for nonwords for both subject groups.

NONWORD
PATTERNS

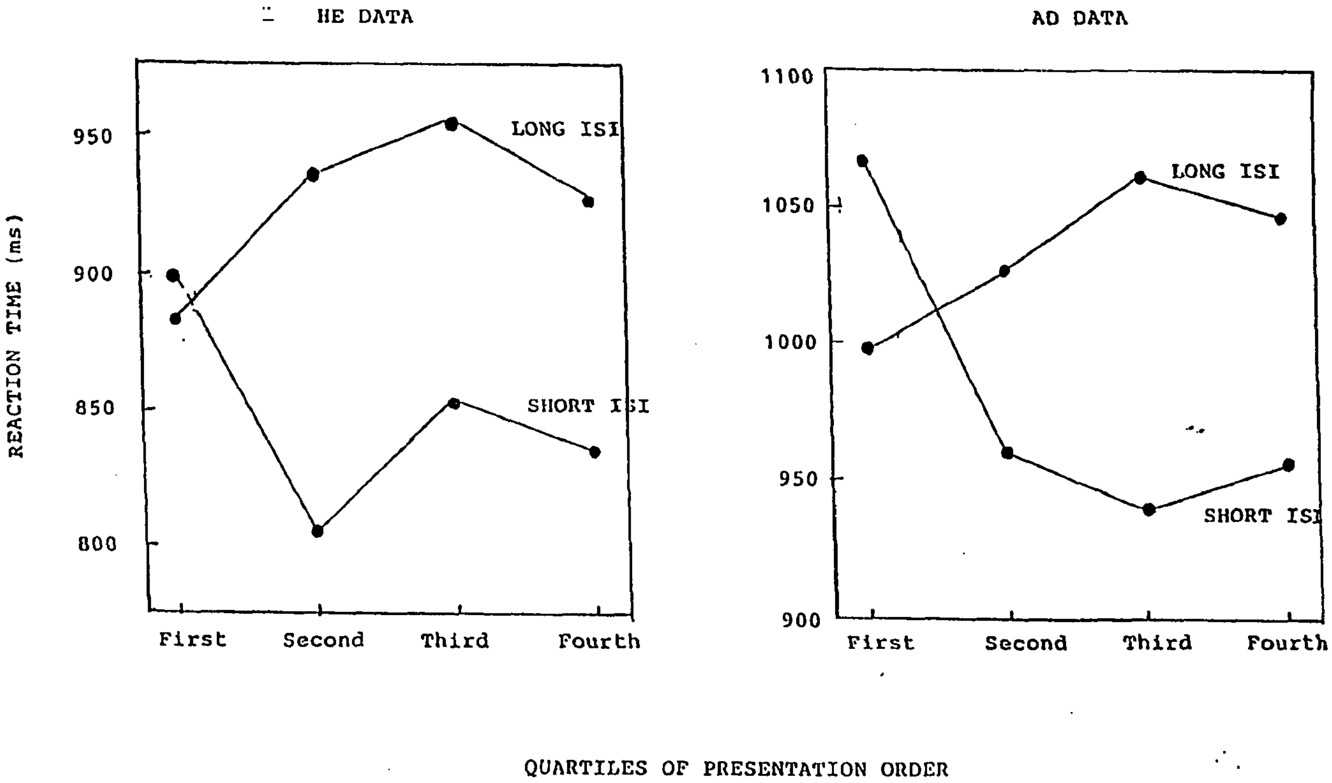


Fig. 2a HE and AD Reaction Times to Nonwords by Quartile of Presentation Order

NONWORD
PATTERNS

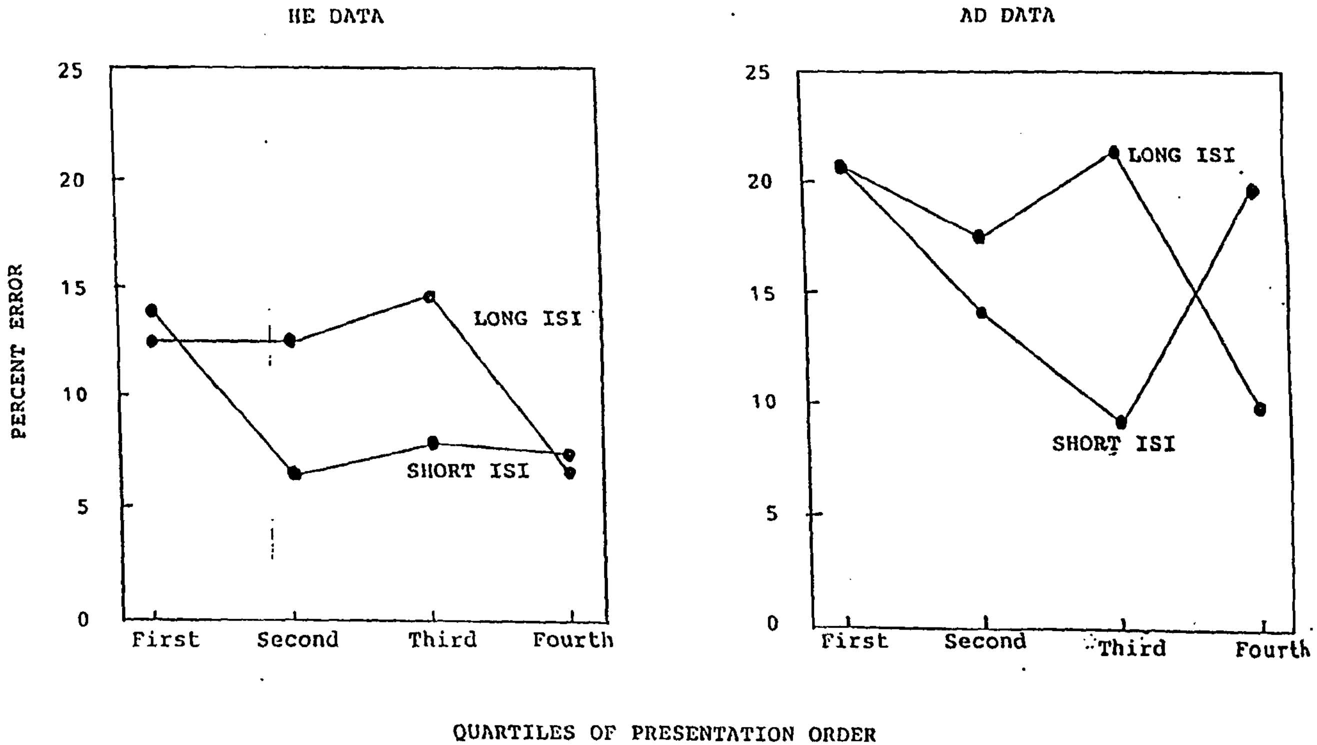


Fig. 2b HE and AD Error Rates on Nonwords by Quartile of Presentation Order

The nonword data patterns are similar for the HE and AD groups, in terms of responses by quartile, with apparently elevated RT's and error rates in the first quartile specifically in the 500 msec ISI condition. Intuitively, it would seem that this pattern might be attributable to "start-up cost" incurred when the subjects are first presented with a nonword target. This possibility was explored by means of the following analysis, and the results of the two groups' data were compared. Where all 18 HE subjects were used in this analysis, only 10 of the 12 AD subjects' data were used. This was due to the fact that review of AD subjects' data protocols revealed consistent withholding of response in the nonword condition, (so that their data were usable in the word analysis, but not in the nonword analysis.) The 48 nonword items were assigned into first, second, third or fourth quartile by order of presentation in the stimuli set. An overall RT and error rate analysis compared response patterns by ISI and quartile.

In the case of the healthy elderly, the error data were highly variable with no further analysis indicated. However, the overall RT data were analyzed by means of a two ISI by four quartile design. Results revealed a significant interaction between prime type and ISI condition for both the subject and item analyses ($F1(3,51)=9.05$, $p<.001$, $F2(3,88)=2.88$, $p<.05$). (See Tables 20 and 21)

TABLE 20

Two-way analysis of variance of overall response times of healthy elderly subjects to nonwords by two ISI conditions and four quartile conditions

SOURCE	SS	df	MSS	F	P
S	2165337.50	17	127372.79		
A	218144.69	1	218244.69	4.33	0.0530
S*A	857462.56	17	50438.97		
B	2354.69	3	7848.03	1.89	0.144
S*B	212236.17	51	4161.49		
AB	118937.19	3	39645.73	9.05	.662E-04
S*AB	223471.56	51	4381.80		

TABLE 21

Two-way analysis of variance of nonword response times of healthy elderly subjects was analyzed by item for two ISI conditions and four quartiles

SOURCE	SS	df	MSS	F	P
A	187266.67	1	187266.67	18.94	.363E-04
B	20866.92	3	6938897.97	.70	0.554
AB	85316.08	3	28438.69	2.88	0.0406
S	870203.67	88	9888.68		

Since it was suspected that the first quartile would have special properties, an additional analysis was performed, omitting the first quartile. When the second, third and fourth quartiles were examined, the significant interaction seen in the overall analysis was no longer present. As illustrated in Tables 22 and 23, there was a highly significant main effect for ISI, $F1(1,17)=8.16$, $p<.025$, $F2(1,66)=29.36$, $p<.001$, but no reliable differences for RT's based on quartile of presentation order.

TABLE 22

Two-way analysis of variance of healthy elderly subject group's response times by subject for two ISI conditions and 2nd, 3rd and 4th quartiles.

SOURCE	SS	df	MSS	F	P
S	1908251.63	17	112250.10		
A	32680.04	1	326480.04	8.16	0.0109
S*A	68041.63	17	40025.98		
B	22979.19	2	11489.59	3.83	0.0317
S*B	10213.81	34	3003.35		
AB	764.07	2	3820.04	1.54	0.228
S*AB	8416.26	34	2475.77		

TABLE 23

Two-way analysis of variance of healthy elderly subject group's response time by item for two ISI conditions and 2nd, 3rd and 4th quartiles

SOURCE	SS	df	MSS	F	P
A	260642.00	1	260642.00	29.36	.894E-06
B	20678.03	2	1039.01	1.16	0.318
AB	11588.08	2	5794.04	.65	0.524
S	58522.33	66	8876.10		

A final analysis restricted to the first quartile was conducted comparing the 500 and the 1500 msec ISI conditions. It was found that the elevation of RT's in the longer ISI was not seen in the first quartile 1500 msec ISI condition, because of marked "start-up" costs for the first trial sequence encountered, (i.e., 500 msec ISI).

An overall analysis of the AD group's nonword patterns of performance was also conducted for error rate and reaction times. Similar to the HE group, there was large variability in the error data, thus, no further analysis of error data was undertaken. The AD overall analysis of RT's revealed no main effect for ISI, quartile or interaction by item analysis. However, the subject-based RT analysis yielded a significant result, $F1(3,27)=8.10$, $p<.001$. (See Table 24).

TABLE 24

Two-way analysis of variance of AD subject group's response times to nonwords analyzed by subjects for two ISI conditions and four quartiles.

SOURCE	SS	df	MSS	F	P
S	8522645.30	9	946960.59		
A	54184.05	1	54184.05	4.15	0.0720
S*A	117426.20	9	13047.36		
B	18057.85	3	6019.28	.56	0.648
S*B	291516.40	27	10796.90		
AB	107200.45	3	35733.48	8.10	.523E-03
S*AB	119051.30	27	4409.31		

Based on the overall similarity to the HE RT pattern, further analysis was undertaken. Similar to the analysis of the HE data, the first subanalysis dropped the first quartile which was deemed likely to have special properties. A highly significant main effect for ISI was revealed in the AD group, which was similar to the pattern for HE group, $F1(1,9)=10.66, p<.01$, $F2(1,66)=19.09$, $p<.001$. (See Tables 25,26)

TABLE 25

Two-way analysis of variance of AD subject group's response times to nonwords analyzed by two ISI conditions and 2nd, 3rd and 4th quartiles

SOURCE	SS	df	MSS	F	P
S	5928190.35	9	65867.82		
A	129084.82	1	129084.82	10.66	0.00975
S*A	108953.02	9	12105.89		
B	819.70	2	409.85	.17	0.847
S*B	43988.30	18	2443.79		
AB	7729.63	2	3864.82	.97	0.399
S*AB	71817.03	18	3989.84		

TABLE 26

Two-way analysis of variance of AD subject group's response times to nonwords analyzed by item for two ISI conditions and 2nd, 3rd and 4th quartiles.

SOURCE	SS	df	MSS	F	P
A	174936.13	1	174396.13	19.09	.451E-04
B	10146.53	2	5073.26	.55	0.578
AB	25884.25	2	12942.13	1.41	0.251
S	604791.08	66	9163.50		

Again similar to the HE results, there was no reliable difference among second, third or fourth quartile in overall RT, and the interaction seen in the previous overall analysis was no longer present for the AD group.

The final analysis which considered first quartile data only reflected the "start-up" costs for the short ISI, however there was large variability and the item analysis failed. Overall, the AD group's performance showed a marked similarity to the HE group in how subjects responded to the nonwords in the initial presentation, with sharp "start-up" costs for the first quartile of first (short ISI) block, and a general slowing in long ISI trials.

Chapter 5 - **DISCUSSION**

The present study examined the priming behavior of healthy elderly and Alzheimer's disease subjects in an effort to gain information concerning the underlying nature of the lexical semantic impairment in Alzheimer's Disease. The overall findings of this study were that the healthy elderly demonstrated only automatic type of priming, and that AD subjects exhibited what would be considered controlled type of priming. The potential reasons for this outcome and implications will be addressed.

Differences in priming behavior relative to normal expectations has been considered a possible marker for early dementia of the Alzheimer's type. A substantial body of evidence exists in the literature to support more of the claim for impaired priming in the AD population, namely both the absence of normal priming (or no priming effect) as well as claims of greater than normal or hyper-priming effects. When priming has been found to be intact or greater than normal, investigators have interpreted these findings as inherently indicative of the integrity of lexical semantic storage, organization and retrieval. These studies include the works of authors such as Nebes, Martin and Horn, 1984; Nebes et al., 1986; Nebes, Brady and Huff, 1989; Hartman, 1987; and Margolin, 1987. However, interpretations are rendered more difficult when priming effects are either absent or impaired (Ober and Shenaut, 1998), and more fundamentally, when one considers that these priming effects are measured by different methodological means in the various studies above. Traditionally, priming refers to the difference between response time to related items versus response times to unrelated items. Using this criteria, AD subjects' priming has been assessed to be normal and/or greater than normal in the studies cited.

As an outgrowth of the priming literature, researchers sought to further analyze priming behavior to account for the underlying processes responsible for the differences in response times obtained when comparing the related and unrelated semantic conditions (Ober and Shenaut, 1990). The addition of a neutral prime, or a baseline measurement, served to more precisely delineate the priming components such as facilitation for the related condition and inhibition for the unrelated condition. Furthermore, the use of ranges of ISI at very rapid stimulus onset times assists in determining priming due to "automatic" activations without effortful processing on the subject's part versus priming which may be related to direct search or "controlled" processes.

Subsequently, controversy arose in the literature regarding the nature of priming in AD, and if it was truly intact. Ober (1991) argued that AD subjects' have intact automatic priming, and suggested that priming effects described in prior studies may not be fully accounting for input of controlled processing. Some of the methodological factors which may contribute to the involvement of controlled processing operations include prolonged interstimulus intervals, as well as the internal construction of the stimuli list and manner of presentation. Specifically, the proportion of related pairs to unrelated pairs affects potential strategizing on the part of the subject insofar as the preponderance of relatedness may influence them to develop expectancies and predict targets, thereby enhancing response time, albeit due to controlled operations. In the same vein, overt pairing in the stimuli presentation may contribute to controlled operations since the subjects may perceive relationships between pairs, as opposed to a continuous stimuli presentation in which it is highly difficult to ascertain relations between the actual prime and target. Similarly, task demands may influence performance by selectively directing the subject's attention. This can be overcome by having the subject respond to all the stimuli as it appears, which is one of the methodological choices made in the present study.

One of the purposes of the present investigation was an attempt to identify automatic and controlled processing input in the priming behavior of AD subjects. As such, this investigator endeavored to develop a comprehensive research design that would take into account methodological considerations described above. In order to differentially control for automatic and controlled operations in one experiment, the following methodological choices were made. These included: the use of a neutral prime, and the manipulation of two ISI boundaries while keeping constant both the task instructions and a .50 semantic proportion in the stimuli. The choice of lexical decision task as opposed to naming task was also selected to determine if an automatic priming effect could be obtained with a rapid ISI condition. All of these choices were a natural extension of the previous research in this area, in an attempt to answer the questions raised in the literature.

In the pilot study conducted on healthy young college students using this research design, priming of a facilitory nature in the short ISI condition and priming of both facilitory and inhibitory natures in the long ISI were obtained. Based on findings obtained from the pilot data and those in the research literature, the present study's prediction was that healthy elderly would perform similarly to healthy young individuals, but with a delay in rise time (Stern et al., 1991). The prediction for AD subjects was that priming would be aberrant. That is, AD subjects would be not only be slower to respond than HE subjects, but would demonstrate qualitative differences in their response to the various types of primes.

The prediction for the HE subject group held true. They demonstrated priming of a facilitory nature in both the 500 and 1500 ms ISI conditions. However, they failed to exhibit priming of an inhibitory nature in the long ISI. Mean RT was 623 in the Related Condition, and 664 msec in the Unrelated Condition, for a total priming effect of 41 msec in the 500 msec condition. In the 1500 msec ISI condition, the HE subjects had a mean RT of 656 msec (Related Condition), and 698 msec (Unrelated Condition), yielding a 42 msec RT advantage in the Related Condition.

By contrast, the AD subjects exhibited no significant priming effect in the 500 msec ISI condition. In the 1500 msec ISI condition, the AD subject group demonstrated a priming effect which was significantly greater than the effect demonstrated by the normal HE subjects, i.e., an 83 msec RT advantage versus the 42 msec RT advantage, respectively. Therefore, in the present research paradigm, subjects' performance in the 1500 msec ISI condition differentiated the HE and AD subject groups. However, as Ober (1991) has suggested, AD subjects' strategy on priming tasks may involve increased response times, and consequently increased inhibition may result. This view of increased inhibition closely dovetails with the findings of the present study, where increased inhibition along with increased response times resulted for the AD subjects.

Due to the rather unexpected outcomes, particularly in reference to the HE expectations, and the lack of any prior comparable research design, it was very difficult to comment upon the original question of the components of priming in the AD population, and the question of ISI conditions for boundaries of automatic and controlled operations input. Therefore, direct comparisons with the findings relative to these questions in the existing literature were not possible. However, several additional factors were suggested post hoc. First is the issue that the 500 msec ISI boundary may itself be too long to reliably tap automatic functions. Second, there are probable differences in the behavior within elderly subject groups. The present group of HE subjects represent the young end of the aging population. These factors must be accounted for if reliable interpretation of the data is to be made. This is so in spite of these two factors, other components of the present study, represent relative methodological strengths and advancements over previous research studies in priming. Notably, this includes more precise clinical diagnosis of AD and dementia severity which was possible due to the subject selection criteria used at the ADRC research site. Additionally, a relatively larger sample size than used in previous studies was possible. There are relatively few studies of priming in the AD population to date. Further, no research designs in past studies incorporated both the study of automatic and controlled processing. Thus, I will first discuss the results of the studies related to automaticity. Ober and Shenaut (in press) reported on a pronunciation task with a stimulus onset asynchrony of 250 msec and a related proportion of .17. Their AD subjects demonstrated an average RT in the Unrelated Condition of 694 msec, in the Related Condition, 695 msec, and a priming effect of -1. In the present study's 500 msec ISI condition, the mean RT in the Unrelated Condition was 710 msec and 692 in the Related Condition, for a priming effect of 18 in the AD subject group. This priming effect, however, was not statistically significant. Despite the employment of different methodologies, there are certain gross similarities in overall RT's obtained between this and Ober et al's research investigation. In terms of automaticity and the healthy elderly subject group, the findings of the present investigation was that the HE subject group did demonstrate facilitory priming in the short ISI condition. This is coincident with the findings of Stern et al. (1991) whose data on the healthy elderly subjects' response to priming showed that automatic operations remain intact in later life, although rise times mat slow down.

In the area of controlled processing studies, a comparison can be made between the present study and those of Hartman (1987, 1991). Where the relatedness proportion between stimuli and range of ISI are similar between Hartman's and the present study, Hartman's AD subjects' mean RT for the Unrelated Condition was 1065 msec, and 991 in the Related Condition, for a priming effect of 74 msec. Her HE controls' mean Unrelated RT was 785 msec, 745 msec for the Related Condition, yielding a priming effect of 40 msec. In the present investigation, mean RT of the AD subject group for the Unrelated Condition was 734 msec, and for the Related Condition was 652 msec, yielding a priming effect was 82 msec. The HE controls' Unrelated mean RT was 698 msec, and Related RT was 656 msec, for a priming effect of 98. Therefore, the results of the present study in the longer ISI are similar to those of Hartman in terms of magnitude of the priming effect.

The present study's data serves well in adding to the body of research findings to codify normal age-related effects in priming, as well as the effects of brain disease, as seen in Alzheimer's Disease. However, the present study's findings cannot fully shed light on the original hypothesis of this study. The hypothesis being that healthy elderly would perform the tasks similarly to healthy young subjects did not prove to be the case in the present study. Rather, the HE showed only facilitation priming effects in both ISI conditions. As based on young and older normals' performance in previous studies, it was first expected that facilitation would be present in only the short ISI condition with the neutral equivalent to unrelated condition. It was further expected based on prior studies' findings that both facilitation and inhibition would be present in the longer ISI condition. This was indeed the noted finding on the present investigator's small pilot study with healthy young adults. However, this finding was not found in the present investigation with healthy elderly. Secondly, it was hypothesized that the AD subjects' automatic, attentional processes would be intact and that controlled processes would be impaired. As based on prior research findings of aberrant semantic priming in this population, as well as clinical reports of preservation of the rote or more automatic aspects of language functioning until the advanced stages of the disease, the pursuit of this latter hypothesis was supported. Given the results of the present investigation, AD subjects failed to exhibit automatic priming, yet exhibited controlled priming. Furthermore, an argument for purely delayed automatic process cannot be made since the neutral condition was used, and allowed for detection of a large inhibitory component.

As to why automatic priming was not found with the present AD subjects, one primary factor is suggested, that the particular set of experimental manipulations put forth in this design did not lend themselves to automatic processing conditions in the AD subjects. This pertains specifically to the ISI of 500 msec. It is possible that AD represents a cognitive condition which effects processing in a way which precludes using the temporal boundaries established in normals. In other words, the exact boundaries during which automatic processing is observed may lie elsewhere in the range of temporal processing, and not at the 250-500 msec range. Thus, if the range had been extended, potentially, significant effects may have been observed.

Given the difference in HE and AD groups' performance, the findings of the present study may point to basic differences in how tasks are approached and information is used by these groups, even in early dementia stages. Therefore, the HE group's performance is more likely to be accounted for by normal age-related factors such as cognitive slowing, as opposed to the processing differences seen in the AD group. In the present study, HE and AD groups demonstrated not only differences in response time latencies, but also different response patterns with regard to prime type relationships. What can be concluded with fair certainty, is that whatever is the underlying nature of the processes involved in the lexical semantic priming task, it did serve to differentiate those subjects in the mild stage of Alzheimer's Disease from those normal older subjects. This in itself is an important finding of its own given the problem of early and accurate clinical diagnosis of Alzheimer's disease. Qualitative and quantitative differences in priming behavior between HE and AD subject groups are quite clear from the present data, that is, size of the priming effect, and the conditions under which the subject groups primed. This speaks to the original thrust of research into this area, that impaired priming is a benchmark of this disease.

Secondarily, another valuable outcome of the investigation is the information regarding how healthy elderly and AD subjects use nonwords. This is not well-reported in the literature, and adds to the integrity of the findings in the present study. In other words, it demonstrates that subjects were truly performing the lexical decision task.

Some possibilities are suggested as to why HE and AD subject groups, as well as individual subjects, behaved differently in the present study on the tasks as a whole. These include the fact that normal aging is still not completely understood in terms of its effect on speed and locus of lexical activations nor how word images are represented and accessed. Additionally, the mild stage of AD presents a unique set of circumstances where the language decline is not uniform across all subjects with the same level of clinical severity. This subsumes the additional indication that AD subjects might not have been able to perform the task as it was set up in the shorter ISI condition, thereby precluding any true analysis of automatic operations. To better answer the questions put forth in this present study, the following methodology considerations are suggested. First, the inclusion of a moderate AD subject group to assess changes as the disease progresses to determine if there is a linear relationship between severity and decline of priming abilities. Second, the use of an extended ISI condition to determine if reliable automatic and controlled effects can be obtained. However, it bears mention that the lack of agreement between the present findings and those of many previous investigations may merely reflect methodological differences since a neutral condition was not used in some of the studies, and therefore only total priming was calculated. Thus, calculation for facilitation and inhibition effects are precluded in these studies, thus, previous report of priming effects may be misleading.

Other unanswered questions remain such as the role of a selection deficit in priming. Large subject performance variance seen in this and other studies may exist when multiple lexical activations arise and target words cannot be appropriately selected or suppressed because activation thresholds for specific items or classes of items are no functioning normally. It appears clear from the cumulative research evidence that AD does not represent an accelerated version of the normal cognitive aging process. When provided with sufficient time, mild AD subjects do appear to correctly discriminate semantic relations among target items. What is not clear is the mechanism by which the AD subjects reach their lexical choices. A study of the present nature demonstrates that slower response times are not the only factor in AD subjects' lexical decisions. The quality of semantic relationships between the prime and target also effects how AD subjects respond. In fact, the unrelated condition seems to slow down AD subjects' responses significantly, as opposed to the HE subjects' responses. Such a delay suggests that perhaps once AD subjects are on a misdirected search, it is difficult for them to then redirect their search. This suggests that there are qualitative differences in how AD subjects in early stages of the disease process language as compared to healthy elderly subjects. While underlying processing operations may be different than that of normal young and older adults, increased processing time may aid AD subjects' lexical decision performance. If the combined factors of impaired language store, impaired lexical semantic organization, impaired attentional processing mechanisms, as well as a generalized slowing of the processing mechanisms are involved, it would explain in part why definitive findings from present and past studies are so elusive with the AD population.

This study's results offer evidence that as a group, these mildly demented AD subjects demonstrated a generalized slowing in processing, which may affect in part lexical retrieval. However, it is difficult to dissociate the mandatory perceptual and central executive cognitive components which may be active due to the timing constraints as were employed in the present study. However, keeping language demands constant, Alzheimer's Disease subjects did perform differently under the two timing conditions, and in a manner different than that the healthy elderly subjects. Therefore, given the preliminary nature of the present findings, it still appears that general processing time and attention do indeed interact with lexical semantic performance in Alzheimer's Disease, both contributing to lexical retrieval problems. However, a question remains whether temporal boundaries for controlled processing as cited by previous researchers for normal younger adults are reliable boundaries for studying controlled processing in healthy elderly and Alzheimer's Disease populations. Hopefully, this question will be addressed by future researchers.

Chapter 6 - SUMMARY, CONCLUSIONS and FUTURE RESEARCH

The present study was undertaken to evaluate lexical semantic priming abilities in healthy elderly subjects and Alzheimer's Disease subjects in the mild clinical stages of the disease.

One of the primary assumptions underlying the study was that automatic and controlled cognitive operations can be assessed based on subjects' performance on semantic priming tasks. While this notion is based on strong empirical evidence, ample controversy abounds regarding the appropriate set of methodological variables which will bring about these strategies reliably. Another factor to be considered is that the intactness of one of the operations does not necessarily indicate the intactness of the other, since they may operate via different mechanisms, i.e., associational retrieval and expectation based strategy. Given this information, the present author decided on one set of manipulations to approach these questions. These included ISI boundaries of 500 and 1500 msec, and a .50 semantic relatedness proportion in the word stimuli. This methodological combination has heretofore never been applied in a lexical decision task with AD subjects. However, there was good reason to suspect that it would shed light on operational breakdowns seen in this population. This assumption was based on the fact that prior studies had been criticized for not applying short ISI's in their design, yet concluding that automatic-based priming was intact in AD when a total priming effect was obtained. A further difficulty with previous designs was the lack of any neutral prime condition, or an ineffective neutral condition. One of the relative strengths of the present study was the use of a reliable neutral condition, yielding baseline response time rates in all conditions for all subjects. Furthermore, all subjects had highly reliable response patterns in distinguishing nonwords, and except for slower speed, AD subjects responded remarkably like the healthy elderly controls. This did not prove to be the case when semantic real word primes were used in the lexical decision task. Here, AD subjects responded differently than normals to conditions of relatedness and unrelatedness. The .50 relatedness proportion was also chosen in this regard to equate the likelihood that a given word pair would be related in half the word stimuli, and unrelated in the other half. There were 12 subjects in the experimental group and 18 subjects in the control group. A semantic priming paradigm using covert related, unrelated and neutral semantic relationships in word pairs was used, in two interstimulus timing conditions. These were 500 and 1500 msecs respectively, chosen to identify the automatic versus controlled cognitive operations.

According to the findings, the results indicated that HE subjects ostensibly demonstrated automatic priming in both ISI conditions, whereas AD subjects demonstrated controlled priming in the 1500 msec condition. These results, while consistent with certain expectations in the literature, appear to provide new information on the priming behavior of these subject groups. However, ultimately, due to differences in methodological choices and differing age characteristics of the healthy elderly in this and other studies which have been described in the text, direct comparison between the present findings and those of prior researchers cannot be reliably made. Not the least of these factors is the choice of ISI conditions. Based on the nature of the present findings, it is necessary to consider that 500 might not be an appropriate locus of automatic priming in

AD or HE. A further consideration is whether an extended ISI, i.e., 2000 msec or greater would have revealed the locus of controlled operations more clearly in these groups. For these reasons, the data is considered to add to the body of information regarding general aberrant priming in AD, but is inconclusive regarding underlying cognitive operations. The findings for the AD group are interpreted as possibly related to problem with selective access of associates, which would be different than impaired automatic operations, whereas the HE appeared to respond just slower as a group.

It is the contention of the present researcher that this same question of methodological variations underlies the differences in the present findings, and is also a confound in the interpretation of the priming literature in Alzheimer's Disease. Certain suggestions arise for follow-up research based on this. One of the issues currently in debate in the psycholinguistic literature is the patterns and expectancies of the relatively younger elderly subjects versus the "older" elderly subject. This is a factor in the present study, in that there was a wide age range in both the HE and AD subject groups. This means that there may be differential findings due to age affect both between and within subject groups. Therefore, a study of priming involving healthy elderly at two ends of the aged spectrum would be helpful in determining which effects are attributable more directly to aging. This would have obvious implications for the brain damaged population. In other words, there may well be different expectancies given the specific age range of the elderly populations being studied, which heretofore are not being accounted for in the literature.

A further consideration for research in this area is the effect of the progression of the dementing condition on priming behavior. A suitable follow-up, therefore, might be a study using both mildly and moderately impaired AD subjects in one design. Even retesting the original AD subjects in this study, given that their dementia may have progressed in the time elapsed since the original investigation, would also shed light on the effects of the progression of the disease. An additional factor in any replication of the present study would be the use of an off-line language task, such as the Boston Naming Test, to assess for any semantic degradation of stimuli used in the priming portion of the investigation. A final consideration would be the use of a very brief ISI, in the range of 250 msec. Although this ISI was considered too brief for AD subjects to process the task, it may have yielded the data to backup this preliminary assumption, and clarified the question of automatic operations.

APPENDIX A - OVERALL TASK DESIGN OUTLINE

	Group A	Group B	Group C
Condition 1: Related	1-12	1-12	1-12
	rug	thread	lung
Condition 2: Neutral	13-24	13-24	13-24
	lung	rug	thread
Condition 3: Unrelated	25-36	25-36	25-36
	thread	lung	rug
Condition 4: Rel. Fillers	37-48	37-48	37-48
	items constant across versions		

	Group A	Group B	Group C
Condition 5: Related	97-108	97-108	97-108
	beer	stone	answer
Condition 6: Neutral	109-120	109-120	109-120
	answer	beer	stone
Condition 7: Unrelated	121-132	121-132	121-132
	stone	answer	beer
Condition 8: Rel. Fillers	133-144	133-144	133-144
	items constant across versions		

Note: Nonword targets were items 49-96 and 145-192, which were analyzed in a separate run.

Above numbers represent only data set identifiers. Subjects saw like items in nonconsecutive fashion. However, all subjects saw prime types in same location, i.e., #1 on all versions would be a related condition, etc. Subjects were organized such that Group A saw list 1 and 2, Group B saw list 3 and 4, and Group C saw list 5 and 6, corresponding to "Location of Targets" attached, including all prime types, fillers and nonwords.

APPENDIX B- STIMULI SET

ISI = 500 msec Condition

Target Type-Related (1)

List No.	1	3	5
01	(carpet+) rug	thread	lung
02	lime	pint	pencil
03	pie	shell	leaf
04	woman	god	fall
05	order	south	hill
06	letter	film	winter
07	tiger	nail	girl
08	spy	cat	touch
09	rape	hate	pants
10	rat	stream	baseball
11	saddle	minister	war
12	navy	cut	uncle

Target Type-Neutral (2)

13	lung	(word+) rug	thread
14	pencil	lime	pint
15	leaf	pie	shell
16	fall	woman	god
17	hill	order	south
18	winter	letter	film
19	girl	tiger	nail
20	war	spy	cat
21	pants	rape	hate
22	baseball	rat	stream
23	touch	saddle	minister
24	uncle	navy	cut

Target Type-Unrelated (3)

25	thread	lung	(tiger+) rug
26	pint	pencil	lime
27	shell	leaf	pie
28	god	fall	woman
29	south	winter	order
30	film	hill	letter
31	nail	love	tiger
32	cat	touch	spy
33	hate	pants	rape
34	stream	baseball	rat
35	minister	war	saddle

36	cut	uncle	navy

Related Filler Targets (4)

Same Items for Lists 1,3, and 5

37	arrow
38	jail
39	artist
40	bottle
41	vase
42	cradle
43	finger
44	hair
45	home
46	avenue
47	crackers
48	stop

Non-Word Targets (5)

Same Items for Lists 1,3, and 5

49	chome
50	hibe
51	mera
52	deme
53	tench
54	pusty
55	bick
56	tirl
57	shants
58	vant
59	munk
60	vam
61	nilt
62	vint
63	grap
64	tase
65	fint
66	rit
67	benk
68	vixel
69	slond
70	bine
71	rigan
72	fints
73	inty

74	ruve
75	stip
76	vort
77	rame
78	drow
79	stin
80	trish
81	plazer
82	trupe
83	viase
84	sarch
85	maith
86	plet
87	tash
88	cawl
89	snock
90	blude
91	jisk
92	ment
93	tiz
94	bast
95	shiter
96	strail

ISI = 1500 msec Condition

	List 2	List 4	List 6
Related (1)			
97	beer	stone	answer
98	sheet	tree	fire
99	circle	sun	night
100	wool	bug	pipe
101	pepper	butter	cow
102	pearl	light	queen
103	chair	book	drum
104	eagle	bed	nickel
105	nurse	iron	pea
106	apple	arm	ant
107	grass	milk	tulip
108	pork	shark	gun
Neutral (2)			
109	answer	beer	stone
110	fire	sheet	tree
111	night	circle	sun

112	pipe	wool	bug
113	cow	pepper	butter
114	queen	pearl	light
115	drum	chair	book
116	nickel	eagle	bed
117	pea	nurse	iron
118	ant	apple	arm
119	tulip	grass	milk
120	gun	pork	shark

Unrelated (3)

121	stone	answer	beer
122	tree	fire	sheet
123	sun	night	circle
124	bug	pipe	wool
125	butter	cow	pepper
126	light	queen	pearl
127	book	drum	chair
128	bed	nickel	eagle
129	iron	pea	nurse
130	shark	gun	grass
131	arm	ant	apple
132	milk	tulip	pork

Related Fillers (4)

Same for Lists 2,4, and 6

133	clock
134	rod
135	devil
136	jelly
137	flag
138	key
139	coat
140	sorrow
141	teacher
142	twist
143	polio
144	minute

Non-word Targets (5)

Same for Lists 2,4, and 6

145	crix
146	furd
147	chup
148	midden
149	grat

150	trove
151	plages
152	stite
153	sile
154	snalk
155	wabe
156	jube
157	vand
158	shet
159	harn
160	quime
161	strize
162	snutches
163	nort
164	lind
165	swires
166	fith
167	prem
168	wull
169	cybles
170	neap
171	nirth
172	sudirt
173	pame
174	maret
175	sall
176	kip
177	vit
178	naxy
179	thune
180	mell
181	plase
182	lype
183	pait
184	snar
185	attle
186	meeth
187	orp
188	tirm
189	vorn
190	snay
191	bloor
192	anch

"AUTOMATIC AND CONTROLLED INFORMATION PROCESSING IN ALZHEIMER'S DISEASE"

INFORMED CONSENT FORM

Principal Investigators: Linda S. Carozza, M.A., CCC, M.Phil.
and David Swinney, Ph.D., City University of New York,
Graduate Center, Speech and Hearing Sciences Department

1. The purpose of this project is to study how ability to rapidly associate words and concepts is effected by Alzheimer's disease.

2. The procedure to be followed involves making decisions about words presented on a portable computer setup. Response times will be analyzed by means of an internal time clock associated with the testing apparatus. The testing will take approximately two one hour sessions to complete. Test results will be compiled and maintained only by members of the research team, and will be kept confidential unless I ask that they be released.

3. NO MEDICAL RISKS are associated with this study, although some subjects may experience a mild degree of fatigue or stress.

4. There are no known direct medical benefits to you for participating in the study.

5. Withdrawal: I may refuse to participate or may withdraw from the study at any time .

6. Questions: My questions about the study have been answered. If I have any further questions or concerns, I may call Linda Carozza, (718)447-5670, or Dr. David Swinney, (212)642-2170

SIGNATURE OF PARTICIPANT/LEGAL REPRESENTATIVE DATE

SIGNATURE OF RESPONSIBLE INVESTIGATOR DATE

I HAVE READ AND UNDERSTAND THE ABOVE AND AGREE TO PARTICIPATE IN THIS STUDY.

CRITERIA FOR CLINICAL DIAGNOSIS OF ALZHEIMER'S DISEASE

(McKhann, Drachman, Folstein, Katzman, Price and Stadlan, 1984)

I. The criteria for the clinical diagnosis of PROBABLE Alzheimer's disease include:

dementia established by clinical examination and documented by the Mini-Mental Test, Blessed Dementia Scale or some similar wxamination, and confirmed by neuropsychological tests;

deficits in two or more areas of cognition;

progressive worsening of memory and other cognitive functions;

no disturbances of consciousness

onset between 40 and 90, most often after age 65;

absence of systematic disorders or other brain diseases that in and of themselves could account for the progressive deficits in memory and cognition.

II. The diagnosis of PROBABLE Alzheimer's disease is supported by:

progressive deterioration of specific cognitive functions such as language (aphasia), motor skills (apraxia), and perception (agnosia);

impaired activities of daily living and altered patterns of behavior;

family history of similar disorders, particularly if confirmed neuro pathologically; and laboratory results of:

normal lumbar puncture as evaluated by standard techniques,

normal pattern of nonspecific changes in EEG such as increased slow wave activity, and

evidence of cerebral atropht on CT with progression documented by serial observation.

III. Other clinical features consistent with the diagnosis of PROBABLE Alzheimer's disease, after exclusion of causes of dementia other than Alzheimer's disease include:

plateaus in the course of progression of the illness;

associated symptoms of depression, insomnia, inconinence, delusions, illusions, hallucinations, catastrophic verbal, emotional, or physical outbursts, sexual disorders and weight loss;

other neurologic abnormalities in some patients, especially with more advanced disease and including motor signs such as increased muscle tone, myoclonus, or gait disorder

seizures in advanced disease; and

CT normal for age.

IV. Features that make the diagnosis of PROBABLE Alzheimer's disease uncertain or unlikely include:

sudden, apoplectic onset;

focal neurologic findings such as hemiparesis, semsory loss, visual field deficits, and incoordination early in the course of the illness; and

seizures or gait disturbances at the onset or very early in the course of the illness.

V. Clinical diagnosis of PROBABLE Alzheimer's disease:

may be made on the basis of the dementia syndrome, in the absence of other neurologic, psychiatric, or systematic disorders sufficient to cause dementia, and in the presence of variations in the onset, in the presentation, or in the clinical course;

may be made in the presence of a second systematic or brain disorder sufficient to produce dementia, which is not considered to be the cause of the dementia; and

should be used in research studies when a single, gradually progressive severe cognitive deficit is identified in the absence of tother identifiable cause.

VI. Criteria for diagnosis of DEFINITE Alzheimer's disease are:

the clinical criteria for probable Alzheimer's disease and

histopathologic evidence obtained from biopsy or autopsy.

VII. Classification of Alzheimer's disease for research purposes should specify features that may differentiate subtypes of the disorder, such as:

familial occurrence;

onset before age 65;

presence of trisomy-21; and

coexistence of other relevant conditions such as Parkinson's disease.

REFERENCE:
McKhann, G., Drachman, D., Folstein, M., Katzman, R.,
Price, D., and Stadlan, E.M. (1984)
Clinical Diagnosis of Alzheimer's Disease: Report on thw NINCDS-ADRDA work group under the auspices of the Health and Human Services task force on ALzheimer's Disease.
Neurology, 34, 939-944.

NAME: ____________________ ID#: __________ DATE: ___/___/___ PERIOD: ________

MINI MENTAL STATE

(MMS)

Orientation	**Score**
What is the (year) (season) (month) (day) (date) (5 points)	( )
Where are we? (state) (county) (town) (hospital) (floor) (5 points)	( )
Registration	
Name 3 objects from list: Apple, Telephone, River, Book, Horse, Chair. 1 second to say each. Then ask the patient to repeat all three after you have said them. 1 point for each correct. (3 points)	( )
Attention and Calculation	
Serial 7s. 1 point for each correct. Stop at 5 answers. Or spell "world" backwards. (Number correct equals letters before first mistake- i.e., dlorw = 2 correct). (5 points)	( )
Recall	
Ask for the objects above. 1 point for each correct. (3 points)	( )
Language Tests	
Name- pencil, watch (2 points)	( )
Repeat- no ifs, ands or buts (1 point)	( )
Follow a 3 stage command: "Take the paper in your right hand, fold it in half, and put it on the floor." (3 points)	( )
Read and obey the following:	
CLOSE YOUR EYES. (show statement printed on prior page.) (1 point)	( )
Write a sentence spontaneously on the next page. (1 point)	( )
Copy the design on the next page. (1 point)	( )
TOTAL (30 POINTS)	( )

TESTER: ____________ COMMENTS: ______________________________

CLOSE YOUR EYES

NAME: ______________________ ID#: ________ DATE: ___/___/___ PERIOD: ______

WRITE A SENTENCE BELOW

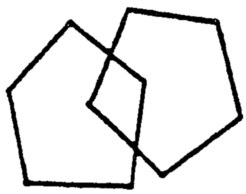
____

____

____

____

COPY THIS BELOW



REFERENCE:
Folstein, M.F., Folstein, S.E. and McHugh, P.R. (1975) "Mini-Mental-State," a practical guide for grading the mental state of patients for the clinician. Journal of Psychiatric Research, 12, 189-198.

NAME: ______________________ ID#: ________ DATE: ___/___/___ PERIOD: ______

GLOBAL DETERIORATION SCALE (GDS)

(Choose the most appropriate global stage and CIRCLE ONLY ONE.)

(1) No subjective complaints of memory deficit.
No memory deficit evident on clinical interview.

(2) Subjective complaints of memory deficit, most frequently in following areas:
- (a) forgetting where one has placed familiar objects;
- (b) forgetting names one formerly knew well.

No objective evidence of memory deficit on clinical interview.
No objective deficit in employment or social situations.
Appropriate concern with respect to symptomatology.

(3) Earliest clear-cut deficits.

Manifestations in more than one of the following areas:
- (a) patient may have gotten lost when travelling to an unfamiliar location.
- (b) co-workers become aware of patient's relatively poor performance.
- (c) word and name finding deficit become evident to intimates.
- (d) patient may read a passage or book and retain relatively little material.
- (e) patient may demonstrate decreased facility remembering names upon introduction to new people.
- (f) patient may have lost or misplaced an object of value.
- (g) concentration deficit may be evident on clinical testing.

Objective evidence of memory deficit obtained only with an intensive interview.
Decreased performance in demanding employment and social settings.
Denial begins to become manifest in patient.
Mild to moderate anxiety frequently accompanies symptoms.

(4) Clear-cut deficit on careful clinical interview.

Deficit manifest in following areas:
- (a) decreased knowledge of current and recent events.
- (b) may exhibit some deficit in memory of one's personal history.
- (c) concentration deficit elicited on serial subtractions.
- (d) decreased ability to travel, handle finances, etc.

Frequently no deficit in following areas:
- (a) orientation to time and place.
- (b) recognition of familiar persons and faces.
- (c) ability to travel to familiar locations.

Inability to perform complex tasks.
Denial is dominant defense mechanism.
Flattening of affect and withdrawal from challenging situations occur.

(5) Patient can no longer survive without some assistance.
Patient is unable during interview to recall a major relevant aspect of their current life, e.g.:
  (a) their address or telephone number for many years.
  (b) the names of close members of their family (such as grandchildren).
  (c) the name of the high school or college from which they graduated.

Frequently some disorientation to time (date, day of the week, season, etc.) or to place.
An educated person may have difficulty counting back from 40 by 4s or from 20 by 2s.
Persons at this stage retain knowledge of many major facts regarding themselves and others.
They invariably know their own names and generally know their spouse's and children's names.
They require no assistance with toileting or eating, but may have difficulty choosing the proper clothing to wear.

(6) May occasionally forget the name of the spouse upon whom they are entirely dependent for survival.
Will be largely unaware of all recent events and experiences in their lives.
Retain some knowledge of their surroundings; the year, the season, etc.
May have difficulty counting by 1s from 10, both backward and sometimes forward.
Will require some assistance with activities of daily living:
  (a) may become incontinent.
  (b) will require travel assistance but occasionally will be able to travel to familiar locations.

Diurnal rhythm frequently disturbed.
Almost always recall their own name.
Frequently continue to be able to distinguish familiar from unfamiliar persons in their environment.
Personality and emotional changes occur. These are quite variable and include:
  (a) delusional behavior, e.g., patients may accuse their spouse of being an imposter; may talk to imaginary figures in the environment, or to their own reflection in the mirror.
  (b) obsessive symptoms, e.g., person may continually repeat simple cleaning activities.
  (c) anxiety symptoms, agitation, and even previously non-existent violent behavior may occur.
  (d) cognitive abulia, e.g., loss of willpower because an individual cannot carry a thought long enough to determine a purposeful course of action.

(7) All verbal abilities are lost over the course of this stage.
Early in this stage words and phrases are spoken but speech is very circumscribed.
Later there is no speech at all - only grunting.
Incontinent of urine;requires assistance toileting and feeding.
Basic psychomotor skills (e.g. ability to walk) are lost with the progression of this stage.
The brain appears to no longer be able to tell the body what to do.
Generalized and cortical neurologic signs and symptoms are frequently present.

CLINICIAN: ______________________________ DATE: _____/_____/_____

REFERENCE:

Reisberg, B., Ferris, S., Deleon, M., and Crook, T. (1982)
The global deterioration scale for the assessment of primary degenerative dementia
Jl. of American Geriatric Society, 1939, 1136-1139.

FOUR FACTOR INDEX OF SOCIAL STATUS

SUBJECT NAME ______________________________

SUBJECT NUMBER __________

GROUP HY HE SDAT

OCCUPATION

Higher executives, proprietors of large businesses, and major professionals Score 9

Administrators, lesser professionals, proprietors of medium-sized businesses Score 8

Smaller business owners, farm owners, managers, minor professionals Score 7

Technicians, semiprofessionals, small business owners Score 6

Clerical and sales workers, small farm and business owners Score 5

Smaller business owners, skilled manual workers, craftsmen and tenant farmers Score 4

Machine operators and semiskilled workers Score 3

Unskilled worker Score 2

Farm laborers, menial service workers, welfare Score 1

MARITAL STATUS

Married, living with spouse

Family without spouse (include widow, divorced, separated)

Single

EDUCATION

Less than 7th grade	Score 1
Junior high school	Score 2
Patial high school	Score 3
High school graduate	Score 4
Partial college	Score 5
College graduate	Score 6
Graduate degree	Score 7

GENDER

Female

Male

A factor weight of 5 is given to the occupation score and a factor weight of 3 is given to the education score. These two scores are combined with the marital, and gender scores to calculate a status score for an individual.

Factor	Scale Score	Factor Weight	Score x Weight
occ		5	
ed		3	
			----------------
total score			

REFERENCES

Albert, M.S. and Milberg, W. (1989). Semantic processing in patients with Alzheimer's disease. Brain and Language, 37, 163-171.

Appell, J., Kertesz, A., and Fisman (1982). A study of language functioning in Alzheimer's disease. Brain and Language, 17, 73-91.

Au, Albert, M.L.,and Obler, L.K. (1989). Language in normal aging linguistic and neuropsychological factors. Journal of Neurolinguistics, 4, 347-364.

Balota, D., and Cheney, M. (in press). Automatic and attentional priming in young and older adults. Journal of Experimental Psychology: Human Perception and Performance.

Balota, D. and Chumbley, J. (1990). Where are the effects of frequency in visual word recognition tasks? Right where we said they were! Comment on Monsell, Doyle, and Haggard (1989). Journal of Experimental Psychology (General), 119, 231-237.

Balota, D., and Duchek, J. (in press). Age-related changes in spreading activation: implications for connectionist models of cognitive aging. To appear in R.M. Coe and Strong (Eds.), Memory Functions in Aging and Aging-Related Disorders.

Balota, D. and Duchek, J. (1991). Semantic priming effects, lexical repetition effects, and contextual disambiguation effects in healthy aged individuals and individuals with senile dementia of the Alzheimer type. Brain and Language, 40, 181-201.

Balota, D., and Duchek, J. (1989). Spreading activation in episodic memory: Further evidence for age independence. The Quarterly Journal of Experimental Psychology, 41A, 849-876.

Balota, D., and Duchek, J. (1988). Age-related differences in lexical access, spreading activation and simple pronunciation. Psychology and Aging, 3, 84-93.

Balota, D., Duchek, J., and Paullin, R. (1989). Age-related differences in the impact of spacing,lag, and retention interval. Psychology and Aging, 4, 3-9.

Balota, D., Ferraro, F.R., and Connor, L.T. (1991). On the early influence of meaning in word recognition: a review of the literature. In P. Schwanenflugel, (Ed.), The Psychology of Word Meanings.

Balota, D., Black, S., and Cheney, M. (1992). Automatic and attentional priming in young and older adults: reevaluation of the two-process model. Journal of Experimental Psychology, 18, 485-502.

Battig, W.F., and Montague, W.E. (1969). Category norms for verbal items in 56 categories. Journal of Experimental Psychology Monographs, 80, 1-46.

Bayles, K.A., and Kaszniak, A.W. (1987). Communication and Cognition in Normal Aging and Dementia. Boston: College-Hill Press.

Bayles, K.A., and Tomoeda, C.K. (1983). Confrontation naming impairment in dementia. Brain and Language, 19, 98-114.

Berg, L. (1985). Does Alzheimer's disease represent an exaggeration of normal aging? Archives of Neurology, 42, 737-739.

Blessed, G., Tomlinson, B.E., and Roth, M. (1968). The association between quantitative measures of dementia and of senile change in the cerebral grey matter of elderly subjects. British Journal of Psychiatry, 114, 797-811.

Bondareff, W. (1986). Neuropathology of nucleus basalis and locus ceruleus in Alzheimer's disease. In Scheibel and Wechsler (Eds.) The biological substrate of Alzheimer's disease, New York: Academic Press, 101-113.

Brody, H. (1970). Structural changes in the aging nervous system. Interdisciplinary Topics in Gerontology, 7, 9-21.

Chertkow, H., Bub, D., and Seidenberg, M. (1989). Priming and semantic memory loss in Alzheimer's disease. Brain and Language, 36, 420-446.

Clark, L.W. (1985). Lexical semantics and Alzheimer's disease. Doctoral Dissertation, City University of New York. New York.

Coyle, J., Price., Delong, M. (1983). Alzheimer's disease: A disorder of cortical cholinergic innervation. Science, 219, 1184-1190.

Collins, A.M. and Loftus, E.F. (1985). A spreading-activation theory of semantic processing. Psychological Review, 82, 407-428.

Cummings, J. (1982). Cortical dementias. In Benson and Blumer (Eds.) Psychiatric aspects of neurological disease, 2, 92-121.

deGroot, A.M.B., Thomassen, A.J.W.M. and Hudson, P.T.W. (1982). Associative facilitation of word recognition as measured from a neutral prime. Memory and Cognition, 10, 358-370.

Flicker, C., Ferris, S., Crook, T., and Bartus, R. (1987). Implication of memory and language dysfunction in the naming deficit of senile dementia. Brain and Language, 31, 187-200.

Fodor, J. (1983). Modularity of mind: An essay on faculty psychology Cambridge: MIT Press.

Folstein, M.F., Folstein, S.E. and McHugh, P.R. (1975). Mini-Mental-State: practical guide for grading the mental state of patients for the clinician. Journal of Psychiatric Research, 12, 189-198.

Forster, K. (1981). Priming and the effects of sentence and lexical contexts on naming time: evidence for autonomous lexical processing. Quarterly Journal of Experimental Psychology, 33A, 465-495.

Forster, K. (1978). Accessing the mental lexicon. In E. Walker, (Ed.), Explorations in the biology of language, Bradford Books.

Forster, K. and Davis, C. (1991). The density constraint on form-priming in the naming task: Interference effects from a masked prime. Journal of Memory and Language, 30, 1-25.

Forster, K., Davis, C., Schoknecht, C., and Carter, R. (1987). Masked priming with graphemically related forms: Repetition or partial activation? Quarterly Journal of Experimental Psychology, 39A, 211-251.

Gewirth, L.R., Schindler, A.G., and Hier, D.B. (1984). Altered patterns of word associations in dementia and aphasia. Brain and Language, 21, 307-317.

Gordon, B. (1982). Confrontational naming: computational model and disconnection simulation. In Neural Models of Language Processes , M. Arbib, D. Caplan, J. Marshall (Eds.) New York: Academic Press.

Grober, E., Buschke, H., Kawas, C., and Fuld, P. (1985). Impaired ranking of semantic attributes in dementia. Brain and Language, 26, 276-286.

Hartman, M. (1991). The use of semantic knowledge in Alzheimer's disease: Evidence for impairments of attention. Neuropsychologia, 29, 213-228.

Hartman, M.D. (1987). A cognitive-neuropsychological study of semantic representation in dementia of the Alzheimer type. Doctoral Dissertation, University of Minnesota, Rochester.

Hasher, L., and Zacks, R.T. (1979). Automatic and effortful processes in memory. Journal of Experimental Psychology, General, 108, 356-388.

Hier, D., Hagenlocker, K., and Gellin-Schindler, A. (1985). Language disintegration in dementia: affects of etiology and severity. Brain and Language, 25, 102-116.

Huff, F., Corkin, S., and Growdon, J. (1986). Semantic impairment in anomia and Alzheimer's disease. Brain and Language, 28, 235-249.

Hunt, K.P. and Hodge, M.H. (1971). Category-item frequency and category-name meaningfulness: Taxonomic norms for 84 categories. Psychonomic Monograph Supplements, 4, 97-120.

Jorm A. (1986). Controlled and automatic information processing in senile dementia: a review. Psychological Medicine, 16, 77-88.

Katzman, R., Terry, R., DeTeresa, B., Brown, T., Davies, P., Fuld, P., Renbing, K., and Peck, A. (1988). Clinical, pathological, and neurochemical changes in dementia a subgroup with preserved mental status and numerous neocortical plaques. Annals of Neurology, 223, 138-144.

Kemper, T. (1984). Neuroanatomical and neuropathological changes in normal aging and in dementia. In M. Albert, (Ed.) Clinical neurology of aging, New York: Oxford University Press, 9-52.

Kempler, D. (1991). Language changes in dementia of the Alzheimer's type. In R. Lubinski, (Ed.) Dementia and Communication, Phila.: Decker Pub.

Kempler, D., Curtiss, S., and Jackson, C. (1987). Syntactic preservation in Alzheimer's disease. Journal of Speech and Hearing Research, 30, 343-350.

Kirshner, D.H, Webb. W., and Kelly, M. (1984). The naming disorder of dementia. Neuropsychologia, 22, 23-30.

Kucera, J. and Francis W.N. (1976). Computational analysis of present-day American English. Providence: Brown University Press.

LaBarge, E., Edwards, D., and Knesvich, J. (1986). Performance of normal elderly on the Boston Naming Test. Brain and Language, 27, 380-384.

Margolin, D.I. (1987). Lexical priming by pictures and words in aging, stroke and dementia, Doctoral Dissertation, University of Oregon, Dissertation Abstracts International, 49, 1416B.

Marshall, N.B. (1993). The effect of priming on the recognition of spoken gated words in healthy young and elderly listeners and listeners with Alzheimer's Disease. Doctoral Dissertation, University of Alabama.

Martin, A., Brouwers, P., Cox, C., and Fedio, P. (1985). On the nature of the verbal memory deficit in Alzheimer's disease. Brain and Language, 25, 323-341.

Martin, A., Cox, C., Brouwers, P., and Fedio, P. (1985). A note on different patterns of impaired and preserved cognitive abilities and their relation to episodic memory deficits in Alzheimer's disease. Brain and Language, 26, 181-185.

Martin, A., and Fedio, P. (1983). Word production and comprehension in Alzheimer's disease: The breakdown of semantic knowledge. Brain and Language, 19, 124-141.

McGeer, E., McGeer, P., Kamo, H., Tago,H., and Harrop, R. (1986). Cortical metabolism, acetylcholinesterase staining and pathological changes in Alzheimer's disease. Canadian Journal of Neurological Science, 13, 511-516.

McKhann, G., Drachman, D., Folstein, M., Katzman, R., Price, D., and Standlan, E.M. (1984). Clinical diagnosis of Alzheimer's Disease: Report on the NINCDS-ADRDA work group under the auspices of the Health and Human Services Task Force on Alzheimer's disease. Neurology, 34, 939-944.

Nebes, R.D. (1992). Cognitive dysfunction in Alzheimer's disease. In F.I.M. Craik and T. Salthouse, (Eds.), Handbook of Aging and Cognition, Erlbaum Publishers.

Nebes, R.D. (1992). Generalized cognitive slowing and severity of dementia in Alzheimer's disease: Implications for the interpretation of response time data Journal of Clinical and Experimental Neuropsychology, 14, 317-326.

Nebes, R.D. (1989). Semantic memory in Alzheimer's disease. Psychological Bulletin, 106, 377-394.

Nebes, R.D., Boller, F., and Holland, A. (1986). Use of semantic context by patients with Alzheimer's disease, Psychology and Aging, 1, 261-269.

Nebes, R.D., and Brady, C.B. (1988). Integrity of semantic fields on Alzheimer's disease. Cortex, 24, 291-300.

Nebes, R.D. and Brady, C.B. (1989). Focused and divided attention in Alzheimer's disease. Cortex, 25, 305-315.

Nebes, R.D., and Brady, C.B. (1990). Preserved organization of semantic attributes in Alzheimer's disease. Psychology and Aging, 5, 574-579.

Nebes, R.D., and Brady, C.B. (1991). The effect of contextual constraint on semantic judgements by Alzheimer patients. Cortex, 27, 237-246.

Nebes, R.D., Brady, C.B. and Huff, F.J. (1989). Automatic and attentional mechanisms of semantic priming in Alzheimer's disease. Journal of Clinical and Exp. Neuropsychology, 11, 219-230.

Nebes, R.D., Brady, C.B. and Jackson, S.T. (1989). The effect of semantic and syntactic structure on verbal memory in Alzheimer's disease. Brain and Language, 36, 301-313.

Nebes, R.D. and Madden, D.J. (1988). Different patterns of cognitive slowing produced by Alzheimer's disease and normal aging. Psychology and Aging, 3, 102-104.

Nebes, R.D. Martin, D.C. and Horn, L.C. (1984). Sparing of semantic memory in Alzheimer's disease. Journal of Abnormal Psychology, 93, 321-330.

Neely, J.H. (1976). Semantic priming and retrieval from lexical memory: Evidence for facilitatory and inhibitory processes. Memory and Cognition, 4, 648-654.

Neely, J.H. (1977). Semantic priming and retrieval from lexical memory: roles of inhibitionless spreading activation and limited capacity attention. Journal of Experimental Psychology: General, 106, 226-254.

Neely, J.H. (1991). Semantic priming effects in visual word recognition: a selective review of current findings and theories. In D. Besner and G.W. Humphreys (Eds.) Basic Processes in Reading: Visual Word Recognition. Hillsdale: Lawrence Erlbaum Associates.

Nicholas, M., Obler, L.K., Albert, M., and Helm-Estabrooks, N. (1985). Empty speech in Alzheimer's disease and fluent aphasia. Journal of Speech and Hearing Research, 28, 405-410.

Ober, B.A., Dronkers, N.F, Koss, E., Delis, D.C. and Friedland, R.P. (1986). Retrieval from semantic memory in Alzheimer-type dementia. Journal of Clinical and Experimental Neuropsychology, 8, 75.

Ober, B.A. and Shenaut, G.K. (1990). Automatic versus controlled semantic priming in Alzheimer's Disease. Journal of Clinical and Experimental Neuropsychology, 12 (Abs).

Ober, B.A., Shenaut, G.K., Jagust, W.J., and Stillman, R.C. (1991). Automatic semantic priming with various category relations in Alzheimer's disease and normal aging. Psychology and Aging, 6, 647-660.

Ober, B.A. and Shenaut, G.K. (1988). Lexical decision and priming in Alzheimer's disease. Neuropsychology, 26, 273-286.

Ober, B., and G. Shenaut (1992). Automatic and controlled semantic priming in Alzheimer's Disease: A synthesis of current findings (In communication)

Obler, L.K. and Albert, M.L. (1983). Language and aging: A neurobehavioral analysis. In D. Beasley and G.A. Davis (Eds.), Speech, Language, Hearing in the Aging Process, New York: Grune and Stratton.

Obler, L.K. and Albert, M.L. (1983). Language in the elderly aphasic and the dementing patient. In M. Sarno (Ed.), Acquired Aphasia, New York: Academic Press.

Palermo, D.S. and Jenkins, J.J. (1964). Word Association Norms, Minneapolis: Univ. of Minn. Press.

Posner, M. and Snyder, C. (1975). Attention and cognitive control, In R. L. Solso, (Ed.), Information Processing and Cognition, The Loyola Symposium. Hillsdale, N.J.: Erlbaum Assoc.

Postman, L. (1970). The California norms: Associations as a function of word frequency. In L. Postman and G. Keppel (Eds.). Norms of word associations. New York, Academic Press.

Prather, P., Zurif, E., Stern, C., and Rosen, T.J. (1982). Slowed lexical access in non-fluent aphasia: A case study (In communication).

Reisberg, B., Ferris, S., Deleon, M. and Crook, T. (1982). The global deterioration scale for the assessment of primary degenerative dementia. Journal of the American Geriatric Society, 1939, 1136-1139.

Rosen, W. and Mohs, R. (1982). Evolution of cognitive decline in dementia In S. Corkin, et. al., (Eds.), Alzheimer's disease: A report in progress. New York: Ravens Press.

Schwartz, M.F., Marin, O.S.M., and Saffran, E.M. (1979). Dissociations of language function in dementia and amnesia: A case study. Brain and Language, 7, 277-306.

Shapiro, S.I. and Palermo, D. S. (1970). Conceptual organization and class membership: Normative data on representation of 100 categories. Psychonomic Monograph Supplements, 3, 107-172.

Shimamura, A.P., Salmon, D.P. Squire, L.R. and Butters, N. (1987). Memory dysfunction and word priming in dementia and amnesia. Behavioral Neuroscience, 1010, 347-351.

Squires, L., Knowlton, B., and Musen, G. (1993). The structure and organization of memory. Annual Review of Psychology, 44, 453-495.

Stern, C., Prather, P., Swinney, D., and Zurif, E. (1991). The time course of automatic lexical access and aging. Brain and Language, 40, 359-372.

Swinney, D. (1982). The structure and time course of information interaction during speech comprehension: lexical segmentation, access, and interpretation. In J. Mehler et. al., (Eds.), Perspectives on Mental Representation. Hillsdale: Erlbaum Assoc.

Tweedy, J.R., Lapinski, R.H., Schvaneveldt, R.W. (1977). Semantic-context effects on word recognition: Influence of varying the proportion of items presented in appropriate context. Memory and Cognition, 5, 84-89.