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Running Head: Frontal Deficit Comparison of Subcortical Dementias

A Comparison of Prospective Memory and Executive Processes in Patients with  
Subcortical Illness

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### Abstract

Dementia is a common disorder affecting neuropsychological function in several spheres of mental activity including language memory, visuospatial function, and cognition. Studies into the cognitive deficits associated with dementia have allowed researchers to rank disorders into two subclasses: cortical and subcortical dementia. Cortical dementias such as Alzheimer's disease have been the focus of a plethora of studies. Subcortical dementia, which is commonly found in Parkinson's disease and Huntington's disease patients, is marked by bradyphrenia, visuospatial abnormalities, personality alterations, memory disturbances primarily involving recall but not recognition, and loss of executive functions. The most recent disorder to be classified as a cause of subcortical dementia is Human Immunodeficiency Virus (HIV) infection. Several studies have focused on memory disturbances associated with HIV infection but few have looked at the affects of the disease on executive function. The current study examined executive functioning, immediate recall, and prospective memory in patients with HIV, HD, older adult controls, and younger adult controls. The young adults performed significantly higher than the older adults and the HIV group on the Color-Word score of the Stroop test. The HIV group did not perform significantly differently from either of the control groups on any of the other measures. A Huntington's patient was analyzed using a case study method. The results suggest that HIV patients do not display significant signs of frontal mediated or executive function loss but several promising trends in the data are discussed. Further research is needed using larger group sizes and improving on several other limitations of the tests used in this study.

## A Comparison of Prospective Memory and Executive Processes in Patients with Subcortical Illness

Dementia was defined by Cummings (1990) as “an acquired persistent disturbance in neuropsychological function involving at least three of the following spheres of mental activity: language, memory, visuospatial function, cognition (abstraction, judgment, mathematics, executive function, and personality or emotion)” (p. 4). These types of symptoms are commonly seen in aging individuals, as well as individuals diagnosed with one of several types of diseases that affect the central nervous system. These diseases may include progressive disorders such as Huntington’s disease (HD) and Parkinson’s disease (PD), or viral infections such as human immunodeficiency virus (HIV). The term dementia, however, is most commonly associated with symptoms of patients with Alzheimer’s disease (AD).

Dementia of the Alzheimer’s type is the most common and extensively studied form of dementia occurring in older adults (Cummings, 1990). Alzheimer’s dementia is a degenerative dementia usually associated with neuronal cell death in the association cortex, parietal-temporal association cortex, and hippocampal tissues of the brain (Cummings, 1990; Stuss, 1986). People with AD primarily exhibit cognitive symptoms including aphasia, combined recall and recognition deficits, and indifference (see Cummings and Benson, 1988 for review). The degeneration, occurring predominantly in cortical areas of the brain, and the behavioral deficits associated with the loss of these areas, has allowed scientists to categorize AD as a “cortical” dementia. This is in contrast to “subcortical” dementias that are usually associated with Huntington’s disease (HD), Parkinson’s disease, and most recently with HIV infection.

Subcortical dementias are marked by degeneration of subcortical areas of the brain such as the basal ganglia (putamen, caudate, and lentiform nuclei), substantia nigra, and limbic system (Cummings, 1990; Dunne, 1993). They are marked by symptoms which may include bradyphrenia, visuospatial abnormalities, personality alterations, memory disturbances primarily involving recall but not recognition, and loss of executive functions (see Cummings and Benson, 1988 for a review). The symptoms that patients with subcortical dementias often exhibit are not entirely related to these subcortical areas of the brain, however. These deficits, especially in executive functioning, are also seen in patients with frontal lobe lesions (Stuss and Benson, 1986). There is little evidence, however, that the frontal cortex degeneration seen in patients with at least one common subcortical dementia (Huntington's Disease) is significant enough to produce the frontal deficits seen in these diseases (Stuss and Benson, 1986; Weinberger, Berman, Iadarola, Driesen, and Zec, 1988). This suggests that, at least in HD, the dementia may be caused by problems between the subcortex and the frontal lobe rather than the degeneration of specific hippocampal and cortical areas as seen in the cortical dementias such as AD.

The differences in the causes and symptoms of cortical and subcortical dementias have been studied at length (e.g., Butters, Swenson, and Bondi, 1995; Fileteo et al., 1995; Lang, Sahakian, Quinn, Marsden, and Robbins, 1995) and have explained such cognitive processes as memory (free and cued recall), visual perceptual abilities, and perseveration. There has also been a plethora of research comparing the different subcortical dementias in functioning (e.g., Drebing et al., 1994; Stuss and Benson, 1986; Peavy et al., 1994; Massman, Delis, and Butters, 1990) and comparing subcortical dementias to individuals with frontal lobe damage (see Cummings and Benson, 1988; Cappa and Wallesch, 1994

for a review). There have been very few studies, however, focusing on the executive function loss associated with HIV (Peavy et. al. 1994; Drebing et. al., 1994). The current study will compare two subcortical dementias, Huntington's disease and HIV, on frontally mediated processes.

Most of the literature on subcortical dementias focuses on the comparison of memory impairments in these dementias as compared to patients with cortical dementias. One such study by Paulsen, Salmon, Monsch, Butters, Swenson, and Bondi (1995), which focused on memory and problem solving between AD and HD patients, found that both AD and HD patients performed significantly worse than controls on a verbal list learning task and the Buschke Selective Reminding Test (BSRT), which is thought to measure cued recall ability. The HD patients, however, committed significantly fewer errors than the AD patients on the BSRT. The results from both sets of participants on the verbal learning task suggest that both diseases can be associated with impairments in memory function, specifically the ability to learn new verbal information. The results of the participants on the BSRT however, suggest that there is an underlying difference in memory impairments in HD and AD patients. While the memory impairments seen in AD may be caused by impaired storage of the information, HD patients' primary difficulty lies in retrieving information which has already been laid down in memory. Other studies focusing on the memory of HD patients have found similar results. Massman, Delis, and Butters (1990) found that HD patients who do not perform well on free recall of learned information, do perform well on cued recall tasks (Massman, Delis, and Butters, 1990). One possible explanation for this finding is that HD patients have difficulty cognitively manipulating memory.

Differences in the ability of HD and AD patients to manipulate new visual information were the topic of a study by Paulsen, Butters, Salmon, Heindel, and Swenson (1993). In their study, Paulsen et al. looked at the ability of HD and AD patients to adapt to perceptual displacement. The participants were required to point at a target while wearing glasses that shifted the appearance of the target 20 ° to the right. The Alzheimer's disease patients adapted as quickly as the controls to the task, but the Huntington's disease patients failed to adapt significantly as compared to both normal controls and AD patients. This seems to support the findings that HD patients, while able to respond and react to new information, have a difficult time processing it. They may be able to recognize that the target has moved, but have a difficult time adjusting to the new task. This difficulty manipulating memory is also demonstrated by a common problem that is found with patients with subcortical dementia, perseveration.

Perseveration is the continued use of a response even when the response is inappropriate. By using a general dementia ratings scale to rank each of their participants and then matching their participants for the level of general dementia, Lange, Sahakian, Quinn, Marsden, and Robbins (1995) found that HD patients demonstrated significant perseveration on a visual discrimination reversal paradigm. The HD participants also performed significantly worse than AD participants on tests of pattern and spatial recognition, spatial working memory, and a visual discrimination learning task. Lange et al. (1995) suggests that this visual perseveration may be caused by difficulties with inhibition of previously learned materials instead of an inability to focus on new information.

Massman, Delis, and Butters (1990) examined perseveration further in a study examining verbal memory in patients with HD and PD. Verbal memory was examined by comparing the similarities and differences of PD and HD patients on the California Verbal Learning Test (CVLT). The CVLT is administered by the oral presentation of five lists of words each with a specific category followed by an “interference” list. Participants are asked to recall as many words as possible from the original five lists immediately following their presentation and then twenty minutes following the interference list. In this study, Massman et al. found that PD and HD participants both displayed significantly lower standard scores than controls. HD and PD patients also demonstrated inconsistency of recall across trials and elevated intrusion rates on delayed recall. HD participants displayed an elevated free recall impairment, a deficient rate of improvement across learning trials, accentuated recency effect, and an increased perseveration rate compared to controls.

The two subcortical dementias focused on by Massman, Dellis, and Butters (1990), Huntington’s disease and Parkinson’s disease, are just two of many possible diseases that fall into the category of subcortical dementias. Probably the most recent addition to the family of diseases that involve subcortical dementia is HIV (Peavy et al., 1994).

HIV dementia is marked by declines in fine motor control, rapid sequential problem solving, visuospatial problem solving, and visual memory (see Everal, 1995 for a review). Twelve months following an individual’s diagnosis with HIV, 7.1 % of survivors report some form of dementia, and the median survival time for these patients following the diagnosis of dementia was six months (McArthur et al., 1993). The cause



of HIV dementia is unknown, but possible explanations range from HIV infection of neuronal cells (see Overall, 1995 for a review), to deficits in the blood brain barrier (Power et al., 1993), to genetic changes (Price, Brew, Sidtis, Rosenblum, Scheck, and Cleary, 1988). Although the cause of HIV dementia is as of yet undetermined, the cognitive deficits associated with the disease appear to be subcortical in nature (Peavy et al. 1994; Drebing et. al., 1994).

Peavy et al. investigated the nature of HIV dementia by comparing symptomatic HIV positive (HIV+) participants, asymptomatic HIV+ participants, and HIV negative controls on the California Verbal Learning Test (CVLT) and found that symptomatic HIV+ participants were significantly impaired relative to HIV controls on measures of acquisition and retention. The asymptomatic HIV+ group fell between the symptomatic HIV+ group and the controls on all measures in this study. The researchers also compared the HIV participants to HD and AD finding the verbal memory deficits exhibited by the HIV+ participants similar to HD patients and less like AD patients. In other words, the HIV+ patients demonstrated perseveration and other memory impairments in the CVLT comparable to the deficits seen in Huntington's disease patients.

Lundervold, Nils, Karlsen, and Reinvang (1994) conducted a study that focused on the memory of HIV patients. This group administered a battery of cognitive tests to patients with HD, PD, HIV, and multiple sclerosis, in an attempt to study the degree to which subcortical dementias differ from one another in memory impairments. The researchers found that all of the groups demonstrated impairments on tests of sensory-motor function and cognitive efficiency and/or memory. They also found that patients

with HIV were more similar to HD patients than to PD patients in each of the categories. These findings suggest that HIV dementia is a subcortical dementia whose cognitive impairments are more closely related to those found in HD than PD. Further investigation into HIV dementia by Drebing et al. (1994) looked at the differences between different subcortical dementias and attempted to categorize the disorders using a case study approach.

Drebing et al. (1994) examined a group of twelve participants each with different subcortical dementias including PD, HD, and HIV. Each subject was tested on eight standardized measures selected to represent six domains of cognitive functioning: motor/psychomotor, attention/concentration, language, visual constructional ability, visual memory, and verbal memory. From the results of the study, Drebing et al. formed two subgroups that were characterized by consistently impaired functioning on the different measures. One of these subgroups contained the three patients with PD, HD, and HIV. This suggests that the symptoms of HIV dementia resemble those seen in HD, in areas of decreased visual memory, naming, verbal fluency, visual-construction abilities, attention/concentration abilities.

The lack of attention and concentration can also be seen in people with frontal lobe damage (see Cummings and Benson, 1988; Cappa and Wallesch, 1994 for a review). Another area where frontal lobe patients demonstrate a significant impairment is in prospective memory. Prospective memory is reflected in a person's ability to remember directions in the past requiring actions in the present. Frontal lobe patients also demonstrate frequent impairments in perseveration which is commonly seen in their performance on Wisconsin Card Sorting Test (WCST) and on the initiation and

perseveration subscale of the dementia rating scale (Janowsky and Shimamura, 1989). Both of these tests are commonly used to test for frontal lobe damage, specifically to damage to executive functioning (Stuss and Benson, 1986) and have been used to demonstrate similar impairments in HD and HIV patients (Lees and Smith, 1983; Butters, Swenson, and Bondi, 1995; Massman, Delis, and Butters, 1990). This comparison may suggest that subcortical dementias affect frontal functioning. Rothlind and Brandt (1993) examined this possibility by focusing on whether HD dementia was related to frontal functioning or just overall dementia. The researchers found patients with HD scored as well as healthy controls on a standardized cortical dementia test, but performed much worse than the healthy controls on a frontal/subcortical assessment battery. This study supports the view that subcortical dementias contain a frontal component, but other research has suggested that there is no significant damage to the frontal cortex in these subcortical dementias.

For instance, Huntington's dementia has been widely associated with frontal functioning but there has been little evidence demonstrating that the neuronal loss in the frontal cortex is significant enough to cause the cognitive deficits observed in HD (Stuss and Benson, 1986). Cortical blood flow to the frontal cortex also appears to be normal in HD patients while they performed frontal lobe tasks (Weinberger, Berman, Iadarola, Driesen, and Zec, 1988). These results suggest there may be other areas of the brain, or connections to other areas affected by the disease, which are causing the frontal type deficits in cognition.

Degeneration of the basal ganglia has been implicated in the cognitive deficits seen in Huntington's disease (reviewed in Cummings and Benson, 1988). The caudate

nucleus located in the basal ganglia, as mentioned by Stuss and Benson (1986), appears to be an area of primary pathology in HD. This area has also been indirectly implicated as a possible area affected by HIV. Glass et al. (1995) found a significantly greater number of macrophages/microglia in the basal ganglia but not the frontal lobes of HIV demented patients compared to HIV positive nondemented patients suggesting that the basal ganglia may be a primary sight of HIV infection. It is clear from the research that the basal ganglia are important when examining the pathology of subcortical dementias. There appears to be very little research, however, into how Huntington's disease patients and individuals infected with HIV differ in frontal lobe functioning.

The current study will attempt to compare Huntington's disease, HIV, older, and younger adults in frontally mediated processes. We will attempt to determine the degree to which each of the subcortical dementias (Huntington's disease and HIV) are related to deficits in executive functioning, prospective memory, and immediate recall using a battery of cognitive tests. We hypothesize that patients with subcortical dementia will demonstrate increased executive deficit, decreased immediate recall ability, and decreased prospective memory when compared to younger adults but will perform similarly on each of the tasks to older adult controls.

## Method

### Participants

One independent variable consisting of four levels was tested in this study. First, the younger adult control group consisted of 19 college students from Illinois Wesleyan University. They ranged in age from 18 to 20 years. Each student received class credit for their participation, but could elect to write several article reviews if they did not want

to participate in the study. Second, 16 older adult participants were selected from an Illinois Wesleyan University alumni list. They ranged in age from 67 to 81. The third group consisted of four HIV patients ranging in age from 34 to 60. The final group consisted of one HD patient from Carle hospital in Champaign. All of the patients and older adults received payment for their participation.

### Materials

Intelligence Tests. The two tests used in this study which were meant to measure general intelligence were the Kaufman Brief Intelligence Test (KBIT) and subtests of the Wechsler Adult Intelligence Scale – Revised (WAIS-R). The KBIT measures both verbal and non-verbal aspects of intelligence and has been correlated highly with other standardized measures such as the WAIS-R and Stanford-Binet. Only the Information subtest of the WAIS-R was used. The Information subtest measures crystallized (long-term) memory by asking for answers to factual questions. It is also one of the most culturally and educationally influenced measures of intelligence.

Prospective Memory Measure. This is a task in which participants take a computerized numbered item trivia quiz. During the quiz, the participant is instructed prior to beginning the task to inform the researcher of any questions that deal with a president. The researcher then records any number that the participant reports. The score is calculated as a percentage out of three since each participant received three president questions.

Immediate Recall Measure. A computer-based test of working memory, this task requires the participant to memorize a group of letters presented to them in five seconds. The group of letters then disappears and a single letter immediately appears on the

screen. The participant is then asked to determine if the single letter was a member of the previous set of letters.

Measures of Executive Function. Two tests of executive function were used in this study. The Stroop Color-Word Task is a 135-second test divided into three 45-second blocks. In the first block, the participant reads a list of color names printed in black ink as quickly as possible. In the second block, groups of “x”s printed in either red, green, or blue ink appear on the page. The participant is required to read the color of the “x”s as quickly as possible in the time allotted. In the third block, the participants once again reads ink colors instead of “x”s, however, color words are used. These color words are red, green, or blue but the words do not match the color of the ink they are printed in. The third block requires the participant to block out their natural tendency to read the printed word and instead report the ink color the words are printed in. The number of colors named within each of the three blocks is measured. This test is thought to be a measure of automatic reading and resistance to interference. Two scores were taken from this task. First, the number of words reported in forty-five seconds in the third block (Color-Word score). Second, an interference score calculated by subtracting the predicted Color-Word score from the actual score.

The second task of executive function used in this study was the Wisconsin Card Sorting Task (WCST). This is a task in which the researcher presents the participant with a deck of cards and asks him/her to sort the cards to four target cards laid in front of the participant. The method for sorting is not told to the participant, but he/she is given feedback on whether the sorting principle he/she is using is correct (i.e., matches the researchers’ principle). Unknown to the participant, the researcher changes the sorting

rule many times during the test. In order to sort correctly, participants must pay attention to feedback and be willing to make changes in strategy if they are unsuccessful. The WCST has been found to be robust in its ability to distinguish frontally damaged patients from normal patients, and is thought to measure cognitive flexibility.

### Apparatus

A Macintosh PowerMac 8500 computer was used to administer the immediate recall and prospective memory measures. A Macintosh Powerbook 170 was also used for participants unwilling to travel to the University.

### Design and Procedure

Each participant was tested individually. Upon arrival to the testing session, participants were presented with a consent form which included the nature of the study, procedures involved, and a statement of the participants' rights to consent, confidentiality, and withdrawal. Participants then received the intelligence tests and other tests of cognitive functioning using the instructions governed by each of the measures in an order determined by Latin Square counterbalancing.

For the prospective memory task, the participants were told that it was a measure of general intelligence that was not fully functional in randomly assigning questions. In order for the experimenter to ensure that the program was randomly assigning the questions correctly, the participants were to inform the experimenter of the number of any question involving a president. Following the testing, participants were informed of the false nature of the prospective memory task as well as receiving a complete debriefing as to the full nature of the study.

## Results

Discussion of Older Adults, Younger Adults, and HIV Group. For this correlational study, there is a predictor variable of group with four levels (older adult, younger adult, HIV, and Huntington's disease) and a criterion variable of tests ( $n = 6$ ). This was a quasi-experimental design. The participants could not be randomly distributed into groups due to the nature of factors determining the groups: age, or presence of HD or HIV. The low participant numbers for the HD group ( $n = 1$ ) did not permit the use of correlational or inferential statistics. For this reason, a case study will be presented at the end of this section on the one HD individual. Also, due to the exploratory nature of this study and small sample sizes, a significance level of 0.05 will be used even though a large number of tests were used.

Determined by a one-way ANOVA, general intelligence measured on the KBIT was found to be not significantly different between the younger adults ( $\underline{M}=112.84$ ,  $\underline{SD}=9.74$ ), the older adults ( $\underline{M}=115.44$ ,  $\underline{SD}=7.30$ ), and the HIV ( $\underline{M}=107.5$ ,  $\underline{SD}=7.42$ ),  $F(2,38) = 1.43$ , ns. On the WAIS-R information subtest the younger adults ( $\underline{M}=23.88$ ,  $\underline{SD}=2.73$ ) performed significantly lower than the older adults ( $\underline{M}=21.18$ ,  $\underline{SD}=2.58$ ) but neither group significantly differed from the HIV participants ( $\underline{M}=22.50$ ,  $\underline{SD}=3.79$ ),  $F(2,38) = 4.19$ ,  $p < .05$ . This was determined using a Scheffe test with significance level of 0.05.

The criterion variables compared between Older Adults, Younger Adults, and HIV groups were percent accuracy on the prospective memory measure and performance on the two measures of executive functioning and the immediate recall task. The data



was not transformed in any way. The means and standard deviations for each of the tests are represented in Table 1.

On the measure of prospective memory, another task related to frontal function, an one way ANOVA revealed no significant differences between the young adults ( $\underline{M}=93.2$ ,  $\underline{SD}=15.2$ ), the older adults ( $\underline{M}=100.0$ ,  $\underline{SD}=0.0$ ), and the HIV participants ( $\underline{M}=100.0$ ,  $\underline{SD}=0.0$ ),  $F(2, 13) = .88$ , *ns*.

On the immediate recall task, a one way ANOVA did not reveal a significant difference between the older adults ( $\underline{M}=2.38$ ,  $\underline{SD}=1.67$ ) and HIV ( $\underline{M}=3.00$ ,  $\underline{SD}=1.41$ ) although it did reveal that the older adults made significantly more errors than the younger adults ( $\underline{M}=1.11$ ,  $\underline{SD}=1.79$ ),  $F(2,38) = 3.45$ ,  $p < .05$ . This was determined using a Scheffe's test with significance of .05. The HIV participants ( $\underline{M}=3.0$ ,  $\underline{SD}=1.41$ ) did not differ significantly from either group.

On the first task measuring executive function, the Stroop Color-Word task, the young adults ( $\underline{M}=50.57$ ,  $\underline{SD}=10.45$ ) performed significantly higher than both the older adult group ( $\underline{M}=37.75$ ,  $\underline{SD}=9.20$ ) and the HIV group ( $\underline{M}=35.78$ ,  $\underline{SD}=7.62$ ),  $F(2, 38) = 9.06$ ,  $p < .001$ . A one way ANOVA revealed that the younger adults ( $\underline{M}=4.23$ ,  $\underline{SD}=4.23$ ) performed significantly higher on the interference score than the older adults ( $\underline{M}=-3.71$ ,  $\underline{SD}=10.31$ ) but neither group differed significantly from the HIV group ( $\underline{M}=.52$ ,  $\underline{SD}=3.12$ ),  $F(2,38) = 3.58$ ,  $p < .05$ . Both of the ANOVA findings were determined using a post-hoc Scheffe's test. A Pearson R also revealed that for the older adults, age was significantly correlated to Color-Word score ( $r = -.6103$ ,  $p < .05$ ) and Stroop interference score ( $r = -.6004$ ,  $p < .05$ ).

The second test of executive function used in this study was the Wisconsin Card Sorting Task. A one-way ANOVA was used to determine that the young adults ( $M=11.53$ ,  $SD=12.58$ ), the older adults ( $M=25.5$ ,  $SD=21.46$ ), and the HIV patients ( $M=25.75$ ,  $SD=26.89$ ) did not differ significantly on perseverative responses in this task  $F(2,38) = 2.89$ ,  $ns$ . A Pearson R did, however, reveal that the score on the WCST was significantly correlated to age for older adults ( $r = .6975$ ,  $p < .005$ ).

Results from Huntington's Disease Patient. Patient LH was a 56-year-old female who had been diagnosed with Huntington's disease in 1990. Her highest level of education was high school. She was in the middle to late stages of the disorder, having noticeable verbal and motion deficits. These deficits made her slow in responding to the tasks. She had to rest between subtests of the KBIT. Her score on the KBIT is considered average for her age, but fell well below the average score of the other three test groups (see Table 1). She did not seem to have any difficulty in recalling answers to the WAIS-R information subtest although she also scored lower than the average older adult, younger adult, and HIV patient tested in this study (see Table 1).

LH scored perfectly on the prospective memory task (100) despite frequent questions regarding the length of the task and how much longer she had to sit for the test. She had four errors on the immediate recall task and frequently asked to be reminded about the directions even though the directions were on the computer screen at all times.

LH also had a difficult time with the Stroop test, showing a marked difficulty reading the words. Both her Stroop Color-Word score (17.14) and her Stroop inhibition score (-6.14) were well below the average scores of the other three test groups. She scored closest to the older adult group on both of these tasks however (see Table 1). She

also appeared to have difficulty with the Wisconsin Card Sorting Task. She reported to the experimenter several times that she believed that they were switching the matching categories, but she continued to match using the same category. The number of perseverative responses that she recorded was 70. Over 50% of her responses were rated as perseverative.

### Discussion

The present study investigated the differences between Huntington's disease, HIV, older, and younger adults in frontally mediated processes. The hypothesis that the participants with subcortical disorders would demonstrate decreased prospective memory scores and decreased immediate recall ability did not hold true for either of the subcortical groups. The hypothesis that the same group would demonstrate increased executive functioning deficits did not hold true for the measure of perseveration (KBIT) but did on one of the resistance to interference measures (Stroop Color-Word) for the HIV participants. Although the hypotheses of these studies were not confirmed statistically, the results of the study did demonstrate some interesting trends.

The intelligence levels of the different groups can not explain the lack of support for the hypotheses of this study. None of the groups in this study differed on the KBIT, which measured general intelligence. This is to be expected if all of the groups were of similar, uniform schooling and did not have any learning disabilities. The results on the WAIS-R information subtest were slightly different, however. On this test the older adults performed significantly higher than the younger adults, but neither control group differed from the HIV group. This result may be due to the nature of the task. The

WAIS-R is a measure of crystallized or long term, memory. This form of intelligence may actually increase with time, or as you learn facts throughout your lifetime. The fact that the HIV group did not differ significantly from either control group may be due to the age of the HIV group. Their average age and mean score on the WAIS-R, lies between both the older adult and younger adult groups. Again, this result may be a reflection of crystallized memory. Since the results of the WAIS-R were expected due to the nature of the test, the findings of the two intelligence tests suggest that the results of any other tests are not due to differences in intelligence levels between groups.

One possible reason that the results of the prospective memory task did not support our thesis is that the older adults, HIV participants, and HD participant all scored perfectly on the task. There was a large ceiling effect for this task. This can be caused by the task being too easy for the participants tested in this study. One way of adjusting for this effect would be to make the measure more difficult. Another way to adjust for the large ceiling effect would be to test more impaired individuals such as older adults more advanced in age and subcortical patients who have had their diseases for a longer period of time.

Too wide of an age range in the older adult group may have also affected the results of the WCST. Several previous studies have found that older adults demonstrate significantly more perseverative errors on the WCST than younger adults (see Woodruff-Pak, 1997 for a review). A reason that the present study did not find similar results when comparing the older adults is that they varied greatly on test score. This can be seen in the large standard deviation for the older adult group on the task (see Table 1). Their score significantly correlated to their age. As the older adults' ages increased, the

number of perseverative errors made on the WCST also increased. The large range in age used in the older adult group may have led to the large standard deviation and the results seen on the WCST.

The results of the HIV group on the WCST can also be attributed to a large standard deviation within the group (see Table 1). This large deviation is most likely caused by the size of the group. Only four HIV participants could be obtained for this study. The variation within the HIV group could be better controlled by separating the group into symptomatic and asymptomatic groups as seen in Peavy et. al. (1994). The present study did not have enough HIV participants to do this. The participants varied widely in their performance on the WCST leading to an increased within-group variance and a decrease in the significance of the ANOVA. The same can be said about the results of the immediate recall task. Too few HIV participants were tested to establish a concrete conclusion on their performance even though the statistics suggest there was no impairment in HIV participants on either the WCST, the Stroop task, or the immediate recall task.

Despite the limitations of this study, several interesting trends were seen in the performance of HIV and Huntington's participants. On the immediate recall task, the older adults committed significantly more errors than the younger adults did. This finding can be attributed to an age-related decline in memory that has been reported in many previous studies (see Woodruff-Pak, 1997 for a review). The HIV participants did not differ significantly but the results suggest an interesting trend. The HIV group made, on average, almost two more errors on the immediate recall task than the younger adults did. The Huntington's patient studied made one more error than the average HIV

participant (see Table 1). Neither of the groups was large enough to demonstrate statistical significance but further investigation is certainly warranted.

On the WCST similar trends can be seen. Statistically, no group differed significantly. Both the older adults and the HIV group made on average more than twice as many errors than the younger adult group (see Table 1). Both groups' standard deviation is also quite high. The one Huntington's patient tested made approximately six times as many perseverative errors as the average younger adult on this task (see Table 1). Furthermore, the HD patient's behavior suggested significant perseverative tendencies common to patients with frontal lobe damage. On several instances, she reported to the investigator that she thought he was switching matching criteria. She did not respond by switching her own criteria, however. This could possibly be due to frontal damage caused by her disease. Performance of this type has been reported in other studies on patients with frontal lobe damage (Osmon & Suchy, 1996).

On the other test of executive function, the Stroop Task, young adults read significantly more colored words than both the older adult and HIV groups on the Color-Word task. Two possible conclusions can be drawn from these results. First, the results may be caused simply by the younger adults' ability to see a color and report it more quickly than the older adults and HIV patients. Second, these results may suggest that the older adults and HIV participants had a more difficult time inhibiting the tendency to report the typed color word, rather than the ink color that the words were printed in. In order to distinguish between these two possibilities, the interference score was calculated. The younger adults also had a significantly higher interference score than the older adults. Neither control group significantly differed from the HIV group on the

interference score, however. The overall results of the Stroop test suggest that the older adults' performance is associated with a decrease in executive function. This decrease is a common finding in aging individuals (see Woodruff-Pak, 1997 for a review). The HIV performance can be associated with their ability to see and report a color, not necessarily to the interference task itself. Impaired motor speed and control has been reported in several studies on HIV (see Cummings, 1990 for review). Although, this again may be due to the small number of HIV participants since the mean interference score of the HIV group was between the older and younger adult groups.

These results provide further support through a case study that frontal functioning and executive processes are affected in patients suffering from Huntington's disease. The study failed to provide further statistical support for few studies that have found deficits in the executive functioning and frontally mediated processes of individuals with HIV (Lees and Smith, 1983; Butters, Swenson, and Bondi, 1995; Massman, Delis, and Butters, 1990), although the results of this study suggest that further research is necessary. The results of the WCST, Stroop interference, and immediate recall tests suggest that further research should be conducted using larger subcortical dementia groups. The groups could also be divided into symptomatic and asymptomatic groups in order to control the performance and standard deviations within the groups. The same could be said for the Older adult control group. These tests should be conducted using an older adult control group consisting of older adults, more advanced in age. The dementia patients selected for further study should also be in the later stages of their diseases in order to examine what the final effect of each of the disorders is on cognitive function. A more difficult prospective memory task should also be used to reduce the ceiling affect

seen in the present study. Further research will hopefully account for the limitations of the present study and will be able to draw a more decisive conclusion about the affect of HIV and other subcortical dementias on frontally mediated processes.



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Table 1: Mean performance (or individual performance for the Huntington's disease participant) of different groups on each test variable.

<u>Group</u>	<u>KBIT</u>	<u>WAIS-R Information Subtest</u>	<u>Immediate Recall</u>	<u>Prospective Memory</u>	<u>WCST</u>	<u>Stroop Color Word</u>	<u>Stroop Interference</u>
Younger Adults ( <u>n</u> = 19)	112.84 <u>SD</u> =9.74	21.16 <u>SD</u> =2.59	1.11 <u>SD</u> =1.79	93.20 <u>SD</u> =15.21	11.53 <u>SD</u> =12.58	50.58 <u>SD</u> =10.45	4.23 <u>SD</u> =7.93
Older Adults ( <u>n</u> = 16)	115.44 <u>SD</u> =7.30	23.88 <u>SD</u> =2.73	2.38 <u>SD</u> =1.67	100.00 <u>SD</u> =00	25.50 <u>SD</u> =21.46	37.75 <u>SD</u> =9.20	-3.71 <u>SD</u> =10.31
HIV ( <u>n</u> = 4)	107.5 <u>SD</u> =7.42	22.50 <u>SD</u> =3.79	3.00 <u>SD</u> =1.41	100.00 <u>SD</u> =00	25.75 <u>SD</u> =26.89	35.78 <u>SD</u> =7.62	0.5150 <u>SD</u> =3.12
Huntington's ( <u>n</u> = 1)	83.00	15.00	4.00	100.00	70.00	17.14	-6.14