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Associations of Psychometric Measures of Frontal Lobe Functioning to Verbal Memory and Memory Complaints in Older Adults

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ASSOCIATIONS OF PSYCHOMETRIC MEASURES OF FRONTAL LOBE FUNCTIONING TO VERBAL MEMORY AND MEMORY COMPLAINTS IN OLDER ADULTS

By

Julie A. Daugherty

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ABSTRACT

ASSOCIATIONS OF PSYCHOMETRIC MEASURES OF FRONTAL LOBE FUNCTIONING TO VERBAL MEMORY AND MEMORY COMPLAINTS IN OLDER ADULTS

By

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This study investigated the relationship between measures of frontal lobe functioning (FLF) and both verbal memory performance and subjective memory complaints among 88 community dwelling older adults. All were administered the Wisconsin Card Sorting Test, the Stroop Color-Word Test, the California Verbal Learning Test (CVLT), Logical Memory Story A from the Wechsler Memory Scale-Revised (VM), the Memory Assessment Clinics Self-Rating Scale, and measures of depression and attention. As predicted, after controlling for the effects of attention, FLF accounted for significant amounts of the variance in verbal memory scores (CVLT: $R^2 = .18$, $p < .01$; VM: $R^2 = .05$, $p < .05$). Age related to the FLF measure according to the level of organization of verbal material to be recalled. Memory complaints were unrelated to the FLF measures. Rather, depression scores accounted for the most variance in memory complaints scores ($R^2 = .23$, $p < .01$). Implications of these data are discussed.

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INTRODUCTION

A substantial body of research has identified measurable declines in some cognitive abilities with normal aging. Verbal memory is one of these, although the specifics of this decline are not well understood. Interestingly, as verbal memory (as well as other types of memory) declines, older adults do not necessarily make increased complaints of memory loss. Only weak associations have been found between such complaints and measures of memory loss have been shown to be weak. Are there explanations for both the decline of verbal memory and the incongruities of subjective memory complaints? Researchers have begun to examine the role of the frontal lobes in a variety of cognitive abilities and phenomenon. This paper focuses on the role of psychometric measures of frontal lobe functioning (FLF) in verbal memory and memory complaints in older adults.

Memory

Normal Aging

Older people often complain about memory problems (Williams, Dennery, & Schadler, 1983). Memory has been one of the most thoroughly studied aspects of cognitive function in aging. Memory changes occur as a part of normal aging, as well as part of dementing processes. Many older adults experience subtle yet disturbing symptoms of forgetfulness while continuing to lead active and intellectually demanding lives. Important and fruitful questions concern which specific memory processes do and do not decline? Under what environmental and task conditions, with what types of information, and with which individual characteristics is stability or decline in function noted? What is the nature of the change in cognitive processing underlying such declines (Swihart & Piozzolo, 1988)? Considerable literature has examined the effects of personal characteristics, task specifics, neuroanatomical correlates, and instructional and training interventions. The effects of aging on a wide variety of tests of everyday memory has been found related to a variety of variables, such as vocabulary, education, depression, gender, marital status and employment status. Among these, however, age has consistently been found to best predict of memory performance (West, Barron, & Crook, 1992). Cockburn and Smith (1991) investigated the relationship between everyday memory, cognitive abilities and participation in social, domestic, and leisure pursuits among healthy, community-dwelling older adults. They found that fluid intelligence or those intellectual abilities which reflect maturational growth and decline of neural structures (as measured by Block Design and Picture Arrangement subtests of the WAIS-R), significantly predicted memory functioning. However, age was found to be a much better predictor of prospective and verbal memory performance, over and above the effects of either fluid or crystallized intelligence (those intellectual abilities dependent upon the accumulation of formal and informal educational experiences, such as vocabulary and arithmetic).

Models of Learning and Memory

The precise nature of memory changes are uncertain and pose diagnostic problems for the clinician. Many investigators think that certain aspects of memory are relatively resistant to change with age (e.g., primary or short term memory) while others (e.g., secondary or long-term memory) undergo significant alterations (Petersen, Smith, Lokmen, Ivnik, & Tangalos, 1992; Craik, 1991; Poon, 1985). Different aspects of memory appear to be variably sensitive to the aging process. Concepts such as "benign senescent forgetfulness" (Kral, 1962) and, more recently, "age-associated memory impairment" (AAMI; Crook et al., 1986) have been proposed in response to the evidence that sensitive tests of memory function can distinguish medically and neuropsychologically healthy older adults from younger controls. Age-related deficits appear most pronounced on measures of recent memory rather than immediate or remote memory (Golomb et al., 1993).

Information-processing models describe how material to be learned undergoes a series of transformations (processing stages) to get from sensory registration to storage in long-term memory. This flow proceeds from sensory registry/memory, to primary memory, to secondary memory, and finally into tertiary memory, which is seen as a permanent store of information. Age-related memory losses have shown minimal declines in sensory, primary and tertiary memory, but more marked decline in secondary memory (Small et al., 1994). Sensory memory provides a relatively complete representation of an external stimulus. It is a preattentive and highly unstable system based on sensory input which decays quickly upon registration. Unless this information is transferred to primary memory, it is lost within a second. Primary memory is described as a short-term, temporary, capacity-limited store in which rehearsal and /or conscious mental effort are required to maintain its contents. This contrasts with secondary memory, a relatively permanent, capacity-unlimited store of acquired information. Age differences in secondary memory are universally accepted, having been reported in numerous studies using a wide variety of methods. However, debate continues as to the underlying cognitive changes responsible for these deficits. Much effort has been expended to determine whether encoding, storage, or retrieval is responsible for secondary memory deficits. Reviews of the literature generally agree that normal age-related deficits are most evident in encoding and retrieval, whereas there is minimal age-related deficit in storage (Kaszniak, Poon, & Riege, 1986).

Attempting to understand and interpret these declines, Craik and Lockhart (1972) proposed the level-of-processing theory. According to this theory, a series or hierarchy of processing stages in memory exists, where greater levels or "depth" implies a greater degree of semantic or cognitive analysis. Memory is seen as a product of processes of information extraction and elaboration carried out for the purpose of perception and comprehension of environmental information and events. Depth of processing determines the nature and durability of the information in memory. Along these lines, it is theorized that normal, older adults engage in less extensive and less efficient initial processing of the material to be learned, resulting in degraded memory traces which are more difficult to retrieve. If the level of extensiveness and efficiency of processing reached by older adults during encoding is less than the level reached by younger adults, then a resultant weaker memory trace could account for much of the observed age difference in memory performance. In a study of differential patterns of memory deficits in different diagnostic groups (normal older adults, older adults in the early stages of dementia, older adults in advanced stages of dementia, and younger persons in the early stages of AIDS related dementia), Mitrushina et al. (1994) found the two elderly demented groups revealed remarkable deficits in learning ability and recognition rates, suggesting impaired encoding. In addition, retrieval efficiency was also considerably impaired. These authors concluded that although both primary and secondary memory mechanisms appeared to be deficient, secondary memory impairment had a greater impact on retrieval.

Craik's (1977, 1984) reviews of the experimental literature on aging and memory attributed much of the age-related decrement in memory to the failure of older adults to spontaneously process information to be remembered at an adequate, deep level. Sander, Murphy, Schmitt and Walsh's (1980) study on the rehearsal strategies of young and older persons during a word list learning supported Craik's conclusion. Older persons were less likely to use clustering strategies, frequently used single-item naming, and used rehearsal strategies which were described as "inactive and nonstrategic" (p. 556).

To remember something requires three things: the information must first be encoded; then it must be stored during a retention interval which is anchored by the original encoding; finally, it must be retrieved at the time memory is tested. How the information to be remembered is converted to a memory code is referred to as encoding. Evidence suggests that under relatively normal learning conditions, older persons do not spontaneously employ as deep of levels of encoding processes as younger persons do, leading to memory deficits. In attempting to understand age-related differences in the use of optimal encoding strategies, some researchers have begun to consider the issue of a more fundamental decline in mental processing resources, processing capacity, or pool of attentional resources (Swihart & Piozzolo, 1988). Since more elaborate and strategic (or deeper) processing is more difficult and effortful to achieve, and when processing resources are limited (as they are in older adults), there is a consequent failure to utilize deeper, semantic levels of processing (Craik & Simon, 1980). Thus, the failure of older adults to spontaneously encode material at deeper levels is due to the difficulty such demands place on age-reduced/depleted attentional and cognitive resources.

Deficits in retrieval are somewhat difficult to evaluate because what is able to be retrieved is contingent on what was encoded. Most often, retrieval deficits are evaluated comparing performances on recall and recognition tasks, with recall demanding an active, self-initiated search of the memory store's contents, with subsequent decision-making about whether the memory trace matches the content of the prior, to-be-remembered item. In contrast, recognition presumably bypasses the necessity of searching the memory store; only a decision about the item's familiarity (Kausler, 1994). The well-replicated finding of small age-related deficits in recognition and large age-related deficits in recall suggests that retrieval (and in a related manner, encoding), rather than storage is impaired in older adults (Kaszniak, Poon, & Riege, 1986).

Finally, the ability of older adults to recall events and people from early in their lives represents tertiary memory. The tertiary memory ability of older adults is anecdotally impressive, with many describing how their remote memories are much clearer than their memory of events of the last few days or weeks (La Rue, 1992).

In summary, information-processing studies of healthy, older adults demonstrate minimal age-related deficits in sensory, primary, and tertiary memory. However, a large body of evidence exists demonstrating deficits in secondary memory, most being related to deficits in encoding and retrieval.

Verbal Memory

Age related memory deficits are much more apparent in some tasks than in others. As demonstrated by the research summarized above, much of the evidence demonstrating deficits in secondary memory originated in studies of verbal memory. Age does not appear to erode knowledge of the sounds of language, the rules of their combination, or word knowledge (La Rue, 1992). Bayles and Kaszniak's (1987) review of the literature led them to conclude that the ability to communicate diminishes with age; however, age effects are subtle and are most likely to be observed when the information to be comprehended is new, complex and must be processed quickly.

Schaie and Willis' (1993) cross-sectional data analyses of the 5th (1984) wave of the Seattle Longitudinal Study on Aging found age difference patterns in a number of ability areas, including verbal memory. Defining verbal memory as the ability to encode, store and recall meaningful language units, they used immediate and delayed measures of verbal recall and verbal fluency to examine age and gender effects. Significant main effects for age and gender were found, with increasing age and male sex predicting poorer scores on all verbal memory measures. Petersen, Smith, Kokmen, Ivni, and Tangalos (1992) evaluated two aspects of memory function thought to be sensitive to the effects of aging in a group of community-dwelling, cognitively normal individuals ranging in age from 62 to 100 years: learning (acquisition) and delayed recall (forgetting). Results demonstrated that acquisition performance declined uniformly with increasing age but was not related to education. Forgetting recall remained relatively stable across age when adjusted for the amount of material initially learned.

Hultsch, Hertzog, and Dixon (1990) examined the ability correlates of verbal memory performance in three age groups (19-36, 55-69, and 70-86 years) of a population of healthy, community dwelling, older adults. They found that: a) individual differences in process and ability variables predicted performance on text and word recall, accounting for approximately half of the variance; b) the pattern of predictors was very similar for text and word recall, with the best predictors being semantic speed, comprehension speed, clustering, and working memory; and c) age-related differences in text and word recall could be substantially accounted for by individual differences in related cognitive abilities, particularly indicators of verbal speed and working memory. A related study examined short-term longitudinal changes in memory performance, information processing, and intellectual ability tasks over a three year period among healthy, community-dwelling older adults (ages 55-86; Hultsch, Hertzog, Small, McDonald-Miszczak, & Dixon, 1992). The results showed significant average declines in working memory, verbal fluency and word knowledge. Interactions for processing time measures and working memory were found, showing greater decline in the earlier-born versus the later-born cohort. A step-down analysis revealed that covarying declines in other variables, including processing time, did not eliminate the noted declines.

That mild memory loss may arise from age-associated brain changes remains an unproven hypothesis. Proposals concerning the neuroanatomic substrate for these changes in age-associated memory loss remain speculative. It has been suggested that a separable brain system underlies episodic memory (information about temporally dated episodes that can be recollected), as evidenced by patients with amnesia having gross impairments of episodic memory while other kinds of memory remain intact. On this premise, Shallice et al. (1994) used positron emission topography in an attempt to identify components of this system in normal volunteers. Brain activity was measured while learning and retrieving verbal material using a verbal paired associates procedure. A dual-task interference paradigm was used to isolate the areas concerned with retrieval from verbal episodic memory. Acquisition was found to be associated with activity in the left prefrontal cortex and the retrosplenial area, whereas retrieval was associated with activity in right prefrontal cortex and the precuneus. The authors concluded that episodic memory involves a network of specific prefrontal and posterior structures which can be fractionated into different component processes. Thus, in addition to the areas traditionally thought to be associated with memory, mesio-temporal and diencephalic structures, the prefrontal cortex also appears to share a role in memory processes.

The Effects of Depression on Memory

Depression can refer to an wide range of phenomenon, from the normal expression of a sad mood to the impaired emotional state of clinical depression. Depressive symptoms include: a persistent and pervasive depressed mood; markedly decreased interest or pleasure in most or all activities; sleep disturbances; significant, undesired weight loss or gain; fatigue or loss of energy; psychomotor agitation or retardation; feelings of worthlessness, hopeless and/or excessive guilt; decreased ability to think or concentrate, indecisiveness, recurrent thoughts of death, suicidal ideation, and/or attempted suicides (DSM-IV; American Psychiatric Association, 1994). Exclusionary criteria also apply. To achieve a diagnosis of major depression, the symptoms cannot be due to bereavement or organic factors, nor can they be superimposed on other psychiatric disorders. The prevalence of depression in the population of persons over age 60 was found to vary from .8 to 8%, according to the method of assessment, with upwards of 46% reporting some depressive symptoms or mild dysphoria (Blazer, Hughes, & George, 1987).

Ordinarily, manifestations of depression appear quite similar in younger and older adults. However, age trends in the overall severity of depression and in the clustering of specific symptoms may exist (La Rue, 1992). Older adults have a tendency to show increased levels of global cognitive impairment during depressive episodes, sometimes severe enough to suggest dementing processes. Depressed older adults can experience and complain of difficulty with memory and cognition, becoming withdrawn and dysfunctional. Additionally, they may complain and show evidence of memory loss and concentration difficulties on neuropsychological testing. Mildly to moderately depressed older adults have been described as showing a "slow start" on memory tasks during neuropsychological testing, but in general, show patterns and levels of performance similar to those of normals (La Rue, 1992). When patterns of test outcomes of normal versus severely depressed older adults are compared, significant differences are observed in many areas, including: learning, recall, visuospatial processing, and most aspects of memory.

Tests of secondary memory require conscious effort. Because effortful processing is an area of weakness for depressed persons (Roy-Byrne, Weingartner, Bierer, Thompson, & Post, 1986), severe impairments can be expected. Studies of impairment on immediate Logical Memory of the Wechsler Memory Scale, Revised (WMS-R; Wechsler, 1987), have reported very low mean scores (4.0 ± 3.3 to 5.3 ± 3.3) for older (over 60 years), depressed patients (La Rue, 1992, pg. 273). These scores are below expected age level scores. Kopelman (1986) observed a 73% retention rate for elderly depressed inpatients on the delayed Logical Memory of the WMS-R, which contrasted with the 82% retention rate for healthy elderly volunteers.

In conclusion, depression can affect cognitive abilities, and in older adults, may cause cognitive difficulties reflective of dementing processes. Because of the prevalence of depression in adults over 60, any memory assessments performed may be confounded by underlying depression. Thus controlling for the effects of depression is imperative.

Attention and Memory

Moscovitch (1979) defined attention as "a controlled process that enables the individual to select, from a number of alternatives, the tasks he will perform, or the stimulus he will process, and the cognitive strategy he will adopt to carry out these operations" (p. 422). Attention has also been viewed as "the capacity or energy to support cognitive processes" (Plude & Hoyer, 1985, p. 49). This view suggests attention is a limited commodity or resource which is necessary to support information processing. From this view comes the idea that older adults experience a global reduction in attentional resources causing a reduction in the efficiency with which cognitive processes can be executed (Craik & Simon, 1980). Thus, attentional disorders may indirectly cause impaired performance in other cognitive functions, including memory. Kinsbourne (1980) stated that all attentional capabilities are pertinent to memory in that they facilitate the encoding of critical features of the memorandum, thus providing a more salient and distinctive experience for subsequent retrieval. Of the four commonly used categories of attention, divided, switching, sustained and selective, evidence exists to support age-related deficits in each category, when studied within the context of age changes in memory.

The frontal lobes appear to be most important in maintaining attention over time, organizing information into workable chunks, and preventing distraction (Fuster, 1980). Susceptibility to interference seems to be an important source underlying impaired performance on memory tests by subjects with frontal lobe pathology. This susceptibility to interference appears to be nonspecific (Stuss & Benson, 1986). Fuster (1980) further suggests that this deficit represents an inability of the patient with frontal lobe damage to maintain consistent, directed attention over time based on an inability to control interfering stimuli. Because of the important role attentional abilities have in the ability to remember, it is imperative that they be separated from and controlled for, when examining memory abilities of subjects, especially older adults.

The Frontal Lobes and Memory

Age-associated neuronal loss has been documented in a variety of areas of the human neocortex, with some areas showing larger age differences than others. In the neocortex, one of the areas where the most pronounced loss of neuronal tissue occurs is the frontal polar cortex (La Rue, 1992). Numerous studies have found evidence for a general reduction in gross brain volume becoming significant in the 7th decade of life, but the more striking feature of these findings is that of regional differences in the degree of reduction across the cortex. Haug and Egers' (1991) estimated the degree of reduction to be approximately 1% in the temporal, parietal, and occipital lobes, compared with volume reduction in the frontal cortex estimated to be from 10-17%. This reduction in brain volume appears to result more form a reduction in neuron size than from an actual loss of neurons. Studies in recent years have begun to suggest that some of impairments of advancing age are based on frontal lobe deterioration. There is some suggestion of selective decrease in blood flow over frontal and prefrontal areas with aging (Dupui, Guell, Bessoles, Geraud, & Bes, 1984). In a magnetic resonance imagery (MRI) study of periventricular high-signal intensity patterns in 151 adults above age 50 years, 7.8% of subjects who had no identified cerebrovascular risk factors or symptoms were found to have MRI periventricular lesions, versus 78.5% of subjects with a history of cerebrovascular risk factors or symptoms. The following periventricular patterns were seen with highest frequencies: round regions contiguous with the anterior frontal horns;

dense bands surrounding the frontal horns; thick caps surrounding the frontal horns with thin bands surrounding the bodies of the lateral ventricles; and thick irregular or smooth bands surrounding the entire ventricular system. The authors concluded that patchy periventricular lesions similar to those of multiple sclerosis are present in 30% of patients older than 60, and could result from the effects of normal aging.

The prefrontal cortex has been afforded the highest functions of the brain, including the capacity for insight, abstraction, self-awareness, and complex problem solving. Many of the changes seen in aging, including general slowing, decreased drive, forgetfulness and deteriorated cognitive functioning, may be frontal lobe-based. Memory alterations in at least some older adults might be considered a frontal lobe system disorder (Moscovitch & Winocur, 1983). A frontal deficit hypothesis has been offered on the basis that older people often perform poorly on measures of cognitive flexibility (a hallmark of frontal lobe impairment) and make some of the same types of errors on neuropsychological tests as patients with frontal lesions (Albert & Kaplan, 1980). Mittenberg, Seidenberg, O'Leary, and DiGiulio (1989) compared the performance of younger and older subjects on tests of frontal, temporal, and parietal functions. The strongest correlation obtained was between age and frontal measures, with increasing age being predictive of decreasing performance on frontal lobe measures.

One area of the frontal lobes that is significantly involved in the performance of many cognitive tasks, including memory, is the inferior convexity, just ventral to the sulcus principalis. Impairment following lesions to this area is characterized by marked perseverative responding, apparently due to an inability to overcome response tendencies that compete with the response to be learned (Squire, 1987). Thus, both flexibility and the ability to alter responses to quickly changing environmental demands would be affected by damage to this area, and would impair performance on many memory tasks.

Although memory function may be affected by frontal damage or neuronal loss, present evidence for a specific frontal input to memory function is somewhat weak, due to: a) the extreme difficulty in constructing a memory task that is not affected by other known dysfunction's of frontal damage; b) control of various factors such as age, education, size and extent of lesion or neuronal loss being very difficult; and c) inconsistent result obtained when comparing animal and human research (Stuss & Benson, 1986). Animal studies using more specific designs have gradually let to the interpretation of the deficits seen on memory tasks being attributable to attentional versus frontal lobe abilities.

The frontal lobes are closely interconnected with the limbic-diencephalic system of memory, as well as with the temporal lobes. Most current research demonstrates that damage to the frontal lobes does not produce classic amnesia, rather, it results in frontal cognitive impairments that influence the successful functioning of these memory systems by allowing information to be remembered in its appropriate context. Knowledge of this qualitatively different memory disorder may be helpful in identifying the neural and neuropsychological basis of memory deficits in older adults.

Descriptions of human clinical studies lend increased support for the role of the frontal lobes in memory. Gardner (1975) observed short-term memory problems in persons with extensive bilateral lesions of the prefrontal cortex. Kolodny (1992) reported that 43% of patients with frontal lobe tumors had subjective or objective evidence of memory problems, concluding that memory disturbance could be considered an early symptom of frontal lobe tumor.

Hecaen and Albert (1978) theorized that memory disturbance with frontal abnormality primarily involved recent events, which they described as, "forgetting to remember". An intended act or memory is forgotten, although it may be retrieved later. An example would be a patient being asked not to do something, but that they forget to

Since all the modality-specific sensory areas project to frontal lobes, it would follow that the frontal lobes must be concerned with the organization and processing of sensory information, regardless of modality. The frontal lobes seem to be required to organize and program voluntary behavior effectively, to suppress interfering stimuli, and to permit appropriate responses to rapidly varying environmental demands (Squire, 1987), all of which contribute to the ability to remember. Additionally, they appear to have a specialized processing function concerning the temporal and strategic organization of behavior and memory. Patients with frontal lesions exhibit deficits on memory tests in the that may recognize an item as familiar but fail to remember the temporal order in which the item occurred, relative to other items. In examining verbal memory, when presented with two lists of items to be remembered, patients with frontal lobe damage have difficulty remembering which list the items were on, making more mistakes that could be explained by poor recognition memory for the items themselves (Squire, 1987).

The Role of the Frontal Lobes in Verbal Memory

Shallice et. al's (1994) study of brain regions associated with acquisition and retrieval of verbal episodic memory, found increased left prefrontal cortex activity was associated with acquisition and right prefrontal cortex and precuneus activity was associated with retrieval. The authors concluded these regions play a major role in the executive component of working memory and are involved in the organization of supervisory thought processes. Recall of words from categorized lists was examined in 77 patients with either excised left temporal or frontal lobes and in 12 normal controls (Incisa, Rocchetta, & Milner, 1993). Both the temporal and frontal groups demonstrated impaired free recall, but the frontal group performed normally when encoding and retrieval strategies were supplied. An experimentally induced interference during cued recall was found to abnormally hamper performance of the frontal group, but not the temporal group, with subsequent removal of the interfering cues resulting in improved performance in the frontal group. The authors concluded that the integrity of the left frontal lobe seems indispensable for normal strategic retrieval and for the suppression of potentially interfering items in verbal memory. Using a standard word pair learning task, Uhl, Podreka, and Deecke (1994) examined the role of the anterior frontal cortex in overcoming older memories exerted on the acquisition of new information (controlling proactive inhibition). Results revealed an increase in right anterior frontal flow indices on Brain-SPECT with the experimental condition. Indeed, the incidence of verbal memory deficits does seem to be related to the ability and functioning of the frontal lobes.

The frontal lobes contribute to verbal recognition and recall abilities, as well. In a study examining the nature of verbal recognition memory in young (mean age = 33.9 years) and old subjects (mean age = 80.0 years), Parkin and Walter (1992) found that explicit recollection declined with age while familiarity-based recognition increased. The extent to which older subjects relied on familiarity-based recognition correlated with indices of frontal lobe dysfunction. They hypothesized that frontal deterioration in older adults reduced their ability to initiate encoding of target information needed for durable explicit representation. Additionally, older persons may fail to utilize retrieval operations on the recognition stimuli which would trigger the episodic information related to the original learning task/stimuli.

Jetter, Poser, Freeman, and Markowitsch (1986) studied the retention performance for learned words in two cortically damaged groups: patients with uni- or bilateral damage to the frontal lobes and patients with post-rolandic damage. Three lists of words had to be recalled after 15 minutes and one day, under free recall, cued recall, and then under a recognition condition. While the performance of both groups was similar under all three conditions when tested after 15 minutes, the frontal group performed significantly worse in the one day free recall retention test. The authors interpreted this deficit as related, in part, to the classic frontal lobe symptomatology of reduced attention and lack of initiative, drive and concentration.

Evidence exists which strongly suggests a role for frontal lobe functioning in verbal memory. Encoding and retrieval seem to be mediated by the functioning of the frontal lobes, leading to possible deficits in recognition and recall. Additionally, the frontal lobes appear to play a crucial role in the suppression of interfering stimuli, including controlling for the effects of previously acquired information. However, much of this research has been conducted with persons who have cortical damage. Do these same effects occur in a population of healthy, older adults?

Hypotheses

The first purpose of this study is to elucidate the role of the frontal lobes in verbal memory in a population of healthy, older adults. The focus will be on more accurately defining the mediating role of the frontal lobes by addressing the following questions: How well do measures of frontal lobe functioning predict verbal memory? Are age-related differences in the recall of unorganized versus organized verbal material comparable and to what extent is this related to frontal lobe functioning? How are these specific components of verbal memory influenced by performance on measures of frontal lobe functioning: semantic clustering; primacy-recency effects; perseveration rates; vulnerability to interference; recognition discriminability; immediate, delayed and cued recall; and learning and forgetting rates? The main premise of this portion of the study is that the prefrontal cortex is critically important for processing verbal information because of its role in the encoding, retrieval, and inhibition of irrelevant information processes. Thus, it is hypothesized that, when controlling for the effects of depression and attentional abilities:

1. A negative relationship is predicted between age and verbal memory performance.

2. A positive relationship is predicted between performance on measures of frontal lobe functioning (FLF) and verbal memory performance.

3. Age and performance on measures of FLF functioning, when considered together, will influence performance differentially on verbal memory procedural skills contributing to verbal memory. The combination of both variables will account for significantly more of the variance in verbal memory performance than either variable's separate effect. Verbal memory performance variables to be examined include: immediate and delayed recall rates; semantic clustering, primacy-recency effects; perseveration rates; intrusion effects; and recognition discriminability.

Memory Complaints and Memory Loss

Much evidence exists documenting the incidence and prevalence of memory problems with advancing age. Thus, it is not surprising that the estimated percentage of older adults who complain of memory problems and memory loss ranges from 50-80% (Flicker, Ferris, & Reisberg, 1993). But how well do these memory complaints correlate with actual memory problems? What is the relationship between memory functioning and memory complaints?

The assumption that memory disturbances are associated with aging is supported by many studies demonstrating declines in the memory capacity of older adults when compared with young and middle-aged persons. This Age Associated Memory Decline (AAMD; Crook et al., 1986) has, as one of its essential criteria, the presence of memory complaints; consequently it is of great interest to know whether such complaints are related to objective findings in memory tests or to some other factors such as personality traits, affective states of the subject, or other cognitive processes mediated by different areas of the brain, such as the frontal lobes. Most studies have found either weak or no associations performance on memory tests and ratings on memory complaint questionnaires. Change in memory performance and its correspondence to change in speed of performance and self-reported memory functioning was investigated longitudinally in 30 adults (mean age of 67.5) with memory complaints (Taylor, Miller, & Tinklenberg, 1992). Those persons demonstrating symptoms of dementia or who scored below a 24 on the Mini Mental Status Examination (MMSE; Folstein, Folstein, & McHugh, 1975) were excluded. Participants were assessed by self-report questionnaires and cognitive tests over a six year period. A significant decline in word-recall scores was found, which was accompanied at the group level by significant self-reported decline in everyday memory functioning. The oldest showed the most substantial declines in memory performance, but at the individual test level, memory change did no significantly correlate with change in self-reports of memory loss. Flicker, Ferris, and Reisberg (1993) conducted a longitudinal study of the cognitive functioning of elderly persons with subjective memory complaints. Using a sample of 59 healthy, elderly individuals (mean age of 68.7 years) with memory complaints but no clinically apparent cognitive dysfunction, they found that these individuals were not at high risk for progressive cognitive deterioration over a subsequent 3 to 4 year time interval.

Attempting to determine if older person's complaints of memory impairment accurately reflect of real memory disturbances, Bolla, Lindgren, Bonaccorsy, and Bleecker (1991) examined the relationship between memory complaints, objective memory performance, mood, age, verbal intelligence and gender. They found that memory complaints demonstrated a stronger association with depressed mood than with performance on memory tasks. Increasing reports of depressive symptoms were associated with more overall memory complaints. Verbal intelligence, age, and gender also contributed to memory complaints, with persons of higher verbal intelligence, who were younger and who were male reporting fewer complaints and placing less emphasis on forgetting. The authors concluded that self-rating of memory disturbance by older adults may be related more to depressed mood than to poor performance on memory tasks.

It is well known that under certain circumstances, negative self-perceptions, as well as other affective and emotional states, can have a remarkable impact on performance. This is especially apparent in the realm of memory abilities. Additionally, many older adults tend to perceive themselves as less efficacious on many cognitive tasks as compared to younger adults or themselves when they were younger (Hultsch & Dixon, 1990). Perhaps poor self-evaluations result in lowered effort and consequent poor performance. The subjective memory complaints and personality traits in normal elderly subjects (ages ranging 67 to 78 years) were examined by Hannien et al. (1994). Complaints of memory loss did not correlate with the actual memory performance on tests. However, those subjects who most emphatically complained of memory disturbance had greater tendencies toward somatic complaining, greater feelings of anxiety about their physical health, and more negative feelings about their own competence and capabilities than those who did not complain of memory deterioration. The authors concluded that subjective feelings of memory impairment are more closely associated with personality traits than with actual memory performance in normal elderly persons.

A number of studies have examined the relationship between memory complaints, depression and actual memory loss more specifically. The influence of depression on memory complaints and performance in a sample of community dwelling older adults was the focus of a study by Popkin, Gallagher, Thompson, and Moore (1982). They compared normal, older adults (mean age of 69.8 years) to "depressed", older adults (mean age of 67.7 years) who were experiencing a current episode of "Major Depressive Disorder" according to Research Diagnostic Criteria for Depression (RDC; Spitzer et al., 1980) on a number of immediate and delayed recall memory tests. Complaints were significantly more frequent in the clinically depressed subsample. However, their actual performance on tests of immediate and delayed recall did not differ significantly from the performance of nondepressed older adults. In addition, results indicated that depressives who responded favorable to a program of psychotherapy demonstrated significant reductions in levels of memory complaints at post-treatment assessment.

Data reviewed thus far suggest, at best, a weak relationship between self-reports of everyday memory functioning and actual performance on memory tests. Some argue, though, this finding is the result of methodological flaws in the tests used to assess memory complaints. Gilewski and Zeliniski (1986) suggested that the relationship might be stronger if the self-report measures were designed more judiciously (i.e., matching the complaint measure with a relevant memory task) and if the cognitive tasks were isometric to the self-report items. Also, it may be the case that individuals differ in their use of the self-report response scales, such as rater differences in scale calibration.

Another reason for the weak relationship found between subjective memory complaints and objective memory loss may be that what is being described as loss of memory functioning may be more accurately labeled as a loss of abilities related to frontal lobe functioning. Because of the intimate role the frontal lobes play in memory and attentional abilities, a decrease in frontal lobe functioning may be translated into either specific or general memory loss, which is interpreted by the individual as just that. But because memory tests are being used in an attempt to measure this "memory loss", rather than using measures of frontal lobe functioning, the results found are leading to the conclusion that subjective memory complaints are, at most, weakly correlated with objective memory loss. It follows that if measures of frontal lobe functioning were use to assess this "memory loss", the results may suggest a stronger relationship and thus a different conclusion. Additionally, older adults are more likely to label any cognitive difficulties as memory problems, versus attributing them to frontal lobe functions such as concept formation, insight, abstraction, and complex problem solving. Small et al.(1994), in their study of the relationships between clinical and brain function in persons with a familial risk for Alzheimer's disease, assessed subjective and objective cognitive abilities, mood states, and cerebral glucose metabolism (using positron emission tomography) in 43 persons (mean age of 60.1 years) with AAMI. One of their findings was that decreased metabolic ratios in the frontal lobes correlated with reports of increased mnemonics usage, one of the factors indicating lower levels of perceived memory functioning. They concluded that self-reports of mnemonics usage may be sensitive indicators of decreased frontal lobe function.

Hypotheses

The second purpose of this study is to elucidate the role of the frontal lobes in memory complaints. How is frontal lobe functioning related to the incidence of memory complaints? Does the incidence of memory complaints, mediated by frontal lobe functioning, differ according to age? The main premise of this portion of the study is that the functioning of the prefrontal cortex is critically important in determining a person's perception of their memory abilities, and thus, subsequent memory complaints. Thus, it is hypothesized that, when controlling for the effects of depression:

1. A negative relationship is expected between performance on frontal lobe measures and memory complaints.
2. The negative relationship between performance on frontal lobe measures and memory complaints will be stronger than the relationship between verbal memory performance and memory complaints.
3. The combination of age and performance on frontal lobe measures will account for significantly more of the variance in memory complaints than either variable's separate effect.

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METHOD

Participants

One hundred older adults were recruited from senior citizen and church groups in the greater Lansing, Michigan area. Those who scored at 24 or better on the Mini Mental Status Examination and reported no significant history of severe neurological or medical problems likely to have adversely affected their cognitive abilities (e.g., stroke, major ischemia, terminal illnesses, significant traumatic brain injury) on a self-report medical history questionnaire were assessed. Twelve participants who reported either a history of major ischemia or a loss of consciousness of greater than five minutes as a result of head trauma were excluded from the analyses. This pool of 88 retained participants contained protocols of older individuals ranging from 60 to 85 years old (M = 72.85; SD = 7.13), including 45 women and 43 men. The group had a mean education of 13.81 years (SD = 2.49) and all lived independently. Correlations between demographic variables and measures of verbal memory and frontal lobe functioning, as well as performance on attentional and depression measures can be found on Appendix A.

Prior to analyses, a subscale score from the Wisconsin Card Sorting Task measuring total categories achieved (WCSTc) and the color-word naming trial from the Stroop (Stroop-cwn) were reversed scored so that higher scores indicated increasing impairment/poorer performance. This made the scores from both of these measures comparable to the scores on the remaining subscale scores of the Wisconsin Card Sorting Test.

Procedure

Participants were assessed at MSU's Psychological Clinic or at their homes, according to their preference. The entire assessment for each participant, including measures unrelated to this study, required from three to three-and-one-half hours.

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Assessments were conducted and data were scored by the author and two additional students enrolled in MSU's clinical psychology program, both of whom had extensive experience in administering and scoring these tests. On completing the assessment, a $10 donation to each participant's senior citizen or church group was made and they were told they would receive feedback on their performance as compared to other group members upon completion of the study.

Measures

Measures of Frontal Lobe Functioning

Wisconsin Card Sorting Task

Since multiple measures of frontal lobe functioning could more fully capture any impairment in frontal lobe functioning, two instruments were chosen. The first instrument, the Wisconsin Card Sorting Task (WCST - Modified; Nelson, 1976), assesses the ability to generate and test hypotheses and to shift and maintain sets. It contains 128 cards which the participant attempts to discover three different rules/categories for sorting multidimensional stimuli by matching each card to one of four key cards. Feedback is provided when cards are matched correctly or incorrectly. After the participant matches 10 cards of a given category, the examiner changes the matching category, without indicating this to the participant. Each category has to be discovered twice. This test yields four measures: total categories (WCSTc); perseverative errors involving continuation of sorting based on a immediately preceding rule (WCSTp); nonperseverative errors (WCSTn); and total errors (WCSTe).

The WCST is widely used in clinical settings to detect cognitive impairments associated with frontal lesions (Stuss & Benson, 1986). Spreen and Strauss' (1991) critique of the WCST reported that studies have generally confirmed that this test is sensitive to frontal lobe function, although some have reported more perseveration in *s*

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patients with right as compared to left frontal lobe damage. Drewe's (1974) study of patient's with schizophrenia who had undergone frontal leucotomy demonstrated significant difficulties with perseveration. Milner (1963) found clear differences between patients with dorsolateral frontal excisions and those with orbitofrontal and posterior lesions. Patients with dorsolateral lesions showed an inability to shift from one sorting principal to another. The work of Taylor (1979) and Hermann et al. (1988) was supportive and suggested that the test is sensitive to function in dorsolateral areas of both frontal lobes, but more to the left than to the right. Based on these several studies, Lezak (1983) concluded that patients with frontal lesions are prone to perseverate on the WCST.

Stroop Color and Word Test

The second measure of frontal lobe functioning is the Stroop (1935) Color and Word Test addressing the ease with which a person can shift perceptual set to conform to changing demands and suppress a habitual response in favor of an unusual one. This three page test yields three basic scores: Word naming (Stroop-wn) determined by the number of page one items completed in 45 seconds; Color naming (Stroop-cn), determined by the number of page two items completed in 45 seconds; and Color-word naming (Stroop-cwn), determined by the number of page three items completed in 45 seconds. The color-word naming score is determined on a page that consists of color words printed in incongruous colored ink (e.g., the word "blue" printed in red ink). The participant is asked to name the color of the ink the word is printed in rather than the word itself. The tendency to read the word may intrude upon the color naming assignment, thus decreasing the score (the interference effect).

Golden (1976) found the Stroop was 88.9% effective in differentiating between normal controls and brain-damaged clients and 82.9% accurate in discriminating between psychiatric controls and brain damaged clients. Regard (1981) reported the Stroop-cwn was greater for patients with left frontal lobe damage than for other patients or control g

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groups. Uchiyama, Mitrushina, D'Elia, Satz, and Mathews (1994) used the Stroop and other measures to assess frontal lobe functioning in geriatric and non-geriatric samples. Stroop-cn and Stroop-cwn scores were found to be two of the most sensitive measures for predicting frontal lobe functioning. This test is also sensitive to severity of dementia (Koss et al., 1984). Spreen and Strauss (1991) reported a one-month test-retest reliability for each page of the Stroop to be .90, .83, and .91, respectively.

Measures of Verbal Memory

Logical Memory

Logical Memory (LM), Story A of the Wechsler Memory Scale (Wechsler 1987) will serve as a measure of prose recall. Total recall scores for LM can range from 1 to 22, with higher scores reflecting more information units recalled. It has been found to be significantly correlated ($r = -.375$) with the Halstead-Reitan Average Impairment Scale among brain-damaged subjects (Russell, 1975) and has an average test-retest stability of .79 over a 4-6 weeks (Bowden & Bell, 1992). LM has consistently shown to load on the memory factor in numerous factor analyses (Scott, 1977; Prigatano, 1978). Clinical investigations using the LM test found it sensitive to memory disturbances and characterizes the learning and memory disorders in numerous different patient groups, including those with dementia, multiple sclerosis, neurotoxin exposure, and depression (Spreen & Strauss, 1991).

California Verbal Learning Test

The California Verbal Learning Test (CVLT; Delis, Kramer, Kaplan, & Ober, 1984) involves learning lists of words presented in successive trials in the same sequence. Its scoring system provides information on the quantity of material learned, as well as for: rate of learning over several trials, the encoding strategy employed (semantic clustering vs. serial ordering vs. phonemic encoding vs. random or inconsistent strategies), the types of errors made, the vulnerability of verbal memory to varying delays in time and to interference conditions, and the degree to which memory performance improves with assisted recall cues.

Rosenbaum's (1984) CVLT critique reported that it is an extremely sensitive instrument for detecting subtle memory deficits; however, this high sensitivity comes at the expense of more false-positive errors. Over a one-year interval, CVLT test-retest reliability coefficients ranged from .26 (percent middle recall) to .79 (long-delay cued recall). Total immediate recall of list A across the five trials correlated .66 with the WMS Memory Quotient and in the .60s with several other WMS variables (Delis, Kramer, Kaplan, & Ober, 1987). These authors also factor analyzed all CVLT intercorrelations and found that its multiple indices identified theoretically meaningful factors consonant with the constructs they were designed to measure. In addition, multiple CVLT studies of selected neurological groups (chronic alcoholics, Parkinson's, Huntington's, and Alzheimer's Disease), have yielded results commensurate with each group's previously determined memory problems.

Measure of Memory Complaints

The Memory Assessment Clinics, Inc. Self-Rating Scale (MAC-S) is an extensive self-rating scale for memory. The original MAC-S consisted of items describing memory tasks or problems encountered in everyday life and global memory evaluation items (Winterling, Crook, Salama, & Gobert, 1986). These items were divided into an "Ability" scale, in which individuals were asked to indicate their ability to remember specific types of information and a "Frequency of Occurrence" scale addressing how often they experienced specific memory problems. Responses are recorded on five-point Likert scales, with choices ranging from "very poor" to "very good" on the Ability scale, and from "very often" to "very rarely" on the Frequency scale. Winterling et al. (1986) conducted factor analyses of the original MAC-S based on the performance of 343 nonclinical persons, resulting in a shortened version comprised of 21 Ability items, 24 Frequency items, and four global ratings.

The performance of 1,106 normal adults on this revised scale was factor analyzed by Crook and Larrabee (1990). Five Ability factors were identified: Remote Personal Memory, Numeric Recall, Everyday Task-Oriented Memory, Word Recall/Semantic Memory, and Spatial and Topographical Memory. Five Frequency factors were also identified: Word and Fact Recall/Semantic Memory, Attention and Concentration, Everyday Task-Oriented Memory, General Forgetfulness, and Facial Recognition. These authors demonstrated the stability of this factor structure by obtaining the same five ability and frequency factors when this sample was divided into males versus females, and also when it was divided into groups of age 60 and above or age 59 and below at its median age of 59. Larrabee, West, and Crook (1989) reported data supporting the validity of the MAC-S in relation to objective, computer-simulated measures of everyday memory function, and affective status. They reported a .53 ($p < .05$) canonical correlation between unit-weighted MAC-S factor scores and the computerized objective measures.

Most recently, Crook and Larrabee (1992) provided normative data on their 1,106 MAC-D subjects. Factor scores calculated by summing MAC-S items salient to each of the ten factors correlated highly with the appropriate orthogonal factor scores generated from principal components' analyses. These correlations ranged from .91 to .95 for the Ability factors and from .69 to .92 for the Frequency factors.

Measure of Mental Status

The MMSE is a 30-item form created to briefly screen for cognitive functioning. It assess orientation, immediate recall, attention and calculation, intermediate recall, language abilities, and constructional dyspraxia. Scores can range from 0, indicating severe impairment to 30, indicating an unimpaired mental status. It was standardized on a sample of 63 healthy elderly controls (mean age = 74 years) whose scores ranged from 24.6 to 27.6 (Folstein, Folstein, & McHugh, 1975). Demented persons scored between 9.6 to 12.2, with no overlap between these two groups. A cut-off score of 24 is often used to identify scores more suggestive of impairment (Lezak, 1983).

Measure of Depression

The 30 yes-no Geriatric Depression Scale (GDS) items address mood and psychological symptoms of depression. Respondents answer each question according to how they feel at that time. GDS scores range from 0, indicating no depressive statements were endorsed, to 30, indicating severe depression. The item-total correlations ranged from .32 to .83 ($\underline{M}$ = .56), while internal consistency and split-half reliability were both .94. The test-retest reliability over one month was .85 (Koenig, Meador, Cohen, & Blazer, 1988).

Factor analysis of the GDS identified a major factor of general depression and minor factors of worry/obsessive thoughts, and apathy/withdrawal (Parmalee et al., 1989). Criterion validity with the Research Diagnostic Criteria was found to be .82. Concurrent validity with the Hamilton and Zung Depression Scales appeared good (.83 and .86, respectively; Yesavage et al., 1986). Stebbins and Hopp (1990) reported that the GDS successfully discriminated between mildly demented depressed and nondepressed individuals.

Measure of Attention

The Paced Auditory Serial Addition Test (PASAT; Gronwall & Sampson, 1974; Gronwall & Wrightson, 1974) is designed to estimate the rate of information processing (the amount of information that can be handled at one time) and sustained attention. A pre-recorded tape delivers a random series of 61 numbers from 1 through 9. The respondent is instructed to add pairs of numbers such that each number is added to the one immediately preceding it: the second number is added to the first, the third to the second, the fourth to the third, and so on. The same 60 numbers are given in four different trials at differing presentation rates (2.4, 2.0, 1.6, and 1.2 seconds). This test requires individuals to comprehend the auditory input, respond verbally, inhibit encoding of one's own response while attending to the next stimulus in a series, and perform at an externally determined pace (Spreen & Strauss, 1991). To be correct, a response must be made before the next stimulus. Correct and incorrect responses per trial are recorded, with a maximum score of 60 per trial.

The PASAT has good internal consistency, with a split-half reliability of .96 (Egan, 1988). O'Donnell, MacGregor, Dabrowski, Oestreicher, and Romero's (1994) principal components factor analysis of a number of neuropsychological tests, including the PASAT, showed that it was one of the measures that defined an attentional factor. Among healthy people, the PASAT correlated strongly ($r = .68$) with general intelligence and numerical ability (Egan, 1988) and was significantly affected by age and IQ ($F[1,520] = 30.0$, $p < .001$; $F[1,520] = 46.1$, $p < .0001$, respectively), with lower performance by older adults and those with lower IQ scores (Brittain, Marche, Reeder, Roth, & Boll, 1991).

RESULTS

Data analyses were subdivided into four components. First, the psychometric properties of the two frontal lobe and two verbal memory measures were assessed. Second, the three hypotheses regarding the relationship between verbal memory and frontal lobe functioning were investigated. Third, the three hypotheses regarding the relationship between memory complaints and frontal lobe functioning were evaluated. Fourth, post-hoc analyses of the overall sample were conducted.

Psychometric Properties

Because the three measures from the WCST (WCSTc, WCSTp, and WCSTn) were found highly intercorrelated as well as strongly associated with the Stroop-cwn score, they were subjected to a scale reliability analysis using Cronbach's (1951) alpha. The scale total statistics and stability coefficients for this composite scale (alpha = .83) and resulting 4 items can be found in Appendix B. In summary, it appears that there was adequate reliability to support combining these measures to produce a composite measure of frontal lobe functioning (FLF). While it is true that the corrected-item total correlations for WCSTc and Stroop-cwn were not as highly related to the rest of the items, they were included in the interest of creating a broad measure of frontal lobe functioning. Whereas combining WCSTp, WCSTn, and WCSTe would have created a composite measure with a higher coefficient alpha, it would represent only one proposed aspect of frontal lobe functioning. Including the WCSTc and Stroop-cwn provided a broader measure. WCSTe was not included in the composite frontal lobe measure because it represents the sum of WCSTp and WCSTn; however, it was used individually in analyses. Stroop-wn and Stroop-cn were omitted from all analyses due to their low correlations with the other frontal lobe measures. Because the relationship between Stroop-cwn scores and other variables was observed to be significantly powerful and different in some instances from the relationship between FLF and other variables, the effects of Stroop-cwn (STROOP) were individually addressed in all analyses.

The same procedure was used to examine the verbal memory measures, as many were also found to be highly correlated. After examining the measure-total statistics and stability coefficients for all 13 measures verbal memory measures, ten measures (all additional scale scores from the CVLT) were deleted because their inclusion would have significantly reduced the reliability of the factor. A principal components factor analysis of the CVLT from 115 individuals with various neurological problems produced five theoretically and clinically meaningful CVLT factors (Vanderploeg, Schinka, and Retzlaff, 1994). This study demonstrated that although all five factors contributed to the overall concept of auditory verbal learning, there are a number of distinct skill areas that comprise auditory verbal memory performance. Furthermore, previous validation studies demonstrating relationships between performance on the Wechsler Logical Memory stories to CVLT performance did not examine the individual CVLT indices; rather, only overall CVLT performance or total items recalled from trials 1 through 5 on the CVLT was used. Thus, although the ten deleted scales from the CVLT address aspects of verbal memory, their inclusion appeared to reduce the reliability of a more global measure of verbal memory performance.

A reliability analysis was conducted on the remaining measures, CVLT, LM1, and LM2. One item, CVLT was deleted from this factor, resulting in a new composite verbal memory measure, VM (alpha = .90; See Appendix C), representing a measure of the recall of organized verbal material. CVLT was used individually in analyses as a measure of the recall of unorganized verbal material.

Hypotheses

Hypotheses regarding the role of frontal lobe functioning and verbal memory

It was first predicted that after controlling for the effects of attention and depression, age and verbal memory performance, as measured by CVLT (California Verbal Learning Test, total items recalled from lists 1-5) and VM (composite verbal memory measure) would relate negatively. This hypothesis was supported (see Table 1). Partial correlations revealed statistically significant relationships between these measures, $r(88) = -.22$, $p < .05$ (CVLT) and $r(88) = -.36$, $p < .01$ (VM). That is, people who were older obtained significantly lower scores on both verbal memory measures.

The next hypothesis predicted a negative relationship between performance on measures of FLF and verbal memory performance after controlling for the effects of attention and depression. As seen in Table 1, this hypothesis was partially supported. Statistically significant, negative relationships were found between CVLT and both frontal lobe measures, indicative of a decline in the recall of unorganized verbal material with poorer performance on frontal lobe measures. The -.22 correlation between VM and STROOP indicates that older adults who performed poorly on STROOP recalled significantly less of the organized verbal material presented to them. The -.06 association between VM and FLF, although in the hypothesized direction, was not statistically significant.

Lastly, it was hypothesized that age and performance on measures of FLF functioning, when considered together, would differentially influence performance on verbal memory procedural skills contributing to verbal memory, as well as overall verbal memory ability. Specifically, it was hypothesized that the combination of both variables would predict significantly more of the variance in verbal memory scores than either variable's separate effect. To test this hypothesis, simple regressions were first conducted examining each verbal memory procedural skill, as well as CVLT and VM, as dependent variables. Regressing semantic clustering rates (SEMANT), primacy effects (PRIM), recency effects (RECEN), perseveration rates (PERSV), intrusion rates (INTRUS), recognition discriminability (RECOG), recall rate (CVLT), and performance on VM on the independent predictor, age, yielded three statistically significant regressions. Scores on CVLT and VM, (see Table 2 for both) were significantly predicted by age, with age accounting for 11% and 19% of the variance in scores, respectively. Similarly, scores on INTRUS were significantly predicted by age, with age accounting for 4% ($R^2 = .21$, $p < .05$) of the variance in scores. Thus, as predicted, performance on immediate and delay recall rates, as well as the number of intrusions made during recall of unorganized verbal material can be explained, in part, by age.

Regressing these same verbal memory procedural skill variables, as well as CVLT and VM on the independent predictor, FLF, yielded four significant regressions. Scores on CVLT and VM (see Table 2 for both) were significantly predicted by scores on FL, with FLF performance accounting for 18% and 5% of the variance in scores, respectively. Similarly, scores on SEMANT and INTRUS were significantly predicted by scores on

Table 1

Partial Correlations Between Age, Verbal Memory Performance and Frontal Lobe Functioning, Controlling for the Effects of Attention and Depression

	Age	CVLT	VM	STROOP
CVLT	-.22*			
VM	-.36**	.40**		
STROOP	.29**	-.50**	-.22*	
FLF	.17	-.28**	-.06	.60**
WCSTe	.10	-.29**	-.21*	.34**
WCSTp	.10	-.20	-.01	.36**
WCSTn	.11	-.17	.00	.35**
WCSTc	-.12	.11	-.01	-.26*

$\underline{N} = 88$; * $\underline{p} < .05$, ** $\underline{p} < .01$. CVLT = California Verbal Learning Test, total items recalled from trials 1-5; VM = composite verbal memory measure; STROOP = color-word naming trial score from Stroop; FLF = composite frontal lobe measure; WCSTe = Wisconsin Card Sorting Task total errors score; WCSTp = Wisconsin Card Sorting Task perseverative errors score; WCSTn = Wisconsin Card Sorting Task non-perseverative errors score; WCSTc = Wisconsin Card Sorting Task total number correct.

FLF, with FLF performance accounting for 5% ($\underline{R} = .23$, $\underline{p} < .05$), and 9% ($\underline{R} = .31$, $\underline{p} < .01$) of the variance in scores, respectively. Thus, as predicted, immediate and delayed recall rates of both unorganized and organized verbal material, as well as semantic clustering and intrusion rates, can be explained, in part, by performance on frontal lobe measures.

Table 2

Linear and Multiple Regressions: Age and Frontal Lobe Measures on CVLT and VM

	Age Alone R^2	FLF Alone R^2	STROOP Alone R^2	Age & FLF Together R^2	Age, FLF, & PASAT Together R^2	Change R^2 Age vs. Age & FLF	Change R^2 FLF vs. Age & FLF
CVLT	.11**	.18**	.40**	.22**	.30**	.12**	.05*
VM	.19**	.05*	.16**	.19**	.25**	.00	.15**

Note: **$p < .01$, *$p < .05$, both values for two-tailed tests. CVLT = California Verbal Learning Test, total recalled trials 1-5; VM = composite verbal memory measure; FLF = composite frontal lobe measure; STROOP = Color-word naming trial from the Stroop Test; PASAT = Paced Auditory Serial Addition Test.

Lastly, these same variables were regressed on the independent predictor STROOP. Five of these regressions yielded significant results. Scores on CVLT and VM (see Table 2 for both) were significantly predicted by performance on STROOP, with STROOP performance accounting for 40% and 16% of the variance in scores, respectively. Similarly, scores on SEMANT, PERSEV, and INTRUS were significantly predicted by performance on STROOP, with STROOP performance accounting for 17% ($R = .42$, $p < .01$), 6% ($R = .24$, $p < .05$), and 8% ($R = .28$, $p < .05$) of the variance in scores, respectively. Again, as predicted, immediate and delayed verbal recall rates, as well as semantic, perseveration, and intrusion rates are associated with performance on STROOP.

To examine the combined effects of age and performance on frontal lobe measures and on verbal memory, multiple regressions were performed holding attentional abilities constant. Originally, it was thought that level of depression should also serve as a predictor variable. But, because of the lack of relationship between depression scores and any measures of verbal memory or frontal lobe functioning, only PASAT was controlled. Utilizing those dependent variables from the single regressions that were significantly associated, in part, by either age or performance on frontal lobe measures, three separate regressions were run; in each case, age and FLF were entered together, followed by age, FLF and PASAT being entered together, followed by age, FLF, and PASAT being entered stepwise.

CVLT served as the first dependent variable in the regression analyses. Zero-order correlations between CVLT and age, FLF (with higher scores denoting poorer performance), and PASAT were -.33, -.42, and .46, respectively (See Appendix A). As shown in Table 2, the Multiple R^2 for all three regression equations were statistically significant ($p < .01$). Adjusted R^2 for each regression demonstrated that the independent variables age and FL accounted for 22% of the variance in CVLT performance. When PASAT was added into the regression equation in the same step as the other two variables, the percentage of variance accounted for in CVLT scores rose to 30%. The step-wise multiple regression final predictive model included PASAT and FLF; together, attentional abilities and performance on frontal lobe measures predicted 28% of the variance in performance on CVLT ($R = .53$, $p < .001$). The contribution of age to the variance in CVLT scores became negligible when the three independent variables were regressed in a step-wise manner. Thus, although, as hypothesized, age and frontal lobe abilities do, both individually and in combination, account for significant amounts of the variance in an older adult's ability to recall unorganized verbal material, when the influence of attentional abilities is considered, the contribution of age effects becomes negligible.

To determine whether the combined effect of both age and FLF performance impaired CVLT scores significantly more than either variable's separate effect, F tests were conducted on the change in R^2. As hypothesized, the combination of the effects of age and FLF significantly predicted more of the variance in CVLT scores than either the separate effects of age or FLF (see Table 2).

VM served as the last dependent variable in the regression analyses. Zero-order correlations between VM and age, FLF, and PASAT were -.43, -.20 and .37, respectively. As shown in Table 2, the Multiple R^2 for all three regressions were statistically significant ($p < .01$). Adjusted R^2 for each regression demonstrated that the dependent variables age and FLF accounted for 19% of the variance in CVLT performance. When PASAT was added into the equation on the same step as the other variables the percentage of variance accounted for in VM scores increased to 25%. The contribution of FLF to the VM variance became negligible when the three independent variables were regressed stepwise. The final step-wise regression model of age and PASAT accounted for 25% of the variance in VM performance ($R = .50$, $p < .01$). Contrary to what was hypothesized, the combination of age and FLF did not influence the recall of organized, verbal material significantly more than either variable's separate effect. Age and sustained/divided attentional abilities were the best predictors of an older adults' ability to recall organized verbal material.

To determine whether the combined effect of both age and FLF impaired VM performance significantly more than either variable's separate effect, F tests were conducted on the change in R^2. Although the combined effects of age and FLF impaired VM performance significantly more that the separate effect of FL (see Table 2), the same was not true of age, which accounted for significantly more of the variance in VM scores than the combined effects of age and FL.

Hypotheses regarding the role of frontal lobe functioning and memory complaints

It was first predicted that, after controlling for the effects of attention and depression, there would be a negative relationship between performance on the frontal lobe measures (FLF and STROOP) and memory complaints (as measured by MACf and MACa). This hypothesis was rejected. Partial correlations between performance on the composite measure of frontal lobe functioning (FLF) and on the STROOP and the frequency of memory complaints (MACf) were non-significant (FLF: r (88) = .10, p = .36; STROOP: r (88) = .04, p = .73). Similarly, partial correlations between these same frontal lobe measures and ratings of memory ability (MACa) were non-significant (FLF: r (88) = -.10, p = .34; STROOP: r (88) = -.09, p = .40). Notably, not controlling for the effects of depression yielded similar findings when relationships between these same variables were examined (see Appendix D).

The second hypothesis, that the relationship between performance on frontal lobe measures and memory complaints would be stronger than the relationship between verbal memory performance and memory complaints, could not be tested due to rejection of the first hypothesis. However, the relationship between verbal memory performance and memory complaints was examined. Pearson product-moment correlations between both verbal memory measures and MACf were not statistically significant (CVLT: r (88) = .04, p = .74; VM: r (88) = -.07, p = .54). Similarly, the relationships between the verbal memory measures and MACa were non-significant (CVLT: r (88) = .10, p = .36; VM: r (88) = .08, p = .49). Taken together, these results indicate that the frequency of memory complaints and memory ability self-ratings of older adults in this sample were unrelated to their actual performance on verbal memory measures.

Lastly, it was hypothesized that the combination of age and performance on frontal lobe measures would account for significantly more of the variance in memory complaints than either variable's separate effect. Since it was already determined that performance on frontal lobe measures did not significantly contribute to the variance in memory complaints, the combined effects of age and frontal lobe functioning were examined through step-wise multiple regression. MACf served as the first dependent variable in the regression analyses. Zero-order correlations between MACf and depression, FLF, and age were -.45, .07, and -.04, respectively. Only the correlation between MACf and depression was significant ($p < .01$). Depression was first entered into the regression, followed by FLF and then age. The final predictive model included only depression (see Table 3), which predicted 23% of the variance in the frequency of memory complaints (R = .48, $p < .01$). The contributions of FLF and age to the variance in MACf scores became negligible when the three independent variables were regressed stepwise. Contrary to what was hypothesized, FLF and age accounted for negligible amounts of the variance in the frequency of memory complaints. Rather, depression served as the best predictor of an older adults' frequency of memory complaints. Notably, the overall depression scores for this sample were low (M = 3.9, SD = 3.5, range = 0 to 16), with the mean score falling into the "normal" range and the highest score

Table 3

Predictor Variable Characteristics for MACf: Standardized Coefficients and Correlations

	B	pr	T	Sig. T
Depression	-1.3	-.48	-5.1	.00
FLF	.10	.12	1.1	.28
Age	.00	.00	.04	.97

N = 88; B = Standardized regression coefficient; pr = partial regression coefficient; Sig. T = significance value of T-test; df = (3, 88); FLF = composite frontal lobe measure.

obtained falling in the "mildly depressed" range according to GDS scoring criteria.

MACa served as the next variable in the regression analyses. Zero-order correlations between MACa and depression, FLF, and age were -.48, -.09, and -.04, respectively. Only the relationship between MACa and depression was significant ($p < .01$). Depression was first entered into the regression, followed by FLF and then age. The final predictive model contained only depression (see Table 4), which accounted for 23% of the variance in older adults' ratings of their memory abilities ($R = .48$, $p < .01$). The contributions of FLF and age were negligible when the variables were regressed stepwise. Contrary to what was hypothesized, FLF and age explained negligible amounts of the variance in older adults' ratings of their memory abilities. Rather, level of depression served as the best predictor of ratings of memory ability.

Table 4

Predictor Variable Characteristics for MACa: Standardized Coefficients and Correlations

	B	pr	T	Sig. T
Depression	-1.3	-.48	-5.0	.00
FLF	-.03	-.03	-.31	.76
Age	.01	.01	.10	.92

N = 88; B = Standardized regression coefficient; pr = partial regression coefficient; Sig. T = significance value of T-test; df = (3, 88); FLF = composite frontal lobe measure.

Post Hoc Analyses

The 12 participants dropped from analyses were functioning independently and involved in activities outside of their home (i.e., attending religious services) despite meeting outlined exclusionary criteria. Additionally, all 12 earned MMSE scores of 24 or above. To examine the qualitative and quantitative differences excluding these participants may have had, each of the previously outlined regression analyses were all conducted on the entire sample ($N = 100$).

Regarding the analyses examining the relationship between frontal lobe functioning and verbal memory ability, all regression analyses conducted on the sample of 100 yielded results similar to those previously presented. The final model which best predicted the variance in CVLT scores contained FLF and PASAT, with performance on the composite frontal lobe measure and attentional abilities accounting for 28% of the variance in older adults' ability to recall unorganized verbal material ($R = .53$, $p < .01$). The final model which best predicted the variance in VM scores contained age and PASAT, with age and attentional abilities accounting for 25% of the variance in the sample's ability to recall organized verbal material ($R = .50$, $p < .01$). F tests conducted to evaluate the change in R^2 between both CVLT and VM regression results comparing the samples of 88 versus 100 yielded non-significant findings. Thus, even with the inclusion of participants who had a history of severe neurological or medical problems which may have adversely affected their cognitive abilities, FLF and PASAT remained the best predictor of an older adults' ability to recall unorganized verbal information. Similarly, age and PASAT remained the best predictor of ability to recall organized verbal information.

Regarding the analyses examining the relationship between frontal lobe functioning and memory complaints, all regression analyses conducted on the sample of 100 yielded results similar to those previously presented. The final model which best predicted the variance in MACf and MACa contained only depression, which accounted for 23 % of the variance in older adults' frequency of memory complaints ($R = .48$, $p < .01$) and 25% of the variance in ratings of their memory ability ($R = .50$, $p < .01$). F tests conducted to evaluate the change in R^2 between both MACa and MACf regression results comparing the sample of 88 versus 100 yielded non-significant findings. Thus, even including those participants who had a history of severe neurological or medical problems which may have adversely affected their cognitive abilities, depression remained the best predictor of the frequency of memory complaints and ratings of memory ability.

DISCUSSION

The analyses for this study were subdivided into four components. First, the psychometric properties of the frontal lobe and verbal memory measures were assessed. Second, the hypotheses regarding the relationship between frontal lobe functioning and verbal memory were evaluated. Third, the hypotheses regarding the relationship between frontal lobe functioning and memory complaints were evaluated. Lastly, post-hoc analyses were conducted. This same format will be used to discuss the findings of these analyses.

Psychometric Properties

Analyses indicated that there was sufficient inter-item reliability to support combining the three subscores of the WCST and the score from the color-word naming trial of the Stroop (STROOP) to yield a composite frontal lobe functioning measure (FLF). These individual measures contributing to FLF were described by Eslinger and Grattan (1993) as measures of reactive flexibility, defined as the readiness to shift cognition and behavior according to situational context and demands. This flexibility is predominantly associated with frontal lobe functioning.

Contrary to Koss et al.'s (1984) finding that Stroop-color naming scores were found to be a sensitive measure for predicting frontal lobe functioning, presently they had only weak correlations with the other frontal lobe measures. The same held for Stroop-word naming scores. Consequently, both measures were excluded from further analyses. It should be noted that the present population had similar demographics to Stroop's original normative sample. Although Stroop-cn may represent an aspect of or skill related to frontal lobe functioning, such as processing speed, it is less similar to the measures of reactive flexibility used in this study to represent frontal lobe functioning. Thus, the specificity of Stroop-cn to detect frontal lobe functioning as represented by the composite frontal lobe measure in this sample (FLF) was weak.

Because the relationship between Stroop color-word naming scores (STROOP) and other variables was observed to be significantly powerful and different in some instances from the relationship between FLF and other variables, the effects of STROOP scores were analyzed individually. Thus, despite the high coefficient alpha of FLF which demonstrated that the contributing individual measures are measuring a particular construct, evidence suggested variability among the individual measures comprising FLF. However, it is difficult to ascertain whether STROOP, by itself, more accurately measures frontal lobe functioning or a component of frontal lobe functioning than does FLF, because of the lack of a "gold standard" frontal lobe measure. Stuss and Benson (1986) stated that correlation of behavior with focal pathology of the frontal lobes is needed, but to date the diagnostic techniques capable of providing information on localization within the frontal lobes remains limited. Furthermore, the commonly used neuropsychological measures used to assess frontal lobe functioning (including STROOP) are described as useful screening tests but are insufficient tools to detect independent frontal lobe functioning.

All verbal memory measures were subjected to a reliability scale analysis. Results indicated there was sufficient evidence of inter-item reliability to support combining the immediate and delayed recall trials of WMS-R Logical Memory Story A to form a composite verbal memory measure (VM). Although VM was highly correlated with numerous measures from the CVLT in various validity studies (Spreen & Strauss, 1991), including any CVLT measure in VM would have significantly reduced the VM scales' coefficient alpha. The total number of items correctly recalled from trials 1-5 on the CVLT (CVLT) was chosen as a measure of recall of unorganized verbal material. Delis et al.'s (1987) factor analysis of all CVLT indices found that this index had the highest factor loading on the factor labeled as General Verbal Learning.

Hypotheses Regarding Verbal Memory and Frontal Lobe Functioning

Previous literature suggested a role for frontal lobe functioning in verbal memory, especially with respect to the encoding and retrieval of verbal information and with the suppression of interfering stimuli. However, much of this research had been conducted on cortically damaged persons. Much less is known about these effects among healthy, older adults. In the past decade, an increasing body of evidence from the field of geriatric neuropsychology has demonstrated a selective, age-related decrease in performance on neuropsychological measures diagnostic of frontal lobe insult. Age associated neuronal loss has been found more pronounced in the frontal cortex, leading a number of researchers and theorists to suggest that the cognitive processes supported by the frontal lobes, and more specifically the prefrontal cortex, are among the first to decline with increasing age (West, 1996). A frontal deficit hypothesis has been offered on the basis that older adults often perform poorly on measures of cognitive flexibility, a hallmark of frontal lobe impairment. This frontal lobe hypothesis of aging suggests that the area of cortex anterior to the central sulcus, the prefrontal cortex, is the first to demonstrate signs of "malfunctioning" in normal aging (Fuster, 1989), indicating that those cognitive abilities supported by this cortical region should demonstrate signs of age-related decline. Thus, it was hypothesized that on the basis of decline in frontal lobe functioning, older adults would demonstrate impaired verbal memory performance.

Several cognitive processes contribute to what is referred to as frontal lobe functioning. For instance, some researchers include attention and concentration as frontal lobe functions, adding to the apparent lack of clarity in delineating the role of the frontal lobes in memory (Fuster, 1980; Hecaen, 1964; and Stuss & Benson, 1986). Conversely, other memory studies have concluded that it is attention and concentration, not frontal lobe functioning, which best predicts memory performance. This view is currently accepted by those utilizing animal models of frontal lobe functioning and memory (Stuss & Benson, 1986). Taking all of this into consideration, there was control for attentional abilities in all analyses in an attempt to more clearly demonstrate the role of frontal lobe functioning in the verbal memory performance of older adults.

Depression has been shown to effect the cognitive abilities of adults of all ages. This, coupled with the prevalence of depression in adults over 60, was the rationale for controlling for depression in all analyses. In the present sample, however, depression was not significantly related to any of the verbal memory or frontal lobe measures, nor was it related to any of the selected demographic variables. Additionally, the level of depression in this sample was very low. This may be an artifact of sampling; since all participants were volunteers, it is unlikely that a person experiencing significant depressive symptomatology would volunteer to participate in any activities. Thus, controlling for level of depression was deemed unnecessary during the investigation of the relationship between frontal lobe functioning and verbal memory ability.

Relationship Between Age and Frontal Lobe Functioning

As hypothesized, age was significantly negatively correlated with both verbal memory measures. This finding is consistent with the previous research relating declines in all aspects of verbal memory to age (Schaie & Willis, 1993; Petersen et. al, 1992; Hultsch, Hertzig, & Dixon, 1990; Hultsch et. al, 1992; West, Crook, & Barron, 1992) and further supports the view that verbal memory is related to age.

Examination of this relationship using regression analysis demonstrated that age accounted for significant amounts of the variance in older adults' ability to recall both organized and unorganized verbal material, as well as the number of intrusions in recalling unorganized verbal material. The finding of age effects on intrusion errors is interesting in that it represents problems in discriminating relevant from irrelevant responses, which are related to degrees of proactive or retroactive interference. Control of interfering stimuli, especially when proactive, has been shown to be related to frontal lobe functioning. Therefore, part of the variance in intrusion rates may represent a frontal lobe functioning effect rather than an age effect.

Although the present relationship between age and verbal memory supported the overall findings of other studies (Parkin & Walter, 1992; Kaszniak, Poon, & Riege, 1986), one difference was noted. In contrast to prior findings age presently accounted for negligible amounts of variance in recognition scores. While the mean age of participants in Parkin and Walter's study was older (M = 80.0) than the mean age in this study (M = 72.9), this was not the case in Kaszniak, Poon, and Riege's summary of studies demonstrating small age effects in recognition. One possible explanation for this is that during the administration of the CVLT, two cued-recall trials are given prior to the administration of the recognition trial. Thus, participants in this study may have had additional opportunities to encode the verbal material presented to them and were provided with a strategy for doing so, perhaps influencing their recognition scores enough so that small age effects would not be evidenced.

Relationship Between Frontal Lobe Functioning and Verbal Memory Performance

As predicted, significant negative correlations were found between the recall of unorganized verbal material (CVLT) and performance on measures of frontal lobe functioning. These people who performed more poorly on both measures of frontal lobe functioning recalled significantly less of the unorganized verbal information. This parallels previous research findings (Shallice et. al, 1994; Incisa, Rocchetta, & Milner, 1993), including Luria's (1973) contention and subsequent research evidence, demonstrating that the frontal lobes are involved in the process of organizing methods of memorization and retrieval. However, the relationship between frontal lobe functioning and recall of organized verbal information (VM) is less clear. It was hypothesized that those who performed poorly on STROOP would recall significantly less of the organized verbal material. Yet, the relationship between the recall of this same information and performance on the composite frontal lobe measure, although in the expected direction, was not statistically significant. This latter finding may be attributable to the nature of the frontal lobe measure involved or to the role frontal lobe abilities actually play in verbal memory, according to how the to-be-remembered material is organized. First, as indicated previously, STROOP and FLF, although highly related, may be addressing somewhat different aspects of frontal lobe functioning. Performance on STROOP represents the ability to overcome the exertion of previous memory on the acquisition of new information, or proactive interference, a role of the anterior frontal cortex (Uhl, Podreka, & Deecke, 1994). Related to this, but perhaps somewhat different, the majority of the subscores comprising FLF assess a readiness to freely shift cognition and behavior according to the particular demands and context of a situation. Since the verbal material to be recalled represented by VM is already organized, the need to be able to overcome the influence of previous acquired information outweighs the need for cognitive flexibility in order to perform adequately.

Second, the difference in the magnitude of relatedness of VM to STROOP and FL may better represent the actual role of frontal lobe functioning in verbal memory ability. As hypothesized by other researchers (Luria, 1973, Shallice et al., 1994), the role of the frontal lobes may be to organize memory, especially with respect to encoding and retrieval. Since the material to be remembered comprising the VM score is already meaningfully organized in paragraph format (as opposed to the material in CVLT, which is comprised of unorganized lists) the encoding, storage, and retrieval of the material comprising VM requires less organization. The constraints offered by the semantic content provide an effective organization for ordering words correctly, decreasing the need for frontal lobe assistance. However, the need to proactively inhibit previously learned material to proficiently learn new material still exists, perhaps accounting for the results obtained with this sample.

Regression analyses examined the relationship between frontal lobe functioning and specific components of verbal memory further. As predicted, performance on frontal lobe measures accounted for significant amounts of the variance in the recall of organized and unorganized material, as well as in the number of intrusions and semantic clustering rates. These studies support the previous speculation that age effects on intrusion rates may more accurately be described as a frontal lobe functioning effect. Qualitatively, frontal lobe functioning accounted for more of the variance in the number of intrusions than did age. Since age-associated memory loss has been proposed by some (Dupui et al., 1984; Moscovitch & Winocur, 1983) to be the result of neurophysiological changes in the frontal lobes, it would follow that intrusion rates are more likely the result of frontal lobe functioning effects, rather than age.

The effects of frontal lobe functioning on the variance in semantic clustering rates has been implied in previous discussions of the role of the frontal lobes in the organization of memory. The results of these regression analyses provided further support for viewing the frontal lobes as a strategizing and organizing agent in memory by illustrating how frontal lobe functioning influences the tendency of older adults to semantically cluster unorganized verbal information to enhance encoding and retrieval. These results are related to Stuss et al.'s (1994) finding that patients with frontal lesions demonstrated poor higher order organization of learning and support Moscovitch's (1982) contention that one aspect of frontal lobe dysfunction is a failure to encode information semantically.

However, in contrast to Stuss et al.'s (1994) findings, this study found frontal lobe functioning explained only negligible amounts of the variance of recognition scores. This is most likely due to sample differences in the severity of frontal lobe damage. In Stuss et al.'s study, patients with frontal lobe lesions documented by either CAT or magnetic resonance imaging scans were evaluated. Even though some neuroimaging studies of older, healthy adults have indicated neurological changes in the frontal lobes, these changes are usually described as being less severe than the acquired brain lesions that result from cerebral vascular disease or other head trauma. Presumably the effects of age-associated frontal lobe neurological changes would be less than those evidenced by more severely neurologically impaired persons. These results of this finding are consistent with Shimamura, Janowsky, and Squire's (1991) report that patients with frontal lobe lesions exhibited significant impairment on a verbal memory measure consisting of multiple trials of free recall for unrelated words, despite good performance on a comparable test of yes/no recognition memory.

A difference was noted between the frontal lobe measures ability to predict perseveration rates when recalling unorganized verbal material. STROOP performance predicted significant amounts of the variance in perseveration rates; however, performance on the composite frontal lobe measure did not. Excess intra-list repetitions, or perseverations, have been shown to be related to impaired frontal lobe functioning (Stuss et al., 1994; Squire, 1987). The difference in predictability of perseveration rates between the two frontal lobe measures in this study is most likely the result of the aforementioned differences in the nature of these two measures.

Single regressions conducted using the individual scales from the WCST comprising the composite frontal lobe measure (FLF) revealed different predictive abilities when recalling unorganized versus organized verbal material. Both the type (perseverative and non-perseverative) and the total number of WCST errors explained significant variance in recalling unorganized verbal material. In contrast, the only WCST individual score to predict significant variance in recalling organized verbal material was the total number of errors. Thus it appears that cognitive flexibility contributes significantly to an older adults' ability to recall verbal material. When this material is unorganized, the type of errors made when shifting cognitive sets has an effect on recall rates. It is possible that when attempting to encode and retrieve unorganized verbal material, specific types of mistakes in shifting set may contribute to specific types of errors in verbal recall (i.e., perseverative errors in shifting set contributing to perseverations in recall). Although errors in shifting set may influence the ability of older adults' to recall organized verbal material, the type of error may not have a great effect if this material was organized prior to encoding.

In summary, all of these findings lend further support to the speculation that frontal lobe functioning, as measured by the instruments in this study, plays a significant role in verbal memory performance. Previous verbal memory research which did not control of the effects of frontal lobe functioning may not fully represent actual verbal memory performance in older adults.

Differential Effects of Age and Frontal Lobe Functioning

As hypothesized, the third set of analyses revealed that the combined effects of age and frontal lobe functioning predicted more of the variance in the recall of unorganized verbal material than did either variable's independent effect. This result indicates that age and frontal lobe functioning are crucially linked and must be jointly considered when investigating the decline in verbal memory abilities, especially when the to-be-recalled material is unorganized. This finding lends clinical neuropsychological support to the previously cited neuroimaging studies relating age-associated memory loss to neurophysiological changes in the frontal lobes. It also reinforces the previously stated need for controlling for the effects of frontal lobe functioning when attempting to examine memory performance in older adults.

Interestingly, the results of this study also suggested that the role of frontal lobe functioning and its relationship to age varies according to the level of organization of the verbal material to be recalled. Results of the hierarchical multiple regression demonstrated that age effects become negligible when the verbal material to be recalled is unorganized; rather, frontal lobe and attentional abilities best explain variations in recall rates of older adults. Thus, the ability to organize, strategize, attend to, and maintain attention is imperative to the recall of unorganized verbal material, regardless of age. This is supported by numerous imaging studies of persons of various ages, demonstrating increased activity in the prefrontal cortex during tasks of acquisition and retrieval of verbal material (Shallice et al., 1994), while controlling for proactive interference in verbal memory recall (Uhl, Podreka, & Deecke, 1994), and during the retention performance for learned words (Jetter, Poser, Freeman, & Markowitsch, 1986).

This finding further illuminates the role of attention in memory performance and its relation to frontal lobe functioning. Although the effects of frontal lobe functioning on verbal memory were apparent when controlling for attention, the results of the hierarchical multiple regression analyses indicate the powerful joint role of both abilities in the recall of verbal material. Many have theorized that the frontal lobes are important in maintaining attention over time and preventing distraction (Fuster, 1980; Stuss & Benson, 1986). Additionally, Stuss and Benson's (1986) summary of related animal studies that the original memory hypotheses of frontal lobe functioning is now interpreted as an attentional deficit disorder. Furthermore, several different cognitive processes in humans contribute to what is referred to as frontal lobe or "executive" functioning (Shallice, 1988; Stuss & Benson, 1986). Commonly used measures to evaluate frontal lobe functioning, including those used in this study, do not appear to be able to clearly differentiate among those processes. Some researchers have begun to examine the factor structure of existing tests to better determine meaningful factors that illuminate the existence of dissociable cognitive processes underlying test performance. For example, recent examinations of the factor structure of the Wisconsin Card Sorting Test have identified a number of factors which represent both purported frontal lobe abilities and attentional abilities (Sullivan et al., 1993; Greve et al., 1996). Taking this into consideration, the results obtained in this study may represent the effects of frontal lobe functioning on verbal memory performance, with attentional abilities being included as a "frontal lobe function". This is one of the conclusions that West (1996) reached when she applied the theory of prefrontal cortex functioning to cognitive aging, suggesting that the study of age-related changes in attention can be widely interpreted within the context of present models of prefrontal cortical functioning. Specifically, age effects on the ability to sustain attention over time, suppress a dominant response, and on the performance of tasks sensitive to effects of interference in the short-term retention of information all can be interpreted within the current theoretical framework of frontal lobe functioning.

Another interpretation of the results is that attentional abilities are separate and distinct from frontal lobe abilities, but that one must first be able to attend and concentrate before being able to utilize higher "executive" functions to recall verbal information. Lezak (1995) has proposed that attention is a basic cognitive process and that attentional deficits can disrupt even intact higher level functions. This would imply that improving attentional function should result in improved behavioral performance based on these higher "executive" functions. Furthermore, when task demands do not require organizing and strategizing to promote acquisition and retrieval, being able to select and maintain attention would be all that is required to remember. The results of the hierarchical regression examining recall of organized verbal material support this. Age and attention best explained the variance in the recall of organized verbal material; the contribution of frontal lobe functioning was negligible. Thus, because the material was already organized in logical, coherent manner, the role of attentional abilities in maintaining consistent, directed attention, along with age, was sufficient to explain recall of the information. This finding seems to suggest that the role of frontal lobe functioning in verbal memory is more complex than hypothesized, involving an interactive process contingent upon the characteristics and format of the material to be remembered.

Results from this study demonstrated a discrepancy with respect to the role that age plays in the variance in recall rates of organized versus unorganized material. As predicted, age and frontal lobe functioning predicted significantly more of the variance in the recall rates of unorganized verbal information than did either variables independent effect. However, the same was not evidenced with respect to the recall of organized verbal material. Although age and frontal lobe functioning better explained the variance in the recall rates of organized verbal material than frontal lobe functioning alone, age, itself, proved to be a stronger predictor than their joint effect. This latter finding is contrary to what was hypothesized; however, it may more clearly represent the true effects of age on verbal recall rates. Because the material presented was organized in a familiar, logical format, the need for organizing and strategizing abilities was negligible. This allowed for a clearer demonstration of the effects of age and attentional ability on older adults' verbal recall performance when the requirement for frontal lobe functioning is minimal.

Overall, these results indicate that frontal lobe functioning, as defined by the instruments used in this study, significantly contributes to the verbal memory abilities of older adults. This contribution appears to be related to the level of organization of the to-be-remembered material, lending support to the notion that frontal lobe or executive functioning involves a multifaceted system of different levels of processing.

Despite the consistent and significant findings of age and frontal lobe effects on the verbal memory performance of older adults, a number of improvements might better elucidate the relationships examined. First, the measures of frontal lobe functioning used may not have been adequate indicators of that construct. Both of the deployed frontal lobe measures address reactive flexibility, the readiness to freely shift cognition and behavior according to situational and contextual demands. Eslinger and Grattan (1993) suggested that measures of spontaneous flexibility are more strongly correlated with, and representative of, frontal lobe functioning. These include measures of the fluency of ideas and the ability to use divergent thought, thus by-passing automatic and habitual responses and strategies in order to attend to other features and aspects of knowledge. The inclusion of measures of verbal and design fluency would have offered a more complete description of frontal lobe functioning and may have further clarified the relationship between the constructs examined in this study.

Furthermore, it is not clear to what extent any measure of frontal lobe functioning actually addresses this construct or if they are dependent on other variables such as attention, general intelligence, or processing speed. A recent factor analytic study of the WCST demonstrated that one of the aspects of cognition measured by this test included attentional functions (Greve, Williams, Haas, Littell, & Reinoso, 1996). This suggests that results obtained from this and other studies utilizing the WCST as a measure of frontal lobe functioning may be confounded and that a re-analysis of data utilizing the factor analytic components of the WCST may yield a clearer picture of frontal lobe functioning.

One explanation for the findings of this study which has not been considered during any of the analyses is the role of processing speed in the cognitive performance of older adults. It is well established that older people process information more slowly than younger people (Salthouse, 1985) and it may be that this speed decrement underlies the poorer memory and frontal lobe performance observed at older ages. Salthouse and Babcock (1991) examined different components of working memory in order to establish their importance in accounting for age-related deficits in overall performance. They observed a pronounced age difference in working memory span that was significantly reduced by processing speed, more so than any other cognitive measures. Fisk and Warr (1996) examined the role of processing speed, executive functioning, and the phonological loop in age and working memory. They found that although controlling for age differences in executive functioning removed over 50% of the age-related variance in working memory span, these age related difference in executive functioning were largely eliminated after controlling for age deficits in processing speed. Thus, to have controlled for the effects of processing speed in this study would have provided a clearer picture of the role of frontal lobe functioning in verbal memory performance in older adults. However, the measurement of processing speed is plagued with many of the same difficulties as the measurement of frontal lobe functioning. Furthermore, although it has been assumed that processing speed indicates the underlying rate at which information is activated within areas of cognitive functioning. This interpretation is open to debate and may not constitute exclusive support for an account of cognitive age deficits in terms of information activation (Fisk & Warr, 1996).

Improving and expanding the verbal memory measures in this study would have also contributed to the strength of the findings. The CVLT is a complex verbal memory measure which yields a number of results indicative of different measures of verbal memory indices. However, using each index individually often times yielded no significant information. Attempting to combine the indices yielded a measure with a very low coefficient alpha, indicating that used in combination, these indices do not reliably measure one construct. To have organized the CVLT data for analyses according to factors gleaned from a more recent factor analytic study may have allowed for more detailed and precise conclusions to have been drawn. For example, using Vanderploeg, Schinka, and Retzlaff's (1994) CVLT factor analysis results would have provided opportunities to examine the effects of age and frontal lobe functioning on the additional verbal memory indices of response discrimination, proactive interference, and retroactive interference.

Because of the interesting findings related to the differentiation of frontal lobe functioning effects according to the level of organization of the verbal material, using additional verbal memory measures containing varying levels of organization would have allowed for further examination of organization effects. For instance, using another verbal memory measure which contains completely unrelated information to be memorized would provide a third "tier" to be examined in the relationship between frontal lobe functioning and verbal memory performance. Additionally, constructing recognition trials as well as primacy and recency measures to accompany the WMS-R Logical Memory Stories would allow for more detailed analysis of memory performance and its relationship to frontal lobe functioning.

Hypotheses Regarding Frontal Lobe Functioning and Memory Complaints

The second purpose of this study was to elucidate the role of the frontal lobes in memory complaints. It was hypothesized that what many older adults describe as decreased memory ability is more accurately decreased frontal lobe functioning. Because of the strong relationship that has been demonstrated in previous studies between memory complaints and depression, this research controlled for this variable so as to more clearly illustrate the role of frontal lobe functioning in memory complaints.

Contrary to what was hypothesized, no significant relationship between frontal lobe functioning and the type or frequency of memory complaints was demonstrated. Furthermore, results from hierarchical regressions demonstrated that both the separate and combined effects of age and performance on frontal lobe measures on the type and frequency of memory complaints were negligible. These results indicate that the self-reported memory problems in this sample of older adults were unrelated to their performance on frontal lobe measures and that frontal lobe performance did not play a significant role in their perception of their memory abilities. The lack of any significant relationship between these two variables even eliminates the opposite explanation that older adults who perform poorly on measure of frontal lobe functioning will demonstrate decreased awareness of their memory abilities and thus report fewer memory complaints.

So what are older adults really complaining of when they endorse experiencing memory problems? Analyses revealed memory complaints were unrelated to attentional abilities, level of education, or gender. Furthermore, as demonstrated in numerous other studies, the memory complaints of older adults in this study were found to be unrelated to their actual performance on verbal memory measures. Depression was the strongest predictor of the type and frequency of memory complaints. Depression was found to be highly correlated with both the frequency and type of memory complaints and explained significant amounts of the variance in the scores on both of these constructs. These results become even more dramatic when level of depression in this sample is considered; based on the self-report of older adults in this sample, merely 3 of the 88 persons experienced mild levels of depression. The ratings of the remaining 85 fell in the "normal" range. These results indicate that even infrequent and isolated complaints of symptoms related to depression are sensitive enough to influence the type and frequency of memory complaints of older adults. Furthermore, it suggests that subjective memory complaints may be a diagnostic indicator for depression in older adults. Clinically, this information could be used by health care workers in formulating more accurate diagnoses, especially with the differential diagnosis of cognitive impairment versus depression and subsequent treatment.

The lack of a relationship between either decreased memory ability or frontal lobe functioning and memory complaints also suggests that individual differences exist in the appraisal of one's memory difficulties. Older adults who experience subjective memory difficulties may have unique attitudes and expectations about their cognitive abilities which may result in increased worry about "losing one's memory or mind". These individuals may be more concerned about the aging process and may be more attuned to age-related changes. This may ultimately lead to distress and contribute to decreased levels of self-efficacy and self-esteem. In contrast, older adults who are content with their memory and thinking abilities may interpret age-related changes differently, resulting in a more positive outlook and a more healthy aging experience. Individual adaptation to the aging process is an area that could contribute to more effective treatment strategies.

The low level of depression in this sample may have contributed to the lack of findings in this study. Boone et al. (1995) examined the relationship of presence and severity of depression to neuropsychological test scores of community dwelling, healthy, unmedicated older adults. They found that presence of depression was associated with subtle weaknesses in visual memory and nonverbal intelligence, with sparing of executive functioning and verbal skills, which included verbal memory. However, severity of depression was associated with mild weaknesses in executive functioning and processing speed, but was essentially unrelated to memory. Their findings help to explain the lack of a relationship found between memory complaints, which are predicted by presence of depression, and frontal lobe functioning in this sample. To have had a more representative sample containing a larger number of depressed older adults may have yielded findings more similar to the Boone et al. (1995) study.

Another reason for the lack of a relationship between memory complaints and frontal lobe functioning may be due to the aforementioned difficulties with the frontal lobe measures used in this study. Problems with the memory complaints questionnaire utilized may have also limited the findings. Gilewski and Zelinski (1986) have argued that the weak relationship demonstrated between self-reported memory difficulties and actual performance on memory tests is due, in part, to the incongruence between the memory tests utilized and the self-report memory items. Because awareness of how memory normally functions and self-awareness of memory abilities are different constructs and are both multidimensional in nature, it is important that tasks used to test the validity of memory complaints have concurrent validity with them. That is, they should measure the aspect of memory or frontal lobe functioning evaluated in the memory complaints assessment. Thus, using frontal lobe measures that are isometric to the memory complaints questionnaire items would increase the likelihood of demonstrating a relationship between these two constructs, if one does exist.

Furthermore, although results from this study demonstrated no overall relationship between performance on measures of frontal lobe functioning and the frequency or type of memory complaints, it may be that frontal lobe functioning is related to specific aspects of memory complaints. For instance, re-analysis of the data comparing frontal lobe functioning to the ten subscales of the MAC-S gleaned from Crook and Larrabee's (1992) latest factor analytic study may elucidate more specific relationships between frontal lobe functioning and different aspects of memory complaints.

Post Hoc-Analyses

Comparative analyses between the results from the sample used in this study to the results from the entire sample (N = 100), including those participants originally dropped from analyses revealed no significant differences. Despite the original assumption that the test performance of older adults who had experienced significant neurological or medical problems would different from that of "normal" older adults, the addition of these participants to the analyses did not significantly change any of the results. This may be due to a number of reasons. First, this was a high functioning sample of older adults. Even those who had experienced significant neurological problems achieved scores above 24 on the MMSE, were living independently, and were involved in activities outside of their homes. Perhaps the participants who were originally omitted from analyses were more similar than dissimilar to the rest of the sample. While this hypothesis may not be generalizable to population of older adults, at large, it suggests that other investigators may want to similarly examine their data to investigate to what extent this may be true, as the implications for confirming such a hypothesis would have far-reaching effects.

Secondly, including these originally omitted participants introduces an uncontrolled or unknown variable into the hypotheses being examined. It may be that this unknown variable does not influence the constructs examined in this research; however, this cannot be assumed when examining other areas of functioning with older adults. Few studies have apparently examined the effects of level of medical illness of any kind on the cognitive functioning of older adults. King, Cox, Lyness, and Caine (1995) investigated the neuropsychological effects of overall level of general medical illness in a sample of 74 older adults, half of whom met criteria for unipolar major depression. They concluded that increased medical burden for both depressed and non-depressed individuals was significantly associated with measures of verbal fluency only; it was not predictive of performance on any other neuropsychological tests, including executive functioning. These authors suggested that more stringent exclusionary criteria be used when working with older adults and that the a priori exclusion of individuals with medical conditions results in the confounding of both independent and dependent variables. This research, as well as the present findings, suggest that replication of similar post-hoc analyses by other investigators examining cognitive functioning of older adults would greatly benefit the field.

APPENDICES

APPENDIX A

APPENDIX A

Table A-1: Zero-Order Correlations Between Demographic, Verbal Memory, Frontal Lobe, Attention and Depression Variables

	Edu	Sex	CVLT	VM	FLF	STROOP	PASAT	GDS
Age	-.20	-.10	-.33**	-.43**	.28**	.40**	-.30**	.09
Edu		.14	.21*	.31**	-.16	.30**	.31**	-.24*
Sex			-.20	-.05	-.09	.07	.26**	-.02
CVLT				.51**	-.42**	-.63**	.46**	-.20
VM					-.20*	-.40**	.37**	-.16
FLF						.64**	-.41**	.12
STROOP							-.64**	.22*
PASAT								-.12

N = 88; * $p < .05$; ** $p < .01$; Edu = Education level; CVLT = California Verbal Learning Test, total items recalled from trial 1-5; VM = composite verbal memory measure; FLF = composite measure of frontal lobe functioning (higher scores indicate higher levels of impairment); STROOP = color-word naming subtest of Stroop (reverse scored), PASAT = Paced Auditory Serial Attention Test; GDS = Geriatric Depression Scale.

APPENDIX B

APPENDIX B

Table B-1: Item-total Statistics for Composite Frontal Lobe Measure

Reliability Coefficients: 4
Alpha = .8258
Mean = 92.69
Variance = 2242.2
Std Dev = 47.35

Frontal Lobe Factor Item	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item Total Correlation	Alpha if Item Deleted
WCSTp	69.88	844.3	.87	.682
WCSTn	73.55	1115.5	.92	.646
WCSTc	71.18	1618.2	.49	.844
STROOP	63.47	1759.8	.47	.855

APPENDIX C

APPENDIX C

Table C-1: Item-total Statistics for Composite Verbal Memory Measure

Reliability Coefficients: 2 items
Alpha = .895
Mean = 23.4
Variance = 56.7
Std Dev = 7.53

Verbal Memory Factor Item	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item Total Correlation
LMI	10.9	17.3	.81
LMII	12.5	14.0	.81

APPENDIX D

APPENDIX D

Table D-1: Pearson Product-Moment Correlations Between Measures of Frontal Lobe Functioning and Memory Complaints

	FLF	STROOP
MACf	.07	-.02
MACa	-.09	-.10

N = 88; FLF = Composite frontal lobe variable; STROOP = Color-word naming trial score from the Stroop; MACf = Frequency of memory complaints; and MACa = Memory ability rating score.

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