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Visual perception in normal aging and Alzheimer's disease: Influences on picture naming and recognition

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Case Western Reserve University, 1990
VISUAL PERCEPTION IN NORMAL AGING AND
ALZHEIMER'S DISEASE: INFLUENCES ON
PICTURE NAMING AND RECOGNITION

by

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Submitted in partial fulfillment of the requirements
for the degree of Doctor of Philosophy

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VISUAL PERCEPTION IN NORMAL AGING AND
ALZHEIMER'S DISEASE: INFLUENCES ON
PICTURE NAMING AND RECOGNITION

Abstract

by

JUDITH A. B. TURNER

Perceptual influences on naming and recognition of picture stimuli were assessed for a sample of 20 nondemented elderly and 20 Alzheimer’s disease patients. Subjects were shown three sets of 32 pictures to name and recognize. One set was presented without perceptual alteration. For the other two sets, a filter was applied to the spatial frequency magnitude spectra of the images to minimize (by degradation or enhancement) the perceptual effects of differences in spatial frequency contrast sensitivity between nondemented and Alzheimer subjects.

Naming and recognition accuracy and latency were analyzed as a function of several stimulus variables (e.g. visual complexity and word frequency), in conjunction with filter condition. Overall, both groups performed ably on naming and recognition tasks. Findings indicated that alterations of spatial frequency amplitude influenced naming performance. Both subject groups were less accurate in naming enhanced images relative to nonfiltered stimuli. The accuracy of Alzheimer patients also suffered under degraded conditions relative to nonfiltered stimuli. Both groups
were significantly slower in responding to degraded images, relative to nonfiltered and enhanced pictures.

Word frequency was found to interact with perceptual filtering. When low frequency words were shown in the enhanced condition, naming accuracy was diminished relative for nonfiltered stimuli for both groups. The accuracy of Alzheimer patients was also diminished when stimuli were degraded. Naming latency for nondemented subjects was not influenced by word frequency. For Alzheimer patients, however, naming latency was significantly decreased for high frequency, enhanced pictures.

Recognition (forced-choice, two alternative) accuracy and latency were not found to vary as a function of filter condition or word frequency for either group.

Correlational analyses suggested that image familiarity was significantly related to performance on naming tasks. This has not been recognized previously as an important variable. Implications of these findings and suggestions for future research are discussed.
Dedication

This work is dedicated to the Alzheimer patients and caregivers who gave so willingly of themselves and made this research possible.
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Introduction

Alzheimer's disease (AD) is an insidious progressive dementia that affects all spheres of cognitive function. It is the leading cause of intellectual impairment and accounts for approximately 55% of all dementias. Data from the 1980 census indicate that approximately 2.5 million Americans suffer from mild to moderate cognitive impairment while another 1.2 million are considered severely demented. If the 55% rate of AD in the demented population is accurate, then there are now over 2 million AD victims in the U.S. (Katzman, 1986). Since the prevalence of AD increases with age, the number of people afflicted with AD will burgeon with the graying of the population.

The costs of this illness are astronomical. Estimates for institutional care alone exceed $25 billion per year (Katzman, 1986). The cost to individual patients and their families is incalculable, as psychological and fiscal resources are consumed at an astounding rate. At the present time, the causes of AD are unclear. Remediation efforts have been directed at management and control of problematic behaviors, as no direct treatment for the primary symptoms of profound memory loss and disorientation have yet been found.

Memory problems are prominent throughout the course of AD, and can be traced to extensive pathology in areas of the brain associated with
memory functioning. This notwithstanding, there is commanding evidence to suggest that higher order visual perceptual deficits are also prevalent in AD patients. Though documented as early as 1950, the implications of perceptual disturbance have remained largely unexplored. Contemporary approaches to the study of visual perception suggest a major benefit may accrue from an increased understanding of the perceptual experience of AD patients. Although perceptual factors may play only a small part in the etiology of behavioral disturbance, that portion may be remediable.

The research described is an attempt to model and influence perceptual functioning through alteration of stimulus materials.

**Alzheimer's Disease**

Alzheimer's disease (AD) has been called "the disease of the century" (Thomas, 1981). Based on observations of a 51-year-old perplexed, disoriented, amnestic woman, Alois Alzheimer (1907) first described the complex of neuropathological findings and decreased cognitive functioning (or dementia) that are characteristic of AD. Because of the age of Alzheimer's patient, AD had been considered a pre-senile type of dementia, with dementia in later life primarily attributed to vascular changes. It is now recognized that the neuropathology of AD is found in both younger (than age 65) and older demented individuals, and
the pre-senile/senile distinction is no longer supported. (Katzman, 1986, among others, presents a concise review of relevant literature).

The onset of AD is insidious and its course is inexorably progressive. Diagnosis is generally accomplished by the exclusion, via examination, history, and laboratory tests, of other known causes of progressive dementia and disorders with symptoms that mimic dementia. In addition, diagnostic criteria generally include incremental decline and demonstrable impairment of short- and long-term memory function along with a disturbance of abstract thinking, judgment, or other higher cortical function (e.g. language, praxis, constructional ability) (McKhann et al., 1984; American Psychiatric Association, 1987). To better distinguish the dementia of AD from more benign forms of memory loss associated with normal aging, a recent revision of the Diagnostic and Statistical Manual of the American Psychiatric Association (DSM III-R, 1987) considers a significant disturbance of occupational or social functioning necessary for diagnosing AD.

Using all available sources of data, AD can be diagnosed with considerable accuracy. Confirmation of diagnosis, however, is only possible following post-mortem brain biopsy. On histological examination, brain tissue of AD victims is remarkable for the presence of neurofibrillary tangles and neuritic plaques in the cerebral cortex and limbic system structures (Katzman, 1986). Neurofibrillary tangles are abnormal nerve
fibers in which the cytoplasm is littered with bundles of structures known as paired helical filaments. Neuritic plaques consist of clusters of degenerating nerve endings with an amyloid protein core. While both of these lesions occur in normal aging and dementias other than AD, their distribution and frequency in AD is highly characteristic. Moreover, both tangles and plaques are composed largely of elements derived from healthy cells. These findings have led some to posit that AD may represent an acceleration of normal aging (e.g. Crook, 1987). Terry (1986) argues however, "that normal aging does not include any degree of dementia; dementia connotes disease; and that, therefore, AD, the major cause of dementia, is not accelerated normal aging but is, rather, abnormal, and is a disease sui generis." (p. 824).

AD is associated with a characteristic pattern of cerebral atrophy. In general, greatest atrophy is seen in the gyri of cortical association areas, with primary motor, somatosensory, and visual cortices relatively spared. Atrophy also occurs in normal aging, however, and although atrophy in AD is, on the average, 10 to 15 percent greater, there is overlap between the two groups. Consequently, atrophy (which is visible in CT scanning) is suggestive, but not diagnostic, of AD in individual cases.

There is also a particular pattern of neuronal cell death common in AD. Larger neurons are chiefly vulnerable, with losses estimated at 40 to 60 percent (Katzman, 1986). There is little or no change in the number of
glial cells and small neurons. Cell loss associated with AD has also been found in the hippocampus, the entorhinal cortex of the parahippocampal gyrus, the locus ceruleus, and the nucleus basalis of Meynert (Terry, 1986).

Interestingly, extent of cell loss does not correlate highly with degree of functional impairment. Loss remains moderate even in individuals who are severely clinically disabled. This suggests that it is not the number of cells affected but rather their type or location that is of key importance in determining degree of dysfunction. As the behavioral hallmark of AD is profound memory loss, particularly for recent information, the central role played by the hippocampus in memory functioning (Mishkin & Appenzeller, 1987) may explain why cognitive performance deteriorates so markedly despite involvement of relatively few cells.

In contrast to cell loss, the number of neuritic plaques in the cerebral cortex is strongly correlated with performance on mental status tests and functional ability (Blessed, Tomlinson, & Roth, 1968; Katzman, 1986). With a pattern of distribution that parallels that of cell loss, the hippocampus, entorhinal cortex, and amygdala (all of which are required for adequate memory function) are also prominent sites for neuritic plaques and neurofibrillary tangles.

Coincident with cell death and dysfunction in AD is a corresponding disturbance of neurochemistry. Though several transmitter
systems are affected, the cholinergic system, because of its relationship to memory and cognitive function, is of primary interest. Associated with AD is a significant reduction in the amount of the enzyme choline acetyltransferase present in the cerebral cortex, hippocampus, and amygdala. This is highly correlated with changes in performance on mental status tests (Terry, 1986). Strong evidence suggests that this deficit stems from neuronal degeneration in specific areas of the basal forebrain, namely the nucleus basalis of Meynert and adjacent structures (Whitehouse et al., 1982). Supported by encouraging preliminary findings, extensive research efforts are now being directed at developing biochemical means to remediate this cholinergic loss.

The increasing numbers of AD victims represent a tremendous challenge to psychology. In contrast to the detailed examination of neuropathological findings, psychological correlates have been studied primarily on a descriptive level. Although there are some differences in characterization of the sequence and pattern of decline in AD, several generalities emerge from the existing body of literature. Clearly, some abilities are preserved until the later stages of the illness while others are compromised from the onset.

Early difficulties typically include word-finding problems, decreased ability to handle complex tasks, getting lost while driving, misplacing objects of value or forgetting important appointments, problems retaining
new information, and impaired concentration. Secondary to these deficits, occupational and social functioning may be disturbed. There is a flattening of affect at this point, along with marked denial of impairment. Social withdrawal is also common (Reisberg, 1983; Reisberg et al., 1986; Shuttleworth, 1986).

Later in the course of AD, concentration and calculation abilities are markedly disturbed, and patients are generally unable to handle their finances beyond the intermediate stages of the disease when dementia is characterized as moderate. Memory continues to deteriorate. Organizational skills are also in decline, making it difficult to successfully complete complex activities such as shopping or planning a meal. Motor functions are typically first impaired in the middle stages of the illness as is speech production (Reisberg et al., 1986).

As the disease progresses, victims can not survive without assistance. Disorientation extends to many significant aspects of daily life, and even simple decision making becomes overly challenging. Marked derangements of personality and emotional functioning are typically prominent when the disease is considered moderately severe. In the end stages of the illness, victims are often unable to communicate or ambulate and require total care (Reisberg et al., 1986).
Perceptual Dysfunction in Alzheimer's Disease

Though behavioral and cognitive deficits are pathognomonic symptoms, recent research in the field of visual perception suggests that there is a significant impairment in visual information processing also associated with AD. Functionally, this would mean that the information available in the visual system of the Alzheimer patient is impoverished in certain respects. The impact of inadequate image representation could have profound consequences throughout the perceptual-cognitive system. Information that is poorly perceived is more difficult to manipulate, process, and remember. Consequently, a disturbance of visual perception could masquerade as a more global cognitive or memory deficit, as Regan, Raymond, Ginsburg, & Murray (1981) have suggested. This could be a particular problem in the estimation of the cognitive deficit in AD, since many of the tests used in assessment of cognitive function rely on visual stimuli.

Several aspects of visual perception in AD have been investigated. Williams (1956) initially documented changes in perception coincident with cognitive impairment in older adults. She noted that demented patients appeared to be deficient in the ability to discern relevant environmental cues, thereby leading to poor performance on perceptual identification tasks. She was able to demonstrate that with specific cuing to focus attention on key perceptual variables, to some degree performance could
be brought closer to the norm. Corkin (1982) observed a similar defect in Alzheimer patients that contributed to their impaired performance on a conceptual closure task. Miller (1981) observed that the ability to manipulate visuospatial relationships may be especially prone to decline in dementia. This may underlie defects in drawing ability and constructional functions observed by Nissen, Corkin, Growdon, Wray & Bauer, (1983) and others (see Lezak, 1983).

In an effort to understand why Alzheimer patients often complain of difficulty seeing despite adequate acuity and no ocular pathology, Hutton (1985) investigated the possibility that this clinical complaint was based on an inability to adequately track and perceive visual stimuli. In a series of experiments comparing normal, depressed, and demented elderly, he found that the smooth pursuit eye movement system is impaired in AD along with a disturbance of oculomotor programming. That is, unlike healthy or depressed older adults, Alzheimer patients are compromised in their ability to direct eye movements in visual search, tending to be disorganized and perseverative in their tracking. These findings may relate to the visuospatial confusion commonly occurring in AD. Hutton also notes that average eye fixation duration was significantly greater for the Alzheimer group, suggesting a slowing in the encoding of visual information. A unique combination of findings from flash and pattern visual evoked potential (VEP) studies have also been found to be
characteristic of AD, and support the contention that the primary visual
cortex is spared (Wright, Drasdo, & Harding, 1987; Wright, Harding, &
Orwin, 1986). In fact, many basic visual processes, including Snellen
acuity, critical flicker fusion, color vision, and Vernier acuity appear to
remain relatively unaffected (Nissen et al., 1985).

Because perceptual disturbances cannot be explained by
derangement of basic visual mechanisms, it appears that the integrity of
the sensory information must be compromised after entering the visual
system. Several studies have noted the increased susceptibility of AD
patients to the effects of pattern masks relative to elderly controls.
Interestingly, this difference does not hold for presentation of a
homogeneous (flash) mask, to which both groups are less but equally
vulnerable (Coyne, Liss, & Geckler, 1984; Nissen et al, 1985; Schlotterer,

In addition, Cogan (1985) reports a number of case observations of
severely deficient visual functioning (without peripheral ocular pathology
or impaired acuity) as the prominent symptom in early AD. Nissen et al.
(1985) also describe a case of profound visual disturbance as a striking
early AD symptom. Recent observations of optic nerve degeneration upon
autopsy (Hinton, Sadun, Blanks, & Miller, 1986) and characteristic
limitation of the visual field (Steffes & Thralow, 1987) may help to explain
these seemingly anomalous findings.
Visual Perception and Spatial Vision

Though visual perceptual changes coincident with AD have been noted since the 1950's, they have not been the subject of much experimentation. Consequently, many aspects of perceptual functioning in AD patients remain unexplored. Our understanding of perception in AD can be greatly enhanced by taking into account recent theoretical and technical developments in the larger field of vision research. Contemporary advances in this area are based on a model of perception as "information processing." Traditional theories of perception assume that visual experience is an immediate outcome of sensory stimulation. In contrast, the major assumption of an information processing model is that perception is not an automatic result of sensory input but is the sum of a number of neurophysiologically mediated cognitive processes that occur over time. The course of processing involves a series of dynamic transformations of the information contained in internal representations of the stimulus (Haber & Hershenson, 1980). Stimuli vary in the kind and amount of information they contain, and individuals vary in the kind and amount of information they can effectively process. Moreover, a disturbance at any stage of processing will influence the quality and quantity of information available throughout the perceptual-cognitive system.
There is compelling theoretical and experimental evidence to support this viewpoint, much of which is derived from the psychophysical literature on spatial vision. Researchers studying the neurological substrates of vision determined that different neural channels in the visual system are differentially sensitive to not only placement of a stimulus in the visual field but also to constructional properties of the stimulus itself (Campbell & Robson, 1968; Livingstone & Hubel, 1987). These channels were found to have varying temporal response characteristics as well. Transient, or magnocellular channels were found to respond quickly to the onset of stimulation and turn off after a brief period. These pathways are also most sensitive to high temporal frequencies, that is, a rapid rate of spatial change or movement. The magnocellular system is predominant in peripheral vision. Another set of visual pathways characterized by a slower response of longer duration were also described and are known as sustained, or parvocellular channels. Parvocellular channels are most sensitive to low temporal frequencies or stationary targets, and predominate in central vision. This conception of visual perception is referred to as the multi-channel model, and underlies the notion that perceptual and cognitive functions are subject to a dynamic flow of information.

Magnocellular and parvocellular neural channels also differ in their response to certain perceptual aspects of the stimulus, particularly spatial
frequency information. Like the analysis of sound into component auditory frequencies, any visual target can be analyzed and described by its unique spatial (two-dimensional) frequency spectra via a process of Fourier transformation. Magnocellular and parvocellular neural channels appear to be tuned to be maximally sensitive to different bands of spatial frequencies. That is, they respond optimally to a particular spatial frequency and also, to a decreasing extent, to spatial frequencies separated from the optimum by a factor of two (one octave) on either side (Blakemore & Campbell, 1969). Magnocellular channels are most responsive to low frequencies that carry information about the global shape of form of the percept, and parvocellular channels to high frequencies that correspond to the details of an image.

A plethora of research documents the significant interindividual differences in visual perception of spatial frequency information, as assessed by sensitivity to the detection of contrast in gratings consisting of sinusoidally varying dark and light bars. The spatial frequency of the grating is determined to be the number of pairs of light and dark bars per degree of visual angle, expressed in cycles per degree (cpd). Experimentally, gratings can be constructed that include only one spatial frequency, and sensitivity to that particular frequency can be determined by increasing grating contrast until the target is visible to the observer. Sensitivity is most often tested over a range of spatial frequencies,
producing a profile that reflects the integrity of the entire visual system. Target gratings are either stationary (no periodic spatial change) or flickered at a predetermined rate. Perception of complex images composed of numerous spatial frequencies is assumed to be a function of sensitivity to pure gratings.

Differences in contrast sensitivity across adulthood have been extensively studied. Historically, data in this area have been quite contradictory, as others have noted (e.g. Kline, Schieber, Abusamra, & Coyne, 1983; Owsley, Sekuler, & Siemsen, 1983). Clarification of sampling and methodology have contributed to the development of a more cohesive literature, with evidence of consistent age-related trends. When presented with stationary gratings, older adults evidence a significant decrease in contrast sensitivity (relative to young adults with targets matched for retinal illumination) only for high spatial frequency information (Kline et al., 1983; Owsley et al., 1983). When gratings are flickered, a different deficit pattern appears. Relative to young adults, the elderly demonstrate a small but significant loss in contrast sensitivity to both low and high spatial frequencies. The extent of low frequency loss is directly related to flicker rate, with a significant difference apparent only at very rapid rates of flicker (Gilmore & Royer, 1984; Royer & Gilmore, 1985). In sum, there appears to be an age-associated loss in sensitivity to high spatial frequency information contained in stationary targets, which extends to
lower spatial frequencies as the target moves or increases its rate of spatial change.

**Contrast Sensitivity in Alzheimer's Disease**

Recent studies of spatial frequency contrast sensitivity in AD have opened up a new avenue toward understanding the perceptual changes described in earlier reports. Schlotterer et al. (1983) first investigated sensitivity to spatial contrast as a function of mental status, and found no significant differences between demented subjects and age-matched controls. However, subsequent investigations have failed to replicate this finding, and instead suggest that there is a meaningful difference in sensitivity between groups across a range of spatial frequencies (Nissen et al., 1985; Gilmore, Turner, & Mendez, submitted for publication). The apparent inconsistency of findings can be reconciled by taking into account differences in sampling and methodology among the studies. The presence of a significant effect attributable to cognitive status may have been obscured in the Schlotterer et al. (1983) study by matching subjects for visual acuity, and by conducting the experiment such that both Alzheimer and nondemented elderly subjects performed quite poorly.

Differences in contrast sensitivity between Alzheimer patients and nondemented elderly were found to be most clearcut at the lowest spatial frequencies tested, implying a deficit in magnocellular channel function. Magnocellular channels play a key role in pattern recognition processes,
suggesting that complex activities such as form identification, reading, and pattern integration may also be compromised.

As a test of whole system integrity, contrast sensitivity assessment represents a major advance over the information obtainable by more traditional measures. For example, there are now ample data to suggest that acuity, the standard screening tool for visual function, provides an incomplete, inadequate, and sometimes inaccurate picture of an individual's visual capabilities. Acuity is typically assessed by having the individual identify optotypes (usually black letters) on a wall chart placed some measured distance from the observer. The data derived from this procedure belie a number of assumptions. First, it is assumed that all observers who can identify the letter at the same distance have equivalent visual capabilities in all circumstances. Secondly, it ignores the fact that unlike many real-world stimuli, the wall chart provides a high-contrast, non-moving target that may influence the probability of correct identification. Finally, identification errors are largely attributed to sensory or optical defects. Neither higher order visual processes or stimulus factors are assessed or considered relevant to performance. It is now recognized that standard acuity measures only predict one's ability to perceive high contrast, high spatial frequency stimuli. Perception of targets primarily composed of low spatial frequencies is not adequately described
by acuity, as sensitivity to low and high spatial frequencies are independent of one another.

To complement the experimental dissociation of acuity and contrast sensitivity is the clinical observation that many individuals with adequate acuity and no ocular pathology complain of difficulty seeing (Bodis-Wollner, 1972; Legge, Rubin, Pelli, & Schleske, 1985; Lovegrove, Martin, & Slaguis, 1986; Regan et al., 1981). A decline in contrast sensitivity would be likely to result in a visual environment that appeared blurry or sketchy, depending on the nature of the deficit. Moreover, deficient spatial frequency processing has also been associated with impaired mobility, as accurate perception of low and high frequency stimuli is necessary for edge detection (Rosenbloom, 1986). Fortunately, compromised vision can often be compensated by nonvisual mechanisms (e.g. memory). For the victim of AD however, impaired spatial frequency contrast sensitivity may have profound consequences. In this population cognitive deficits make compensation improbable.

More importantly, the limited perception of visual input may play an etiological role in the production of neuropsychological deficits in the Alzheimer patient. Stimuli that are perceptually impoverished are less likely to be encoded adequately, which in turn may affect higher order information processing. The performance of AD patients on cognitive
tests that involve visual stimuli would also be hampered by defects in perception.

Several points can be derived from the existing body of data on visual perception in AD. First, it is apparent that basic visual processes remain intact while other aspects of perceptual function are disturbed. That is, the integrity of visual information is compromised after it enters the system, suggesting an impairment in higher order perceptual processing. Secondly, current descriptors of visual functioning, such as acuity, do not necessarily reflect higher order deficits. Finally, it is unclear to what extent perceptual dysfunction contributes to the behavioral abnormalities typical of AD. While this association has been hypothesized, empirical studies have not tested the relationship directly.

As a first step toward examining the link between perceptual dysfunction in Alzheimer's disease and concomitant behavioral abnormalities, Gilmore, Turner, and Mendez (submitted for publication) determined contrast sensitivity functions for two groups of elderly subjects, Alzheimer and nondemented. Contrast sensitivity for a range of spatial frequencies was tested using two presentation conditions, static and flickered at the rate of 7.5 Hz. Alzheimer patients exhibited a consistently low level of sensitivity across the entire range of spatial frequencies (0.5, 1, 2, 4, and 8 cpd), with a particularly distinctive loss of sensitivity to low spatial frequencies. (see Figure 1). These data were then used in the
present investigation to create a filter, which, when applied to the magnitude spectra of visual images, would minimize the perceptual effects of group differences in contrast sensitivity. The filtering procedure used is described in detail on page 31.

Figure 1. Mean contrast sensitivity for Alzheimer's patients and healthy elderly adults under static (0 Hz) and counterphase (7.5 Hz) conditions.
Perceptual Influences on Confrontation Naming

Although the role of visual perception has not been extensively addressed in the neuropsychological assessment literature, there has been some attention paid to the role of perceptual factors involved in confrontation naming ability. In confrontation naming tasks, the subject is presented with a visual stimulus (an object, a photograph, or a drawing) and asked to provide its name. Unlike most other cognitive functions, confrontation naming ability is relatively stable across much of adulthood, and significant decline is not apparent until the seventh decade of life (Albert, Heller, & Milberg, 1988; Borod, Goodglass, & Kaplan, 1980; LaBarge, Edwards, & Knesevich, 1986; Nicholas, Obler, Albert, & Goodglass, 1985). In contrast, impairment of naming abilities seems to be ubiquitous in the course of dementia, regardless of the age of the patient (Appel, Kertesz, & Fisman, 1982; Barker & Lawson, 1968; Bayles & Tomoeda, 1983; Flicker, Ferris, Crook, & Bartus, 1987; Kirshner, Webb, & Kelly, 1984; Rochford, 1971; Skelton-Robinson & Jones, 1984).

Success on naming tasks appears to depend on a number of variables. Though several explanatory models of naming ability have been posited (e.g. Caramazza & Berndt, 1982; Goodglass, 1980; Lachman & Lachman, 1980; Oldfield, 1966) they have in common a tripartite schema in which perceptual, semantic, and motor-articulatory processes are involved. From this theoretical standpoint, defects in any of the three
systems (perceptual, semantic, motor) could lead to impairment in naming performance. The fact that spontaneous speech, repetition, and oral reading are largely preserved in dementia (Appel, Kertesz, & Fisman, 1982; Bayles & Kaszniak, 1987; Overman & Geoffrey, 1987) argues against a significant deficit in the articulatory stage.

There has been considerable debate in the literature as to the relative contribution of semantic versus perceptual disturbance to naming failures in dementia. Using the comparative frequency of semantic over perceptual errors in misnaming analyses of several dementia patient groups (Alzheimer's disease, Multi-infarct dementia, Huntington's disease, and Parkinson's disease), Bayles and colleagues (Bayles & Kaszniak, 1987; Bayles & Tomoeda, 1983) have argued strongly for the primacy of the semantic store. In addition to their work, data from a number of other studies (e.g. Bowles, Obler, & Albert, 1987; Schwartz, Marin, & Saffran, 1979) also support this point of view.

Research suggesting that perceptual defects are responsible for naming failures is also compelling, as a direct link between manipulation of perceptual information and naming performance has repeatedly been demonstrated. Rochford (1971) compared the performance of dysphasic and demented individuals on two naming tests. Subjects in both groups were first presented with a set of line drawings to name. Not only did demented subjects make more naming errors, they made different types of
errors than did dysphasics. The typical incorrect naming response of
dysphasic individuals was either no response or a description of the object,
while demented patients were prone to give the name of an item that was
visually similar to the target. Rochford considered this suggestive of the
fact that naming disturbance in dysphasia and dementia stems from
different underlying impairments; dysphasics recognize stimuli but fail to
name them, whereas demented patients commonly fail to recognize targets
and therefore fail to name them. When Rochford's subjects were
presented with highly recognizable stimuli to name (body parts, with the
experimenter pointing to the target item on his own body), the dysphasics
continued to demonstrate a naming deficit but almost all demented
individuals performed flawlessly. Rochford considered this to be clear
evidence of perceptual derailment in dementia. A similar finding of
enhanced naming following "demonstration" of stimuli was observed by
Barker & Lawson (1968).

In an early study of nondemented individuals, Bisiach (1966)
explored the hypothesis that the degree of "redundancy" of visual
information in a stimulus may have a differential effect on naming. He
used three sets of stimulus cards varying only in "redundancy": one set of
realistically colored figures, an identical set of uncolored figures outlined
only in India ink, and a third set of the same figures that had been
perceptually degraded ("mutilated") by having a jagged or curved line
drawn across the picture. As predicted, enhanced (colored) drawings were correctly named most often, followed by intact line drawings, and finally "mutilated" pictures. Bisiach concluded by noting that the ability to name recognized objects varies to some extent with the amount of information transmitted through visual mechanisms, and that either a reduction in the "redundance" of a stimulus or a change in the signal-to-noise ratio can lead to naming failures. Tweedy and Schulman (1982) later confirmed and extended Bisiach's (1966) findings by demonstrating that other forms of perceptual degradation could also impede naming processes, and that some clinical groups (e.g. cardiac patients) may be more vulnerable than others (e.g. aphasics) to degradation effects.

In a more recent effort, Kirshner, Webb, & Kelly (1984) attempted to study the relationship between perceptual difficulty and naming ability in dementia patients and normal elderly. Perceptual difficulty varied according to the nature of the stimulus, being either an actual object, a black and white photograph of the object, a line drawing of the object, or a masked line drawing where a background pattern of intersecting lines was superimposed on the picture. Kirshner et al. found a significant relationship between perceptual difficulty and naming performance for subjects with dementia. For this group, objects were named more easily than other stimuli. Photographs were named more readily than masked drawings but not significantly better than standard drawings. There was no
difference in naming between the two sets of drawings. No comparisons among perceptual levels reached statistical significance for control subjects, who performed well at all tasks.

Analysis of naming failures is also informative. Both subject groups made significantly greater number of perceptual misnaming errors on more difficult perceptual stimuli. Control subjects made a higher percentage of perceptual errors overall, however (56.9% vs. 35.7% for the demented group), a finding which has led others (Bayles & Tomoeda, 1983; Bayles & Kaszniak, 1987) to question the validity of the perceptual deficit hypothesis. Critics of this work generally fail to note the relatively high frequency of "no response" errors among demented subjects in this study, which may also reflect perceptual disturbance as Goodglass (1980) suggests.

In an attempt to elucidate the role of semantic dissolution in naming disturbance, Flicker et al. (1987) conducted a number of studies of language functioning in dementia. Using stimuli from the Boston Naming Test (Kaplan, Goodglass, & Weintraub, 1978), confrontation naming was found to be progressively impaired in the course of dementia. A standardized set of pictures described by Snodgrass and Vanderwart (1980) was used to explore object identification and recognition of object function. In these experiments, significant disturbance was evident only for the most severely demented sub-group. In contrast, when Boston Naming Test
stimuli were used to test object function identification and recognition of the object name from among four alternatives, performance of all demented subjects, regardless of degree of cognitive impairment, was significantly disturbed. Flicker et al. consider this discrepancy reflective of the fact that the Snodgrass and Vanderwart stimuli are comprised of relatively common household items while the Boston Naming Test captures object names that vary in their frequency of usage. An alternative interpretation would take into account possible differences in the quality or quantity of visual information provided by the two sets of stimuli. In any case, the data imply that the strength of semantic association between picture and concept may be perceptually mediated.

This contention is supported by the work of Shuttleworth and Huber (1988). In this work, AD patients and age-matched controls were asked to name line drawings and real objects. In both cases, of the items represented a combination of low, medium, and high frequency words. The difference between drawings and objects represented a perceptual manipulation, while variations in word frequency were believed to affect linguistic aspects of the naming process. The findings indicated that for object drawings, there was a consistent effect for word frequency, that was progressive in magnitude. For real objects, however, there was a prominent effect for low frequency items (less than 0.5 million occurrences per million words) only.
Rather than persist in debate, it seems most prudent to acknowledge that both semantic and perceptual deficits may underlie the naming problems typical of dementia. Disturbance of semantic processing is likely to be a manifestation of generalized cognitive dysfunction. To what, then, can perceptual failures be attributed? Analysis of the literature reviewed above suggests that these findings may be most parsimoniously explained by examining the relative amount of spatial frequency information contained in various stimuli, while taking into account the already compromised processing abilities of the Alzheimer patient. For example, the perceptual degradation of stimuli described in several studies (Bisiach, 1966; Kirshner et al., 1984; Tweedy & Schulman, 1982) would most probably impede one's ability to process spatial frequency information available in the stimulus. While unimpaired subjects may still have adequate information to successfully recognize and name the stimulus, the percept of the Alzheimer patient may be disturbed beyond recognition. On the other hand, manipulation of real objects would serve to provide enhanced spatial frequency information relative to pictured objects, and thus account for the improvement in naming evident in reports where stimulus materials were "demonstrated."

Stimuli vary along a continuum with regard to the quality and quantity of spatial frequency information they provide. Three dimensional objects are richer in visual information than are pictures, and targets with
shading (e.g. black and white photographs, colored drawings) or other
detailing generally offer a broader spectrum of spatial frequencies to
process than do simple line drawings. Taking this into account, one can
understand the modality-specific naming effects described by Bisiach
(1966), Kirchner et al. (1984), and Shuttleworth and Huber (1988). In the
latter study, lack of differential effects for intact versus masked drawings in
Alzheimer patients may reflect the fact that spatial frequency information
processing in these individuals is already profoundly disturbed.

Understanding the perceptual origin of naming disturbance as a
defect in spatial frequency information processing also serves to explain
the apparent lack of nonlinguistic behavioral evidence of visual impairment
noted by Bayles & Tomoeda (1983). Spatial frequency processing deficits
often occur gradually and generally go unrecognized. Only specific testing
is likely to reveal the existence of a handicap in this domain. More
importantly, it is possible that once the role of higher-order perceptual
disturbance in naming failures is better understood, efforts can be directed
toward developing techniques for remediation.

A final point of consideration is the memorability of perceptually
impoverished visual stimuli. While previous research has not addressed
this question, it would appear that stimuli which are poorly perceived are
also likely to be poorly remembered. The influence of perceptual
mechanisms, namely spatial frequency information processing, on both
naming and recognition of visually presented stimuli, is explored in the following research.

More specifically, an experiment was conducted to address the hypothesis that the spatial frequency-amplitude of stimulus materials is related to the performance of Alzheimer patients and nondemented elderly on tests of confrontation naming. As a direct test of this hypothesis, the amplitude of spatial frequencies within the spectra of the stimuli was manipulated. It was predicted that for Alzheimer patients, naming performance (accuracy and reaction time) and recognition memory for stimuli would be improved when spatial frequency content was enhanced by increasing the amplitude of frequencies that were most difficult for them to perceive, while performance of nondemented elderly would be disturbed when stimuli were perceptually degraded as a function of the contrast sensitivity of Alzheimer patients. The impact of other stimulus variables on performance (e.g. visual complexity, word frequency) was also investigated, though no specific effects were predicted.
Method

The literature reviewed above suggests the need for further research into the visual perceptual capabilities of the Alzheimer patient from an information processing perspective. Employing recent theoretical and technical advances, an experiment was conducted to examine one aspect of visual perception, spatial frequency information processing, and its relationship to performance on confrontation naming tests. Nondemented elderly served as comparison subjects to help clarify the nature of observed effects.

To reiterate, the present research was designed to test the hypothesis that the spatial frequency magnitude spectra of stimulus materials related to performance on tests of confrontation naming.

Subjects

Two groups of age-matched subjects participated in this research. The Alzheimer's disease (AD) sample was drawn from volunteers participating in the research registry of the Alzheimer Center, an outpatient facility of University Hospitals of Cleveland. Individuals over the age of 60 who met criteria for AD established by the NINCDS-ADRDA work group and the Health and Human Services Task Force on Alzheimer's Disease (McKhann et al., 1984) were recruited. Diagnosis of probable AD was determined by Alzheimer Center medical staff prior to participation in this research. Informed consent was obtained from each
subject or caregiver. Twenty Alzheimer patients participated in each experimental condition in a repeated measures design. The mean age of these subjects was 71.83 years, SD = 8.00, with an average of 11.7 years, SD = 2.76, of education.

Those included in the AD sample also had the severity of their dementia evaluated with a screening measure, The Mini Mental State (Folstein, "Folstein, & McHugh, 1975), described below. MMS scores of subjects ranged from 15 to 28, with a mean of 19.15, SD = 3.48. While the MMS ranges include those who are considered severely demented (following Reisberg et al., 1986), all subjects were able to understand and comply with the experimental procedures. The MMS was administered during the first experimental session.

AD patients also underwent extensive neuropsychological evaluation to document and quantify the specific cognitive deficits. Objective test data were corroborated by clinical findings of deficit in two or more areas of cognitive function, a progressive course of impairment, no clouding of consciousness, and onset of the disturbance between ages 40 and 90. Alternative causes of a dementia syndrome, such as multi-infarct dementia or depressive pseudodementia, were ruled out in all cases.

A healthy, nondemented elderly comparison sample was drawn from among independent community dwelling adults in the Cleveland metropolitan area. Nondemented subjects were recruited from individuals
who responded to announcements calling for volunteers to participate in experiments in the Perception Laboratory, Department of Psychology, Case Western Reserve University. Informed consent was obtained from all subjects. A sample of 20 individuals participated in each experimental condition using a repeated measures design.

The MMS was administered to the nondemented elderly subjects during the first experimental session. Scores for this group ranged from 26 to 30, with a mean of 28.75, SD = 1.16. The average age of nondemented adults was 72.36 years, SD = 3.53, with an average of 13.3 years, SD = 2.16, of education.

All subjects were screened for visual acuity and ocular pathology. Those with binocular Snellen acuity of less than 20/70 (corrected) at the test distance (31.5 in.), prominent central cataracts, or other optical defects that might influence performance on experimental tasks were excluded. The mean acuity level for nondemented controls was 20/30; for Alzheimer patients it was 20/36.

**Apparatus**

**Image Analysis and Presentation.** All image analyses (including enhancement and degradation of spatial frequency information) were done under the control of an IBM AT microcomputer with a Matrox 1024 imaging board and a Conrac high resolution monitor. This system is capable of processing and storing $512 \times 512$ images with 8 bits of
resolution. Slides of the pictures developed by Snodgrass and Vanderwart (1980) were obtained and digitized. For degradation and enhancement of stimuli, a function was fit to the contrast sensitivity data collected in a previous investigation (Gilmore, Turner, & Mendez, submitted for publication) for samples of nondemented elderly and Alzheimer disease patients. The difference between the two functions was used to shape the magnitude spectrum of the filter. The filter was then applied to the magnitude spectrum of each digitized image to be named. For images to be presented in the degraded condition, the spectrum of the image was diminished to fit the function representing the contrast sensitivity of the Alzheimer group. For enhanced images, the magnitude spectrum was increased to fit the contrast sensitivity function for the nondemented elderly group. Digitized images, both filtered and nonfiltered (as in the "normal" presentation condition) were captured on videotape using a Panasonic VCR. They were presented to the subject on a Panasonic monitor.

Photometry. A Pritchard photometer was used to measure the luminance and illumination of stimuli, and for calibration of display devices. Luminance of the display was determined to be 13.30 fL for nonfiltered stimuli, 13.04 fL for degraded stimuli, and 13.55 fL for enhanced stimuli. Differences in gray level of this magnitude are not apparent to the viewer.
Tests

Mini-Mental State. The MMS is a brief questionnaire covering assessment of time and place, registration of information (i.e. the ability to recall three verbally presented objects following a few seconds delay), attention and calculation (subtracting serial sevens or spelling "world" backward), recall (of the three previously registered items), some measures of "language ability" (simple naming, repetition, comprehension of short oral and written statements), composing and writing a sentence, and copying a complex polygon. This instrument has been used extensively as a brief measure of cognitive status. Folstein et al. (1975) have estimated the concurrent validity (determined by correlating MMS scores with WAIS IQ) to be .776 (p < .000) for verbal IQ and .660 for performance IQ (p < .001). MMS scores were also used successfully by Folstein et al. (1975) to discriminate between diagnostic groups (dementia, pseudodementia, depression without cognitive impairment, schizophrenia, neurosis, normal), MMS scores were found to agree with the clinical opinion of the presence of cognitive difficulty, and were dispersed in a manner roughly agreeing with the severity of dysfunction. In addition, MMS scores vary with change in cognitive function, which also suggests the validity of the measure.

Test-retest and interrater reliability of the MMS for have also been assessed (Folstein et al., 1975). Correlation between initial testing and 24 hour delay was .887 when administered by the same experimenter on both
occasions, and \( .827 \) when experimenters varied. A 28 day retest on a clinically stable sample of demented, depressed, and schizophrenic patients found reliability to be \( .988 \).

**Visual Acuity.** Both subject groups were tested using a near-chart with Sloan optotypes. Acuity was measured at two distances: 31.5 inches, the test distance, and 16 inches, the standard distance for measurement of near vision.

**Naming Stimuli.** Naming stimuli were chosen from the set of 260 pictures described by Snodgrass and Vanderwart (1980). These pictures had been evaluated by a large sample of college students \( (n=219) \) on a number of dimensions, including name agreement (the degree to which the subjects reached consensus regarding the object's name), image agreement (how closely the picture resembled the subjects' mental image of the item), familiarity (how "usual or unusual" the concept was in the subject's range of experience), and visual complexity (the subjects' rating of the amount of detail or intricacy of line in the stimulus).

Each experimental condition used 32 different target pictures. These items were selected from the Snodgrass and Vanderwart picture set according to specific criteria: (1) name agreement measured by the \( H \) statistic was \( \leq 1 \), indicating that a maximum of two equally frequent names were elicited for any stimulus. In most cases, \( H=0 \) indicating perfect name agreement for subjects in the standardization sample. The
decision was made to include items with less than perfect name agreement because of the relationship between this variable and visual complexity; the more complex pictures tended to elicit a less than unanimous response. (Alternative responses were, in the great majority of cases, generally accepted synonyms.) (2) Image agreement, ranked on a five point scale reflecting similarity between the stimulus picture and the subject’s mental image of the object, was \(\geq 3\). The average for stimuli presented to the subjects was \(3.90, \text{SD} = 0.459\); (3) Familiarity, also ranked from 1-5 with 1 representing relatively unfamiliar and 5 very familiar concepts, was \(\geq 3\). The average for stimuli presented was \(3.93, \text{SD} = 0.609\). (Descriptive statistics for all stimulus variables are presented in the Appendix.)

Visual complexity rankings were allowed to vary from 1 (very simple) to 5 (very complex). Also of interest was the frequency of the word name of each picture, derived from the ranking of the standardized frequency index (a log transformation of \(U\) values reflecting estimated frequency-per-million tokens in print) (Carroll, Davies, & Richman, 1971). Word frequency is the standard metric by which naming tests are organized; objects representing high frequency words are typically considered easiest for the subject to name, while low frequency items are considered most challenging. It may be that a better understanding of task difficulty for elderly and demented individuals will be evident when the
effects of other stimulus variables (e.g. visual complexity) and word frequency are dissociated.

The sets were designed to be as comparable as possible across the dimensions of interest (image agreement, familiarity, visual complexity, word frequency). Normative data from Snodgrass and Vanderwart (1980) were compiled for each list. Mean values for stimulus variables broken down by complexity and frequency are presented in Tables 1 and 2, respectively. Table 1 includes weighted means for stimulus variables on each list, while Table 2 shows median values for the same data.

Prior to filtering, the stimulus lists were pretested on a sample of college students to insure comparability among lists. Average response time per item was 0.880 sec on List A (used in the nonfiltered condition) 0.879 sec on List B (used in the degraded condition) and 0.893 sec on List C (used in the enhanced condition).

Three sets of 32 items were also selected from among the Snodgrass and Vanderwart stimuli to serve as foils for testing recognition memory in a two-alternative, forced choice paradigm. The relationship between target and distractor was either semantic, that is, sharing category membership as defined by Battig and Montague (1969), visual, meaning a comparable visual complexity rating, or perceptual, reflecting similarity of size and shape of the picture. The recognition foil was presented in the same filter state (normal, degraded, or enhanced) as the test item.
Table 1
Lists Organized by Complexity

<table>
<thead>
<tr>
<th>Complexity</th>
<th>Low(^b)</th>
<th>Medium(^b)</th>
<th>High(^b)</th>
<th>Weighted Mean(^c)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>List 1</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Complexity</td>
<td>1.90 ± 0.30</td>
<td>2.71 ± 0.34</td>
<td>3.83 ± 0.46</td>
<td>2.67 ± 0.80</td>
</tr>
<tr>
<td>Frequency</td>
<td>55.57 ± 101.09</td>
<td>42.87 ± 55.31</td>
<td>93.26 ± 76.22</td>
<td>58.26 ± 78.04</td>
</tr>
<tr>
<td>Image Agreement</td>
<td>3.99 ± 0.53</td>
<td>4.02 ± 0.34</td>
<td>3.73 ± 0.58</td>
<td>3.95 ± 0.47</td>
</tr>
<tr>
<td>Familiarity</td>
<td>4.25 ± 0.47</td>
<td>3.67 ± 0.63</td>
<td>3.95 ± 0.51</td>
<td>3.93 ± 0.60</td>
</tr>
</tbody>
</table>

| **List 2** |          |             |           |                     |
| Complexity | 1.65 ± 0.32 | 2.83 ± 0.38 | 3.91 ± 0.34 | 2.66 ± 0.92         |
| Frequency  | 99.52 ± 101.50 | 88.46 ± 124.58 | 91.60 ± 123.53 | 92.95 ± 113.18     |
| Image Agreement | 4.19 ± 0.45 | 3.78 ± 0.43 | 3.88 ± 0.42 | 3.94 ± 0.46         |
| Familiarity  | 4.03 ± 0.57 | 4.19 ± 0.57 | 3.36 ± 0.68 | 3.95 ± 0.66         |

| **List 3** |          |             |           |                     |
| Complexity | 1.83 ± 0.36 | 2.67 ± 0.28 | 3.73 ± 0.34 | 2.61 ± 0.77         |
| Frequency  | 53.96 ± 39.31 | 33.70 ± 21.12 | 65.46 ± 85.03 | 47.61 ± 47.53       |
| Image Agreement | 3.86 ± 0.47 | 3.75 ± 0.49 | 3.84 ± 0.42 | 3.81 ± 0.46         |
| Familiarity  | 4.00 ± 0.51 | 3.79 ± 0.52 | 3.97 ± 0.88 | 3.91 ± 0.60         |

\(^a\) Data derived from Snodgrass & Vanderwart, 1980.

\(^b\) Mean and standard deviation are given for low, medium, and high complexity stimuli.

\(^c\) Weighted means for stimulus variables on each list, collapsed across complexity.
Table 2
Lists Organized by Frequency

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Low&lt;sup&gt;b&lt;/sup&gt;</th>
<th>High&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Median&lt;sup&gt;c&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>List 1</strong> (n=20)</td>
<td>(n=12)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Complexity</td>
<td>2.60 ± 0.70</td>
<td>2.80 ± 0.96</td>
<td>2.49</td>
</tr>
<tr>
<td>Frequency</td>
<td>13.50 ± 9.45</td>
<td>132.86 ± 85.41</td>
<td>23.25</td>
</tr>
<tr>
<td>Image Agreement</td>
<td>4.02 ± 0.47</td>
<td>3.83 ± 0.45</td>
<td>4.08</td>
</tr>
<tr>
<td>Familiarity</td>
<td>3.81 ± 0.57</td>
<td>4.13 ± 0.60</td>
<td>3.84</td>
</tr>
<tr>
<td><strong>List 2</strong> (n=18)</td>
<td>(n=14)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Complexity</td>
<td>2.73 ± 0.98</td>
<td>2.58 ± 0.87</td>
<td>2.74</td>
</tr>
<tr>
<td>Frequency</td>
<td>16.04 ± 13.53</td>
<td>191.84 ± 107.64</td>
<td>34.49</td>
</tr>
<tr>
<td>Image Agreement</td>
<td>4.07 ± 0.43</td>
<td>3.77 ± 0.47</td>
<td>3.92</td>
</tr>
<tr>
<td>Familiarity</td>
<td>3.70 ± 0.67</td>
<td>4.28 ± 0.50</td>
<td>4.10</td>
</tr>
<tr>
<td><strong>List 3</strong> (n=17)</td>
<td>(n=15)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Complexity</td>
<td>2.68 ± 0.80</td>
<td>2.54 ± 0.76</td>
<td>2.54</td>
</tr>
<tr>
<td>Frequency</td>
<td>19.32 ± 11.42</td>
<td>79.68 ± 52.71</td>
<td>36.32</td>
</tr>
<tr>
<td>Image Agreement</td>
<td>3.87 ± 0.37</td>
<td>3.74 ± 0.54</td>
<td>3.85</td>
</tr>
<tr>
<td>Familiarity</td>
<td>3.65 ± 0.56</td>
<td>4.19 ± 0.51</td>
<td>4.00</td>
</tr>
</tbody>
</table>

<sup>a</sup> Data derived from Snodgrass & Vanderwart, 1980.

<sup>b</sup> Mean and standard deviation are given for low and high frequency words.

<sup>c</sup> Median values for stimulus variables on each list, collapsed across frequency.
Procedure

Subjects were given the following verbal instructions: "I am going to show you a videotape of pictures of common objects and other things that should be familiar to you. I want you to name each picture as quickly as you can. You don't have to say "a" something or "the" something; just the name of the thing will be fine. Before you see the picture you will hear a beep. The beep is to warn you that the picture is coming right up. Each picture will stay on the screen for 15 seconds. This is to give you enough time to see and name the picture. I want you to have a good long look at it because when we are done naming the pictures, I will show you the pictures you have just seen and some pictures that you've never seen before, and I'll ask you to tell me which one's you've seen before. You don't need to try and remember the pictures. I want know what sticks in your memory when you aren't trying. For right now, just name each picture as quickly as you can. Do you have any questions? Ready? Listen for the beep and name each picture as quickly as you can." There were five practice pictures. If the subject did not appear to readily understand the task, practice pictures were presented again.

The pictures appeared as black line drawings on a light background, surrounded by a dark border. The size of the light area was approximately 2.6 in. x 4.4 in., subtending a visual angle of 7.9°. The subject was seated
31.5 inches from the screen. Following each picture, the screen was dark for an 8 sec interval. Response accuracy and latency were recorded in two ways. An automatic timer, accurate to 1 msec (Lafayette Instruments) was triggered by an audible tone on the videotape which preceded the presentation of each stimulus by one second. This timer was manually stopped by an experimenter when the subject had responded. A digital stopwatch, accurate to 10 msec, was used by a second experimenter. The stopwatch was started when the stimulus appeared on the screen and was stopped when the subject had responded. This procedure was instituted to insure that a latency value would be available for all stimuli. In all cases when the automatic timer had accurately recorded the subjects response, this value was entered into data analysis. For the few instances where this information was unavailable through equipment malfunction or experimenter error, the stopwatch time was used in data analyses.

A forced-choice, two alternative procedure was then used to probe recognition memory for test stimuli. The subjects were given these instructions: "On the screen you will see two pictures at one time. One will be up on the screen (point), one will be down on the screen (point). One of the pictures will be a picture that I just asked you to name, the other will be a new picture. I want you to tell me which one I asked you to name. If its the one that's up on the screen say "up"; if its the one that's down on the screen say "down". "Up" or "down" is all you need to
say. Just tell me which one you've seen before. Now in each case one of
the two pictures is one that you've just seen. So if you're not sure, go
ahead and guess. Do you have any questions? Again, there will be a beep
before each set of pictures. Just listen for the beep and say "up" or "down"
to tell me which picture you've seen before." The target was located in the
"up" position in half of the trials in each condition. Assignment of the
target to the upper or lower position was random. The pictures remained
on the screen for 15 sec, with a 6 sec interstimulus interval.

This task was readily understood and performed by all
nondemented subjects. There were certain AD subjects, however, who
were unable to identify the recognized pictures by saying "up" or "down",
and automatically proceeded to name the pictures a second time. When
naming persisted despite practice and correction, the subject was allowed
to continue in this fashion. Response accuracy and latency were recorded
as described above.

Each subject participated in all three experimental conditions. The
nonfiltered stimuli were presented first in each case. The degraded and
enhanced stimuli were presented in counterbalanced order. Degradation
was an attempt to perceptually equate the stimuli across groups by
decreasing the amplitude of particular spatial frequencies already
inaccessible to the Alzheimer subjects. Enhancement served to boost the
amplitude of the spatial frequency information that is most difficult for the
Alzheimer patient to perceive, in an effort to equate the perceptual information accessible to the AD and nondemented subjects.
Results

Overall, both groups performed ably on the naming and recognition tasks. While this was anticipated, the extremely high degree of accuracy yielded by nondemented subjects, particularly on picture recognition, made statistical data analysis nonmeaningful in some instances. In cases where analysis of variance could be conducted, there were always significant main effects for group, indicating that the Alzheimer subjects yielded lower levels of accuracy.

All data were analyzed using BMDP on a personal computer. Posteriori tests of mean differences revealed by analysis of variance (ANOVA) were done with the Tukey HSD (Honestly Significant Difference), which uses the $Q$ statistic. The Tukey HSD permits making all possible paired comparisons while controlling alpha inflation.

The terms degraded and enhanced will be used to describe filtered stimuli, as these labels reflect the direction in which the spatial frequency magnitude spectra of images were altered. These terms are not meant to imply direction of performance effects. In many instances, "degraded" pictures led to increased accuracy and decreased reaction time relative to "enhanced" images, while enhancement was, in some cases, associated with diminished performance.
Naming Accuracy

Effects of group and list. Both nondemented elderly subjects and Alzheimer patients were highly accurate on the naming task (95.0% and 88.4% respectively). ANOVA revealed a significant main effect for list, \( F(2,76) = 14.14, \text{MS}_e = .002, p<.001 \). A significant list by group interaction suggested that the accuracy of each group was compromised somewhat when stimuli were filtered, \( F(2,76) = 5.30, \text{MS}_e = .002, p<.007 \) (see Table 3, Figure 2). Post hoc comparisons indicated that the accuracy of nondemented elderly subjects was significantly less for enhanced stimuli relative to nonfiltered, \( Q(2, 76) = 12.125, \text{MS}_e = .002, p<.01 \), or degraded pictures, \( Q(2,76) = 10.517, \text{MS}_e = .002, p<.01 \). In all cases, however, mean accuracies for nondemented elderly subjects remained above 90%.

Table 3

Naming Proportion Correct - Group by List

<table>
<thead>
<tr>
<th>Group</th>
<th>Nondemented</th>
<th>Alzheimer</th>
<th>Marginal</th>
</tr>
</thead>
<tbody>
<tr>
<td>List</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nonfiltered</td>
<td>.975 ± .028</td>
<td>.917 ± .093</td>
<td>.946 ± .060</td>
</tr>
<tr>
<td>Degraded</td>
<td>.960 ± .032</td>
<td>.858 ± .109</td>
<td>.909 ± .070</td>
</tr>
<tr>
<td>Enhanced</td>
<td>.917 ± .057</td>
<td>.877 ± .076</td>
<td>.897 ± .067</td>
</tr>
<tr>
<td>Marginal</td>
<td>.951 ± .039</td>
<td>.884 ± .093</td>
<td>.917 ± .066</td>
</tr>
</tbody>
</table>
Figure 2. Naming Proportion Correct - Group by List.

The ability of AD subjects to accurately name pictures was diminished under both filter conditions, $Q(2,76) = 4.204, MS_e = .002$, $p<.05$ for degraded, $Q(2,76) = 6.148, MS_e = .002, p<.01$ for enhanced, relative to nonfiltered images. It is interesting to note that the accuracy of the nondemented elderly group for enhanced pictures was exactly that of the AD subjects for nonfiltered stimuli.

Effects of visual complexity. When naming accuracy was analyzed as a function of visual complexity, a novel pattern of findings was revealed. A significant main effect for complexity was evident, $F(2,76) = 3.44, MS_e = .005, p<.004$, as well as an interaction between complexity and list
$F(2,76) = 11.14, MS_e = .004, p < .001$ (see Table 4, Figure 3). No complexity effects were yielded by nonfiltered stimuli. When pictures were degraded, naming accuracies for medium complexity images were diminished to a significant degree (in most cases, $Q < 4.39, MS_e = .004, p < .05$) relative to all other list/complexity combinations. When stimuli were enhanced, those of moderate visual complexity were not distinctive, relative to low and high complexity items. This finding is not readily interpretable. It is interesting to note that degraded, medium complexity items had a higher mean word frequency value than did items with the same degree of visual complexity in other filter conditions, and they were the same in terms of mean image agreement and familiarity (see Table 1). Moreover, degraded medium complexity items were equal to low and high complexity words on this list in terms of word frequency. The most parsimonious explanation of these data would suggest that it may have been the particular items in the degraded-medium complexity condition, rather than the interaction of complexity and filtering per se that drove the poor performance of subjects.
Table 4

**Naming Proportion Correct - Complexity by List**

<table>
<thead>
<tr>
<th>Complexity</th>
<th>Low</th>
<th>Medium</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>List</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nonfiltered</td>
<td>.936 ± .062</td>
<td>.943 ± .042</td>
<td>.968 ± .108</td>
</tr>
<tr>
<td>Degraded</td>
<td>.950 ± .048</td>
<td>.865 ± .061</td>
<td>.932 ± .125</td>
</tr>
<tr>
<td>Enhanced</td>
<td>.875 ± .081</td>
<td>.916 ± .056</td>
<td>.893 ± .100</td>
</tr>
<tr>
<td>Marginal</td>
<td>.920 ± .064</td>
<td>.908 ± .053</td>
<td>.931 ± .111</td>
</tr>
</tbody>
</table>
Effects of word frequency. Examination of naming accuracy as a function of word frequency also yielded interesting findings. In addition to a main effect for frequency, $F(1,38) = 72.35$, $MS_e = .007$, $p < .001$, ANOVA revealed significant interactions for group by frequency, $F(1,38) = 6.11$, $MS_e = .007$, $p < .018$ and list by frequency $F(2,76) = 12.14$, $MS_e = .004$, $p < .001$ (see Table 5, Figure 4). Naming accuracy of nondemented elderly and AD subjects was significantly different on low frequency items, $Q(1,38) = 4.844$, $MS_e = .007$, $p < .01$. Nondemented elderly and AD differences were nonsignificant, however, with respect to high frequency words (98.6%, SD = .037, and 95.0% accuracy, SD = .064, respectively). Again, the absence of significant group differences and the highly accurate performance of the Alzheimer patients is noteworthy.
### Table 5

**Naming Proportion Correct - Frequency by Group and List**

<table>
<thead>
<tr>
<th>List</th>
<th>Low Frequency</th>
<th>High Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Nondemented</td>
<td>Alzheimer</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nonfiltered</td>
<td>.965 ± .040</td>
<td>.890 ± .126</td>
</tr>
<tr>
<td>Degraded</td>
<td>.942 ± .056</td>
<td>.806 ± .163</td>
</tr>
<tr>
<td>Enhanced</td>
<td>.859 ± .094</td>
<td>.803 ± .105</td>
</tr>
<tr>
<td>Marginal</td>
<td>.922 ± .063</td>
<td>.833 ± .131</td>
</tr>
<tr>
<td>Nonfiltered</td>
<td>.992 ± .026</td>
<td>.963 ± .057</td>
</tr>
<tr>
<td>Degraded</td>
<td>.982 ± .032</td>
<td>.925 ± .075</td>
</tr>
<tr>
<td>Enhanced</td>
<td>.983 ± .037</td>
<td>.960 ± .059</td>
</tr>
<tr>
<td>Marginal</td>
<td>.986 ± .032</td>
<td>.950 ± .064</td>
</tr>
</tbody>
</table>
Figure 4. Naming Proportion Correct - Frequency by Group and List.

Post hoc comparisons of means produced by the interaction of list and word frequency reflected a significant filtering effect for low but not high frequency stimuli; those low frequency items which were not filtered were named more accurately than degraded or enhanced images, $Q(2,76) = 5.98, MS_e = .004, p<.01$, and $Q(2,76) = 10.18, MS_e = .004, p<.01$, respectively.

Because of the unequal number of low and high frequency stimuli within lists, low and high frequency items were analyzed separately to gain
a clearer understanding of frequency effects. Analysis of variance in naming accuracy also indicated that, for low frequency stimuli, degradation and enhancement both impaired the performance of AD subjects, relative to no filtering, \( Q(2,76) = 5.25, MS_e = .007, p < .01 \) and \( Q(2,76) = 5.41, MS_e = .007, p < .01 \), respectively, as noted above (see Table 5). The performance of the nondemented elderly group was more robust. The apparent contrast of low frequency stimuli could be degraded without a performance decrement, however when contrast was enhanced to a similar degree, performance faltered relative to nonfiltered and degraded images, \( Q(2,76) = 6.60, MS_e = .005, p < .01 \), and \( Q(2,76) = 5.14, MS_e = .005, p < .01 \), respectively. It is also noteworthy that enhancement of apparent contrast served to attenuate group differences in naming accuracy for low frequency stimuli to a nonsignificant level (85.9%, SD = .063) for nondemented elderly, 80.3%, SD = .131 for AD).

Analysis of high frequency words yielded only a main effect for list, \( F(2,76) = 3.77, MS_e = .002, p < .028 \). Degradation appeared to diminish performance, relative to nonfiltered stimuli, by a small but significant degree \( Q(2,76) = 3.68, MS_e = .002, p < .05 \).

**Naming Reaction Time**

Effects of list and group. Examination of correct naming latency, or reaction time, revealed that AD patients were approximately 1 sec slower to correctly respond to stimuli compared to nondemented elderly
controls. Their response time overall (regardless of accuracy) was 1.250 sec. greater than that of nondemented controls. These group differences are similar to those found in other studies (e.g. Shuttleworth & Huber, 1988), and suggest that subjects in the present investigation were comparable to those in other samples. Taking this into account, it appears unlikely that the high naming accuracies obtained for AD patients can be attributed to differences in subject sampling.

An analysis of list effects on naming latency revealed a main effect for list, $F(2,76) = 6.00, MSE = .051, p < .004$. Mean latency for nonfiltered stimuli was 1.847 sec (SD = .329), as compared to 1.995 sec (SD = .379) for degraded items and 1.839 (SD = .388) for enhanced. Post hoc comparisons indicated that degradation significantly slowed reaction time, relative to unfiltered or enhanced images, $Q(2,76) = 4.13, MSE = .051, p < .05$, and $Q(2,76) = 4.35, MSE = .051, p < .01$, respectively. There was no latency difference between unfiltered and enhanced conditions. In addition, no list by group interaction was evident.

**Effects of visual complexity.** Analysis of the influence of visual complexity on naming latency yielded significant overall main effects for complexity, $F(2,76) = 4.91, MSE = .169, p < .01$ (see Table 6, Figure 5). There was also a significant interaction between complexity and group, $F(2,76) = 3.61, MSE = .169, p < .032$. Post hoc comparisons indicated that nondemented elderly subjects were faster at naming low, medium, and high
complexity stimuli than were AD patients. Complexity trends within groups were not found to be significant in post hoc comparisons.

Table 6

Naming Reaction Time - Complexity by Group

<table>
<thead>
<tr>
<th></th>
<th>Nondemented</th>
<th>Alzheimer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complexity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>1.353 ± 0.168</td>
<td>2.261 ± 0.635</td>
</tr>
<tr>
<td>Medium</td>
<td>1.445 ± 0.206</td>
<td>2.406 ± 0.701</td>
</tr>
<tr>
<td>High</td>
<td>1.379 ± 0.178</td>
<td>2.556 ± 1.177</td>
</tr>
<tr>
<td>Marginal</td>
<td>1.392 ± 0.184</td>
<td>2.408 ± 0.838</td>
</tr>
</tbody>
</table>
Figure 5. Naming Reaction Time - Complexity by Group.

**Effects of word frequency.** The analysis of variance for naming latency as a function of word frequency revealed a main effect for frequency, $F(1,38) = 31.69$, $MS_e = .099$, $p < .001$. The interaction between list and frequency was also significant, $F(2,76) = 4.70$, $MS_e = .092$, $p < .012$, as was a three-way interaction involving subject group, $F(2,76) = 3.81$, $MS_e = .092$, $p < .027$ (see Table 7, Figure 6). Inspection of these data indicated that nondemented elderly showed no overall reaction time advantage for low versus high frequency stimuli. The same was true for the Alzheimer patients with nonfiltered or perceptually degraded stimuli. However, perceptual enhancement of high frequency images produced a
significant decrease in naming latency for this group, relative to their latency for naming low frequency stimuli across lists, and degraded high frequency images.

Table 7

**Naming Reaction Time - Frequency by Group and List**

<table>
<thead>
<tr>
<th>List</th>
<th>Nonfiltered</th>
<th>Degraded</th>
<th>Enhanced</th>
<th>Marginal</th>
<th>Nonfiltered</th>
<th>Degraded</th>
<th>Enhanced</th>
<th>Marginal</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Low Frequency</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>High Frequency</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1.368 ± 0.210</td>
<td>1.621 ± 0.212</td>
<td>1.427 ± 0.172</td>
<td>1.472 ± 0.198</td>
<td>1.305 ± 0.207</td>
<td>1.378 ± 0.115</td>
<td>1.254 ± 0.159</td>
<td>1.312 ± 0.160</td>
</tr>
<tr>
<td></td>
<td>2.393 ± 0.665</td>
<td>2.550 ± 0.694</td>
<td>2.651 ± 0.784</td>
<td>2.531 ± 0.714</td>
<td>2.259 ± 0.747</td>
<td>2.392 ± 0.700</td>
<td>2.048 ± 0.559</td>
<td>2.233 ± 0.669</td>
</tr>
</tbody>
</table>
For reasons noted above, data for low and high frequency stimuli were analyzed separately across group and list (see Table 8, Figure 7).
For low frequency stimuli there were significant main effects for group and list, $F(2,76) = 4.59$, $MS_{e} = .100$, $p<.013$. Post hoc comparisons revealed a significant effect of degradation on reaction time for low frequency items, compared to latency for nonfiltered stimuli, $Q(2,76) = 4.09$, $MS_{e} = .100$, $p<.05$. For high frequency labels there was also a significant main effect for list, $F(2,76) = 6.0$, $MS_{e} = .091$, $p<.003$. In contrast to list effects for low frequency words, with high frequency words enhanced stimuli were
identified significantly faster than degraded, $Q(2,76) = 4.91$, $MS_e = .091$, $p < .01$. This was noteworthy as it suggested that cognitive efficiency may be augmented by perceptual means.

Table 8

<table>
<thead>
<tr>
<th>Naming Reaction Time - Frequency Levels by List</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency</td>
</tr>
<tr>
<td>Low</td>
</tr>
<tr>
<td>High</td>
</tr>
<tr>
<td>List</td>
</tr>
<tr>
<td>Nonfiltered</td>
</tr>
<tr>
<td>Degraded</td>
</tr>
<tr>
<td>Enhanced</td>
</tr>
<tr>
<td>Marginal</td>
</tr>
</tbody>
</table>
Recognition Accuracy

Overall, nondemented elderly made very few errors on the recognition task, averaging 99.2%, SD = .014, correct. Alzheimer patients also recognized a majority of the stimuli, with a mean group accuracy of 81.7%, SD = .129. List (filter condition) had no statistically significant effect for either group.

Visual complexity appeared to have no effect on recognition accuracy for either nondemented elderly or Alzheimer patients. Because data for the nondemented elderly group yielded perfect accuracy in a number of cells, ANOVA was not performed. Word frequency also
seemed to bear no statistically significant relationship to recognition accuracy. This was contrary to other findings suggesting that recognition is usually better for low frequency than high frequency words (e.g. Shepard, 1967; Underwood & Freund, 1970). Again, because of perfect cell accuracies, ANOVA was not carried out.

Each naming stimulus was paired with a foil for recognition memory testing in the forced-choice, two alternative paradigm. Targets and foils were matched for either semantic similarity, perceptual similarity, or a similar degree of visual complexity. Due to high accuracies, the effect of foil on recognition memory was difficult to analyze. Only perceptual foils generated errors in all conditions. However, differences in error rate between foils was small, as overall accuracy for perceptual foils was at 89.4% (SD = .092) compared to 91.5% (SD = .105) accuracy for semantic foils and 90.4% (SD = .167) for complexity foils.

When each type of foil was analyzed separately across group and list, it became apparent that perceptual foils in the enhanced condition generated higher error rates than did nonfiltered or degraded target-distractor perceptually matched pairs (see Table 9, Figure 8). In this condition, accuracy was 74.0%, SD = .185, as compared with 85.4%, SD = .154, for nonfiltered targets and 82.0%, SD = .117, for degraded targets. Nondemented elderly subjects showed no significant list effect. Similar effects were not observed for either semantic or complexity matched pairs.
in the enhanced condition. This suggests that the AD subjects were most vulnerable to misrecognition when enhanced stimuli were paired with distractors of the same size and shape, and that items with similar global form characteristics may be more readily confused.

Table 9

**Recognition Proportion Correct - Perceptual Foil by Group and List**

<table>
<thead>
<tr>
<th>List</th>
<th>Nondemented</th>
<th>Alzheimer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nonfiltered</td>
<td>0.996 ± 0.019</td>
<td>0.854 ± 0.118</td>
</tr>
<tr>
<td>Degraded</td>
<td>0.965 ± 0.049</td>
<td>0.820 ± 0.154</td>
</tr>
<tr>
<td>Enhanced</td>
<td>0.990 ± 0.031</td>
<td>0.740 ± 0.185</td>
</tr>
<tr>
<td>Marginal</td>
<td>0.984 ± 0.033</td>
<td>0.805 ± 0.152</td>
</tr>
</tbody>
</table>
Figure 8. Recognition Proportion Correct - Perceptual Foil by Group and List.

Recognition Reaction Time

Nondemented elderly subjects were very quick to respond to recognition pairs, yielding latencies very similar to those for naming. Alzheimer patients required an average of 1.344 sec longer to recognize which of two pictures they had seen relative to latency for naming a single picture. There was no effect for filter condition (nonfiltered, degraded, enhanced) for either group.
Standard deviations for AD overall group means across conditions were very large, much larger than in naming. Nondemented elderly subjects showed no such difference (see Table 10). This may reflect variance in the response modes of AD patients. Some subjects readily grasped the "up" "down" concept, others resorted to naming the stimuli again, and some subjects alternated between the two. In certain cases, subjects also had difficulty understanding the recognition task, that is, identifying the picture previously named. Taken together, latency and accuracy data suggest that while AD patients were often subject to difficulties that resulted in long response latencies, when they offered a response it was most often a correct one.
Table 10

Naming and Recognition Reaction Time - Standard Deviations

<table>
<thead>
<tr>
<th>Group</th>
<th>Nondemented</th>
<th>Alzheimer</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>List</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nonfiltered</td>
<td>.205</td>
<td>.632</td>
</tr>
<tr>
<td>Degraded</td>
<td>.137</td>
<td>.622</td>
</tr>
<tr>
<td>Enhanced</td>
<td>.146</td>
<td>.631</td>
</tr>
<tr>
<td><strong>Naming</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nonfiltered</td>
<td>.181</td>
<td>1.316</td>
</tr>
<tr>
<td>Degraded</td>
<td>.171</td>
<td>1.251</td>
</tr>
<tr>
<td>Enhanced</td>
<td>.160</td>
<td>1.246</td>
</tr>
</tbody>
</table>

ANOVA for recognition reaction time yielded few significant findings with regard to visual complexity overall, or for each complexity level analyzed independently across groups.

Analysis of recognition latency as a function of word frequency also produced no significant effects using ANOVA. In fact, recognition latency was quite similar across frequency, within groups (low frequency = 1.427 sec, SD = .180, high frequency = 1.455 sec, SD = .177 for nondemented elderly); (low frequency = 3.803 sec, SD = 1.045, high frequency = 3.691, SD = 1.269 for AD).
Prediction of Accuracy and Reaction Time

In an effort to more fully understand the effects of various stimulus variables on accuracy and reaction time, correlation analyses were performed. Visual complexity, word frequency, image agreement, and image familiarity were entered as predictors, with naming accuracy, naming reaction time, recognition accuracy, and recognition reaction time used as dependent variables in separate analyses. Naming accuracy and reaction time were significantly correlated with image familiarity (see Table 11). This effect was evident for both subject groups. Considering the relatively restricted range of values for this variable, the significance of the effect is quite striking. No significant pattern of correlations for recognition accuracy and reaction time was observed.

Table 11

<table>
<thead>
<tr>
<th></th>
<th>Image Familiarity</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Proportion Correct</td>
</tr>
<tr>
<td>Nondemented</td>
<td></td>
<td>.216*</td>
</tr>
<tr>
<td>Alzheimer</td>
<td></td>
<td>.325**</td>
</tr>
</tbody>
</table>

*p < .05.  **p < .01.
Discussion

Naming

As was hypothesized, manipulation of the spatial frequency magnitude spectra of pictures appeared to affect performance of tests of confrontation naming. The nature of this effect, however, did not confirm predictions. Enhancement of spectra was associated with decreased accuracy for both nondemented and Alzheimer subjects. This suggested that increasing spatial frequency amplitude may, in fact, overload information processing mechanisms and lead to diminished accuracy. A model of interchannel inhibition would support this contention (see Graham, 1981).

This finding may also be attributable in part to a technical artifact of the enhancement process. When images were filtered in this way, small details of some pictures were actually distorted and obscured. In one case, a picture of a needle was enhanced to the extent that the eye appeared dark and was difficult to discriminate. In another, the subtle mottling of an orange peel took on a stippled effect. While the majority of nondemented subjects were still able to identify these images, several misnamed them based on their distorted appearance. AD patients as a group were more stimulus-bound and less able to overcome such effects, though individuals were able to accurately identify these items.
It was noteworthy that for nondemented elderly subjects enhancement of stimuli reduced accuracy to the extent that their performance was equal to that of the AD patients viewing nonfiltered images. It was predicted that performance of the nondemented elderly in the degraded condition would approximate that of the Alzheimer sample. Alzheimer patients were also vulnerable to the attenuation of spatial frequency amplitude, as evidenced by their relatively poor accuracy in the degraded condition. While degradation was designed to mimic a priori deficits in this group, when the amplitude of spatial frequency information was diminished (producing a weaker stimulus signal), performance was further compromised.

Our findings suggested that, rather than attributing performance deficits simply to weak stimulus signals, a more accurate model of Alzheimer-like perception may be one in which performance is also compromised by the distorting effects of perceptual noise. That is, it may not only be the strength but also the clarity of the signal that supports effective naming performance, as Bisiach (1966) had suggested. It may also be that a spatial frequency filter derived from contrast sensitivity to simple sinusoidal gratings could not adequately account for the visual perception of complex stimuli. A filter based on contrast sensitivity for complex gratings may have greater predictive value.
Nondemented elderly appeared to be able to compensate for stimulus attenuation with other cognitive mechanisms, and performance accuracy was maintained. It was interesting to note that while nondemented elderly were able to escape degradation effects with respect to accuracy, they did suffer a performance decrement in reaction time. Degradation appeared to affect response latency for both subject groups in a similar fashion.

Analysis of visual complexity effects on accuracy suggested a small advantage for high complexity stimuli, supporting the contention of Vanderwart and Snodgrass (1979). It was interesting that enhancement served to mitigate this effect, again by artifactually distorting image details. In this study, low complexity images were also readily named, as low complexity stimuli were, for the most part, familiar, high frequency items (see Table 1). It may be that with less familiar, low frequency stimuli, the benefits of greater image complexity may be more easily discerned.

Findings regarding the interaction of spatial frequency amplitude with word frequency have both practical and theoretical import. Again, the attenuation of accuracy was evident for enhanced stimuli, but only in the low frequency condition. That is, despite the consistent moderating effect of enhancement on accuracy, high frequency words were not affected. This was a striking example of the interaction of perceptual and semantic (word search) processes in confrontation naming and suggests
that naming (dis)ability is indeed a product of both perceptual and semantic functioning.

The relatively quick reaction times of Alzheimer patients to enhanced, high frequency stimuli was quite striking. Enhancement did not lead to decreased latency for low frequency items, suggesting that the effect is not simply due to the impact of increased contrast. In addition, reaction times for degraded and nonfiltered stimuli were not significantly different from each other, either for low or high frequency words, again mitigating against a simple interpretation of contrast effects. It appeared that for names to which the Alzheimer patient had ready access, increasing the amplitude of spatial frequency information did facilitate the matching of percept and label. This finding suggests that manipulation of perceptual information may support more efficient functioning in some cases.

Recognition

Recognition accuracy proved quite difficult to influence. For the nondemented elderly sample, the forced-choice procedure was unchallenging, and accuracies were close to ceiling. For the AD sample, accuracies were also relatively high, and did not appear to vary with stimulus manipulation. It did appear that some distractors, namely those of similar size and shape to the target, were more likely to lead to misrecognition in the enhanced condition. This may suggest that when stimulus details were more difficult to discriminate (as may have been the
case for certain enhanced items), the size and shape of an image took on particular salience in recognition memory.

Recognition reaction time data were uninformative in most cases. Nondemented controls demonstrated little variation across conditions. It did appear that enhanced, high frequency words tended to yield faster reaction times. The large standard deviations in latency for AD subjects made it difficult to confirm trends in the data with statistical methods.

**General Conclusions**

A consistently striking aspect of these data was the strong performance of Alzheimer patients on both picture naming and recognition. Differences in sampling do not appear to account for performance, as the subjects in this investigation were similar to those in other studies in terms of age, education, and dementia severity. Consequently, one might look to differences in methodology to account for performance. Methods did, in fact, vary between studies and in none of the literature reviewed were pictures presented on videotape. It is difficult to understand, however, how this manipulation would lead to improved performance. In addition, in contrast to other studies, exposure time was limited in this experiment. This cannot account for the effects observed.

One clear difference, however, between this work and others of a similar nature is the fact that image familiarity was controlled, and only
relatively familiar images were included as stimuli. Correlational analyses strongly support such an explanation, as familiarity was significantly related to naming accuracy and reaction time for both subject groups. It may be that the high accuracies demonstrated by the Alzheimer patients reflect the effect of this manipulation. The effects of image familiarity may also help to explain the impairment in naming accuracy found for enhanced stimuli. Filtering the stimuli may actually have served to make the images, in effect, less familiar. In any case, it seems prudent to consider the conceptual familiarity, as well as word familiarity (frequency) in designing and interpreting picture naming tasks.

Findings from this research also suggest that contrast sensitivity data derived from detection of simple sinusoidal gratings may not be directly applicable to the understanding of visual functioning with real-world stimuli. Contrast sensitivity profiles based on sensitivity to compound gratings may have far greater predictive and explanatory value with regard to understanding and intervention in visual information processing.

A final point of consideration involves the role of visual acuity in performance of Alzheimer patients on cognitive tasks. It may be that the strong performance of the AD sample in this study reflects the fact that acuity was considered in subject selection. It has been suggested that good acuity may be associated with the mitigation of group differences in some
instances where AD patients are compared to nondemented elderly controls. While this seems an unlikely explanation for observed effects, it seems prudent to assess visual acuity when testing with visual stimuli to eliminate an unknown source of variance.

**Suggestions for Future Research**

In an effort to provide a parsimonious explanation for observed findings, scientific investigation may overlook meaningful within-group differences. Such may be the case with studies designed to enhance our knowledge of Alzheimer's disease. While there are clearly consistencies within this population, there is also much variability. It may be worthwhile to explore the existence of behavioral subtypes, both for research and clinical efforts.

The advantages of understanding naturally existing subtypes are manifold. Certainly this would aid in the interpretation of data, especially with regard to unusual or unanticipated findings. More important are implications for intervention. It seems unlikely that an intervention would be successful at the population level, given obvious within-group variability. However, for an intervention designed for use with a certain subgroup with a similar symptom pattern, the probability of a successful outcome would be significantly enhanced.
Findings of this study also strongly supported the interaction of perceptual and semantic processes in naming. The fact that a manipulation of the spatial frequency magnitude spectra of images affected nondemented elderly and Alzheimer subjects differently is suggestive of a particular perceptual dysfunction in Alzheimer’s disease which affects naming performance. Further work must be done, however, to dissociate the effects of cognitive and perceptual disturbance, and to more fully characterize perceptual functioning in AD beyond the spatial frequency contrast sensitivity deficits that have previously been described.

It seems likely that perceptual functioning interacts with other cognitive operations as well. Reaction time and accuracy data from the present experiment were unsuited to the examination of perceptual effects on memory. Further exploration of potential effects may be warranted, however, as this too may serve as a much needed avenue for intervention in Alzheimer’s disease.
References


## Appendix

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