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Natalie Lisa Denburg

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ATTENTIONAL ABILITIES IN THE ABLE ELDERLY: EXAMINATION OF STRUCTURE, CORRELATES, AND SELF-REPORT

By

Natalie Lisa Denburg

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ABSTRACT

ATTENTIONAL ABILITIES IN THE ABLE ELDERLY: EXAMINATION OF STRUCTURE, CORRELATES, AND SELF-REPORT

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Natalie Lisa Denburg

The issue of attention, while commonly researched in cognitive and experimental studies of aging, is less frequently examined in the clinical literature. This is unfortunate since clinical measures of attention are heavily relied upon for diagnostic and rehabilitative purposes. A reduced processing resources perspective (Salthouse, 1991) has been put forth to account for attentional decline with age in various cognitive domains. The current study revolves around four sets of variables: chronological age, memory, intelligence, and attention. An age- and sex-stratified sample ($\underline{N}$ = 100, ages 60-85) of able-elderly persons were individually administered a battery of commonly-used neuropsychological tests. Multiple regression procedures were conducted to measure the contributions of attention and age to memory and intelligence. As an initial step in this research, the factor structure of a range of attentional tasks was obtained. The results indicated, with the current sample and the measures utilized, that attention is unidimensional. Two causal models were tested in the subsequent analyses. The first, examined the relationship between age and the dependent variables; namely, auditory-verbal memory, visual-spatial memory, fluid intelligence, and crystallized intelligence. For all dependent variables, except crystallized intelligence, a negative relationship emerged ($\underline{p} < .001$). In the second model, attention was introduced as a moderating variable between age and the

dependent variables. All four dependent variables were regressed on age, attention, and the interaction term. The main effects of age ($p < .001$) and attention, above and beyond age ($p < .001$) reached statistical significance for three of the four dependent variables. Only crystallized intelligence showed a different pattern: the age x attention interaction term was meaningful (beta = –1.82, R^2change = .04, $p < .05$) as was the main effect of attention ($p < .001$). It is notable that attention behaved much more like a mediating, than a moderating variable. Moreover, examination of unique variance revealed that attention played a greater predictive role than did age of subject, although approximately 20% of the R^2 value must be considered shared variance. Finally, results aimed at examining task complexity suggested that measures of attention which involve a visual component present the greatest difficulty for older adults.

For my parents, Sandra and Marvin Denburg

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INTRODUCTION

The issue of attention, while commonly researched in experimental studies of aging, is less frequently examined in the clinical literature. This is unfortunate since clinical measures of attention are heavily relied upon for diagnostic and rehabilitative purposes. Cognitive psychologists are interested in attentional (often called processing resources) explanations for age-related decrements in diverse domains. However, the measures utilized tend to be unpublished, non-normed tasks tested on animal models or with small numbers of humans. As a result, these findings have limited generality and applicability in the clinical arena. The current research project represents an early attempt to apply cognitive models of attention to commonly used clinical measures of attention. There are two goals in mind for this review of the literature. The first is to discuss theories of attention, most of which are taken from the experimental literature. A second, related goal is to examine important correlates of attention; namely, memory and intelligence. In addition, the issues of attentional task complexity and self-report will be addressed.

Taxonomic Issues

Attention as a theoretical concept has been around almost as long as the formal discipline of psychology. Wilhelm Wundt, the founder of experimental psychology, devoted the first chapter of his introductory textbook to attention. Other prominent historical figures in psychology such as Edward Titchener and William James expanded upon Wundt's research on attention. Today, some 90 years later, a lack of taxonomic consensus in the field remains. Some definitions of attention have been straightforward, as in the case of William James (1890):

> Everyone knows what attention is. It is the taking possession by the mind, in clear and vivid form, of one out of what seem several simultaneously possible objects or trains of thought. Focalization, concentration, of consciousness are of its essence. It implies withdrawal from some things in order to deal effectively with others. (Vol. 1, pp. 403-404).

Others are more elaborate, as in Lezak's (1983) description of attention in which she states that the capacity for selective perception and concentration is an effortful, usually intentional, and enhanced sense of attention in which irrelevant stimuli are selectively excluded from conscious awareness through inhibitory processes.

While a clear and universally accepted definition of attention has not yet appeared in the literature, four aspects of attention have been popularized. Focused or selective attention refers to our capacity to attend to particular information in the environment while suppressing or ignoring distractions. When a task requires attentional persistence over a period of time, it is said to demand vigilance or sustained attention. Divided attention involves the ability to respond to more than one task at a time or multiple aspects within a single task. Finally, alternating attention occurs when an individual must shift their focus relative to task demands. These four aspects of attention may be affected by brain damage, age, or emotional problems.

In an effort to empirically investigate these aspects of attention, a number of studies have been conducted and, as a result, additional classification systems have been created. Early research by Sack and Rice (1974) identified three processes involved in paying attention: degree of selectivity, resistance to distraction, and shifting. These researchers administered a battery of clinical tests, each of which fell under one of the three aforementioned categories, to 164 eight-grade students. An analysis of test loadings confirmed the authors' original attentional scheme. More recently, Sohlberg and Mateer (1989) divided commonly used clinical attention tests into four conceptual categories: immediate or working memory, timed tests of information processing, paced tests of information processing, and distractibility tests. Similarly, Mirsky (1989), derived a clinical model of attention from a factor analytic study. The factors were: focus and execute, vigilance, encode, and ability to shift factors. To put it even more succinctly, Shum, McFarland, and Bain (1990) derived just three factors using a factor analytic technique. They suggested that a visuo-motor scanning factor, a sustained selective processing factor, and a visual/auditory spanning factor exemplify the majority of clinical attentional measures available.

In an effort to further define attention, Shum, McFarland, and Bain (1994) examined attentional tasks against stages of information processing. It was found that, overall, performance on three clinical components of attention (visual-motor scanning, sustained selective attention, and visual/auditory spanning) can be significantly predicted by six indices of information processing (mean reaction time, mean movement time, feature extraction, identification, response selection, and motor adjustment). Thus, the demonstration of relationships between the clinical and information processing or cognitive approaches to attention is a step in overcoming the limitations and problems unique to each approach.

Due to variability in the aforementioned models, Schmidt, Trueblood, Merwin, and Durham (1994) performed a "methodologically strict" factor analysis of a broad collection of clinical tests often cited as attentional measures. In their first analysis, 11 variables were examined and, surprisingly, a one-factor solution emerged. A second factor analysis, utilizing only eight measures, was conducted in an effort to replicate Shum et al.'s (1990) three factor finding. Results indicated only two factors, namely, a visual-motor scanning factor and a weak, but significant visual/auditory spanning factor. The existence of a sustained selective processing factor was not substantiated.

From the above discussion we can conclude that theories of attention have progressed well beyond clinical use of these measures, implying that it is time that theory and clinical practice reach more congruity. The fact remains that even though clinical measures of attention are often criticized, (in part because of the elusive nature of an overall delineation of attention) these measures are heavily utilized and relied upon in clinical assessment. The present investigation aims to take the best of what the clinical field has to offer by performing an additional factor analytic study investigating both simple and complex attentional measures in a large sample of older adults.

After reviewing the literature, it may be possible to predict attentional clusters on experimental and theoretical grounds. I propose that the following clusters will be confirmed via statistical analysis. It is hypothesized that four groups of attention variables will emerge. The first, an execute/motor factor will include such manual tasks as Trail Making and the Ruff Figural Fluency test. Secondly, the Paced Auditory Serial Addition Test and the Stroop test will load on a sustained attention factor. Next, the Wisconsin Card Sort Test and verbal fluency measures are hypothesized to provide evidence for a shifting in attention. Lastly, the fourth factor, encode, will consist of both digit span and visual memory span.

Theories of Attention

Automatic vs. Effortful Processing

In a classic study, Hasher and Zacks (1979) postulated that attentional capacity for effortful processing declines with age. In contrast, automatic processes (i.e., tasks that require little or no attention) are thought to remain relatively stable across the life span. By this account, different mental operations and activities will require different amounts of energy or attentional resource (Craik & Byrd, 1982). Craik and McDowd (1987) demonstrated that effortful recall requires more processing resources than recognition in their finding greater absolute costs for the old associated with cued recall than with recognition. Evidence supporting the notion that automatic processes remain relatively stable with increasing age has come from Light and Singh's (1987) findings of no age differences in performance in an implicit memory task, one that requires little or no conscious-effort processing. Moreover, McDowd and Craik (1988) found that age-related decrements appear consistently in all but the simplest of tasks.

Depth of Processing Model

The depth of processing model (Eysenck, 1974) stated that more complex (that is, semantic, associative, and inferential) processes typically require more effort and attention to achieve, and it is these processes that older subjects demonstrate impairment in memory performance. However, given appropriate orienting conditions, age group differences in memory performance will disappear. Thus, whereas older subjects will show greater decrements at deeper levels of processing because such encoding usually demands more effort and attention, there seems little that is absolute or inevitable about this position. If deeper processing is made easy or accessible by some means, then the older person will make use of the constraints provided by the task or the material to accomplish those deeper types of processing.

Spatial Localization Hypothesis

Plude and Hoyer (1985) proposed the spatial localization hypothesis, stating that age decrements in selective attention are due to a decline in the ability to locate task-relevant information in a visual field. They offered that the operation of the selective attention mechanism is more demanding for the already limited resources of older adults. Further, they stated that the resources available for attending are inversely related to the amount of resources demanded by the selective attention mechanism. Thus, older adults are slowed significantly when task-relevant information is not easily located.

Reduced Processing Resources

The reduced processing resources perspective allows for sufficient generality to account for age-related decrement across a range of cognitive tasks. Capacity theories of attention such as the this one originated with the observation of interference between simultaneously-executed tasks. The reduced processing resources perspective states that many age differences in cognitive performance are due to the limited resources required for the successful execution of different processing components. A fundamental assumption of the processing resource perspective is that m, the number of hypothesized resources, is considerably smaller than n, the number of age-sensitive processing components.

There are a number of interpretations associated with this theory. The simplest states that the quantity of processing resources declines with increased age. Another possibility is that the supply of resources does not change, but instead increased age is associated with an increase in the demands on those resources. Lastly, it has been proposed that the quantity of resources does not decline, instead there is an age-related impairment in the efficiency or selectivity of resource allocation.

According to Salthouse (1988), one way to investigate this reduced resources theory of attention involves a statistical control of an index of processing resources. This method would allow one to investigate the premise that age effects on cognitive tasks are mediated through reduced attention. Salthouse (1991) has suggested that it may be most useful to categorize attentional resources in terms of the metaphors, time, space, and energy. Limitations of time, in the form of rate of processing, state that the faster cognitive operations are executed, the more likely it is that other operations can be initiated. The space metaphor infers that there are restrictions on working memory in the amount of short-term storage or computation that is simultaneously possible. Lastly, the limitations of energy are described as some form of attentional capacity that functions as a general-purpose "fuel" for information processing (Salthouse, 1988).

Attention and Aging

As can be seen from the above discussion, there are a number of different theories to account for changes in attentional ability across the age-span. Perhaps most helpful to the issue of clinical attention and this current study is the last of these theories, Salthouse's (1991) reduced processing resources perspective. The essence of this theory is that age differences in cognitive functioning can be attributed to a reduction in quantity of some essential processing resource (Salthouse, 1991). Craik and McDowd (1987) asserted that older adults have a diminished supply of processing resources and attentional capacities, and that more complex processing requires more cognitive effort and attentional resources than are accessible. As can be seen from the literature, age differences in processing resources seem salient to age-related declines in memory and intelligence. Salthouse (1991) stated, "...there have apparently been no studies in which age differences in cognition have been examined before and after statistical control of an index of attention (p. 18)."

Memory

There has been much investigation aimed at elucidating the mechanisms responsible for memory failure with advancing age. A reduction in attentional resources has been implicated in age-related declines in memory performance. Craik and Byrd (1982) postulated that "reduced attentional resources lead to an attenuation or shrinkage in the richness, extensiveness, and depth of processing operations at both encoding and retrieval" (p. 208). Attention and memory are generally considered separate but interdependent processes. The attentional construct is necessary to account for the fact that our responses constantly vary in a shifting universe of stimuli. Memory can be viewed as the endproduct of attention. Attention increases the likelihood that processed information will result in memory. Conversely, the way in which information is encoded, stored, and retrieved from memory influences attentional demands (Cohen, 1993).

There is overwhelming evidence that the quality of memory traces is largely determined by the amount and type of processing given to the information to be remembered. Items that escape attention cannot be remembered. However, as soon as we pay attention, even with no intention to learn, some information will be retained in what has been called "incidental memory". The strength of the trace appears to be directly proportional to the duration and intensity of the attention given to the material. Craik and McDowd (1987) stated that older individuals have a diminished supply of processing resources and attentional capacities, and that more complex memory processing requires more cognitive effort and attentional resources than are available.

In a recent study by Fastenau, Denburg, and Abeles (in press), a statistical control procedure was used to isolate retrieval efficiency and to measure contributions of processing resources to retrieval. A negative relationship between age and retrieval efficiency emerged on all measures with fewer processing resources being required for visual memory retrieval as compared to verbal memory retrieval. Thus, the more visual-spatial a stimulus, the fewer processing resources it requires. These researchers, however, utilized only tasks requiring very low level processing resources, such as letter cancellation and mental tracking, investigating just time and space classifications of attention. In addition, secondary memory or retrieval was investigated in lieu of examining initial memory or encoding. Salthouse, Rogan, & Brill (1984) suggested that the locus of age differences is in the initial state or registration or encoding. It appears important to also assess the effect of more complex attentional tasks, with fewer speed requirements, on initial memory performance.

A meta-analysis was conducted on 12 developmental memory studies (Nissen & Corkin, 1985). A rather clear picture emerged from these fairly diverse experiments, further stressing the need to statistically control for attention while continuing to examine memory over the life-span. First, under standard intentional memory instructions, statistically reliable age differences in free recall have been obtained. Similarly, when orienting tasks have been paired with intentional memory tests, we again see the same reliable age-memory negative relationship. Interestingly, however, when memory tests have followed an orienting task, age differences in free recall were greatly reduced, to the point of nonsignificance. This pattern of results suggest that when attentional ability is maximized (i.e., orienting condition), age differences in memory seem to vanish.

Intelligence

Over twenty-five years ago Horn and Cattell (1967) developed a theoretical model for understanding the aging process. This model has two main components described as fluid and crystallized intelligence. Fluid intelligence was defined as the ability to solve novel problems and involves the capacity to be flexible and adaptive when faced with a novel problem-solving situation. In contrast, crystallized intelligence refers to knowledge and skills dependent on the individual's education and experience. Horn and Cattell found that fluid intelligence declined through adulthood while crystallized intelligence tended to remain stable over the life span. It is assumed that the decline in fluid intelligence with age can be attributed to the decline in some processing resource rather than vice versa.

As a result of this premise, Cornelius, Willis, Nesselroade, and Baltes (1983) examined the hypothesis that individual differences on measures of attention would converge with select factors of intelligence, especially fluid intelligence. The investigators conducted a confirmatory factor analysis to examine the relationships among ability factors and attention tasks. Their findings were only partially consistent with the hypothesized pattern of convergence; in general, the greatest convergence occurred between attention variables and the ability factor of perceptual speed rather than with factors of broad reasoning, crystallized knowledge, or memory span. These results are consistent with research literature concerned with speed factors in gerontological research (Salthouse, 1992). It is notable, however, that Cornelius et al. (1983) chose exceptionally low-level attentional tasks aimed at feature extraction and vigilance.

Stankov (1983, 1988) studied the relationship of different types of attentional processes to measures of intelligence and described the relationship of attentional performance to normal aging. Utilizing factor analysis, he identified three aspects of attention: search or perceptual speed, concentration or sustained attention, and attentional flexibility. Further, Stankov (1988) searched for the underlying cognitive causes of changes in intelligence. Presumably, all cognitive tasks call up a certain amount of processing resources, thereby implicating attention. It was found that three attentional factors (search, concentration, and attentional flexibility) exist at the primary ability level and subsequently define fluid intelligence. Thus, declines in fluid intelligence with increasing age, according to this researcher, disappear if attentional factors are statistically controlled. This finding is contradictory to that of Cornelius et al. (1983). The seemingly higher-order measures of attention used by Stankov may account for the discrepancy in findings.

More specifically, using the dichotomy of Horn and Cattell, it is possible to investigate the contradictory evidence of attentional contributions to fluid and crystallized abilities. Fluid tasks include the Wechsler Adult Intelligence Scale-Revised (WAIS-R) Block Design task as well as the Wisconsin Card Sorting Test. In contrast, WAIS-R Vocabulary coupled with a reading test of difficult to pronounce words (Wide Range Achievement Test-

Reading) produce a crystallized factor. Thus, based on previous discussion we could further surmise that if attention factors are statistically controlled, fluid intelligence would decline to a greater extent than crystallized intelligence.

The Issue of Complexity

While factors such as psychomotor speed have been implicated in declines in cognitive processing with age, often a significant discrepancy between younger and older persons is revealed on untimed tests. As a result, other explanatory factors have been examined. It has frequently been observed that the performance of older persons is affected more than that of younger adults by increases in the complexity of a cognitive task. In an early study by Clay (1954), the issue of complexity in the absence of speed demands was investigated. Although performances of older and younger persons were similar on the simplest problem, this and other complexity research have noted that older adults are differentially affected as the conditions of a task become more complex (Salthouse, 1992).

Thus, increments in task complexity appear to tax the limited resources of older adults. This age-complexity phenomenon identification is useful in understanding the causes of adult age differences in cognitive processes, namely attention. Specifically, an understanding of why age differences often become larger with increased task complexity might lead to a better understanding of the nature of the difficulty that exists. Thus, age-related performance differences in complex versions of tasks may reveal the necessity for unique contributions to performance at higher levels of complexity. In contrast, decrements in both elementary and more complex processes would suggest that many of the age-related effects in complex attentional tasks may be mediated through age-related influences on elementary processes.

Using the research literature, it is possible to rank attentional measures in terms of complexity. Lezak broke down the concept of attention into four main categories (Lezak, 1995) placed in increasing order of difficulty: vigilance, short-term storage capacity, mental tracking, and complex attention. Vigilance is defined as an individual's ability to sustain and focus attention over a period of time. According to Lezak, tests of vigilance include cancellation tasks. Digit span forward would be an example of a short-term storage capacity task, generally exposing the subject to increasingly larger strings of stimuli. Mental tracking is much like short-term storage capacity but also includes perceptual tracking, supposedly a more complex type of stimuli manipulation. Examples include digit span backwards, both aurally and visually, Paced Auditory Serial Addition Test, and the Stroop Test. Complex attention tasks require both sustained, focused concentration as well as directed visual shifting. The Halstead-Reitan Trail Making Test is a complex attention measure which requires connecting dots and letters in an alternating fashion. Although not empirically confirmed, Lezak's formulation appears helpful in understanding attentional processes in that she includes multiple and sophisticated categories, concentrating less on experimentally-derived concepts such as reaction time.

Closely resembling Lezak's modeling of attention, such a ranking would go as follows: short-term storage capacity (Digit Span Forward, Visual Memory Span Forward); mental tracking (Digit Span Backwards, Visual Memory Span Backwards, Speech-Sounds Perception Test, Paced Auditory Serial Addition Test, Stroop); and complex attention (Trail Making Test, Fluency, Ruff, and the Wisconsin Card Sort Test). This hypothesized ordering will be statistically confirmed during analyses investigating age and attentional performance.

Attentional Self-Report

Numerous psychological studies have compared self-reported performance with objective test data. Most notable in the area of gerontology is the relationship between increased memory complaints and objective memory decline (Lamberty & Bieliauskas, 1993). Such correlations between self-report and objective data often suggest an intervening, third factor. For example, memory complaints have been significantly related to the presence of depression (Niederehe & Yoder, 1989) regardless of objective memory performance (Kahn, Zarit, Hilbert, & Niederehe, 1975). Although memory complaints can and do represent real memory decline in some older adults, they seem to relate more to levels of depression rather than to actual deficits in memory.

Other investigators have found that memory complaints did predict actual memory performance on objective measures. Niederehe (1976) found that depressed subjects did not make distorted self-appraisals and were no more likely to underestimate performance than control subjects. Similarly, Cavanaugh and Murphy (1986) found that metamemory and personality variables accounted for significant portions of the variance in memory performance on two different tasks (free-recall list learning and free-recall prose; p. 386).

Thus, investigations of the relationship between subjective evaluation and objective performance are not in agreement. Contradictory findings have, however, helped to elucidate processes and contributing factors associated with memory and aging. However, a thorough PSYC-INFO examination of the attentional literature revealed the absence of any research investigating attentional self-evaluation compared to objective data.

Moreover, only a limited number of questionnaires seek to measure attentional self-report. One such questionnaire, the metamemory questionnaire titled Memory Assessment Clinics Self-Rating Scale, asks five factor-analytically confirmed questions directed at gleaning attentional confidence in aged subjects (MAC-S; Crook & Larrabee, 1990). Given the lack of clinical literature on attentional processes in the aged, comparisons of attentional self-reports with objective performance measures might prove fruitful as an additional way in which clinical manifestations of attention may be investigated.

A review of the literature suggests that attention figures equivocally in a number of different cognitive domains. Therefore, further research examining the relationship between attention and its correlates may prove fruitful. The current project represents an early attempt to understand and elucidate the clinical implications of attention. This study revolves around four sets of variables: chronological age, memory, intelligence, and attentional variables.

HYPOTHESES

After examining the results of a number of studies, the following hypotheses were formulated:

1) The four-factor model of attention proposed in this study will be analyzed using confirmatory factor analytic techniques. In the case of a poor fit, an exploratory factor analytic representation of the attention variables will be generated.

2a) Performance on memory tasks will decline with age.

2b) Performance on intelligence tasks will decline with age. It is further hypothesized that this decrement will be greater for fluid than crystallized tasks.

2c) Causal models will be tested in which attention will moderate the relationship between age and the dependent variables. Therefore, it is expected that attention will account for a significant amount of the variance normally attributable to age.

2d) Attentional elements will account for significantly more of the variance attributed to memory performance than variance attributed to intellectual ability.

3) As attentional tasks become more complex, significantly larger age-associated decrements will be evident.

4) The presence of self-reported attentional difficulties will correlate negatively with actual attention performance.

METHOD

Participants

A total of 100 older adults (50 men and 50 women) volunteered to participate in the study. Community-dwelling, older adults involved in a local church or senior citizen organization were solicited. All participants lived independently and can be considered able elderly. Older adults were divided into five age groups, each containing 20 participants (10 men and 10 women): 60-65, 66-70, 71-75, 76-80, and 81-85. Volunteers with self-reported uncorrected vision, uncorrected hearing, or impaired use of their preferred hand were excluded from participation. An effort was made to obtain relatively equal representation from each organization in all age-sex groups so as to minimize the extent to which any socioeconomic differences between organizations would bias age and sex analyses. The U.S. Census Bureau (U.S. Department of Commerce, 1990) reported that only one-fourth of adults who were 60 or older in 1990 had education beyond high school, compared to nearly one-half of young adults. Thus, every attempt was made to recruit a sample that is representative of the majority of older adults. It is notable that this sample was predominantly Caucasian (96%).

The mean age of participants was 73.07 years old (SD=7.2). Educational level ranged from 8 to 20 years (M=13.47, SD=2.5). While regression analyses to be presented in the results section treated age as a continuous variable, it was dichotomized for the following t-tests in an effort to facilitate description.

Thus, "older" subjects refer to the oldest 50 individuals contained in the sample; likewise, the youngest 50 participants are considered "younger" subjects. No difference between older and younger groups on vocabulary (Wechsler, 1981) was found [$t(97) = -0.88$, $p > .05$]. In contrast, education level between older and younger groups was found to be significantly different [$t(88) = -1.99$, $p = .05$] with younger adults having higher educational attainment. Further investigation of education and vocabulary revealed a moderate correlation ($r = .52$). Moreover, when older and younger groups were examined on variables (WRAT-3 Reading and American Version of the Nelson Adult Reading Test) designed to correlate highly with WAIS-R IQ, a nonsignificant relationship with age emerged [$t(97) = 0.98$, $p > .05$ and $t(98) = 0.81$, $p > .05$, respectively]. Thus, it appears that while education was significantly different between older and younger groups contained in this sample, it did not effect premorbid cognitive abilities such as vocabulary or reading ability.

Measures

Able elderly were administered a battery of neuropsychological tests, each of which fell under one of the following four clusters: General functioning, intellectual functioning, memory performance, or attentional performance.

General Functioning

a) Neuropsychological Questionnaire: This survey was used to collect demographic and medical information for the study. Questions addressed the participant's age, sex, educational background, medical history, and current medication use. An examination of this questionnaire revealed fifteen individuals with outstanding health histories of either cerebral vascular disease or closed head injury with extended loss of consciousness (5+ minutes); these participants were excluded from further analyses.

b) Geriatric Depression Scale (GDS; Yesavage et al., 1983): The GDS consists of 30 yes/no self-administered questions. The directionality of answers scored for depression changes randomly. The GDS was developed specifically for use with older adults and, therefore, deliberately omits items that deal with guilt, sexuality, and suicide, which the authors considered inappropriate for this population. Additionally, this measure minimizes the number of questions geared at somatic complaints (e.g., sleep disturbance, weight loss, gastrointestinal symptoms), as they were not found to be highly discriminating symptoms of depression in older adults. The GDS correlates .73 with the Beck Depression Inventory (Beck, 1978) and .83 with the Hamilton Depression Scale (Hamilton, 1967) (Yesavage et al., 1986).

Item-total correlations of the GDS range from .32 to .83; internal consistency (alpha) was .94; and split-half reliability was .94 (Koenig et al., 1988). Factor analysis revealed a major factor of dysphoria (unhappiness, dissatisfaction with life, emptiness, downheartedness, worthlessness, and helplessness). In addition, two minor factors were generated; the first consists of worry, dread, and obsessive thought, while the second involves apathy and withdrawal (Parmelee et al., 1989). Criterion validity has been measured against the Research Diagnostic Criteria and reported as .82 (Yesavage et al, 1983).

c) Mini Mental State Exam (MMSE; Folstein, Folstein, & McHugh, 1975): The MMSE was created as a measure of orientation commonly used in hospital settings to assess cognitive functioning. Satisfactory performance on this test necessitates memory ability, orientation, visuospatial skills, written expression, and the ability to follow simple commands.

When subjects were evaluated over a 24-hour period, the test-retest reliabilities were .85 to .99. MMSE scores separated by a period of two years were correlated .38. The convergent validity of MMSE scores with scores on the Wechsler Adult Intelligence Scale-Revised was .39 for Verbal IQ and .30 for Performance IQ (Mitrushina & Satz, 1991).

Intellectual Functioning

a) Wechsler Adult Intelligence Scale-Revised (WAIS-R; Wechsler, 1981): Estimates of general cognitive functioning will be assessed with the Vocabulary and Block Design subtests of the WAIS-R. These subtests were cited by Silverstein (1982) as providing the best short-form estimate of general mental ability. The Vocabulary subtest consists of 35 words arranged in increasing difficulty. Subjects are required to define words in response to the examiner's query, "What does _______ mean?" Administration continues until subjects fail five consecutive words or reach the end of the word list. In the Block Design subtest, subjects are required to use colored blocks to reproduce the geometric design depicted on a card. Testing continues until three consecutive designs have not been completed within the time limits.

Silverstein (1982) reported that the combination of Vocabulary and Block Design subtests correlated .91 with Full Scale IQ scores. Reliability was calculated at .94. Similarly, Thompson, Howard, & Anderson (1986) found that correlations between the Vocabulary-Block Design short form and WAIS-R Full Scale IQ scores ranged from .91 to .94.

b) Wide Range Achievement Test-3rd edition: Reading (WRAT-3; Jastak & Wilkinson, 1993): The purpose of this test is to measure reading skills (word recognition and pronunciation). This test is often used as a measure of premorbid verbal intelligence.

Memory Performance

a) Complex Figure Test (CFT; Rey, 1941, Osterrieth, 1944): The purpose of this test is to assess visuospatial constructional ability and visual memory. The CFT consists of a copy trial, an immediate recall trial, and a delay recall trial (20-minute delay).

Significant age effects on recall trials consistently emerge. The data suggest that decline begins in the 30's, continues fairly steadily until the 70's when a larger drop in scores occur. Men's recall of the figures tends to be betten than women's (Lezak, 1995).

b) California Verbal Learning Test (CVLT; Delis, Kramer, Freedland, & Kaplan, 1988): The CVLT is a learning task which assesses verbal learning and memory. More specifically, the instrument assesses immediate, short delay, long delay, cued and free recall of presented information. This study is particularly interested in the number of words learned during the immediate and short delay acquisition period.

Factor analysis of CVLT scores utilizing normal subjects revealed a six-factor solution (general verbal learning, response discrimination, learning strategy, proactive effect, percent primacy and recency recall, and acquisition rate). For our needs, general verbal learning was the only factor of interest. Analyses on the normative sample have produced a coefficient alpha of .74, and split-half reliability of .63. The test-retest reliability has been found to be .59 (Delis, Kramer, Freedland, & Kaplan, 1988).

c) Wechsler Memory Scale-Revised Logical Memory (WMS-R LM; Wechsler, 1987): LM is a measure of auditory secondary memory; both immediate (LMI) and delay recall (LMII) are assessed 30 minutes apart. Thus, LM examines the ability to recall the number of ideas presented in a passage read to the subject.

d) Visual Spatial Learning Test (VSLT; Malec, Ivnik, & Hinkeldey, 1991): Is a visuospatial learning task in which the stimuli are nonsense designs that are difficult to verbalize. After seeing the 7 designs placed on a 6 x 4 grid, subjects are given an identical, but empty grid and 15 designs with the task of selecting the target seven and placing them as they were when seen on the grid. Five learning trials are given followed by a 30 minute delayed recall. Performance is scored for recognition learning of the designs, recall of the target positions on the grid, and recall of designs in their proper places on the grid.

The VSLT was originally developed to be useful in the administration of memory tests to individuals with language or motor impairment. Additionally, the VSLT appears to contribute to an assessment of dementia. Normative data utilizing the VSLT with persons over age 55, indicated that this measure correctly identified 87.9% of demented and 78.9% of normal subjects (Malec et al., 1992). Due to the recent development of this test, additional psychometric information is not yet available.

Attentional Performance

a) Trail Making Test (TMT; Reitan & Wolfson, 1985): The TMT is a test of speed for visual search, attention, mental flexibility, and motor function. The TMT requires the connection, by making pencil lines, between 25 encircled numbers and letters in alternating order. Normative studies show that performance times increase significantly in each succeeding decade.

b) Letter Fluency and Category Fluency: Is considered an indirect measure of attention. As a measure of language production and organizational skills, subjects were asked to say as many words as possible that begin with a designated letter of the alphabet or within a given category. Three trials were conducted using different stimulus letters (C, F, L); another three trials used different stimulus categories (animals, fruits, vegetables). A one-minute time limit was imposed for each trial.

Following brain injury many persons experience changes in the speed and ease of verbal production. Impaired verbal fluency is also associated with frontal lobe damage. Furthermore, problems in word generation are prominent among the verbal dysfunctions of dementia.

c) Wisconsin Card Sort Test (WCST; Heaton, 1993): Cognitive flexibility and abstract reasoning were assessed by the WCST. The general procedure used in the WCST requires the subject to match individual cards taken sequentially from two packs of 64 response cards to one of four sample cards placed in front of the examiner. Each of these key cards contains a specific shape and color: The first has a red triangle, the second has two green stars, the third has three yellow crosses, and the fourth has four blue circles. All response cards have designs similar to those on the stimulus cards but vary with color, geometric form, and number. The subject is first required to sort according to color of the stimuli. After ten consecutive correct color responses, the sorting principle is changed without the subject's knowledge to the shape or form of stimuli; after ten consecutive correct form responses, the sorting principle is changed again, this time to the number of shapes represented on cards. This procedure is continued until six categories have been completed (i.e., color, form, number, color, form, number) or all 128 cards have been used. Subjects must implement corrective feedback (i.e., whether the match was "right" or "wrong") given by the examiner on individual items in order to determine the principle to which cards must be matched.

The WCST has been demonstrated to be sensitive to a number of variables. Drewe (1974) indicated that performance on the WCST is particularly sensitive to frontal lobe functioning. Milner (1963) found that the number of categories correctly sorted was related to the ability to both shift and maintain set. Both intrascorer and interscorer reliabilities are impressive, and range from .88 to .96 (Heaton, 1993).

d) WMS-R Digit Span (DS; Wechsler, 1987): DS assesses verbal attention, short-term memory, and/or working memory in which subjects are aurally presented increasing strings of digits which they must repeat back to the examiner.

e) WMS-R Visual Memory Span (VMS; Wechsler, 1987): VMS assesses visual attention which is considered to be a visual-spatial analog to the auditory-verbal Digit Span test discussed previously.

f) Golden Stroop Test (Stroop; Stroop, 1935): This test measures the ease with which a person can shift his or her perceptual attention to conform to changing demands and suppress a habitual response in favor of an unusual one. There are four parts to this test; in part one, the subject reads randomized color names (blue, green, red) printed in black type. Next, in part two, the subject is asked to name the color of X's which are printed in the correct, corresponding ink. In part three, subject are asked to name the color of words that do not correspond to what is written (e.g., the word red written in blue ink would necessitate a 'blue' response). It has been reported that normal people can read colored words printed in the colored ink as fast as when the words are presented in black ink. However, the time to complete the task increases significantly when the subject is asked to name the color of ink rather than read the word. The decrease in color-naming speed is called the "color-word interference effect" (Golden, 1976).

Golden (1976) found that scores on the Stroop could discriminate between a psychiatric and organic group with 83% accuracy. More specifically, difficulties with color naming have been shown to be indicative of generalized brain damage, especially anterior (frontal) injuries (Golden, 1976).

g) Paced Auditory Serial Addition Test (PASAT; Brittain, LaMarche, Reeder, Roth, & Boll): This test is a serial-addition test used to assess the rate of information processing and sustained attention. The subject is required to comprehend the auditory input, respond verbally, inhibit encoding of one's own responses while attending to the next stimulus in a series, and perform at an externally determined pace. A pre-recorded tape delivers a random series of 61 numbers from 1 through 9. These numbers are then presented in four different trials of differing rates. Thus, the PASAT increases processing demands by increasing the speed of stimulus input.

The PASAT is thought to measure some central information processing capacity similar to that seen on reaction time and divided attention tasks. Gronwall and Wrightson (1981) suggest that although the PASAT is a cognitive task, there is a small correlation with arithmetic ability (.28) and general intelligence (.28). Brittain et al. (1991) examined the effect of age, IQ, gender, race, and education on PASAT performance in 526 normal, healthy subjects aged 17-88. While education and race had no significant effect, age and IQ did significantly affect PASAT test results. Furthermore, a mild significant effect for gender was evident in which males, overall, performed slightly better than females.

h) Ruff Figural Fluency Test (RUFF; Ruff, Allen, Farrow, Niemann, & Wylie, 1994): A measure of design generation, the RUFF appears to be effective in exploring executive functioning. While productivity and the ability to vary one's responses rapidly are essential to success on this test, other aspects of executive functioning also contribute to good performance, such as self-monitoring, remembering and following rules, use of strategies, and creative imagination.

Performances are scored for number of unique patterns and for number of repetitions of a pattern. Normative studies have shown that both age and education affected productivity, to a significant degree, but not accuracy. Motor skill may also contribute to higher productivity on the RUFF. Ruff et al. (1994) found that the RUFF production score discriminated mild from severe head trauma patients and both groups from normal control participants. Inspection of the data shows that the number of repeated patterns (i.e., perseverations) increased from control (5.8) to mildly injured (8.8) to severely injured (10.1) (Lezak, 1995).

i) Memory Assessment Clinics-Scale - Attention subtest (MAC-S; Crook & Larrabee, 1990): This subtest purports to measure self-reported attentional abilities. This brief five-item scale is one of the few measures available that provides subjective appraisals of an individual's attentional abilities. The questions, numbered 29, 37, 39, 42, and 45 read as follows: "Miss the point someone else is making during a conversation", "Have difficulty following a conversation when there are distractions in the environment such as noise from a TV or a radio", "Have to re-read earlier paragraphs from a newspaper or magazine story to understand the point", "Have trouble finding your place again when interrupted in reading", and "Confuse one word with another when they sound the same", respectively (Crook & Larrabee, 1992). Factor analysis of this scale demonstrated the usefulness of MAC-S factors based on a sample of 1106 participants. It has a large normative base that covers the adult range of 18-92 years. Data has been provided by the researchers showing the concurrent validity of this new self-report scale.

Crook and Larrabee (1992) examined the test-retest reliabilities and practice effect magnitudes comprising the MAC-S battery and five traditional neuropsychological tests in 115 subjects and reported significant practice effects on reevaluation. The test-retest reliabilities were equal or superior to the other traditional neuropsychological measures but the traditional measures were superior in the areas of attention and concentration.

Procedure

All participants were tested individually in a comfortable and quiet location. Many participants were tested on campus, while others preferred their home or church. Able elderly were administered the neuropsychological test battery of approximately 3.5 hours in length. All measures employed in this study were administered based on their published standardized procedures. Furthermore, a number of self-report demographic and emotional measures were mailed to the subject's home prior to actual testing. These completed materials were then collected at the outset of testing. Most participants completed the exam in one session; however, several older participants required two sessions for optimal testing.

Using funds from a research grant, organizations were given $10 for each volunteer who completed testing; in addition, a $50 bonus for every 20 volunteers who matched the minimum age-sex distribution (i.e., one man and one woman in each of 10 5-year age bands) was provided. Participants were informed about the findings of the study following data analysis via a letter and informal group meeting at their respective organizations.

Recruitment

The investigator contacted churches and older adult organizations in the greater Lansing, Michigan area. The purpose of the study and the need for healthy adults living in the community was described. Also explained was the testing (approximately 3.5 hours of paper and pencil tests of memory, attention, and related skills such as hearing and drawing); the assurance of confidentiality; and the subject's right to decline any part of the testing and withdrawal from the project. Subjects' names and phone numbers were provided by the coordinator of each organization, with the consent of the participants.

RESULTS

Descriptive Statistics

Health and Emotional Measures. A structured interview assessed 10 health conditions known to affect cognition. Based on this interview, 15 individuals were excluded for history of cerebrovascular insult (stroke or TIA) and/or head injury with loss of consciousness exceeding a five minute duration. The remaining 85 individuals reported no significant neurological insults and were used in all subsequent analyses. I also assessed depression using the Geriatric Depression Scale (GDS; Yesavage et al., 1983), because of the influence of affective states on cognition. Formal analysis revealed that moderate to severe depression was absent in this sample (M = 3.9, SD = 3.4) and, therefore, no participants were excluded based on this criterion.

Cognitive Measures. WAIS-R Block Design (BD), California Verbal Learning Test (CVLT), WAIS-R Digit Span-Backwards (DS-B), the Extended Complex Figure Test (ECFT), Verbal Fluency (FLUENCY), WMS-R Logical Memory-Story A (LM-A), the attention subtest from the Memory Assessment Clinics-Scale (MAC-S), the Paced Auditory Serial Addition Test (PASAT), the Ruff Figural Fluency Test (RUFF), the Golden Stroop Test (STROOP-CW), Trial Making-B (TM-B), WMS-R Visual Memory Span-Backwards (VMS-B), WAIS-R Vocabulary (VOCAB), the Visual Spatial Learning Test (VSLT), the Wisconsin Card Sorting Test Categories Achieved (CAT-ACH) and Perseverative Responses (PERSEV), and the Wide Range Achievement Test-3

Reading subtest (WRAT-3) were used in the following analyses. Means and standard deviations for these measures are presented in Table 1. Potential outliers were investigated using boxplots and histograms; those with lower scores tended to be the participants that were excluded based on outstanding health conditions, as outlined above.

The Mini Mental State Exam (MMSE) is a frequently cited brief measure of general cognitive functioning used with older adult samples. On this 30-point screening instrument, scores below 24 are considered a performance that falls within the demented range. In the present sample, no participants fell in the impaired range; the average MMSE score (N=85) was a 28 (Min. = 24; Max. = 30). Thus, we can assume that this sample was a group of cognitively intact older adults.

1) Testing the Four-Factor Model of Attention:

The first hypothesis aimed to establish a factor analytic representation of the domain of attentional variables utilized in this study. The theoretically-driven four-factor model of attention described previously was used as a target model. Factor analysis of scores obtained on the eight attention measures, constrained to a four-factor solution using varimax rotation, revealed a very different combination of variables than was initially proposed. Stated briefly, these forced factors were not theoretically nor empirically consistent. To understand better the factor structure of these attentional measures, variables with eigen values greater then one were extracted, yielding a one-factor solution. Factor loadings are shown in Table 2. All variables loaded in the expected direction.

Table 1

Means and Standard Deviations of Measures (N=85)

Variable	Mean	SD	Min	Max
BD	24.44	8.3	6	45
CVLT	42.15	9.9	19	68
DS-B	6.12	1.7	3	11
ECFT	14.62	5.7	0	30
FLUENCY	83.07	20.4	37	140
LM-A	12.64	3.6	4	20
MAC-S	17.92	3.0	10	24
PASAT	93.35	45.5	0	187
RUFF	56.85	21.7	1	120
STROOP-CW	30.08	9.7	6	59
TM-B	97.53	40.4	38	264
VMS-B	7.02	1.4	3	10
VOCAB	48.35	10.1	18	65
VSLT	15.49	7.4	0	33
CAT-ACH	4.78	1.8	0	6
PERSEV	20.62	17.6	4	123
WRAT-3	46.92	5.0	33	55

Note. The means and standard deviations are based on raw scores.

Table 2

Factor Loadings of the Attentional Variables (N=85)

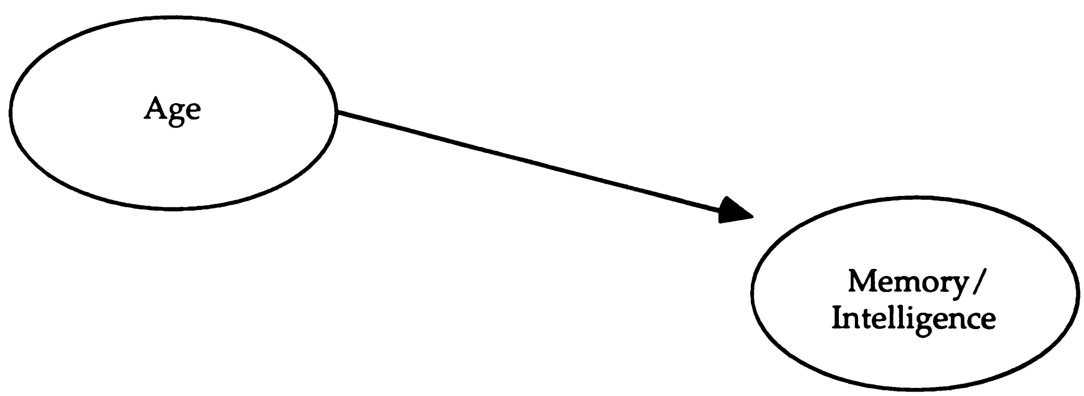
Variable	Factor I Loadings
DS-B	.63
FLUENCY	.63
PASAT	.81
RUFF	.75
STROOP-CW	.79
TM-B	.73
VMS-B	.68
PERSEV	– .60
Eigenvalue	3.99
% of Variance	49.9

It is notable that in addition to a principal components analysis, a maximum likelihood and generalized least squares analysis was conducted. These additional factor analyses were subjected to various methods of rotation, yet still yielded a one-factor solution. Therefore, it appears that while these tasks purport to assess different aspects of attention, they statistically load on one factor and, thus, tend to measure a single criterion in this older adult sample. This one-factor model was adopted to define a unidimensional structure for attentional variables in subsequent analyses.

Model Evaluation

Two causal models were tested in the subsequent analyses. The first, Model 1, examined the relationship between age and the dependent variables, namely, memory and intelligence. In Model 2, attention was introduced as a moderating variable between age and the dependent variables. In addition, the interaction of the main effects (age and attention) was considered.

Model 1



2a) and 2b) Tests of Model 1

Memory

Model 1 proposed a negative relationship between age and memory. Composite factors were created for performance on measures of visual-spatial memory and auditory-verbal memory by averaging the *z* scores from the two relevant measures for each subject. Thus, a visual-spatial memory factor (V-SMEM) was created by combining scores from the VSLT and the ECFT. Likewise, LM-A and CVLT were clustered into an auditory-verbal memory factor (A-VMEM). Correlations among the memory factors and age are located in Table 3. Family-wise alpha was controlled at .05 using a Bonferroni correction. Thus, alpha per comparison for these correlations was .0125.

Intelligence

A negative relationship between age and intelligence was also proposed, as shown in Model 1. As in Hypothesis 2a, to test this model, composite factors were created for performance on measures of crystallized intelligence and fluid intelligence by averaging the *z* scores from the two relevant measures for each subject. Thus, a crystallized intelligence factor (CRYSINTELL) was created by combining VOCAB and WRAT-3. Similarly, BD and WCST-CAT were clustered into a fluid intelligence factor (FLUINTELL). Correlations among the intelligence factors and age are located in Table 3. Family-wise alpha was again controlled at .05 using a Bonferroni correction, with an alpha per comparison of .0125.

It was further hypothesized that the negative relationship between age and intelligence would be greater for fluid than crystallized tasks. A two-tailed *t*-test for dependent correlations (Cohen & Cohen, 1983) indicated that the correlation of age with crystallized intelligence was indeed statistically smaller than the correlation of age with fluid intelligence [$t(82) = 2.40$, $p = .009$].

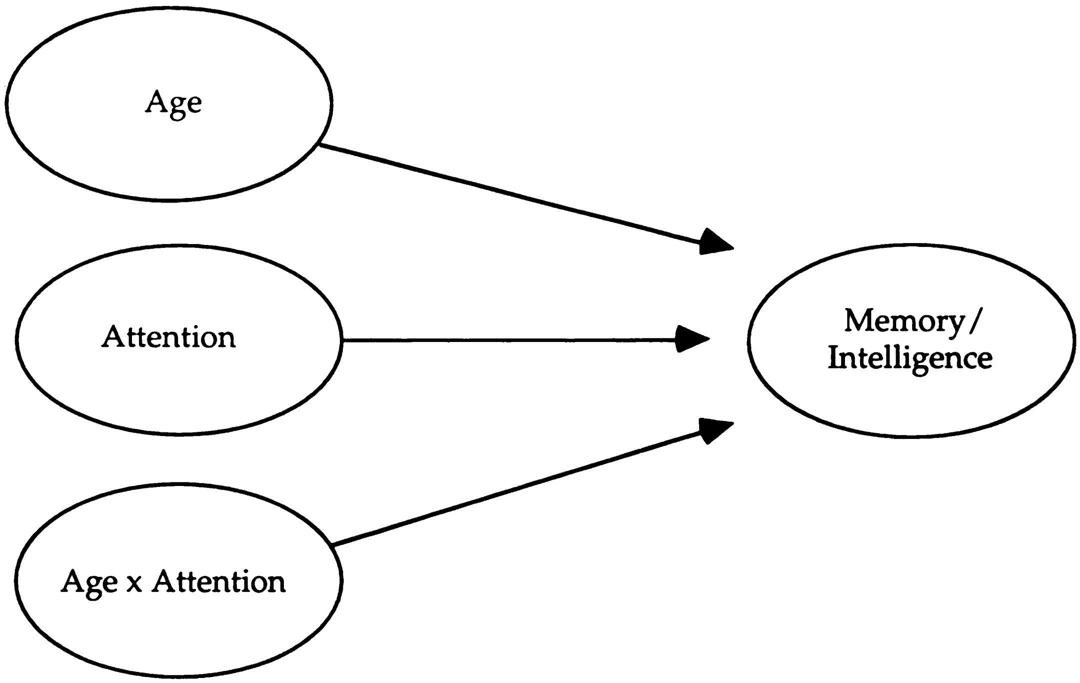
Table 3

Correlations Between the Dependent Variables and Age (N=85)

DEPENDENT VARIABLE	rAGE
Auditory-Verbal Memory Factor	−.48*
Visual-Spatial Memory Factor	−.50*
Crystallized Intelligence Factor	−.18
Fluid Intelligence Factor	−.42*

* significant $\alpha = .01$; two-tailed

Model 2



2c) Tests of Model 2

Hierarchical regressions were used to test the hypotheses that attention would moderate the relationship between age and both memory (A-V MEM and V-S MEM) and intelligence (CRYSINTELL and FLUINTELL). In each of these regressions, age was entered first. Then the single attentional factor was entered. Lastly, to test the hypothesis that the effect of age differs for different levels of attention, the two-way interaction (Age x Attention) was entered into the regression analysis. These analyses were repeated using memory and intelligence as dependent variables.

Memory

For auditory-verbal memory, the interaction between age and attention was not significant; therefore, I tested for main effects. Significant main effects for age (beta = –.48, $R^2 = .23$, $p < .001$) and attention, above and beyond age (beta = .45, R^2change = .14, $p < .001$), were demonstrated. Next, visual-spatial memory was regressed on age, attention, and the interaction term. Again, the main effects of age (beta = –.50, $\underline{R}^2$ = .25, $\underline{p}$ < .001) and attention, above and beyond age (beta = .41, $\underline{R}^2$change = .12, $\underline{p}$ < .001), reached statisitical significance.

Intelligence

Similarly, in evaluating intelligence and attention, crystallized intelligence was regressed on age, attention, and the interaction term. The only statistically significant interaction of age and attention for each of the four dependent variables was with crystallized intelligence. As shown in Figure 1, attention was always positively related to crystallized intelligence. However, at low levels of attentional ability, age was positively related to crystallized intelligence, whereas for high levels of attentional ability, age had a slightly negative relationship to crystallized intelligence (beta = –1.82, $\underline{R}^2$change = .04, $\underline{p}$ < .05). Age, as expected, was not a significant predictor of crystallized intelligence (beta = –.18, $\underline{R}^2$ = .03, $\underline{p}$ > .05), but attention, above and beyond age (beta = .67, $\underline{R}^2$change = .31, $\underline{p}$ < .001), was significantly predictive of crystallized intelligence.

Lastly, fluid intelligence was regressed on age, attention, and the interaction term. Age (beta = –.42, $\underline{R}^2$ = .18, $\underline{p}$ < .001) and attention, above and beyond age (beta = .73, $\underline{R}^2$change = .37, $\underline{p}$ < .001), were found to be significant predictors of fluid intelligence. Thus, as depicted in Figure 2, for all four dependent variables, attention and age together revealed a greater magnitude of statistically significant variation than did age alone. Figure 2 also highlights the independent contribution of attention to each of the dependent variables.

The beta values reported in all regression results are standardized betas.

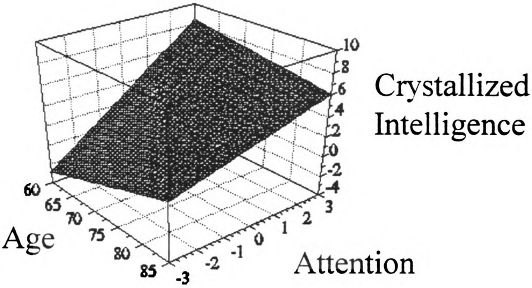


Figure 1
Age x Attention Interaction for Crystallized Intelligence

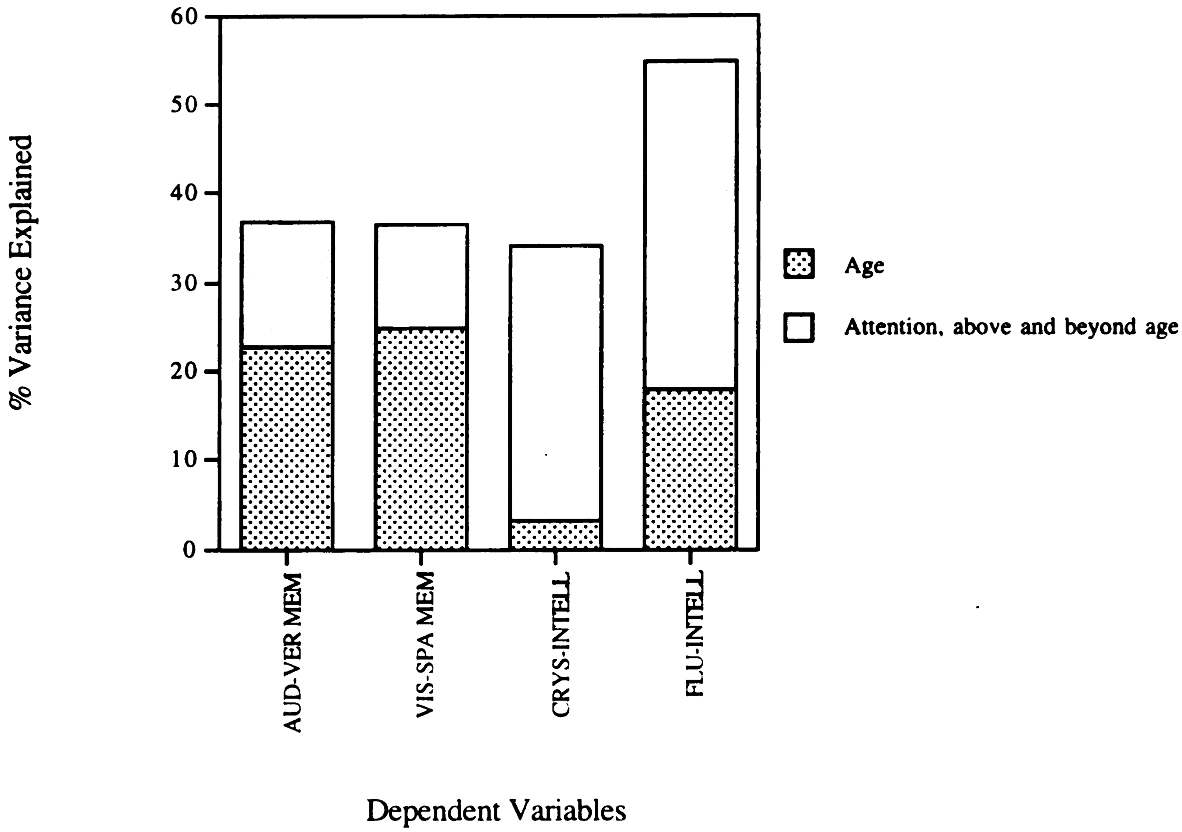


Figure 2
Percent of Variance Explained by Age and Attention

2d) Comparing the Effects of Attention on Memory and Intelligence

It was further hypothesized that attentional elements would account for significantly more of the variance in memory performance than variance in intellectual ability. To investigate this hypothesis, a two-tailed *t*-test for dependent correlations (Cohen & Cohen, 1983) indicated that the correlation of attention with memory was statistically smaller than the correlation of attention with intelligence [$t(82) = -.26$, $p < .013$]. Thus, in contrast with the hypothesis, it was found that attention accounted for more variance in intellectual functioning.

Testing the Unique Contribution of Age

In an effort to better understand the relationship of attention to age in explaining variation in memory and intelligence, four additional regressions were conducted in which the single attention factor was entered first, followed by age. The change in R^2 for the different steps are presented in Table 4. The first column indicates the R^2 after entering the attention variable. The second column contains the increment in R^2 associated with the addition of age. It is apparent for each dependent variable that accounting for attention in the regression equation greatly reduces the magnitude of the age-related influence on cognitive performance. To illustrate, the attention-related variance in auditory-verbal memory was 33% before statistical control of attention; after this control, we can see that age accounted for only 4% of variance in auditory-verbal memory.

Gender Analyses

In addition to isolating attention, analyses aimed at examining gender differences were conducted. In predicting each of the dependent variables,

Table 4

Results of Additional Hierarchical Regression Analyses (N=85)

	Attention R^2	Age ΔR^2, controlling for attention
Auditory-Verbal Mem.	.33	.04
Visual-Spatial Mem.	.31	.05
Crystallized Intelligence	.32	.03
Fluid Intelligence	.55	.00

gender was entered first, followed by attention, age, and the interaction terms. None of the interaction terms reached signficance. However, for auditory-verbal memory, a main effect for gender occurred wherein females performed consistently better than males on this index of functioning (beta = –.24, R^2 = .06, p < .05). Because of this significant effect, the initial age-attention regression for auditory-verbal memory was re-run, this time controlling for gender. The inclusion of gender did not appear to affect prior reported values for age or attention in any analysis.

3) Testing Differential Complexity of Attentional Tasks

This hypothesis aimed to examine attentional task complexity. It was hypothesized that as attentional tasks become more complex, significantly larger age-associated decrements will be evident. Closely resembling the hypothesized theoretical ordering of complexity (short-term storage capacity --> mental tracking --> complex attention), the following ordering, from lowest to highest complexity, was derived through the examination of age-variable correlations: Digit Span-Backwards, Wisconsin Card Sorting Test-Perseverations, Fluency, Paced Auditory Serial Addition Test, Golden Stroop Test, Visual Memory Span-Backwards, Ruff Figural Fluency Test, and Trial Making Test-B. Correlations of age with these variables are shown in Table 5.

4) Subjective Report vs. Objective Attentional Performance

The final hypothesis examined the correlation of self-reported attentional difficulties' with observed attention performance on the measures of attention. A simple correlation between MAC-S attention subtest scores and the one-factor attention variable was generated. Contrary to this prediction, self-report was poorly correlated with actual attentional performance ($\underline{r}$ = .20, $\underline{p}$ > .05).

Table 5

Correlations Between Attentional Variables and Age (N=85)

ATTENTIONAL VARIABLE	rAGE
Digit Span-Backwards	−.23*
WCST-Perseverations	.31**
Fluency	−.33**
Paced Auditory Serial Addition Test	−.37***
Stroop Color-Word Test	−.40***
Visual Memory Span-Backwards	−.43***
Ruff Figural Fluency Test	−.49***
Trail Making Test-B	−.52***

* significant $\propto$ = .05; two-tailed
** significant $\propto$ = .01; two-tailed
*** significant $\propto$ = .001; two-tailed

DISCUSSION

Discussion of these data must necessarily be preceded by a cautionary note. This sample was not typical of the general population in terms of ethnic diversity. Instead, these data reflect a description of the differences between a sample of predominantly Caucasian older adults on measures of cognitive functioning. In addition, a second caveat must be considered. The present study is cross-sectional in design and conclusions drawn from this research may reflect cohort differences instead of aging per se. Moreover, cross-sectional methodologies limit causal interpretations.

This study explored clinical measures of attention from a variety of perspectives. As an initial step in this research, the factor structure of a range of attentional tasks was obtained. Second, the role of attentional abilities was investigated in relation to age-related changes in memory and intelligence. The issue of task complexity was examined in the third hypothesis. Fourth, the correlation between actual attention performance and self-report of perceived attentional abilities was demonstrated. Taken together, results from the present study indicate that attentional abilities play a significant role in the cognitive areas of memory and intelligence. As hypothesized, performance on attention tasks played a greater predictive role than did age of subject. Finally, older adults' performance on a range of attentional tasks differed greatly from performances collected on younger groups of subjects, suggesting that attention must be treated as a unique construct in aged populations.

This study sought to achieve an educational level commensurate with that of data derived from the 1990 U.S. Census (i.e., only 1/4 of older adults had education beyond high school). The current sample contained 28 individuals with a four-year college degree or advanced degree such as an M.A., J.D., Ph.D. (e.g., 28%); another 12 participants had some college education (i.e., 1 to 2 years of post-high school education). The issue of elevated educational levels has been an ongoing obstacle for researchers studying older adult populations. Samples typically contain participants with above average amounts of education. For example, four frequently cited gerontological studies utilized participants with the following years of education: 14.5 $\pm$ 3.5 (Axelrod, Jiron, & Henry, 1993), 15.0 $\pm$ 3.0 (Fromm-Auch & Yeudall, 1986), 14.0 $\pm$ 3 (Mack et al., 1992), and 14.5 $\pm$ 3.0 (VanGorp et al., 1986). Therefore, the results of this current study may be more generalizable than previous research to a population of older adults.

Testing the Four-Factor Model of Attention

The results of Hypothesis 1 indicate, with the current sample and the measures utilized, that attention is unidimensional. That is, older adults, aged 60-85, performed fairly consistently on the measures of attention included in our battery. Perhaps, then, these findings suggest that the existing models of attention need to be modified when they are applied to older adults. A number of researchers (Shum et al., 1994; Shum et al., 1990, and Sack & Rice, 1974;), while using slightly different measures of attention, derived three-factor models of attention; it is notable, however, that their samples consisted of adults aged 20-50, college students, and eighth graders, respectively. Other studies have created as many as four factors (Mirsky, 1989 and Sohlberg & Mateer, 1989) or as few as two (Schmidt et al., 1994). It would be interesting to examine, utilizing the same attentional measures as in this study, whether attention is unidimensional in other populations (e.g., age groups, ethnicity, educational level).

Tests of Model 1

Hypotheses 2a and 2b posited that the effects of aging produce a substantial decrement in both memory and intelligence. In an effort to avoid reliance on single instruments, two tasks that purport to measure the respective dependent variable (e.g., Auditory-Verbal Memory, Visual-Spatial Memory, Crystallized Intelligence, and Fluid Intelligence) were included. As predicted, three of the four dependent variables showed a statistically significant negative relationship with age, while one, crystallized intelligence, revealed a mild correlation with age given the overlearned quality of the tasks. Moreover, the relationships between age and fluid intelligence and age and crystallized intelligence were reliably and significantly different, further corroborating Horn and Cattell's (1967) model.

Tests of Model 2

Building upon Hypotheses 2a and 2b, the next Hypothesis (2c) attempted to show that the commonly accepted age deficits in memory and intelligence are, in part, attributable to a reduction in attentional ability. In our model, attention was assumed to act as a moderating variable between age and the various dependent variables. Following formal analyses, however, it became clear that attention was behaving more like a mediating than a moderating variable. That is, the impact of the independent variable (age) on the dependent variable (memory or intelligence) was largely attributable to the mediating variable (attention). In other words, results indicated that the decline in memory or intelligence with increasing age is greatly reduced, or even disappears, when attentional factors are statistically controlled.

To illustrate, the largest attention effect was observed on tasks of fluid intelligence, explaining at least 55% of the variance. All three other dependent variables also showed attention effects, albeit smaller in magnitude. For auditory-verbal memory, attention explained 33% of variance; for crystallized intelligence and visual-spatial memory, attention explained 32% and 31%, respectively. Most notable, however, was the magnitude of age-related variance after statistically controlling for attention. For visual-spatial memory, age accounted for just 5% of the variance; 4% in auditory-verbal memory; 3% in crystallized intelligence; and the age effect was eliminated completely (0%) in the case of fluid intelligence. Taken together, the results from this hypothesis suggest that age differences in memory and intellectual performance can be attributed to deficiencies in attentional ability. These deficiencies may be due to a decline in the availability of attentional resources or simply an inability to use these resources effectively.

Regression analyses revealed a single statistically significant interaction between age and attention for the dependent variable, crystallized intelligence ($p \leq .05$). It was found that among individuals with lower scores on tasks of attention (low attention), age was positively related to crystallized attention. In other words, amongst subjects with poor attentional abilities, age was associated with better performance on tasks of crystallized intelligence. Similarly, among participants with higher scores on tasks of attention (high attention), age was negatively related to crystallized intelligence. Therefore, amongst subjects with good attentional ability, age was associated with poorer performance on crystallized tasks.

Before attempting to explain this finding, it should be noted that this interaction was only significant at the uncorrected alpha level (.05) and, therefore, not significant at the corrected alpha level of .01. As a result, this finding may be more accurately interpreted as a trend. Moreover, the simple effects for high and low attention were not significant ($r_{\text{age, crystallized intelligence}}$ for low attention = .17, p = .28; $r_{\text{age, crystallized intelligence}}$ for high attention = −.22, p = .15). Additional analyses revealed that participants in the high attention group tended to be the younger individuals contained in this sample (M age = 69 years). Likewise, the low attention group contained a disproportionate number of older adults (M age = 75 years). Therefore, the interaction between attention and age may be more accurately described as an artifact of age.

Gender Analyses

Gender analyses for memory, intelligence, and attention revealed one meaningful finding; namely, that a main effect for gender was shown in auditory-verbal memory. Therefore, on auditory-verbal memory tasks, women performed better than men.

Interest in sex differences has prevailed across most areas of psychological inquiry. Neuropsychology is no exception. In fact, a large literature is devoted to neuroanatomical differences between the genders which can be demonstrated through neuropsychological assessment. It is a commonly accepted notion that males are stronger in the visual-spatial domain, whereas females excel on auditory-verbal tasks. Increasingly, however, numerous studies, reviews, and meta-analyses have reported mixed findings regarding the proposed lateralized differences between males and females. Hyde (1990) documents "a trend over approximately two decades toward a decline in the magnitude of gender differences" (p. 72). She concludes that this decline reflects increasing convergence of the socialization processes for males and females, thus supporting social role explanations as opposed to theories of neurological differences. Results from the current study may further illuminate the etiology of the gender effect; most notable, was the absence of a two-way interaction in which age and gender impacted upon auditory-verbal memory, thereby supporting more of a neuroanatomical explanation.

Comparing the ffects of Attention on Memory and Intelligence

Hypothesis 2d examined the premise that attentional ability plays a greater role in successful memory performance than intellectual ability. Contrary to expectations, it was found that attention's role in intellectual functioning was measurably larger than attention's impact on memory processes. An intuitive approach to this finding may be most appropriate. The ability to memorize material is driven by an individual's intellectual status. Perhaps, then, the intellectual tasks we used exist at a primary ability level, while performance on measures of memory are found at a second-order level. For example, adequate performance on Block Design, a visuoconstructional fluid intelligence task, (may be necessary for one to succeed on) underlie one's ability to succeed on visual-spatial memory tasks, especially the drawing nature of the Complex Figure Test. Likewise, it makes sense that in order to memorize a prose passage (Logical Memory, an Auditory-Verbal Memory measure), an individual must have adequate crystallized language skills such as reading (WRAT-3 Reading) and word knowledge (WAIS-R Vocabulary).

Testing Differential Complexity of Attentional Tasks

Hypothesis 3 examined what has come to be known as the age-complexity effect, or the tendency for the magnitude of age differences on cognitive tasks to increase with the level of complexity. Although this premise seems intuitive, relatively little is known about which attentional tasks present the most difficulty for a group of older participants. From the ordering shown in Table 5, it can be seen that attention tasks that stressed verbal abilities had the least age decrement associated with them (i.e., Digit Span, Fluency). However, visually loaded attentional tasks such as the Stroop Test, Visual Memory Span, Ruff Figural Fluency, and the Trail Making Test, showed the greatest age-associated decrement. In addition, this latter group contains three timed tasks. Of the verbal tasks, only verbal fluency is timed, although most participants report feeling little time pressure on this task. Additionally, the most complex tasks, Ruff Figural Fluency and Trail Making, also necessitated a motor component. Thus, the visual attention tasks, time requirements, and motor demands appear to present the greatest difficulties for older adults. In contrast to the theoretically driven complexity ordering reviewed previously in the literature, the present findings, like those generated from the factor analysis, suggest that attention in older adults may be organized and processed differently than younger adults. However, to assume that this pattern is due to aging, we would need to replicate this study with younger adults to see if the slopes are similar.

Subjective Report vs. Objective Attentional Performance

The fourth hypothesis sought to correlate attentional self-report with objective attention performance. Contrary to this prediction, self-report was poorly correlated with actual attentional performance ($r = .20$, $p > .05$). This finding is most likely a function of low self-report validity. The authors themselves (Crook & Larrabee, 1992) reported that of the 10 MAC-S subscales, attention and concentration was the least psychometrically sound. In addition, it maintained the lowest correlation with age. As this was the only self-report measure available in the published psychological literature, the need for a more thorough attentional self-report measure is obvious.

Perhaps one of the biggest problems with this subscale is the relatively small number of questions (five) contained within it. Furthermore, these questions are somewhat vague and a respondent may respond affirmatively due to issues other than attention; for example, the question, "Have difficulty following a conversation when there are distractions in the environment such as noise from a TV or a radio", may elicit a positive response from an individual who is suffering from attentional difficulties, a hearing deficit, and/or affective problems. I conducted a simple correlational analysis examining the MAC-S attention and concentration subscale as well as measures of attention, auditory perception, and depression. Interestingly, the Geriatric Depression Scale was the only measure to correlate significantly ($r = -.48$, $p \leq .001$), suggesting a possible affective component to elevated scores on this subscale.

Methodological Limitations and Future Directions

Multicollinearity

A number of limitations of the current study should be addressed. The issues of cross-sectional design and heterogenous subject sampling was addressed at the outset of the discussion section. In addition, and perhaps more troubling, is the issue of multicollinearity. This problem is most relevant to the analyses that utilized attention as a moderating variable. In that type of model, the moderator is expected to have a low correlation with the independent variable. However, age and attention were found to be moderately correlated ($r = .54$, $p > .05$), implying the possibility of a linear relationship. Moreover, this correlation is higher than any of the four dependent variables' correlations with age (see Table 3). In addition, the zero-order correlations between the attention variable and the four dependent variables were: .56 for visual-spatial memory; .57 for crystallized intelligence; .58 for auditory-verbal memory; and .73 for fluid intelligence, suggesting a good deal of overlap.

Most investigators agree that correlations greater than .80 are considered problematic (Grimm & Yarnold, 1995). Therefore, while the relationship between attention and age as well as the relationship between attention and the outcome variables were moderately strong and the issue of multicollinearity cannot be ruled out, the magnitude of the correlations fell below a commonly used .80 rule of thumb. Moreover, a common treatment of multicollinearity is to use just one of the highly correlated variables in an effort to avoid redundancy. Although not as a direct response to this issue, this treatment was conducted by the additional analyses aimed at testing the unique contribution of age. In summary, the results of the current study present both attention and age as important predictors of memory and intellectual performance. However, due to the problem of multicollinearity, it is difficult to assess the unique effects of individual predictors upon the dependent variables.

In an effort to address the problem of shared variance among the predictor variables, the multiple regressions were again conducted, this time using simultaneous entry (i.e., one block/step) of age and attention for each of the dependent variables. From this type of regression analysis, one can infer the unique contribution of the independent variables. Results of this analysis are depicted below in Table 6. The results of this analysis confirm earlier findings suggesting that the contribution of attention to memory and intelligence appears to be greater than the contribution of age.

Table 6

T-Values, Unique Variance, and Shared Variance for Simultaneous Entry (N=85)

	Aud.-Verbal Memory	Visual-Spatial Memory	Fluid Intelligence	Crystallized Intelligence
Age	.0342	.0110	.7808	.0795
Unique to Age	4%	5%	0%	3%
Attention	.0000	.0002	.0000	.0000
Unique to Attention	14%	12%	36%	31%
Shared Variance	19%	20%	19%	0%

Measurement Issues

As another qualification of the results presented, the tasks chosen for the current study may have limitations. For example, one could argue that some of the attention measures chosen may be more accurately described as executive functioning tasks. Likewise, very basic attentional tasks such as letter or symbol cancellation tests were not included in the current study due to their overreliance on motor performance. In addition, a large amount of the literature aimed at attention and processing resources have only included very basic measures of attention, leaving out those assessment techniques that clinical practitioners are dependent upon. Lastly, the fluid intelligence measures utilized in the current research were heavily visual-spatial while the crystallized intelligence measures were purely verbal, suggesting a functional dissociation.

On a post-hoc basis, a final factor analysis was conducted that included all measures utilized in the analyses; thus, 16 measures were factor analyzed to establish whether the initial breakdown of memory, intelligence, and attention would be observed. Utilizing a rotated Principal Axes Factoring method, four factors were generated. The results were only partially consistent with the hypothesized pattern of convergence. Factor 1 contained six of the eight attention measures (Digit Span, PASAT, Ruff Figural Fluency, Stroop, Trail Making, and Visual Memory Span) as well as Block Design, initially described as a fluid intelligence task. All four memory measures loaded onto Factor 2. Factor 3 was heavily verbal, comprised of Vocabulary and WRAT-3 Reading (crystallized intelligence tasks), as well as Fluency (an attentional task). Finally, factor 4 contained both aspects of the Wisconsin Card Sorting Test: Number of categories achieved (CAT-ACH; a fluid intelligence measure) and total number of perseverative responses (PERSEV;

an attentional task). Therefore, this post-hoc factor analysis revealed roughly accurate loadings for attention, crystallized intelligence, and memory; however, the two fluid intelligence tasks did not have a commensurate factor structure. Perhaps, then, the most important measurement issue for the current study is in the choice of fluid intelligence tasks.

The factor analysis of all 16 variables generated three reliable factors; namely attention (albeit, a new conceptualization), memory, and crystallized intelligence (with the inclusion of the attentional task, verbal fluency). For the final analysis of this research project, multiple regression was again conducted to assess the contribution of age and attention to auditory-verbal and visual-spatial memory. Crystallized intelligence was not included in this analysis as it is not informative in the absence of fluid intelligence. Results of these analyses are presented in Table 7. These findings are very similar to those generated in the earlier analyses. Once again a pattern emerged such that attention plays a significant role in age-associated decrement in memory abilities, whether relying on sequential or hierarchical analyses.

Table 7

Results of Final Regression Analyses (N=85)

	Auditory-Verbal Memory	Visual-Spatial Memory
Attention R^2	.30	.30
Age ΔR^2, controlling for attention	.04	.05
Sig. T for Age	.0209	.0098
Sig. T for Attention	.0003	.0003
Unique for Age	4%	5%
Unique for Attention	11%	11%
Shared Variance	20%	20%

Future Directions

There are several directions to consider for future research. First, it may be beneficial to replicate these findings with measures that are more typical of everyday memory events in an effort to increase ecological validity. Second, many of these findings are worthy of replication and extension. In particular, it would be interesting to examine attentional factor structure in other populations to examine whether attention remains a unidimensional factor. This same design would be useful to further examine the age-complexity issue. Research in the area of developmental neuropsychology, comparing performance in disparate populations such as children and older adults, is much needed and rarely found in the literature. It would also be interesting to extend the mediational model of attention to different aspects of memory; for example, to compare attentional resources necessary for initial encoding versus retrieval versus recognition. Finally, weak results with the

MAC-S point to the need for creation of a valid and reliable measure of attentional self-report.

APPENDICES

APPENDIX A:

Neuropsychological History Questionnaire

Age	____________
Sex	M F
Hand used for writing/drawing	R Both L
Race White Black Hispanic Asian	Multi
Education (# of years completed, full-time equivalence)	____________
Did you ever repeat a grade or did you require any special eduation services?	N Y
Can you remember the WORST time that you hit your head or suffered a blow to the head?	N Y
(If yes to above question): How long were you unconscious (# of minutes)?	____________
How many times have you been knocked unconscious?	____________
Have you ever had a stroke or a transient ischemic attack (sometimes called "TIA's" or "ministrokes")?	N Y
(If yes to above question): How many times?	____________
Have you ever had hydrocephalus, too much fluid on the brain?	N Y
Have you ever been treated for seizures?	N Y
Have you had high blood pressure?	N Y
(If yes to above question): How long (# of years)?	____________
Have you had any heart problems?	N Y

(If yes to above question): Please describe the nature of these heart problems:

____

Do you have diabetes?	N	Y
(If yes to above question): Do you take insulin for that?	N	Y
Do you have kidney disease or have you had kidney failure?	N	Y
Did you have liver disease, such as sclerosis of the liver?	N	Y
Do you have lung disease, such as emphysema?	N	Y
Have you ever had cancer?	N	Y

(If yes to above question): Describe when, where in the body, type, and treatment: ____

____

Are you HIV+?	N	Y
(If yes to above question): Have you been diagnosed with AIDS?	N	Y
Have you smoked cigarettes regularly?	N	Y

(If yes to above question): How many years total? __________
On average, how many packs per day? __________

In your heaviest year of drinking...
How many alcoholic drinks did you have per week? __________
How long did you drink at that level (# of years)? __________

Over the course of your life...
How many years total have/did you drink any alcohol? __________
On average, how many drinks did you have per week? __________

Have you ever used street drugs?	N	Y

(If yes to above question): How many years? __________
What substances did you use the most? ______________________________

Have you been treated by a psychologist or a psychiatrist?	N	Y

(If yes to above question): How many years total, over the course of your life? __________

Do you have any difficulties hearing? ____________

(If yes to above question): Please describe the extent of the difficulty and whether correction devices are necessary/used?____________________________

Are you color blind? N Y

Is English your first language? N Y

(If no to above question):
How old were you when you first learned English? ____________
What was your first language? ____________

Are you currently taking any medications? N Y

(If yes to above question, please continue to list your medications in the space provided below):

Can you list all the medications you have taken in the last week:

	Name of Medication	Dosage	Frequency
1.	__________________	______	____________
2.	__________________	______	____________
3.	__________________	______	____________
4.	__________________	______	____________
5.	__________________	______	____________
6.	__________________	______	____________
7.	__________________	______	____________
8.	__________________	______	____________
9.	__________________	______	____________
10.	__________________	______	____________

APPENDIX B

Michigan State University (MSU) Research Study

The MSU Psychological Clinic is looking for volunteers for neuropsychological testing. Your contribution to this study will be invaluable to us. In this project, we are trying to better understand normal thinking and reasoning in older adults. We are also trying to improve our current tests in these areas, and the results that you provide will help us to do that.

In this study, you will do many different things. Many of the tests measure thinking and reasoning directly. There are also some tests that will measure your ability to read, write, hear, and draw. The exam will take approximately 3 hours; in addition, a few questionnaires will be mailed to your home prior to our meeting.

All information that you provide us will be strictly confidential. After your exam, your test results will be filed under a code, without using your name or any biological information. These records will be maintained in a secured file. This exam is for research purposes, so no written report will be issued. However, if your test results suggest a possible problem, we may recommend that you see your primary care physician.

Participation in this study is voluntary, and you will be free to withdraw from the project at any time. In addition, you may refuse to do a particular task, and we will continue with the next one. Certainly, the more that you are able to complete, the more your participation will assist us in our research.

In exchange for your participation, we will make a contribution of $10. to your church or to a fund your church designates. IF ALL 20 SIGN-UP PLACES ARE FILLED AND THESE VOLUNTEERS COMPLETE TESTING, A BONUS OF $50. WILL BE PAID in addition to the $10. per person, FOR A TOTAL OF $250.

Please indicate your interest by providing you name and phone number on the sign-up form. You will be contacted by one of the research coordinators who will answer any questions you might have and who will schedule you for testing. We will try to make arrangements as convenient as possible.

This research project has been reviewed and approved by the MSU University Committee on Research Involving Human Subjects. It is conducted under the supervision of Norman Abeles, Ph.D., ABPP. For more information, contact the Project Director, Natalie Denburg, M.A., at 355-9564.

APPENDIX C:

Ordering of Tests Administered

Self-Report (sent to participant's home):
- Neuropsychological History Questionnaire (see attached)
- Activities-Specific Balance Confidence (ABC) Scale
- Geriatric Depression Scale
- Memory Assessment Clinics-Self Rating Scale (MAC-S)
- Morningness and Eveningness Measure

Battery (administered to participant by examiner)
- Mini Mental State Exam
- AMNART
- Cowboy Story (imm.)
- Digit Span
- Visual Memory Span
- Category Fluency
- PASAT
- Cowboy Story (del.)
- Ruff Figural Fluency Test
- Logical Memory I (imm.)
- Extended Complex Figure Test (imm.)
- Wisconsin Card Sort Test
- Stroop
- Logical Memory I (del.)
- Extended Complex Figure Test (del.)
- WAIS-R Vocabulary
- Logical Memory II (imm.)
- Trial Making Test
- Speech-Sounds Perception Test
- Letter Fluency
- WRAT-3 Reading
- Logical Memory II (del.)
- California Verbal Learning Test
- Visual Spatial Learning Test
- Judgment of Line Orientation
- WAIS-R Block Design
- Boston Naming Test
- Reading with Distraction

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