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DEPTH OF PROCESSING AS AN INDEX OF FRONTAL LOBE AND MEMORY FUNCTIONING IN OLDER ADULTS

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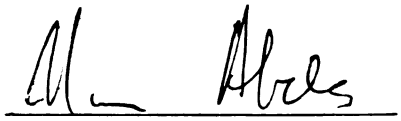

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DEPTH OF PROCESSING AS AN INDEX OF FRONTAL LOBE AND MEMORY FUNCTIONING IN OLDER ADULTS

By

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ABSTRACT

DEPTH OF PROCESSING AS AN INDEX OF FRONTAL LOBE AND MEMORY FUNCTIONING IN OLDER ADULTS

By

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An analysis of the relationship between the type of strategies used on a verbal fluency test and a verbal learning test in older adults was conducted. A significant positive relationship was between use of complex strategies on a verbal fluency task and use of complex strategies during retrieval on a verbal memory test. Use of semantic clustering strategies on a verbal fluency test was a significant predictor of use of semantic strategies on a verbal memory test. The results are discussed within the context of a deficiency in depth of processing as one component of age related memory loss, and the involvement of the frontal lobes in these processes are discussed.

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INTRODUCTION

As the population of older adults continues to grow, so does the importance of understanding the processes that accompanies aging. Serious cognitive problems have been diagnosed in 15-25% of adults over the age of 65 and the number rises to 70% in nursing homes and other institutional settings (Knight, Teri, Wohlford, & Santos, 1995). Some degree of cognitive decline and memory loss are typically assumed to be a part of the aging process. However, organic mental disorders are overdiagnosed in the elderly (La Rue, 1992). Understanding the process and extent of cognitive decline and memory loss in older adults is essential to being able to make the distinction between normal aging and organic disorders.

Some evidence of intellectual function decline has been demonstrated by research, although significant decline does not reliably occur until the 70 or 80 year age range (Birren & Schaie, 1977; Benton, Eslinger & Damasio, 1981). Furthermore, the documentation of cognitive deterioration in the elderly is largely dependent on the neuropsychological tests employed. Certain intellectual functions tend to remain more intact, such as verbal skills, while nonverbal, visuospatial skills tend to decline more sharply in older adults (Hochanadel & Kaplan, 1984). The pattern of decline of nonverbal abilities in old age has been referred to as the "classical aging pattern" by Hochanadel and Kaplan (1984). Horn and Cattell (1967) described this distinction

as "crystallized" intelligence which subsumes factual and cultural assimilation that occurs throughout the life-span, versus "fluid" intelligence which includes problem-solving abilities and capacity to deal with novel tasks that tends to decline with aging.

Attentional Processes

When questioned regarding the most troubling aspects of cognitive decline, the elderly often mention memory difficulties and lapses in attention and concentration. Despite the absence of a widely accepted definition of the term attention among scientists, some older adults are aware of the kinds of their attention problems and the effect that lapses in attention have on their ability to remember. The phrase "paying attention" suggests both that attention can be consciously focused and that its intensity level has certain costs to attention resources (van Zomeren & Brouwer, 1994). Age-related changes of attention processes are of primary importance in understanding cognitive decline in the elderly; Stankov (1988) suggests that changes in fluid intelligence in older adults are dependent on changes in attentional processes.

Elucidating the impact that attention has on other areas of cognitive functioning in the elderly requires breaking down attention into its specific functions. Components of attention include concentration, perceptual

speed, attentional flexibility, selective attention, and freedom from distraction (van Zommeren & Brouwer, 1994).

Concentration, or sustained attention is the ability to maintain mental effort on tasks. Given the length of some neuropsychological batteries, decrements in sustained attention resources of older adults are presumed to occur. However, the research seems inconclusive regarding the existence of an age decrement in sustained attention. Surwillo and Quilter (1964) found that older and younger adults were about equally capable in detecting a target over the first 15 minutes of a 62 minute task, but that the older registered a greater decrement in sustained attention during this task's last 15 minutes. Stankov (1988) found that a concentration factor was significantly negatively correlated with age. However, in contrast to these findings, Giambra and Quilter (1988) found that while the likelihood of detecting the target decreased over time, this occurred at an equal rate in older and younger adults.

Another facet of attention is perceptual speed or searching defined as the ability to find a specific target within an array of similar targets. Research by Plude and Doussard-Roosevelt (1989) examined the approach to visual search tasks in younger and older adults and found that although they used similar approach strategies, older adults required twice as long to consider each item. These results seem consistent with a theory of generalized reduction in energy for cognitive processing, resulting in a

slowing effect (Salthouse, 1988).

Attentional flexibility, described as the ability to shift attentional resources from one task to another, is another aspect of attention that may decline in older adults. Stankov's (1988) factor analysis identified an attentional flexibility factor that correlated negatively and significantly with age. Furthermore, when the effects of the attentional flexibility component were partialled out, age-related decline in fluid intelligence was essentially eliminated. Age-related difficulties in shifting attention are similar to the reduced capacity to shift attention that Luria (1973) found in patients with frontal lobe pathology. Indeed, a study by Teece (1978) implicated the involvement of the frontal system, as measured by evoked potentials, in the ability of older persons to change attention to a different task.

The ability to attend to a particular stimuli while ignoring other, distracting stimuli is described as selective attention. Layton (1974) found a decrement in this aspect of attention for simple stimuli. In this study, participant's were required to detect a target out of a large array; elderly participant's were more penalized by this distracting information. Deficits in selective attention have been consistently demonstrated in older adults (see Hochanadel and Kaplan, 1984 for review). Hasher and Zacks (1988) hypothesized that inhibitory functioning is reduced in older adults, as evidenced by more frequent

intrusions of personal memories into recall of text. A reduced ability to filter out irrelevant information would seem to explain the difficulties some elderly participants have on tasks that require selective attention. One hypothesized mechanism for this decrement in inhibitory functioning has been suggested by Arbuckle and Gold (1993) as a frontal lobe deficit. The involvement of the frontal system in specific inhibitory deficits has received other support. Kramer, Humphrey, Larish, Logan, and Strayer (1994) found that older adults exhibit deficits in inhibitory processing on a task in which processing has been linked to frontal lobe function.

Tasks that require subjects to divide their attention for successful performance show substantial age effects (McGhie, Chapman, & Lawson, 1965; Craik , 1973). Divided attention is another aspect of attention functioning that has demonstrated a consistent decrement in older adults relative to younger adults; that is, older adults are more penalized on tasks that require the allocation of their attentional resources between two tasks simultaneously (see Hartley, 1992 for review).

The abilities to divide attention, suppress irrelevant stimuli, and shift attention to new tasks are critical to performance on neuropsychological tests. In particular, the relationship between attention deficits and memory problems has been demonstrated (Craik & Lockhart, 1972). If a stimulus to be remembered does not receive focused attention

of sufficient intensity it will not be entered into memory. Furthermore, the concept of working memory--the conscious rehearsal of information in an attempt to remember it in the long term--is as much a concept of attention as it is of memory (Baddeley, as cited in van Zomeren & Brouwer, 1994). Working memory requires focused attention in the rehearsal of information; therefore, the impact on memory, of a reduced ability to inhibit distracting information during this rehearsal can be clearly seen. In order for memory to occur, attention must precede it. Understanding the extent to which attentional processes are compromised, as well as the mechanisms responsible for this loss, are of particular importance in examining the specific memory function declines that older adults experience.

Memory Functioning

One of the most consistent complaints of the elderly is of memory decline (Lowenthal, Berkman, Buehler, et al. 1967). One of the primary concerns of older adults is the loss of memory ability. In a study by Lowenthal, Berkman, Buchler, Pierce, Robinson and Trier (1967) over 50% of elderly respondents reported a decline in their memory function. However, demonstration of actual memory decline in elderly populations has been largely dependent on the specific aspect of memory being measured. Information-processing models have been used to understand the process

through which to-be-learned material is entered into memory and recalled.

The initial stage of memory has been conceptualized as sensory memory (La Rue, 1992). In this stage of memory, external stimuli is assumed to be provided with a fairly complete representation, although this image is subject to rapid decay if deeper processing is not engaged in. An example of this stage of memory includes, registering the specific letters of a presented stimuli (e.g. having a representation of the letters that compose the name of a newly introduced person). The deficits of older adults in sensory memory function has been demonstrated by research (Cerella, Poon & Fozard, 1982; Walsh, Till, & Williams, 1978). These investigators found that older adults require increased exposure to material in order for an adequate image to be generated. Furthermore, when longer presentation of stimuli is allowed for, age is not a factor in the rate of decline (Botwinick, 1973).

Primary or short-term memory is conceptualized as a temporary memory store that requires rehearsal of to-be-remembered items and focused conscious attention. The capacity of this primary memory is limited to the number of items that can be consciously rehearsed. Despite subjective reports of the elderly that they are experiencing short-term memory decline, objective research measures have not consistently demonstrated the presence of short-term or primary memory impairment, at least through age 70 (Craik,

1977). Secondary memory is conceived of as a cache of essentially permanent acquired knowledge. Learning of new information occurs when the new material has been encoded into secondary memory, a process which may be one source of memory difficulty in the elderly.

Research Data for Older Adults

Thirty older adults were equivalent to young adults in their ability to recognize probe words from a short list of items after presentation (Lorsbach & Simpson, 1984). In this experiment subjects were required to determine if a probe word was identical, sounded the same, or meant the same thing as, one of the ten words in a list of to-be-remembered items. Although older adults were equivalent to younger adults in the identical trial, they were slower than younger adults in recognizing synonyms of list items; thus, the implication from this study being that while the elderly exhibit no deficits relative to younger adults in the functioning of primary memory, the encoding of more elaborate information, such as meaning may be more difficult for the elderly. Older adults typically engage in less efficient encoding strategies during initial presentation of the new material; Sanders, Murphy, Schmitt and Walsh (1980) found that the elderly use less efficient learning strategies--repetition as opposed to organizatonal strategies--and engage in such strategies less actively. Furthermore, Hulicka and Grossman (1967) found that most

older adults did not report spontaneously employing mnemonic techniques when learning a list of verbal paired associates, while most young adults admitted to using some type of association strategy.

Age Consistent Memory Decline

The utilization of semantic information during encoding represents a complex operation that requires more time than more superficial encoding based on the pronunciation or perceptual characteristics (Posner, 1978). Indeed, there is some evidence that older adults have more difficulty in using semantic information to enhance the processing of material to be remembered.

One explanation for this deficit in efficiency of encoding in older adults has been proposed by Salthouse (1982) as a generalized slowing of processing speed that accompanies aging. According to Salthouse, the elderly require more time to engage in more efficient encoding, and are consequently penalized more than younger adults in most experimental paradigms. Furthermore, if the processes involved in the organization of material to be learned, or deeper encoding, are assumed to require more time than superficial encoding, then a speed-loss explanation seems to account for the difficulty that older adults demonstrate in utilizing more elaborate, semantic processing. Simon (1979) found some support for this hypothesis by demonstrating that while semantic cues decreased in effectiveness for retrieval

in the elderly, younger adults demonstrated a similar pattern when the presentation rate of to-be-learned items was increased. However, Lorbasch and Simpson (1984) found that the manipulation of presentation rate did not selectively impair older adults when the processing of meaning was required, suggesting that the speed-loss hypothesis can not fully account for the difficulty older adults exhibit in encoding semantic cues of to-be-learned material.

An additional explanation for this age-related memory decline has been proposed by Craik (1977) as a deficiency in the depth of processing used by older adults. One representation of this is the utilization of phonemic and semantic characteristics of words. Phonemic cues are associations between words based on the pronunciation characteristics. In a list of words to be remembered, the clustering of words with similar sounds (e.g., farm, fake) would represent a phonemic strategy and a more surface-level of processing. On the other hand, semantic cues are associations based on related meanings of words, require more elaborate processing, and produce stronger memory connections (Craik, 1977). This type of strategy would be demonstrated by the clustering of words from a list of to be remembered items that belong to the same meaning category (e.g., apricot, apple). Hulicka and Grossman (1967) found that older adults were less likely to incorporate a semantic encoding strategy on a verbal learning task than

were younger adults. However, when elderly participants are instructed to use more elaborate types of organization on a memory task, they improve more than do younger participants, although they still perform at a lower overall level than younger adults (Hulicka, Sterns & Grossman, 1967). Furthermore, phonemic cues--which represent a less elaborate level of processing--were more effective for older adults in a recall task than were semantic cues, suggesting that older adults suffer from a reduced ability to process information at deeper levels (Simon, 1979).

These results suggest that older adults tend to utilize features of to-be-learned material that are perceptually prominent, rather than using the meaning of to-be-learned material. In other words, this means that older adults tend to rely on a phonemic strategy as opposed to a more elaborate and effective semantic one (Craik, 1977).

This pattern of being bound to perceptual features of stimuli is characteristically seen in the performance of patients with frontal lobe pathology on memory tasks (Goodglass & Kaplan, 1979). Thus, deterioration of the frontal lobes has been hypothesized as a contributing mechanism to the cognitive and memory decline specific to older adults. The frontal system is implicated in the allocation of attention, planning and beginning of complex activity, the ability to screen out irrelevant information, and monitoring and adjusting behavior in response to feedback (Luria, 1973).

Frontal Lobes

Evidence for decreased functioning of the frontal lobes in older adults has been found in research with neuropsychological measures. A study by Mittenberg, Seidenberg, O'Leary, and DiGiulio (1989) compared the performance of older and younger adults on several neuropsychological measures of lateralized and focal function. Frontal-lobe measures accounted for more variance in relation to age than did measures of parietal or temporal functioning (1989). Anatomical studies by Haug (as cited in Mittenberg et al., 1989) found that neuronal loss was pronounced in the frontal lobes of the elderly. Further evidence for the possibility of a decrement of frontal lobe functioning in the elderly was found by Veroff (1980). A qualitative analysis of the visual reproductions of older adults revealed that the segmentation of strategy and perseverations seen in patients with frontal system pathology was also demonstrated by elderly participants (1980).

Certain problem-solving tasks, which require frontal-lobe functioning, exhibit a decline in elderly populations (Hochanadel & Kaplan, 1984). Both the Wisconsin Card Sort Test (WCST) and the Word Fluency Test--each purported tests of frontal lobe functioning--demonstrate a decline in performance in older adults relative to younger adults (Parkin & Lawrence, 1994). These neuropsychological tests

require the ability to monitor output, and flexibility to generate different strategies and shift between strategies efficiently. This constellation of abilities is subsumed under the rubric of executive functioning (Shallice 1988; Stuss & Benson, 1986). Older adults often make more errors on tasks that involve executive functions relative to younger adults, but also have difficulty inhibiting incorrect responses and shifting strategies appropriately (Parkin & Lawrence, 1994; Veroff, 1980). Parkin and Lawrence found a significant correlation between performance on the WCST and a recall and recognition task, suggesting that the frontal lobes are involved in these facets of memory. However, performance on a measure of verbal fluency was not significantly correlated with memory performance.

Parkin and Lawrence's (1994) finding may be due to differential sensitivity of the WCST and verbal fluency tests to frontal lobe deficits. A study by Butler, Rorsman, Hill and Tuma (1993) found that the verbal fluency task was less sensitive to tumors in the frontal lobe than more complex tasks. However, a significant deficit in verbal fluency was demonstrated by subjects with both left frontal lesions and bilateral frontal lesions (Benton, 1968; Perret, 1974). Furthermore, the analyses of verbal fluency mentioned above, were constrained to the total number of words produced. The executive functioning aspects of a verbal fluency task include the ability to quickly generate strategies, and to shift strategies when the current one is

no longer effective—both aspects which would be more accurately measured by analysis of the order in which words are produced. These findings illustrate the complex nature of the relationship between the function of the frontal system and performance on certain neuropsychological tests.

Further evidence for the involvement of the frontal lobes in memory performance comes from studies of patients with frontal lobe pathology. Gershberg and Shimamura (1995) found that patients with frontal lobe damage were deficient in both encoding and retrieval on a list learning task relative to controls. The performance of older adults on a list learning task was also evaluated in comparison with patients with frontal lesions, in terms of strategic functions and overall performance (Stuss, Craik, Sayer, Franchi, & Alexander, 1996). Stuss and his colleagues found that older adults demonstrated a modest impairment in list learning, equivalent to that shown by patients with unilateral right frontal lesions. Furthermore, when their use of organizational strategies was evaluated, older adults were deficient relative to younger adults and performed equivalent to patients with unilateral right frontal lesions (Stuss, et al., 1996). However, neither the older adults, nor the frontal lobe lesion patients in the Stuss et al. study were impaired on tasks of primary memory such as digit span, suggesting that the frontal lobes are primarily involved in secondary memory deficits.

However, caution must be used in making inferences from studies of patients with pathology to the performance of the able elderly. Although the performance of older adults on certain neuropsychological tasks may resemble the performance of those with pathology of the frontal system, the elderly do not consistently demonstrate deficits in social appropriateness as might be expected with such impairment (LaRue, 1992).

Another consideration that must be made in the evaluation of neuropsychological performance of the elderly is the incidence of depression. Depression is considered the second most common mental disorder in old age (LaRue, 1992). Although the percentage of older adults who meet the criteria for major depression is low, the effects of mild to severe depression can impact neuropsychological approach and performance. Tasks that require attentional flexibility reveal greater deficits for depressed elderly subjects (Caine, 1981). Furthermore, memory tasks that require more effortful processing for success are performed poorly by depressed older adults (LaRue, 1992).

Verbal Fluency: Semantic and Phonemic Associations

The relationship between measures of executive functioning and memory performance are complex and require an analysis of the approach taken on the task, in order to understand the relationship more clearly. However, most studies have employed a quantitative approach in examining

the relationship between fluency tests and measures of memory; that is, most studies have used the total number of words produced, for analysis, while ignoring the production strategies employed. Of particular interest to this study is not only the performance demonstrated by older adults on these fluency tests, but the manner of approach that is employed by older adults in this task, and its potential relationship to memory functioning and extent of executive functioning deficits.

Perhaps the most rudimentary approach to a verbal fluency task is a random generation of words as they come to mind. However, given the constraints of this task--generating words that begin with a certain letter--the random approach is typically least effective. Another approach to a verbal fluency task utilizes associations between words that rhyme or have similar sounds (e.g., fake, flake or flake, flap) as well as utilizing associations between words that belong to the same semantic category (e.g., fun, frolic or apple, apricot). Associations based on perceptual or sound characteristics of words represents phonemic associations, while associations based on meaning of words represents semantic associations. Hochanadel and Kaplan (1984) reported that in clinical observation, subjects with frontal system impairment not only produced fewer words, but tended to demonstrate reliance on a phonemic strategy; that is, they were more likely to use associations between the perceptual and pronunciation

characteristics of words, such as "flake" and "flap" when trying to generate as many words as possible that begin with a certain letter. While empirical validation of this observation has not yet been achieved, a study by Raskin, Sliwinski, and Borod (1992) found that patients with Parkinson's Disease were impaired in their ability to use semantic clusters on a verbal fluency task compared to normal controls. Most studies employing verbal fluency measures have focused on the quantity of words produced, while ignoring
the production strategy that is being used by older adults.

Performance on verbal fluency tests should be greatest when subjects are able to shift between using semantic associations to phonemic associations and back again quickly. The demand of the verbal fluency task for shifting between strategies requires spontaneous flexibility for greatest performance, and is similar to demand of the WCST for shifting strategies. Analysis of this aspect of the verbal fluency test in relation to performance on the WCST should elucidate the relationship between these two measures of frontal lobe functioning.

Furthermore, the relationship between tests of verbal fluency and memory functioning may be made clearer by analysis of the association strategies utilized by older adults in production of words on a verbal fluency test and the encoding process of forming associations between words on a memory test. The deficiency in using a semantic

association strategy on the verbal fluency test and preference for phonemic production strategies may be reflective of an overall decline in the depth of information processing engaged in by older adults, due in part to frontal lobe deterioration. Although, the elderly are capable of utilizing and forming associations between words, they typically do not engage in this type of effortful encoding process on memory tasks (Craik & Byrd, 1982). Light and Burke (1988) found a larger age difference in older adults' ability to form associations between weakly related events than between strongly related events, and that in general, the elderly have more difficulty forming new connections in memory. On a verbal fluency task, a deficiency in depth of processing would be represented by the difficulty older adults have in utilizing the semantic associations of words, while relying on the more surface level phonemic associations, or a random production strategy to generate words. This failure to engage in more effortful processing on a verbal fluency task may be related to the decline in effortful encoding processing used on memory tasks by older adults. Furthermore, when an analysis of the production strategy used on the verbal fluency task is done, the relationship between this executive function task and strategy use on a memory task may be more clear.

Aims of Current Study

The aim of this study is to investigate the relationship between the ability of older adults to shift strategies on a verbal fluency task and their ability to shift strategies on another task of executive function. Performance on the verbal fluency task should be greatest when the elderly are quickly able to produce all of the words that are associated either phonemically or semantically and quickly shift when a particular association is no longer productive. This ability should be related to the ability of older adults to shift from a sorting strategy that is no longer correct to another sorting strategy, using tests designed to assess attentional flexibility (e.g. Wisconsin Card Sort Test).

Furthermore, an investigation of the relationship between the ability of older adults to generate and shift between strategies on a verbal fluency task -- as evidenced by the incorporation of semantic associations between words -- and the ability to use semantic associations between words on a memory task, is an additional aim of this study. Although older adults are capable of utilizing semantic information when encoding information to be remembered, they do not spontaneously do so (Craik & Byrd, 1982). Rather, the elderly tend to use less effortful encoding strategies such as phonemic characteristics of words to be learned. Light and Burke (1988) suggested that older adults were impaired in their ability to form new associations on a

memory task, and that they were more likely to use the most readily available information during encoding rather than generating novel strategies.

An analysis of the strategies used on a verbal fluency task requires that the clusters of words produced be examined as to their relationship. Whenever two successive words are produced that share the same second phoneme such as "fork" and "form" or two successive words rhyme, such as "flake" and "fake" is considered a phonemic cluster. Semantic clusters consist of two consecutive words that share a semantic category such as "apple" and "apricot" or are similar forms of a word such as "fun" and "frolic". Analysis of the pattern of phonemic clusters and semantic clusters are of particular value in evaluating the relationship between performance on a verbal fluency task and performance on the WCST, another task of executive functioning. Specifically, it is the hypothesis of this study that limited word production on a verbal fluency task, dominated by a random (no associations) strategy or reliance on phonemic associations, will predict lower performance on the WCST. This finding would demonstrate that one aspect of executive functioning that is assessed by both a verbal fluency task and the WCST is attentional flexibility, demonstrated by the ability to shift strategies when one is no longer effective. Verbal fluency tasks as they are typically utilized (analyzing total number of words produced) may not be particularly sensitive to frontal lobe

functioning (Butler, Rorsman, Hill, & Tuma, 1993). However, if verbal fluency tasks are analyzed as a measure of attentional flexibility, their utility in detecting the executive functions of the frontal lobe may be improved.

Furthermore, the use of phonemic and semantic clusters is of interest for the examination of the relationship between performance on a verbal fluency task and performance on a memory task. It is the hypothesis of this study that the ability of older adults to generate more elaborate strategies on a verbal fluency task, demonstrated by utilization of semantic associations will be related to the ability to generate more elaborate encoding strategies on a memory task (e.g. California Verbal Learning Test) as evidenced by utilization of semantic categories. That is, word production on a fluency task, dominated by a random or a phonemic association strategy, will predict a reduced ability to utilize the semantic characteristics to cluster items during encoding on a memory task. If this is found it will provide evidence for the relationship between the executive functions (specifically, attentional flexibility) of the frontal lobe and age related memory decline. More specifically, the more intact an individual's frontal lobe functioning, as measured by the ability to spontaneously use a variety of effortful associations on a verbal fluency task, the more likely they will spontaneously engage in effortful strategies on a memory task.

To summarize, the hypotheses are:

Hypothesis 1. Total number of words produced by semantic associations on a verbal fluency task will be positively correlated with use of semantic clusters during recall on a new learning task (i.e. CVLT, observed semantic clusters).

Hypothesis 1a. The use of semantic associations on a verbal fluency task is indicative of executive functioning and will predict the use of semantic encoding on the CVLT, (as evidenced by the use of semantic clusters during recall).

Hypothesis 2. The use of a semantic association strategy on a verbal fluency task, will be negatively correlated with perseverative errors on the WCST. Perseverative errors on the WCST are indicative of a failure to shift strategy in response to feedback, and should be negatively correlated with semantic associations used on a verbal fluency task if these associations are the best indicator of executive function, specifically attentional flexibility.

Hypothesis 3. Increased depression scores as measured by the GDS will be negatively correlated with total strategy (total number of phonemic, semantic and random association clusters) use on a verbal fluency task.

METHODS

Participants

Seventy older adults (over age 55) were recruited from the East Lansing and Lansing communities, through newspaper

advertisements to participate in the ongoing Michigan State University (MSU) Psychological Clinic Aging Research Project. Each individual was offered assessments of their mood and memory, as well as a seven-session workshop designed to teach relaxation and cognitive strategies for the relief of depression and / or memory difficulties. From these respondents, 62 older individuals ranging from 55 to 90 years of age (M = 67.13; SD = 8.10) were included in the analysis. These 70 participants (51 Women and 19 men), with a mean education of 14.7 (SD =2.5) were screened for depression, mental status, and a range of health problems to rule out the effects these might have on mental functioning and subsequent performance on the administered neuropsychological measures. Individuals with severe depression, as determined by scores of 20 or higher on the GDS were referred elsewhere for treatment. Furthermore, individuals scores lower than 25 on the MMSE were not included in the analysis. Eight participants were dropped from the analysis for MMSE scores lower than 25. No other data was trimmed.

Measures

a. Geriatric Depression Scale (GDS; Yesavage & Brink, 1983)

The GDS was used to asses the depression of participants in the study. This scale was specifically designed for rating depression in the elderly. The GDS is composed of 30 true/false self-referent statements. Yesavage and Brink (1983) found a positive correlation

between conventional cutoffs and selected diagnosis classifications of the Research Diagnostic Criteria for definition of major and minor depressive disorders. Furthermore, test-retest reliability was found to be .85 over a two week time frame, suggesting that the GDS reflected stable individual differences. Convergent validity was found between the GDS and the Zung Self-Rating Scale for Depression and the Hamilton Rating Scale for Depression as .84 and .83 respectively.

b Mini Mental State Exam (MMSE; Folstein, Folstein, & McHough, 1975)

The MMSE is a measure of orientation that has received extensive use in determining gross cognitive functioning. This test requires memory ability, orientation, and the ability to follow commands. When subjects were evaluated over a 24-hour period
test-retest reliability was between .85 to .99. The standardization sample of the MMSE consisted of 63 healthy elderly control subjects (mean age 74). Control subjects' scores were in the range of 24.6 to 27.6, while demented subjects scored between 9.6 to12.2. A cut-off score of 25 is often applied to discriminate scores more suggestive of impairment. The MMSE was used to rule out dementia in the participants of this study.

c. Measures of Executive Functioning
Controlled Oral Word Association Test (FAS; Benton & Hamsher, 1977)

The FAS requires subjects to produce as many different words as possible that begin with a letter of the alphabet (F, A, and S) excluding proper nouns in 60 seconds. Subjects are also instructed that variations of the same root word (e.g. book, bookworm) are not permissible. Responses are recorded verbatim and words that meet the above criteria are included in the total score. Proper nouns and words that are repeated are scored as perseverations. In addition to this quantitative scoring of the FAS, the production strategies of older adults was also of interest for this study. Phonemic clusters were defined as two successive words with the same second phoneme (e.g. fork, form) or two successive words which rhyme (e.g. flake, fake). Semantic clusters included any two words that share a semantic category (e.g. apple, apricot) or were similar forms of a word (e.g. fun, frolic). Total number of words produced by phonemic association clusters and semantic association clusters to total word production were computed for the purpose of comparison. Two independent raters were used to determine the number of words produced by phonemic, semantic and random association strategies. One-year retest reliability in older adults has been reported as .70 (Snow et. al., 1988). Concurrent validity has also been established for the FAS (Coelho, 1984).

Wisconsin Card Sorting Test (WCST; Heaton, 1981)

The WCST requires subjects to sort stimulus cards when they are not given any instructions as to the sorting

principles, which change during the task. Feedback is given, as to whether the response was right or wrong, but the sorting principles are never revealed. Perseverations on this test are demonstrated by using the sorting principle from a previous category, repeatedly after the principle has changed. Generalizability coefficients, which reflect the fidelity of true-score measurement, and can be viewed as analogues of traditional reliability coefficients (according to Heaton, 1981) were calculated and averaged .57 with a median of .60, based on a single test administration. The WCST has demonstrated good construct validity for use with the elderly (Paolo, Troster, Axelrod, & Koller 1995). Good support was found for a general conceptualization/problem solving factor and for a failure to maintain set component. Both of these factors subsume several aspects of frontal system functioning.

d. California Verbal Learning Test (CVLT; Delis, Kramer, Kaplan, & Ober, 1987)

The CVLT is a learning task which assesses verbal learning and memory. The CVLT measures the immediate, short delay, cued, long delay and free recall of presented information. The CVLT was developed to go beyond traditional memory tests, and quantify additional indices such as semantic clustering and perseveration rates. The CVLT requires subjects to remember 16 items that belong to four semantic categories. The normative sample found test-retest reliability was .59 on the CVLT; further analyses of the

normative sample have cited a coefficient alpha of .74 and split-half reliability as .63. Criterion-related validity of the CVLT has been demonstrated by its correlation with the Wechsler Memory Scale, Memory Quotient of .66. Factor analysis studies have supported the utility of the component factors of the CVLT (Delis, Freeland, Kramer & Kaplan, 1988).

RESULTS

Individuals with scores lower than 25 on the MMSE were not included in the analysis. Eight participants were dropped from the analysis for MMSE scores lower than 25, resulting in a final N of 62. No other data was trimmed. Two independent raters were recruited to calculate the number of semantic, phonemic and random clusters of the participants on a verbal fluency test. Semantic clusters were defined as any two consecutive words that shared a semantic category such as "apple" and "apricot" or were similar forms of a word such as "fun" and "frolic". Phonemic clusters were defined as any two successive words that shared the same second phoneme such as "fork" and "form" or two successive words rhyme, such as "flake" and "fake". Random clusters were defined as any two consecutive words that did not meet criteria for being a phonemic or semantic cluster. A reliability coefficient alpha of .92 was achieved by the independent raters for semantic clusters. Random and phonemic clusters achieved a reliability coefficient alpha of .90 and .99 respectively, but were

not used in the analyses. The independent ratings for semantic clusters were averaged for the purposes of analysis.

The averaged semantic clusters ranged from 0 to 6 (M 1.73, SD ±1.49). The observed semantic clusters on the CVLT ranged from 4 to 76 (M 26.29, SD ±15.71). Perseverative errors on the WCST ranged from 3 to 54 (M 20, SD ±18.32). The total number of depressive symptoms endorsed on the GDS ranged from 0 to 29 (M 7, SD ±6.47).

Hypothesis 1. **Total number of words produced by semantic associations on a verbal fluency task will be positively correlated with use of semantic clusters during recall on a new learning task (i.e. CVLT, observed semantic clusters).**

It was predicted that the total number of words produced by semantic associations on a verbal fluency task would be positively correlated with use of semantic clusters during recall on a new learning task. This hypothesis was supported. A one-tailed Pearson correlation coefficient was calculated between the average of the total semantic clusters used on a verbal fluency task and the total number of observed semantic clusters on the CVLT and was found to be significant ($r = .23$, $p<.05$) indicating that these two variables are positively related.

Hypothesis 1a. **The use of semantic associations on a verbal fluency task is indicative of executive functioning and will predict the use of semantic encoding on the CVLT, (as evidenced by the use of semantic clusters during recall).**

It was also expected that use of semantic associations on a verbal fluency task would be indicative of executive

functioning and would predict use of semantic encoding on the CVLT. This hypothesis was supported. A linear regression was conducted to determine if semantic clusters used during recall on a new learning test (i.e., CVLT, observed semantic clusters) was predicted by total number of words produced by semantic associations on a verbal fluency task. The Beta coefficient for the semantic associations on a verbal fluency task indicated that these associations are a significant predictor of semantic clustering strategy on the CVLT (Beta = 2.62 ; $p<.05$).

Hypothesis 2. **The use of a semantic association strategy on a verbal fluency task, will be negatively correlated with perseverative errors on the WCST. Perseverative errors on the WCST are indicative of a failure to shift strategy in response to feedback, and should be negatively correlated with semantic associations used on a verbal fluency task if these associations are the best indicator of executive function, specifically attentional flexibility.**

Use of a semantic association strategy on a verbal fluency task was expected to be correlated positively with perseverative errors on the WCST, as perseverative errors on this task indicate a failure to shift strategies in response to feedback. This hypothesis was not supported. A one-tailed Pearson correlation coefficient was conducted between the total semantic clusters used on a verbal fluency task and the perseverative errors made on the WCST and was found to be non-significant ($r = .08$; ns).

Hypothesis 3. **Increased depression scores as measured by the GDS will be negatively correlated with total strategy (total number of phonemic, semantic and random association clusters) use on a verbal fluency task.**

Finally, it was predicted that increased depression scores as measured by the GDS would be negatively correlated with the total number of strategies used on a verbal fluency task. This hypothesis was not supported. A one-tailed Pearson correlation coefficient was conducted between the total number of association clusters used on the verbal fluency task and the total GDS score and was not found to be significant ($r = .09$; ns).

DISCUSSION

The first hypothesis of this study was that the total number of words produced by semantic associations on a verbal fluency task would be positively correlated with use of semantic clusters during recall on a new learning task. This hypothesis received empirical support. Furthermore, this finding suggests that the degree to which healthy older adults are able to generate words quickly (on the verbal fluency test) is related to the ability to use strategies when presented with unorganized verbal material that is to be learned. The foregoing results suggest that there is utility in examining the approach to studying neuropsychological tests in a more qualitative manner. Verbal fluency tasks require the participant to generate as many words as possible that begin with a certain letter, within a constrained amount of time. In order to maximize performance, effective word retrieval strategies must be readily activated. The use of a semantic association strategy on a verbal fluency task is a more complex means of

retrieving words than is using phonological aspects (i.e. rhyming or similar sounds). A study by Parks and his colleagues (1988) of metabolic activation during a verbal fluency task found that participants who performed well exhibited lower metabolic activation than those who performed poorly. It has been suggested by Parks et al., that this reduced activation was indicative of an increased availability of efficient strategies, which required less metabolic activation. However, no distinction between what constitutes efficient strategies was made in this study. Furthermore, the speculation that efficient strategies require less metabolic activation requires further empirical study.

The second part of the first hypothesis was that the semantic associations used on a verbal fluency task were indicative of executive functioning and would predict use of semantic encoding on the CVLT. This hypothesis was supported and implicates the involvement of the frontal lobes, as the mediator of executive functions, in the process of strategy generation for both of these tasks (CVLT and verbal fluency). The relationship between the frontal lobes and strategy generation has been supported by additional research. Parks et al. (1988) found that although several cerebral structures were activated during a verbal fluency task, participants with left frontal damage had poor performance. Additionally, a study by Mangels (1996) implicated the involvement of the frontal lobes in

memory retrieval. Patients with frontal lobe lesions were impaired in recall for remote information and were not aided by the provision of semantic or phonemic cues.

Additional evidence for the involvement of the frontal lobes in age-consistent memory decline, through a decrement in strategy use was found by Stuss et al., (1996). Stuss and his colleagues found that older adults show impairment on learning lists that are unorganized. Furthermore, the poor use of organizational strategies employed by older adults were similar to the use of these strategies by patients with unilateral frontal lobe lesions. Eslinger and Grattan (1994) found that organizational abilities in memory are affected in frontal lesions although not from lesions to other cortical areas. Spontaneous flexibility is similarly disturbed in patients with frontal lobe lesions; suggesting that spontaneous flexibility and memory organization abilities are related mediated through the frontal lobes (Eslinger & Grattan, 1994). This finding seems to be supported by the current findings. A question which still needs investigation is whether or not data from brain impaired individuals is applicable to individuals with "normal" brains.

The second hypothesis of the present study was that failure to shift strategies in response to feedback on the WCST would be negatively correlated with semantic associations used on a verbal fluency task. This hypothesis was not supported as using a semantic association strategy

was not negatively correlated with perseverative errors on the WCST. Both verbal fluency and the WCST involve executive functions of the frontal lobe and would be expected to be correlated. Although the frontal lobe has been implicated in the performance of verbal fluency tasks as well as the WCST (Parks, et al., 1988; Anderson, Damasio, Jones & Tranel, 1991) there has been some research suggesting that performance on either task alone is not predictive of frontal lobe dysfunction (Butler, Rorsman, Hill, & Tuma, 1993; Robinson, Heaton, Lehman, & Stilson, 1980).

Verbal fluency and the WCST require executive functions that have been labeled cognitive flexibility; that is, the ability to shift avenues of thought and process information in a variety of ways (Eslinger & Grattan, 1993). Eslinger and Grattan distinguished between verbal fluency and the WCST as representing spontaneous flexibility and reactive flexibility measures, respectively. Verbal fluency is more dependent on the ability to generate a diversity of strategies, and switch quickly among them, based on internal perceptions of the effectiveness of a particular strategy for generating more words. On the other hand, the WCST requires readiness to freely shift strategies in response to explicit feedback. Eslinger and Grattan found that while both spontaneous flexibility and reactive flexibility were similarly impaired in patients with frontal lobe and basal ganglia damage, spontaneous flexibility tasks were markedly

disturbed by frontal lobe damage. The findings of the current study seem to support this distinction between the types of cognitive flexibility measured by these two tasks. Given the findings of Eslinger and Grattan, the finding of this study that a measure of the strategies used on a verbal fluency task and the ability to shift strategies in response to explicit feedback on the WCST is not surprising.

The frontal lobe has similarly been implicated in normal age-consistent memory loss (Parkin & Lawrence, 1994; Stuss et al., 1996). However, the relationship between the frontal lobes and memory performance in older adults has been largely dependent on the aspect and type of memory (e.g., recall vs. recognition; episodic vs. verbal) being considered (Tulving, Kapur, Craik, Moscovitcch, & Houle, 1994; Kapur et al., 1994). It may be of interest in a follow-up study to use the WCST and verbal fluency task to determine if these tests are capable of dissociating different memory functions on a learning task such as the CVLT. Specifically, if the WCST perseverative error score is related to the ability to shift strategies in response to explicit feedback, that score should be associated with the ability to use semantic categories on the CVLT after a delay, when the categories are provided prior to the delay.

Finally, the third hypothesis of this study was that depression would be negatively correlated with use of strategies on a verbal fluency task. This hypothesis was not supported. Given the finding that tasks requiring

attentional flexibility reveal greater deficits in depressed elderly subjects (Caine, 1981) the finding of the current study is somewhat surprising. However, the sample of the present study does not include a large number of subjects who would qualify as more than mildly depressed. Indeed, the mean score on the GDS for the sample (M 7, SD $\pm$6.47) falls in the normal range (Yesavage & Brink, 1983). Furthermore, the GDS consists of a variety of symptoms related to depression. A more specific analysis of items that pertain to symptoms of depression, such as a loss of energy, may be more related to effort expended in the generation of strategies

However, some caution in interpreting the current findings is warranted due to methodological limitations of the current study. Despite the evidence from previous research implicating the frontal lobe in the memory process of encoding, and in generating words on a fluency task, no neuroimaging was conducted in this study; therefore, no conclusions can be made as to the specific neuroanatomical location of these functions. However, both the generation of strategies during a learning task and a verbal fluency task seem to be functionally related.

Furthermore, there has been some research that has found that gender and verbal intelligence account for a significant portion of the variance in FAS performance, although they found that level of education was unrelated (Bolla, Lindgren, Bonaccorsy, & Bleecker, 1990). It has

also been suggested that verbal fluency is a measure of IQ as opposed to a measure of frontal lobe functioning (Miller, 1984). Neither of these variables were accounted for in the present study as both men and women were included in the analysis. However, the participants in the present sample consisted of a highly educated group with a high level of verbal intelligence as estimated by the AMNART (M=115, SD $\pm$16.57). It is also important to note that the study by Bolla et al., was principally concerned with total number of words produced on a verbal fluency task and did not analyze the strategies employed.

Similar to the finding of Bolla et al. (1990), Veroff (1980) found a significant difference in the performance of males and females on a verbal fluency task. However, neither study examined differences in production strategies on this task. Furthermore, when the influence of gender was factored out the correlation between semantic clusters and use of semantic encoding strategies was close for both men and women. In the present study the following results were obtained when the effect of gender was partialled out for men (N=18; r = .20) and for women (N=44; r = .18).

One alternative explanation of the current findings in regard to a deficit in using effective strategies at encoding has been proposed by Salthouse (1982) as a generalized slowing of processing speed that is consistent with normal aging. Salthouse (1993) found that when the effects of perceptual speed were partialled out, age-related

effects on memory performance accounted for only a small proportion of the variance. The finding of this study that a relationship between generation of strategies on a verbal fluency task and a memory task exists may be due to a generalized slowing of processing in older adults, rather than to the hypothesized decrease in efficiency of frontal lobe functioning. Although Salthouse has found support for the influence of processing on memory performance, the mechanism through which this influence is mediated is still open to speculation.

It is possible that reduced efficiency of executive functions of the frontal lobes is a consequence of normal aging and responsible for reductions in processing speed. However, this question can not be addressed by the current study. The measure of verbal fluency used in this study requires the quick generation of strategies to produce as many words as possible in one minute. It may be that the performance of older adults on this task would demonstrate an increased use of strategies if an unlimited or extended amount of time was provided to accommodate reductions in processing speed. Furthermore, the CVLT does not restrict time allowed for immediate recall, however, the words to be learned are presented at a rate of approximately one per second. It is possible that the deficit in use of efficient encoding strategies demonstrated by older adults is due to a reduction in processing speed, rather than in a deficit of an executive function such as strategy generation.

It is also important to note that no normative data exist on strategies used on a verbal fluency task. Furthermore, no study was done with younger adults to determine if they are more likely to use elaborate strategies on a verbal fluency task such as semantic clustering; therefore, it can not be determined from the present study if subtle deterioration of the frontal lobes is responsible for the detriment in strategy use on verbal fluency and memory tasks by older adults. It would be interesting to determine the extent to which the decline in verbal fluency in older adults is due to an age-consistent reduction in strategy generation.

Collecting normative data on strategy use on a verbal fluency task throughout the lifespan would be instrumental to providing additional support to the findings of a decrease in this particular executive function in older adults. Furthermore, neuroimaging data may be able to make clear the relationship between generating strategies on a verbal fluency task and generating strategies on a memory task, and provide more specific localization information in regard to these abilities.

Finally, the role of different types of cognitive flexibility in memory functioning could be elucidated by further analyses of the WCST and the CVLT. Specifically, it was found in this study that the shifting of strategies in response to explicit feedback on the WCST was not related to shifting of strategies on a verbal fluency task, despite

both of these tests supposed reliance on frontal lobe functioning. However the distinction made by Eslinger and Grattan (1993) of spontaneous flexibility and reactive flexibility as functions assessed by verbal fluency tasks and the WCST respectively, may be of use in discriminating the role of these executive functions in memory performance. The CVLT presents an unorganized list of items five times, followed by a cued recall trial after a short delay. Approximately 20 minutes after this cued recall, a free recall trial is administered. If an increased use of semantic strategies was demonstrated during this long-delay free recall, this should be related to WCST perseverative errors, as these are an index of incorporating feedback to use different strategies.

Further research is needed to elucidate the importance of the current findings. Normative data on the patterns of strategy use throughout the lifespan needs to be collected, in order to make any comparative remarks about the process of normal aging on strategy generation. Additional neuroimaging studies similar to those undertaken by Parks et al. (1988) which separate types of strategies used, may provide further understanding of the localization of strategy generation on both verbal fluency tasks and memory tasks. Furthermore, studies of the frontal lobes involvement in tasks of executive functions such as spontaneous and reactive flexibility, and the role of those functions in memory remain to be conducted.

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