2012

Time-Of-Day Effects on Younger and Older Adult Executive Functioning

Carly E. Violand
Cleveland State University

TIME-OF-DAY EFFECTS ON YOUNGER AND OLDER ADULT EXECUTIVE FUNCTIONING

CARLY E. VIOLAND

Bachelor of Arts in Psychology

The University of Akron

May 2009

submitted in partial fulfillment of requirements for the degree

MASTER OF ARTS IN PSYCHOLOGY

at the

CLEVELAND STATE UNIVERSITY

December 2012

This thesis has been approved

for the Department of PSYCHOLOGY

and the College of Graduate Studies by:

_____

Thesis Chairperson, Benjamin Wallace, Ph. D.

_____

Department & Date

_____

Methodologist, Katherine Judge, Ph. D.

_____

Department & Date

_____

Committee Member, Conor McLennan, Ph. D.

_____

Department & Date

TIME OF DAY EFFECTS ON YOUNGER AND OLDER ADULT EXECUTIVE FUNCTIONING

CARLY E. VIOLAND

ABSTRACT

The most recent time-of-day (TOD) body of research has explored how TOD effects can influence certain cognitive domains such as semantic memory, episodic memory, processing speed, and executive functioning (Allen et al., 2008). Research by Horne and Ostberg (1976) has shown how differences in age can be associated with a preference for a certain TOD (i.e., morning or afternoon). Seventy-five percent of adults 65 years or older tend to prefer the morning, whereas fewer than 10% of younger adults tend to prefer the afternoon (Horne & Ostberg, 1976; West et al., 2002). Research by Allen and colleagues (2008) has shown how performance on certain tasks related to assessing different cognitive domains can be influenced by TOD effects (Allen et al., 2008; Intons-Peterson, Rocci, West, McLellan, & Hackney, 1998; May & Hasher, 1998; May, Hasher, & Stoltzfus, 1993). The adult western society has tended to focus on morning performance; however, the opposite effect is seen for younger adults. Morning performance has been found to be slightly impaired for younger adults when compared to older adult performance in the morning, and younger adults have shown the greatest advantage on tasks performed in the afternoon, when compared to older adults. To date, research has not examined the effects from TOD using a comprehensive and standardized measure of executive functioning (i.e., The Delis-Kaplin Executive Function System or D-FEFS) to compare difference in younger and older adult performance. The current

study was intended to extend on the Allen et al. research and examine younger and older adult performance on executive functioning when they are tested at their preferred TOD or less preferred TOD.

TABLE OF CONTENTS

Page

CHAPTER I

INTRODUCTION

Most of us are aware that we may feel more alert and perform better on various tasks during a certain time of the day; sometimes we consider ourselves early birds or night owls. In fact, research has found that individual differences in biological and physiological processes that are related to circadian rhythm can be associated with an individualôs preference for a certain time of day (TOD).

1.1 Circadian Rhythm

We know it is important to get enough sleep at night, otherwise we may feel tired or sluggish the next day. In fact, individuals need a certain amount of sleep to maintain a certain level of wakefulness. Individuals experience sleep-wake cycles that are associated with fluctuations in biological rhythms and physiological markers (commonly measured by body temperature), which have been found to influence certain cognitive functions (Bodenhausen, 1990; Folkard, 1975; Kleitman, 1963; Li, Hasher, Jonas, Rahhal, & May, 1998; Lustig, Hasher, & Zacks, 2007; Natale & Cicogna, 2002; Wright, Hull, & Czeisler, 2002; Yoon, May, & Hasher, 1998).

Body temperature has been found to be elevated when a circadian rhythm is at a peak or at a point of increased arousal, which results in better performance on cognitive tasks (Folkard, 1975, 1982; Schmidt, Collette, Cajochen, & Peigneux, 2007; West, Murphy, Armilio, Craik, & Struss, 2002; Wright, Hull, & Czeisler, 2002). One particular study by Wright and colleagues (2002) had participants keep track of sleep-wake schedules for three weeks, and sleep logs for one week prior to participation. Participants also kept a 28-hour clock, instead of the normal 24-hour clock, and body temperature was recorded.

Participants completed several neurobehavioral tests upon waking up every two hours. The tests performed included a digit-symbol substitution test and a mathematical test for working memory. All participants completed a recall test to measure memory and a visual analog scale to measure subjective alertness. Lastly, a test measuring visual vigilance and reaction time was also used.

Results indicated that neuropsychological performance was better when body temperature was higher. Also, the working memory tasks, such as the digit-symbol substitution task and the mathematical test, showed better performance when body temperature was increased. Subjective alertness ratings were parallel to increases in body temperature. This study, and the research by West and colleagues (2002), shows that subjective alertness can be a useful tool to measure peak arousal.

The level of an individualôs circadian arousal has been found to correspond to how well one performs on certain cognitive tasks (e.g., verbal fluency, processing speed, and inhibition) depending on the TOD, so higher levels of arousal mean performance should be better, as compared to when arousal levels are low (Wright et al, 2002). Also,

the best individual performance on certain tasks is related to the most arousal one experiences at a certain point during the day (Bodenhausen, 1990; Colquhoun, 1971). This system may become more variable as we age; however, fluctuations in circadian rhythm can be measured by establishing an individualôs membership in one of the categories on a self-report alertness questionnaire (Lustig, Hasher, & Zacks, 2007; Schmidt et al., 2007; West et al., 2002).

One particular study examined body temperature, preferred TOD, and individual alertness ratings across younger and older adultsô performance on working memory tasks (West et al., 2002). The researchers tried to compare subjective and objective measures of arousal by using a measure to determine TOD preference and body temperature. Results indicated that across both age groups, body temperature increased from the morning into the evening. This research provided additional support to show dissociations between self-reported alertness ratings and actual body temperature. Older adults (morning types) reported to be more alert during the morning hours whereas younger adults (neutral types, classified by being neither morning or evening types) tended to report being more alert during the evening time. These findings are consistent with research done by Horne and Ostberg (1976), and show that subjective measures of alertness can be useful in TOD research. Understanding how useful subjective measures can be is important to the current research because individual differences in circadian arousal patterns have shown to alter certain cognitive performance depending on the time of day (Allen et al., 2008; Bodenhausen, 1990; Folkard, 1975; Lawrence & Stanford, 1999; Li et al., 1998; May & Hasher, 1998; May, Hasher, & Stoltzfus, 1993; Natale & Cicogna, 2002; Wright et al, 2002; Yoon, May, & Hasher, 1998).

1.2 Morningness-Eveningness Questionnaire

The widely used Horne and Ostberg Morningness-Eveningness Questionnaire (MEQ) allows for a TOD preference to be established, also known as a *chronotype*. The MEQ places individuals on a continuum between extreme morning and evening chronotypes based on their summed scores on the questionnaire. The range of chronotypes helps to classify people as definitely morning, moderately morning, neutral, moderately evening, and definitely evening. They found that peak performance for individuals on a certain task could depend on a specific time of day, and there is evidence of inter-individual variability across the lifespan for TOD preference (Horne & Ostberg, 1976; May et al., 1993; West et al., 2002). The findings from research using subjective alertness measures, morning types make up over 75 percent of the adult population that are 65 years of age or older. On the other hand, fewer than 10 percent of adults younger than 65 years of age identify themselves as being definitely morning chronotypes (Horne & Ostberg, 1976; Intons-Peterson, Rocchi, West, McLellan, & Hackney, 1998; May, Hasher, & Stoltzfus, 1993; Natale & Cicogna, 2002, Yoon, May, & Hasher, 1998).

Age is an important factor that has been found to be related to a shift in TOD preference across the lifespan. Age has been found to influence the performance on a given task for younger and older adults. A review of the literature has shown that as an individual ages, the shift of TOD preference changes from later to earlier in the day (Horne & Ostberg, 1976; Intons-Peterson et al., 1998; May, Hasher, & Stoltzfus, 1993; Mecacci, Zani, Rocchetti, & Lucioli, 1986; Schmidt et al., 2007; West et al., 2002; Yoon, May, & Hasher, 1998). We may stereotype older adults as early risers, but this is not far from the truth. The majority of older adults prefer doing certain tasks during the day or

morning hours, whereas younger adults (e.g., less than 65 years of age) typically prefer the afternoon or evening hours to complete certain tasks. A substantial amount of research has explored TOD effects within an inhibitory framework, and has shown clear age-related differences in performance on cognitive tasks related to inhibitory processes (Lawrence & Stanford, 1999; Li et al., 1998; Lustig, Hasher, & Zacks, 2007; May & Hasher, 1998; Yoon, May, & Hasher, 1998).

Due to the influence of circadian rhythm fluctuations on performance we know that people perform better on some cognitive tasks at a certain TOD, and that extreme caution must be taken when testing different age groups (such as younger and older adults) at different times during the day because of an age-related shift in chronotypes (Horne & Ostberg, 1976; Intons-Peterson et al., 1998; May, Hasher, & Stoltzfus, 1993; Mecacci et al., 1986; Schmidt, Collette, Cajochen, & Peigneux, 2007; West, Murphy, Armilio, Craik, & Stuss, 2002; Wright, Hull, & Czeisler, 2002; Yoon, May, & Hasher, 1998). One aspect that has been looked at closer with respect to preferred TOD and cognitive performance between younger and older adults is the *synchrony effect.* The synchrony effect is when an individualôs performance on certain cognitive tasks is influenced by the match between the TOD tested and their preferred TOD, which results in better performance on certain cognitive tasks when compared to those tested at their less preferred TOD (Li et al., 1998; May & Hasher, 1998; Schmidt et al., 2007; Yoon, May, & Hasher, 1998).

To fully understand the synchrony effect, an individualôs preferred TOD to complete certain tasks must be measured. An individualôs preferred TOD can be evaluated through the use of a self-report measure such as the MEQ, or other similar

measures that have a strong correlation with this measure (e.g., the Wallace [1993] Alertness Questionnaire, WAQ). Understanding the specific TOD a person feels most alert can give researchers more insight as to when inhibition (or the component to numerous other cognitive processes) may be influenced.

It is assumed from the Horne and Ostberg research that younger adults will be associated with evening types, and older adults will be associated with morning types. Thus, the best performance on executive functioning tasks are predicted to show that older adults that strongly prefer the morning TOD will demonstrate overall better performance in the morning, and younger adults that strongly prefer the evening TOD will show overall better performance in the evening. It is hypothesized that significant differences will be obtained in TOD preferences across younger and older adults, and more specifically, that those tested at their preferred TOD will demonstrate their best performance, as compared to the same individualôs performance when tested at their less preferred TOD.

1.3 Inhibitory Framework

Inhibition or *inhibitory processes* are controlled by the executive functions system, and more specifically related to processes underlying selective attention and perceptual recognition. Inhibition plays a role in controlling thoughts and actions (e.g., preventing inappropriate responses), and to keep thinking goal-oriented (May & Hasher, 1998). Inhibitory functioning has been found to be further impaired in older adults, young children, and those experiencing fatigue during low points in the circadian cycle. Inhibitory processes are responsible for three different functions, such as deleting irrelevant information from attention and working memory, being able to access and

focus your attention, and refraining from inappropriate responses. Common tasks related to inhibitory restraint are go/no-go tasks, the Stroop Test, and response compatibility tasks (Lustig, Hasher, & Zacks, 2007).

Younger and older adultsô preferred TOD and less preferred TOD performance was compared to examine inhibitory efficiency (May & Hasher, 1998). The experiment involved inhibitory control for thoughts that were no longer relevant using the garden-path sentence procedure (Hartman & Hasher, 1991; May & Hasher, 1998). The goal was to determine if participants would show differences between the disconfirmed or target endings. Participants were given the MEQ, and then they were divided into two groups of younger adults and older adults. From here, the groups were further divided in half such that half of the participants in each group were tested at their preferred time, and the other half were tested at the less preferred TOD. After the test, participants were also given a vocabulary test to examine sentence completion and memory on an implicit word-stem task. Results showed that when younger and older participants were tested at less preferred times, their ability to suppress irrelevant information was impaired. This study shows that automatic (or highly learned) tasks did not fall to the mercy of TOD, but those that required more attention and inhibition did.

May, Hasher, and Foong (2005) further examined implicit (our previous knowledge of a task facilitates our performance at a later time) and explicit (conscious or effortful recollection of previous experiences or information) memory, and TOD preferences between younger and older adults. Participants were split into groups of younger and older adults, and they were divided further based on MEQ scores between extreme morning and evening chronotypes. Both age groups were tested in the morning

(between 8 a.m. and 9 a.m.) and in the late afternoon (between 5 p.m. and 6 p.m.). Participants viewed a list of words, and then they were asked to write the first word that came to mind to complete the word based on the stem of letters that was provided. They found that explicit memory performance was better during the preferred TOD, whereas implicit memory was better during less preferred TOD across both age groups. These results imply that these systems function on different schedules of circadian rhythm, and are influenced differently by different times during the day. The findings showed that inhibition and attention are impacted by when the TOD testing occurred, and furthermore, that conscious, effortful processing is best when we are tested at our preferred TOD.

Previous research on TOD effects has also explored how other cognitive domains such as semantic memory, episodic memory, processing speed, and executive functions may be influenced by different times of the day. The evidence for younger adults suggests that performance on certain tasks (e.g., processing speed, inhibition, and verbal fluency) is poorer in the morning when compared to performance on the same tasks assessed in the afternoon or evening (Allen et al., 2008, Intons-Peterson et al., 1998; Manly, Lewis, Robertson, Watson, & Datta, 2002; May & Hasher, 1998; May, Hasher, & Stoltzfus, 1993; Skinner, 1985). Conversely, older adults have shown better performance on certain tasks in the morning rather than the afternoon or evening (Horne & Ostberg, 1976; Intons-Peterson et al., 1998; May & Hasher, 1998; May, Hasher, & Foong, 2005; May et al., 1993; West et al., 2002).

However, research to date has not examined TOD effects on older and younger adult performance using a newly available, comprehensive, and standardized measure of

executive functioning. The frontal lobes of the brain are responsible for executive functions. The components of executive functions involve higher levels of thought such as problem solving, planning, flexibility of thinking, concept formation, inhibition, impulse control, abstract thinking, and creativity ranging from simple to complex tasks that allow us carry out our daily lives (Homack, Lee, & Riccio, 2005). The majority of the mechanisms that are controlled by executive functioning are a combination of multiple cognitive processes, so that is why it is important to use a comprehensive measure to examine the components of executive functioning. These specific components of executive functions can be measured by somewhat complex game-like tasks.

1.4 Younger Adult Effects

Younger adults have been widely studied due to availability to researchers in the university setting and their flexible schedules. Allen and colleagues (2008) provided evidence for TOD effects on college students through the use of five different standardized tests to determine which cognitive domains were responsible for actual and preferred TOD differences. To measure processing speed, they administered the standardized Wechsler Adult Intelligence Scale-Revised (WAIS-R) Digit Symbol Substitution Task (DSST), which has been shown to be a strongly reliable and valid measure (r= .97) for the full scale (Neill, 2004). The Mill Hill Vocabulary Test, which has strong test-retest reliability (between r= .94 and r= .96), was used to measure semantic memory performance. For executive control, a verbal fluency Test with a moderately strong reliability, was administered using the letters ñSò, ñTò, and ñMò, which differed from the usual letters ñFò, ñAò, and ñSò, but proved to be psychometrically sound with the production of 11 to 12 words per minute for each letter,

compared to the usual ñFò, ñAò, and ñSò that is used for most verbal fluency tasks, where one condition typically produces between 9 or 10 words for one letter. Participants were given 60 seconds to recall as many words as they could that started with one of the letters. Also, participants completed a learning task to examine the outcome of actual TOD testing and preferred TOD on episodic memory. These standardized cognitive assessments were used to generalize the effects of TOD and TOD preference across the cognitive domains of semantic memory, episodic memory, processing speed, and executive functions. The current study will included the same WAIS-R DSST to measure processing speed, the Mill Hill Vocabulary Test was used to measure semantic memory performance, and a similar verbal fluency measure from the Delis-Kaplin Executive Function System (D-KEFS) was used amongst other measures from the D-KEFS, which will be mentioned later.

The procedure for the Allen et al. study had participants split into three groups, and each group was administered the tests between 8 a.m. and 10 a.m., between 12 p.m. and 2 p.m., and again between 6 p.m. and 8 p.m. Everyone was given the same tests and had to take them in the morning, afternoon, and evening, but the order of testing time of the three groups was randomized (such that the first group was assigned a morning, afternoon, and evening test order, the second group was assigned an afternoon, evening, and morning test order, and the last group of participants were assigned to be tested during the evening, morning, and afternoon).

The results from performing independent mixed univariate analyses of variance (ANOVAs) for the DSST, the Mill Hill Vocabulary Test, the Verbal Fluency Test, and the learning tasks showed that TOD influenced performance on processing speed, but not

on episodic or semantic memory performance. TOD and test order interactions were found for all tasks performed, meaning that performance in the afternoon and evening was better than the morning performance.

As evident from these results, verbal fluency and processing speed components of executive control should be examined more closely, as they have been shown to be influenced above and beyond semantic and episodic memory by TOD effects, regardless of TOD preference. By using more standardized measures, the extent of impairment influencing executive functioning performance may also be able to negatively impact functioning on daily tasks that require higher level, integrated cognitive processes. The TOD research needs to examine executive processes more closely through the use of a comprehensive battery. More evidence is needed to fully understand how performance can be influenced by the actual TOD, and how a range of factors related to influencing physiological processes can impact performance on cognitive tasks.

The Allen et al. research failed to include certain factors such as diet, amount of sleep, and caffeine intake, which may have contributed to differences in performance. The study lacked an older adult group to further examine individual differences in performance, as well. Despite these limitations, the main results have provided evidence that more research needs to be done, thus the current study was designed. A similar research design was used in the current study by testing participants in the morning and afternoon hours, but the current study expands on the Allen et al. study by focusing more specifically on executive functioning performance differences across older and younger adults that were tested at their preferred and less preferred TOD, as well as differences within these groups.

Based on the Allen et al. research, it was predicted that significant differences would be found in cognitive performance between the two age groups for the morning and afternoon testing times. More specifically, younger adults that prefer the afternoon were predicted to show the best performance in the afternoon, whereas older adults that prefer the morning were predicted to show their best performance in the morning.

1.5 D-KEFS Research

Few studies have used a standardized executive functions battery, and have instead used other experimental tasks that were not comprehensive in nature. The use of single standing experimental tasks that are not comprehensive in nature may be convenient to use in research since these tasks may take less time to administer, however, a comprehensive measure can cover different components under the broad range of executive functions. The majority of research using the D-KEFS has focused on more detailed clinical diagnoses that are very specific in nature to the cognitive dysfunction (Delis, Kramer, Kaplan, & Holdnack, 2004; Razani, Casas, Wong, Lu, Alessi, & Josephson, 2007; Wodka, Loftis, Mostofsky, Prahme, Gidley Larsen, Denckla, & Mahone, 2008).

The D-KEFS is a comprehensive measure of executive functioning, which may turn researchers off due to the extensive nature of the battery, including multiple tests that may be more complex than others in administration or scoring all the tests and their individual subtest conditions. Although it takes only a little over an hour to complete the entire battery, administration and scoring may be somewhat confusing for novice administrators on tests such as the Tower Test, the Sorting Test, and the Proverb Test (Shunk, Davis, & Dean, 2006).

However, using the D-KEFS can be valuable to get a snapshot of what aspects of executive functions are related to everyday functional ability. As previously mentioned, clinical researchers have used the D-KEFS to measure very specific components of cognitive impairment whereas the current study compared executive functioning to daily functioning. Aging research has looked at the relationship between executive dysfunction and activities of daily living (Razani et al., 2007). To examine impairment in executive functions the Sorting Test, the Tower Test, the Trail Making Test, and the Color-Word Interference Test from the D-KEFS were used. Also, a preliminary cognitive screening measure was included, another version of a card sorting test was used, and a Verbal Fluency Test involving the letters ñFò, ñAò, and ñSò was administered. The neuropsychological performance tests were used along side reliable and valid measures related to activities of daily living in the elderly. Participants included those with mild-moderate stages of dementia and a control group of healthy adults matched by age and education.

As expected, the healthy controls outperformed the individuals with mild-moderate dementia on the D-KEFS. Strong correlations were found between some of the executive functioning tasks and different observation-based functional tasks that participants were asked to try and complete. Difficulty with shopping was moderately correlated with poor performance on the D-KEFS Sorting Test (r= .47). Also, the other version of the Sorting Test was moderately correlated with impaired performance on a number of functional measures. Difficulty shopping was moderately correlated with poor performance on the D-KEFS Tower Test (r= .52). Low scores on the Verbal Fluency Test were moderately correlated with problems in communication (r= .42), difficulty

driving (r= .49), trouble keeping their finances in order (r= .54), and shopping (r= .44). Verbal fluency performance was found to be the best predictor for the ability to manage finances (Razani et al., 2007).

When compared to healthy controls, this research shows that having mild cognitive impairment can influence multiple functions related to daily living tasks that require the use of executive functions. Strong moderate relationships were found when using the D-KEFS battery to indicate possible deficits, and more investigation is needed to help validate cognitive performance related to daily functioning. Razani and colleagues suggest that more research needs to be done using the D-KEFS to measure executive functioning performance as related to activities of daily living (ADLs).

Even when measuring one specific cognitive function, the use of brief standardized tests that can explain away some of the other influences from other cognitive domains should be included. The responsibilities of other cognitive domains may also influence functioning on ADLs. Further use of the D-KEFS needs to be done to better understand the mechanisms underlying executive functioning in healthy adults as related to simple and complex tasks in daily life. Using the D-KEFS on adults with mild-moderate dementia has shown to be useful for diagnoses, to help understand what is functionally lost, and to develop possible techniques to help deal with the impairment that occurs with the onset of illness. Although the authors noted their study should have included more tests from the D-KEFS battery, the D-KEFS is a valuable tool when measuring executive functioning. The Razani et al. study showed how the D-KEFS can hold up when testing healthy older adults, and even those with mild-moderate dementia.

Further research using the D-KEFS has looked at scores from male and female children between the ages of 8-16, with and without Attention Deficit Hyperactivity Disorder (ADHD; Wodka et al., 2008). Gender and ADHD subtype performance on executive measures were examined separately to see if different cognitive processes were influenced depending on whether the child was male or female. In this study they used the D-KEFS: Tower Test, Verbal Fluency, Trail Making Test, and Color-Word Interference Test. Also, children were administered a word reading task, and an intelligence test, if this information was not readily available.

Results indicated that the control group (e.g., healthy participants) and the experimental groups (e.g., those with ADHD) performed the majority of previously mentioned tasks within the average range (Wodka et al., 2008). However, the children with ADHD performed significantly worse overall on the Color-Word Interference Test and the Tower Test. Results indicated that two of the four D-KEFS measures used can help recognize problems in executive functioning for children with ADHD. This research helps solidify the use of the D-KEFS for assessing problems related to inhibitory processes.

The bulk of research using the D-KEFS is related to dysfunction (Delis et al., 2004; Razani et al., 2007; Wodka et al., 2008). The present study was concerned with how tasks related to daily functioning may be impaired for younger and older adults depending on the TOD tested. The tests from the D-KEFS battery that were used included: Verbal Fluency, Color-Word Interference, Twenty Questions, and the Tower Test. The four domains that were examined by the D-KEFS are planning, concept formation, fluency and productivity, and flexibility in thinking.

Pertinent to the TOD body of research, the current study extends beyond the work by Allen and colleagues by focusing more specifically on executive functions, and by expanding on the types of tests used to assess executive functioning. Another goal of the current study was to add to the body of research related to using a comprehensive measure of executive functioning, rather than select experimental tasks related to executive functioning that have been seen in the literature. Also, it is recognized that the older adult population must not be excluded when comparing differences in performance on cognitive tasks. Most importantly, the current study will examine how younger and older adults differ in executive functioning performance when they are tested at preferred and less preferred times during the day.

CHAPTER II

TIME-OF-DAY EXPERIMENT

2.1 Method

2.1.1 Participants. The first experimental group included 29 undergraduate psychology students from Cleveland State University receiving extra credit for participating. The college-aged students included those between the ages of 18-31. Participants volunteered for the study through their introductory psychology course. Prior to beginning the first research session the WAQ was used to screen available participants on their TOD preference. Using the WAQ allows for preferred and less preferred TOD performance on executive functioning tasks across younger and older adult participants to be compared.

Also, a second experimental group of 29 older adults were tested as a comparison group. The older adult group was made up of 65-83 year old volunteers. The older participants were independent living, community dwelling older adults, which were drawn from local senior centers in the Cleveland area. Again, the WAQ was administered prior to the first session to measure TOD preference.

Younger and older adults were tested twice during the course of a week. Participants agreed to be tested once in the morning (between 8 a.m. and 11 a.m.) on one of the days, and once in the afternoon or evening (between 3 p.m. and 7 p.m.) on another day of the week. Testing order was counter-balanced and randomly assigned to participants so that half of all younger and older participants were administered tests starting with the morning testing time, followed by participation in the evening, whereas the other half of all younger and older adult participants were tested first in the evening and later, in the morning. In order to reduce fatigue and practice effects, participants were tested on two different days separated by at least one day, but no more than four days from the initial testing.

2.1.2 Materials. All participants completed a short questionnaire involving diet, sleep, and caffeine intake to assess potential variables that can influence alertness, which may ultimately influence cognitive performance during a certain TOD. Younger adults were given the WAQ. This questionnaire has held up to the widely used MEQ, having a strong correlation (r= .84) with it. The WAQ is a shortened version of the MEQ consisting of 10 questions that measure whether an individual is more active during the morning or earlier times of the day, or the later times of the day. Using this measure permitted for TOD preference to be examined against actual performance for preferred and less preferred times during the day on executive functioning tasks.

Following the procedure in the Allen and colleagues study, the Mill Hill Vocabulary Scale and the WAIS-R DSST were administered (Raven, Raven, & Court, 1998; Wechsler, 1981). These tests were used in the current study to control for semantic memory or memory for knowledge, and processing speed, respectively. The Mill Hill

Vocabulary Scale consists of 34 words and the participant must select the word that matches the item as closely as possible. The WAIS-R DSST gives participants 60 seconds to fill in as many symbols for each digit as they can. Participants are not expected to complete the entire task within the time given, but to go as fast as they can without skipping any portion.

2.1.3 The Delis-Kaplin Executive Function System. The D-KEFS is a comprehensive, standardized battery to measure executive functioning. This assessment consists of nine stand-alone tests that are used to measure frontal brain systems responsible for higher levels of thought processing (Shunk et al., 2006). These tests provide qualitative and normative results of these functions for people between the ages of 8-89. The D-KEFS is comprised of: Trail-Making, Word Context, Sorting, Twenty Questions, Color-Word Interference, Verbal Fluency, Design Fluency, Proverb, and the Tower Test (Homack, Lee, & Riccio, 2005). The four domains in which the nine tests are organized are planning, concept formation, fluency and productivity, and flexibility in thinking (Shunk et al., 2006). The following two tests out of the four tests from the D-KEFS that were administered included alternate forms; those are the Color-Word Interference Test and the Tower Test. Reliability rates across all tests have been shown to be in the moderate range. It was predicted for all of the executive functioning tests that younger and older adults tested during their preferred TOD will show an advantage in performance compared to cognitive performance at the less preferred TOD. An advantage in performance may be a result when the TOD preference is congruent with the actual TOD of testing. Better performance is assumed to be associated with better executive functioning performance, which is predicted to occur at the individualsô preferred TOD.

2.1.4 Verbal Fluency. The D-KEFS Verbal Fluency Test measures fluency for speech by counting the number of responses. Specific letters are spoken to the participant, and then the individual has 60 seconds to list as many words that begin with these letters. Also during this task, participants must list words that belong in the same categories (see Appendices G and H). The test-retest reliability of this measure is strong for letter fluency (r= .80) and category fluency (r= .79; Homack et al., 2005). Internal consistency measures to establish item interdependence range from moderate to strong (r= .32 to r= .90; Shunk et al., 2006). It was predicted that younger adults will outperform older adults on this timed task (see Salthouse, 1996). The Salthouse (1996) research illustrates that with age, the amount of time it takes to process information increases. It can be assumed that the same would apply in this case.

2.1.5 Color-Word Interference. The D-KEFS Color-Word Interference Test involves recognizing ambiguous ink colors. This measures interference from competing verbal response inhibition during the task. Participants are asked to complete four tasks that increase in complexity for each successive trial. The first task has participants say colored squares that are in random order of red, blue, or green. The second task has participants read color names that are in black ink. The third task, and most like the traditional Stroop Test (Homack et al., 2005), involves saying the color of the word printed in a different color ink, and not reading the word. The fourth task is similar to the third but involves more interference by having participants say the color of a word and not reading it, unless it is in a little box (see Appendices I-M). Test-retest reliability for this measure was found to be fairly moderate (between r= .62 and r= .76; Homack et al.,

2005). Internal consistency measures to determine the interdependence of the test was found to be moderate as well (between r= .62 and r= .86; Shunk et al., 2006).

2.1.6 Twenty Questions. The D-KEFS Twenty Questions assesses visual attention and perception, along with object recognition and naming. This test determines if the participant can name the unidentified target object by asking the fewest number of yes or no questions to 30 common objects that are exposed to them (see Appendices N and O). The test-retest reliability for this measure was found to be somewhat weak (between r= .24 and r= .43; Shunk et al., 2006). This could be due to examinees adjusting problem-solving techniques based on feedback from the test examiner.

2.1.7 Tower Test. Some of the D-KEFS assessments are also game-like such as the Tower Test. The last test uses a board with three pegs attached and includes five disks that are of different sizes. The disks are arranged in a specific pattern and the participant is asked to remember the ñending positionò. This test starts off basic and easy, and then gets progressively more difficult with each trial. The goal is to create the same position with the disks on the pegs as before, working as quickly as possible, and with the least number of moves (see Appendices P and Q). The Tower Test measures for the main domains of planning and problem solving. It also measures inhibition of impulsive responses by following instructions and rule-learning (Shunk et al., 2006). The split-half reliability of this measure has been determined to be in a moderate to strong range (between r= .50 and r= .80; Homack et al., 2005).

2.2 Procedure

Prior to formally coming in to be tested, the WAQ was completed by all participants to screen for the time during the day in which the individual believes they

prefer most for engaging in a variety of activities (see Appendix B). This 10-item questionnaire requires individuals to select either a *day* or *night* response to measure whether an individual has a preference for completing activities during the day or at night. Three questions had to be modified to relate to daily activities completed by older adults (see Appendix C).

Participants were tested individually at a table in a quiet room without distractions. After the participant consented (see Appendix A) to be involved in the study, the WAIS-R DSST was administered to determine processing speed. This test takes approximately 30 seconds to explain the directions and 60 seconds to complete (see Appendix E). It was predicted that younger adults will show better performance than older adults on this timed task, as explained in the Salthouse (1996) research on speed of processing. The Mill Hill Vocabulary Scale was included to measure semantic memory (see Appendix D). This was not timed, but it required about five minutes to complete. When examining age differences, it is predicted that older adults will show an advantage in performance on this task, compared to younger adult performance on the task. Research has shown that crystallized intelligence improves as individualsô age and can increase vocabulary knowledge (Horn & Cattell, 1967), from this information it is assumed that older adults will show an advantage in performance for a vocabulary task.

Based on the mixed results reported by Allen and colleagues, it would appear necessary to administer a comprehensive measure of executive functioning to further examine the TOD issue. To expand on the Allen et al. study, the D-KEFS was administered to measure executive functions (see Appendices R-P). After the D-KEFS tests had been completed, participants were reminded at the end of the first session when

the next session would take place. Depending on the individualôs test order (morning/afternoon or afternoon/morning), they came back and were administered the alternate forms of two of the D-KEFS tests which included the Verbal Fluency Test and the Twenty Questions Test. Also, they completed the same Color-Word Interference Test and the Tower Test. After participants were tested in the morning and in the evening, participation was complete.

CHAPTER III

ANALYSES

3.1 Analyses

A 2 X 2 mixed Analysis of Variance (ANOVA) was performed with one between participantôs factor (age, younger or older adult) and one repeated measures factor (preferred TOD and less preferred TOD). There were 18 younger adults in the study that preferred the daytime, whereas only 11 younger adults preferred the night time. There were 24 older adults that preferred the daytime, whereas only older adults 5 preferred the night time. The dependent measures were separate mean differences in reaction time or performance on each of the D-KEFS tests. A main effect for age was predicted. More specifically, younger and older adult performances on executive functioning tasks were predicted to be different. As seen in the results of the Salthouse (1996) on research of processing speed, younger adults were predicted to show an advantage over older adults in performance tasks that are timed. It is also predicted that TOD preference will be a better predictor of executive performance compared to the TOD alone. Measuring TOD preference allows for preference for a certain time of day to be compared against executive functioning performance at a less preferred TOD.

Results from this type of basic research can provide evidence in support for or as evidence against the impact TOD preference may have on performance outcomes. Those individuals that preferred the day time and are tested during the morning hours were compared to those individuals that preferred the night time and were tested in the afternoon hours. The results are concerned with the comparisons for each test between performance at a preferred TOD and a less preferred TOD for each younger and older adult. Newman-Keuls post-hoc analyses were completed on each of the significant interactions.

It was predicted that those with a preference for a certain TOD will perform better on complex tasks when tested at that particular TOD. This study looked at individuals with a range of moderate to more extreme preferences for either day or night. These results may indicate that there are differences in performance across both times of day, but it will not be able to directly compare how having a moderate or extreme TOD preference impacts executive functioning performance. As we know, research shows that younger adults tend to prefer the evening TOD, whereas older adults tend to prefer the morning TOD. However, this research includes more, younger adults that prefer the day time (n= 18) than compared to those that prefer the evening (n= 11). Across age groups, generally more people identified themselves as day time people (n= 42), compared to, those that identified themselves at evening people (n=16).

Even with this understood, it was predicted that younger adults would perform better in the afternoon, whereas older adults will perform better in the morning, but the differences might be much smaller, and potentially not as accurate as it might be when

using more extreme TOD preference individuals. Younger and older adult performance differences are predicted to be greater on tasks that are timed (see Salthouse, 1996).

CHAPTER IV

RESULTS

The results of the 2 X 2 ANOVAs for each of the D-KEFS tests were performed to examine matched and mismatched TOD preference for younger and older adults. Each ANOVA yielded analyses looking at main effects for TOD preference (matched and mismatched TOD preference performance) and age (younger and older adults). The Bonferroni correction was included in each of the ANOVAs. Interactions were examined for younger and older adults that were matched and mismatched on TOD preference and time of testing for each of the D-KEFS tests. Significant interactions were further compared to find the source of significance using the Newman-Keuls post hoc test.

The results from the ANOVA for the D-KEFS Verbal Fluency tested in the morning found a main effect for age. Significant differences in performance were found for younger and older adults, $F(1, 54)= 139.77$, $MSE= 1333.09$, $p< .001$. Young adults scored higher on this test (M= 41.75, Std. Error= .59), compared to older adult performance (M= 30.38, Std. Error= .76). Higher scores on the Verbal Fluency Test indicate better performance for this test. No significant differences were found between those that were matched (M= 36.37, Std. Error= .48) by TOD tested and TOD preference,

and those that did not match in the morning (M= 35.76, Std. Error= .83), $F(1, 54)= .395$, $MSE = 3.77$, p= .532. No significant differences were found for the interaction between matched and mismatched TOD preference and age, $F(1, 54)= .332$, $MSE = 3.16$, p= .57.

On the other hand, a main effect for age was found from the ANOVA on the D-KEFS Verbal Fluency tested in the afternoon. Significant differences were found for the D-KEFS Verbal Fluency Test in the afternoon for younger and older adults, $F(1, 54)= 223.91$, $MSE= 2298.51$, p< .001. Younger adults (M= 45.17, Std. Error= .61) out performed older adults (M= 30.24, Std. Error= .79) on this task. No significant differences were found between those that were matched (M= 38.53, Std. Error= .86) by TOD tested and TOD preference, and those that did not match (M= 36.88, Std. Error= .50), $F(1, 54)= 2.72$, $MSE = 27.90$, p= .105. No significant differences were found for the interaction between matched and mismatched TOD preference and age, $F(1, 54)= 1.17$, $MSE = 12.01$, p= .28.

Results from the ANOVA for the D-KEFS Verbal Fluency Category Condition tested in the morning found a main effect for age. Significant differences in performance were found for younger (M= 34.41, Std. Error= .64) and older adults (M= 25.37, Std. Error= .83), $F(1, 54)= 74.43$, $MSE= 842.19$, p< .001. Higher scores on this test indicated better performance. Significant differences were found between those that were matched (M= 31.53, Std. Error= .52) on TOD tested and TOD preference, and those that did not match (M= 28.45, Std. Error= .91), $F(1, 54)= 9.81$, $MSE = 111.03$, p= .003. Significant differences were found for the interaction between matched and mismatched TOD preference and age, $F(1, 54)= 19.70$, $MSE = 222.93$, p< .001 (see Appendix Q). Younger adults (M= 33.72, Std. Error= .79) that were matched on TOD preference had better

scores compared to older adults (M= 29.33, Std. Error= .69), but older adults (M= 21.40, Std. Error= 1.50) did not perform better than young adults (M= 35.09, Std. Error= 1.01) that were mismatched on TOD preference. The source of the significant interaction was between the performance of younger adults matched for TOD preference compared with older adults mismatched on TOD preference (Newman-Keuls, p <.01).

Results from the ANOVA for the D-KEFS Verbal Fluency Category Condition assessed in the afternoon showed a main effect for age. Significant differences in performance were found for younger adults (M= 37.90, Std. Error= .592) and older adults (M= 25.86, Std. Error= .761), *F* (1, 54)= 155.92, *MSE*= 1494.73, p< .001. However, no significant differences were found between those that were matched (M= 31.22, Std. Error= .835) by TOD preference and those that did not match (M= 32.54, Std. Error= .483), *F*(1, 54)= 1.88, *MSE* = 18.05, p= .176. A significant effect was found for the interaction between matched and mismatched TOD preference and age, *F*(1, 54)= 8.39, *MSE* = 80.40, p= .005 (see Appendix S). Young adults (M= 38.64, Std. Error= .934) outperformed older adults (M= 23.80, Std. Error= 1.39) that were tested at their preferred TOD. Results for younger adults (M= 37.17, Std. Error= .730) that were mismatched on TOD preference, compared to older adult performance on mismatched TOD preference (M= 27.92, Std. Error= .632) showed differences in performance. However, the important finding is the older adultsô mismatched performance, which was found to be the most impaired performance across all TOD preferences and age groups. The source of the significant interaction was between the performance of younger adults matched for TOD preference compared with older adults mismatched on TOD preference (Newman-Keuls, p <.01).

Results from the ANOVA for the D-KEFS Verbal Fluency Switching Condition tested in the morning indicated a main effect was found for age. Younger adults performed better (M= 20.53, Std. Error= .368) compared to older adult performance (M= 16.50, Std. Error= .473), $F(1, 54)= 45.22$, $MSE= 167.26$, $p< .001$). Across younger and older adult performance, no significant differences were found between those that were matched on TOD preference (M= 18.91, Std. Error= .300) and those that did not match (M= 18.13, Std. Error= .519), $F(1, 54)= 1.71$, $MSE = 6.31$, p= .197. The interaction between matched and mismatched TOD preference and age was not found to be significantly different, $F(1, 54)= 1.09$, $MSE = 4.04$, p= .301.

Results from the ANOVA found a main effect for age on the D-KEFS Verbal Fluency Switching Condition tested in the afternoon. Young adult performance (M= 22.06, Std. Error= .375) and older adult performance was found to be statistically different (M= 16.03, Std. Error= .481), $F(1, 54)= 97.59$, $MSE= 374.08$, $p< .001$. Mean differences in performance appeared to be approaching significance for the match of TOD preference (M= 19.56, Std. Error= .528) and mismatch of TOD preference (M= 18.53, Std. Error= .305), which may be influenced by having fewer people in the mismatched group $F(1, 54)= 2.89$, $MSE = 11.06$, p= .095. Significant differences were found for the interaction between those that were matched and mismatched on TOD preference and age, $F(1, 54)= 7.75$, $MSE = 29.70$, p= .007 (see Appendix T). The source of the significant interaction was between the performance of younger adults matched for TOD preference compared with older adults mismatched on TOD preference (Newman-Keuls, $p <.01$).

Results from the ANOVA found a main effect for age on the D-KEFS Color-Word Interference Test administered in the morning. Younger adult performance (M= 2.34, Std. Error= .038) and older adult performance (M= 2.85, Std. Error= .05) was found to be statistically different, $F(1, 54)= 66.30$, $MSE= 2.67$, $p< .001$. However, no significant differences were found between those that were matched on TOD preference (M= 2.58, Std. Error= .03) and those that were mismatched on TOD preference (M= 2.60, Std. Error= .05), $F(1, 54)= .16$, $MSE = .01$, $p= .69$. No significant differences in performance were found for the interaction between those that were matched and mismatched on TOD preference and age, $F(1, 54)= .15$, $MSE = .01$, $p= .71$.

Results from the ANOVA indicated a main effect was found for age on the D-KEFS Color-Word Interference tested in the afternoon. Younger adult performance (M= 2.31, Std. Error= .051) and older adult performance was found to be statistically different (M= 2.82, Std. Error= .07), $F(1, 54)= 36.89$, $MSE= 2.63$, $p< .001$. No significant differences were found between those that were matched on TOD preference (M= 2.55, Std. Error= .07) and those that were mismatched on TOD preference (M= 2.57, Std. Error= .04), $F(1, 54)= .07$, $MSE = .01$, $p= .79$. No significant differences were found for the interaction between matched and mismatched TOD preference and age, $F(1, 54)= 2.51$, $MSE= .18$, $p= .12$.

Results from the ANOVA did not show a main effect for age on the D-KEFS Twenty Questions tested in the morning, $F(1, 54)= .33$, $MSE= 2.22$, $p= .57$. Also, no significant differences were found between those that were matched on TOD preference (M= 20.52, Std. Error= .40) and those that were mismatched on TOD preference (M= 19.82, Std. Error= .70), $F(1, 54)= .76$, $MSE = 5.09$, $p= .39$. No significant differences in

performance were found for the interaction between those that were matched and mismatched TOD preference and age, $F(1, 54)= 2.12$, $MSE = 14.16$, p= .15.

Results from the ANOVA did not indicate a main effect for age on the D-KEFS Twenty Questions test. Young adult performance (M= 21.80, Std. Error= .47) and older adult performance was not found to be statistically different (M= 20.64, Std. Error= .59), $F(1, 54)= 2.35$, $MSE= 13.88$, p= .13. No significant differences in performance were found between those that were matched on TOD preference (M= 20.61, Std. Error= .66) and those that were mismatched on TOD preference (M= 21.83, Std. Error= .38), $F(1, 54)= 2.59$, $MSE = 15.27$, p= .11. No significant differences in performance were found for the interaction between those that were matched and mismatched TOD preference and age, $F(1, 54)= 2.76$, $MSE = 16.30$, p= .10.

Results from the ANOVA found a main effect for age. Significant differences in performance were found for younger (M= 110.15, Std. Error= 1.56) and older adults tested in the morning (M= 120.64, Std. Error= 2.00), $F(1, 54)= 17.06$, $MSE= 1134.27$, p< .001. Significant differences in performance were found between those that were matched on TOD preference (M= 109.99, Std. Error= 1.27) and those that were mismatched on TOD preference (M= 102.79, Std. Error= 2.20), $F(1, 54)= 18.7$, $MSE = 1201.59$, p< .001. The interaction between those that were matched and mismatched on TOD preference and age was found to be significant, $F(1, 54)= 7.013$, $MSE = 466.38$, p= .01 (see Appendix R). Younger adults (M= 108.11, Std. Error= 1.92) that were matched on TOD preference scored better than older adults matched on TOD preference (M= 111.88, Std. Error= 1.67). Results from the mismatch of TOD preference showed that younger adult performance (M= 112.18, Std. Error= 2.46) and older adult performance did differ (M=

129.40, Std. Error= 3.65). The source of the significant interaction was between the performance of younger adults matched for TOD preference compared with older adults mismatched on TOD preference (Newman-Keuls, p <.01).

Results from the ANOVA showed a main effect was found for age on the D-KEFS Tower Test administered in the afternoon. Younger adult performance (M= 114.58, Std. Error= 1.86) and older adult performance was found to be statistically different (M= 124.04, Std. Error= 2.39), $F(1, 54)= 9.73$, $MSE= 921.15$, p= .003. A significant difference was found between those that were matched on TOD preference (M= 123.10, Std. Error= 2.62) and those that were mismatch (M= 115.52, Std. Error= 1.52), $F(1, 54)= 6.25$, $MSE = 592.00$, p= .015. Significant differences in performance were found for the interaction between those that were matched and mismatched on TOD preference and age, $F(1, 54)= 4.95$, $MSE = 468.98$, p= .03 (see Appendix U). Older adults that were matched on TOD preference (M= 116.88, Std. Error= 1.99) showed impaired performance, whereas younger adults that were matched on TOD preference (M= 114.17, Std. Error= 2.29) scored similarly to younger (M= 115.0, Std. Error= 2.93) and older adults that were mismatched (M= 131.20, Std. Error= 4.35). The source of the significant interaction was between the performance of younger adults matched for TOD preference compared with older adult performance when mismatched on TOD preference (Newman-Keuls, p <.01).

CHAPTER V

DISCUSSION

The current study was designed to examine TOD effects when testing younger adults and older adults at the time they prefer and their less preferred TOD. Consistent with the Horne and Ostberg (1976) body of research, the results from the current study generally indicated that there was a difference in performance across individuals of different ages. Younger and older adults performed differently on executive functions tasks when measured at different times of the day that they prefer or may not prefer. Twenty Questions was the only test not affected by age differences for the morning and the afternoon times. Also, it was found that those of different ages influenced performance on all of the Verbal Fluency Condition, Color-Word Interference, and the Tower Test in the morning time only. Age differences influenced performance on specific tests in the afternoon such as, all the Verbal Fluency Conditions, Color-Word Interference, and the Tower Test. These results may indicate these specific measures could be more sensitive to executive functioning impairments. Overall, older adult performance did not exceed younger adult performance on any of the D-KEFS tests.

For all of the significant interactions, the important finding was the older adultsô mismatched performance, which was found to be the most impaired performance across all TOD preferences and age groups. The majority of older adults preferred the daytime to complete tasks, as measured by the WAQ, performance on matched times was always better than performance on mismatched times. Older adults need to be cautious when completing tasks in the afternoon and evening, since they were significantly impaired on performance at mismatched TOD preference test times, which we now understand is the afternoon and evening.

Certain tests were found to be statistically different when comparing the match between the TOD tested and the TOD preference such as, the Verbal Fluency Category Condition for the morning, and the Tower Test for the morning, and the Tower Test in the afternoon. Twenty Questions was the only test that may not be influenced by the match between TOD preference and actual TOD tested, age, or the combination of both. This test may not being measuring exactly what we think it measures. On the other hand, the Tower Test was found to be significant on univariate and interaction analyses across morning and afternoon times. Clearly, the Tower Test is sensitive to cognitive domains that are influenced by TOD effects, as seen by the results for the match between TOD preference and actual TOD tested, age, and the combination of both factors.

Higher scores for the Verbal Fluency conditions mean that performance is better, and thus, the individual is suspected to have a higher level of vocabulary and word production. In the initial analyses the afternoon performance for the D-KEFS Verbal Fluency measure was slightly better than the morning performance. Across younger and older adult performance, the Verbal Fluency Category Condition was found to be better

in the morning than the afternoon. However, the afternoon performance was better than the morning performance on the Verbal Fluency Switching Condition for younger and older adults. Consistent with the hypothesis based on the Horne and Ostberg (1976) research, younger adult performance was found to be best in the afternoon, and older adult performance was typically better in the morning. The interactions, and subsequent post hoc tests, helped indicate the sources of difference in performance between younger and older adults. The greatest differences in scores were between older adult performance on tasks completed at the matched TOD preference and the mismatched TOD preference.

Consistent with the speed of processing hypothesis (Salthouse, 1996), it was clear that younger adults did much better on tasks that were timed, compared to older adult performance on timed tasks at preferred and less preferred TOD. Similar results were found for the Tower Test.

The Verbal Fluency Test involves higher abstract thinking to eliminate as many objects as possible. This task integrates the use of verbal and spatial cues, along with questions that require the use of categories and subcategories in order to use feedback to create better questions, which requires a great deal of verbal knowledge and other processes. Better scores typically show greater verbal knowledge, whereas lower scores may illustrate deficits in one or more fundamental higher abilities such as a lower vocabulary and a reduced pool of items in the mental lexicon. Deficits in fundamental abilities are shown through poor spelling and basic attentional problems.

When doing future research involving verbal fluency and processing speed components of executive functions, researchers should be advised that it is possible for TOD effects to influence performance. Executive functioning components should be

looked at closer as they have been shown to be influenced above and beyond semantic and episodic memory, and the results have indicated that executive functioning task are influenced by TOD effects. Furthermore, the results from the interactions between the match of TOD preference and actual testing TOD showed older adults had significantly different scores when they matched on TOD preference and actual TOD tested, which showed scores were more favorable in the morning. The match between TOD preference and actual TOD testing may not be influencing the results for younger adults as much as we had initially thought, since results were limited in finding significant effects for the match and mismatch between preference and actual testing time. By using more standardized measures in addition to the tests in this study that were found to show significance, the extent of impairment influencing executive functioning performance may also be negatively impacting functioning on daily tasks that require higher level, integrated cognitive processes, without individuals being aware of it. This can lead to risky decision making, and in turn, can accumulate to cause problems in the larger picture.

The Color-Word Interference Test was a time-measured test that involves four conditions that get progressively harder. This allows for a specific point in initiation of speech, simultaneous processing, speed of processing, and systematic retrieval of lexical items to be recognized as dysfunctional. Breaking down tasks into their components allows for simple and complex issues related to dysfunction to be treated, if possible. The inhibition and color naming scores shows if there is a verbal inhibition deficit over and above a naming impairment. Low scorers may show word-finding impairments or developmental verbal learning disability. This impairment may come through as having a

limited knowledge of English or other neural factors that affect speed of processing. The Tower Test is measured by how many moves an individual takes to complete the test, so the lower the number of moves the better performance is. Performance on this test across younger and older adults was found to be different only in the afternoon, and scores were found to be statistically different for younger and older adults. It was hypothesized that younger adults would perform better on timed tasks, consistent with the Salthouse (1996) research, and they would exceed performance in the afternoon above and beyond older adult performance at their preferred TOD. When comparing testing times across those of different ages, results indicated that there was a significant difference in younger and older adult performance on tasks that were timed (i.e., Color-Word Interference and the Tower). The match between the TOD one prefers and the actual TOD they were tested did not have an effect on performance for every test that was compared, and did not affect younger adults. The greatest difference was found for older adults that were tested at their mismatched TOD preference, which can influence how one completes daily tasks.

The Tower Test is a timed task that involves inhibition, rule learning, spatial planning, impulsive responses, and establishing and maintaining a set of instructions. Higher scorers reflect cognitive strengths in these fundamental areas. Low scorers have shown to correlate with impairment in higher level functioning abilities such as visual attention and visual perceptual deficits. This measure would be considered one of the more complex tasks out of the D-KEFS battery. Patterns for scores show that younger adults and older adults are lower in the morning, compared to the afternoon times, and younger adults out performed older adults in both cases. An interaction was found for the morning and the afternoon testing times for those of different ages, and of different TOD

preferences. The Tower Test measures multiple components and could be a possible explanation for the magnitude of the effects. It is possible that this test captures most of the processes that can be influenced by TOD effects. A positive aspect of this test is the fun, game-like nature of this measure. However, in a clinical environment, an assessment like this might be more difficult for individuals with more severe cognitive deficits to complete.

This study has examined how individuals across different age groups perform on executive functions tasks during the morning and afternoon. This research will help determine how a battery of standardized tests measuring higher levels of cognitive processing may be used to measure at a basic level, how individuals of different ages perform better or worse at certain times of the day. Also, this research helped determine how preference for a certain TOD and the match between testing at that TOD could influence performance. This research extends beyond the Allen et al. (2008) study to include younger and older individuals, instead of only college-aged student volunteers. Within the groups of participants, there were more individuals that preferred the daytime. From these results, a distinction in the shift in TOD chronotypes was not able to be pinpointed, but making this distinction may help explain how certain individuals can be influenced on certain tasks when they are tested at a time they do not prefer. A future study should examine older adult performance on matched and mismatched TOD preference on other tasks, including tasks of daily living to see how this research applies to real world situations.

The D-KEFS have been used to examine how frontal lobe damage can influence executive functions in a clinical setting and in research. The D-KEFS involves

procedures or tasks that have been identified in research to having sensitivity to frontal lobe dysfunction. Measuring executive functions can be done by using verbal and nonverbal tasks that tap into fundamental and higher-level components that can influence functioning on daily tasks. Specific components of executive functioning can be measured through the use of the D-KEFS. Deficits may ultimately impact daily life such as individuals attending college, or an older adult that is driving or going shopping.

Directions for Future Research

Performance on the D-KEFS has shown to correlate with different real world applications. Poor performance on the D-KEFS Tower Test was associated with difficulty with shopping. Shopping involves creating a list of items, organizing them by where they can be found in the store, and efficiently navigating the store. Poor scores on the Verbal Fluency Test have been found to be associated with communication problems, difficulty driving, trouble organizing finances, and with shopping. Verbal Fluency Test performance was found to be the best predictor for the ability to manage finances (Razani et al., 2007). The D-KEFS battery may be applicable to helping determine what issues someone may be having that could help them better manage their finances.

When compared to healthy individuals, this research shows that having mild cognitive impairment can influence multiple functions related to daily living tasks that require the use of executive functions. Using the D-KEFS performance outcomes may be a valuable tool to assess how able an older adult is to complete tasks related to daily life. However, more research needs to be done using the D-KEFS to measure executive functioning performance as related to activities of daily living.

Clinical applications of the D-KEFS have provided the majority of knowledge about deficits. It is imperative that the D-KEFS be used further in research, as it has proven to be a good clinical tool for detecting deficits. Using the D-KEFS in research would allow for a real-world application as to how executive functioning performance can be influenced. A further application of this study, and a potential limitation of the current study, would involve taking the diet, sleep, and caffeine intake variables into consideration. Taking these variables into consideration will allow researchers to better understand how other aspects of individual differences can be influential factors tied to executive functioning performance. Another potential limitation, which may or may not be influential but should be included in a future study to more definitively rule out TOD preference, would be to use individuals that have more extreme TOD chronotypes.

REFERENCES

Allen, P.A., Grabbe, J., McCarthy, A., Bush, A.H., & Wallace, B. (2008). The early bird does not get the worm: Time-of-day effects on college studentôs basic cognitive processing. *American Journal of Psychology, 121,* 551-564.

Bodenhausen, G.V. (1990). Stereotypes and judgmental heuristics: Evidence of circadian variations in discrimination. *Psychological Science, 1*, 319-322.

Ciccarelli, S.K., & White, J.N. (2009). *Psychology* (2nd edition). Pearson: New Jersey.

Colquhoun, W.P. (1971). Circadian variations in mental efficiency. In W.P. Colquhoun (Ed.), Biological rhythms and human performance (pp. 39-107). London: Academic Press.

Delis, D.C., Kaplin, E., & Kramer, J.H. (2001a). The Delis-Kaplan Executive Function System (D-KEFS). San Antonio, TX, The Psychological Corporation.

Delis, D.C., Kaplin, E., & Kramer, J.H. (2001b). The Delis-Kaplan Executive Function System (D-KEFS). Examinerôs Manual. San Antonio, TX, The Psychological Corporation.

Delis, D.C., Kramer, J.H., Kaplan, E., & Holdnack, J. (2004). Reliability and validity of the Delis-Kaplan Executive Function System: An update. *Journal of International Neuropsychology Society,* 10, 301-303.

Folkard, S. (1982). Circadian rhythms and human memory. In F. M. Brown & R. C. Graeber (Eds.), *Rhythmic aspects of behavior* (pp. 241-272). Hillsdale, NJ: Erlbaum.

Hartman, M., & Hasher, L. (1991). Age and suppression: Memory for previously relevant information. *Psychology and Aging, 6,* 587-594.

Homack, S., Lee, D, & Riccio, C.A. (2005). Test Review: Delis-Kaplin Executive Function System. *Journal of Clinical and Experimental Neuropsychology, 27,* 599-609.

Horn, J.L., & Cattell, R.B. (1967). Age differences in fluid and crystallized intelligence. *Acta Psychologica, 26,* 107-129.

Horne, J.A., & Ostberg, O. (1976). A self-assessment questionnaire to determine morningness-eveningness in human circadian rhythms. *International Journal of Chronobiology, 4,* 97-110.

Intons-Peterson, M.J., Rocchi, P., West, T., McLellan, K., & Hackney, A. (1998). Aging, optimal testing times, and negative priming. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *24*, 362-376.

Kleitman, N. (1963). *Sleep and Wakefulness.* Chicago: Univ. of Chicago Press.

Lawrence, J.B., & Stanford, M.S. (1999). Impulsivity and time of day: Effects of performance and cognitive tempo. *Personality and Individual Differences, 26,* 199-207.

Li, K.Z.H., Hasher, L., Jonas, D., Rahhal, T.A., & May, C. (1998). Distractibility, Circadian Arousal, and Aging: A boundary condition? *Psychology and Aging, 13,* 547-583.

Lustig, C., Hasher, L., & Zacks, R. (2007), Inhibitory deficit theory: Recent developments in a "new view". In D.S. Gorfein and C.M. MacLeod (Eds.), *The place of inhibition in cognition* (pp. 145-162). Washington, DC: American Psychological Association.

Manly, T., Lewis, G.H., Robertson, I.H., Watson, P.C., & Datta, A.K. (2002). Coffee in the cornflakes: Time-of-day as a modulator of executive response control. *Neuropsychologia*, *40*, 1-6.

May, C.P., & Hasher, L. (1998). Synchrony effects in inhibitory control over thought and action. *Journal of Experimental Psychology: Human Perception and Performance, 24*, 363-379.

May, C.P., Hasher, L., & Foong, N. (2005). Implicit memory, age, and time of day. *Psychological Science, 16 (2),* 96-100.

May, C.P., Hasher, L., & Stoltzfus, E.R. (1993). Optimal time of day and the magnitude of age differences in memory. *Psychological Science, 4,* 326-330.

Mecacci, L., Zani, A., Rocchetti, G., & Lucioli, R. (1986). The relationship between morningness-eveningness, ageing and personality. *Personality and Individual Differences, 7,* 911-913.

Natale, V., & Cicogna, P. (2002). Morningness-eveningness dimension: is it really a continuum? *Personality and Individual Differences, 32,* 809-816.

Neill, J. (April 13, 2004). Wechsler Adult Intelligence Scale (WAIS). In Personality and Individual Differences. Retrieved July 23, 2010, from http://wilderdom.com/personality/intelligenceWAISWISC.html.

Pilcher, J.J., & Walters, A.S. (1997). How sleep deprivation affects psychological variables related to college studentsô cognitive performance. *Journal of American College Health, 46,* 121-126.

Raven, J., Raven J., C., & Court J.H. (1998). Manual for Ravenôs Progressive Matrices and Vocabulary Scales. Section 5: The Mill Hill Vocabulary Scale. Oxford,

England: Oxford Psychologists Press/San Antonio, TX: The Psychological Corporation.

Razani, J., Casas, R., Wong, J.T., Lu, P., Alessi, C., & Josephson, K. (2007). Relationship between executive functioning and activities of daily living in patients with relatively mild dementia. *Applied Neuropsychology, 14,* 208-214.

Salthouse, T.A. (1996). The processing-speed theory of adult age differences in cognition. *Psychological Review, 103,* 403-428.

Schmidt, C., Collette, F., Cajochen, C, & Peigneux, P. (2007). A time to think: Circadian rhythms in human cognition. *Cognitive Neuropsychology*, 24, 755-789.

Shunk, A.W., Davis, A.S., & Dean, R.S. (2006). Test Review. *Applied Neuropsychology, 13,* 275-279.

Skinner, N.F. (1985). University grades and the time of day of instruction. *Bulletin of the Psychonomic Society, 23,* 67.

Wallace, B. (1993). Day persons, night persons, and variability in hypnotic susceptibility. *Journal of Personality and Social Psychology, 64,* 827-833.

Wechsler, D. (1981). Manual for the Wechsler Adult Intelligence Scale- Revised. New York: Psychological Corporation.

West, R., Murphy, K.J., Armilio, M.L., Craik, F.I.M., & Stuss, D.T. (2002). Effects of time of day on age differences in working memory. *Journal of Gerontology: Psychological Sciences, 57B,* P3-P10.

Wodka, E.L., Loftis, C., Mostofsky, S.H., Prahme, C., Gidley Larson, J.C., Denckla, M.B., & Mahone, E.M. (2008). Prediction of ADHD in boys and girls using the D-KEFS. *Archives of Clinical Neuropsychology, 23,* 283-293.

Wright, K.P., Hull, J.T., & Czeisler, C.A. (2002). Relationship between alertness, performance and body temperature in humans. *American Journal of Physiology: Regulatory, Integrative, and Comparative Physiology, 18,* 329-338.

Yoon, C., May, C.P., & Hasher, L. (1998). Aging, circadian arousal patterns, and cognition. In *Cognitive Aging: A Primer* (eds. Park and Schwarz), Psychology Press.

APPENDICES

APPENDIX A

(**Informed Consent**)

Research Participation Consent Form

My name is Carly Violand and I am a graduate student at Cleveland State University, asking you to participate in a research project for my Masterôs degree through the Department of Psychology. The purpose of this research is to gain insight on how performance on certain tasks can be influenced depending on what time of day an individual prefers. This type of research is aimed to add to the current knowledge of how the time of day can influence performance for younger and older adults. The implications from the results of this research can help contribute to a better understanding of how individuals may function better at a certain time of day, which can influence simple to complex daily tasks (i.e., planning and organizing). This research project will involve a two day commitment within the same week, and will last about an hour each session for a total of two hours.

Your record sheet that I will be completing throughout this experiment will be confidential. Although I may know who you are, your identity will not be recognizable by the information recorded on the sheet. Only the researcher will know who you are. The data collected from this experiment may be used in publications or presentations. Participation is voluntary and you may withdraw at any time without penalty. Any data collected from you prior to withdrawal will be destroyed and will not be included in the research results. Any risks associated with participation in the study are no greater than those of daily living. The data collected from this research project is important, and hopefully your participation adds to your learning about psychological research.

For further information on this research you may contact Carly Violand at (440) 915-2908, email: c.violand@csuohio.edu, or Dr. Benjamin Wallace (216) 687-6986 email: b.wallace@csuohio.edu.

For further assistance, you may schedule an appointment at the Cleveland State University Counseling and Testing Center by calling (216) 687-2277.

If you have any questions about your rights as a research participant you may contact the Cleveland State University Institutional Review Board at (216) 687-3630.

There are two copies of this form. After signing them, keep one for your records and return the other copy to the researcher. Thank you in advance for your participation in this research.

By signing below I certify that I agree to participate in this double session research project, and I am at least 18 years of age or older.

Signature: _____

Name (please print): _____

Date: _____

APPENDIX B

(Wallace Alertness Questionnaire, 1993)

Young Adult Alertness Questionnaire

Please indicate your response to each of the following items by circling either *day* or *night*.

1. I am most alert during the	Day	Night
2. I feel I have the most energy during the	Day	Night
3. I prefer to take classes during the	Day	Night
4. I prefer to study during the	Day	Night
5. I prefer to work during the	Day	Night
6. I come up with the best ideas during the	Day	Night
7. I enjoy recreation most during the	Day	Night
8. I am most productive during the	Day	Night
9. I am most intelligent during the	Day	Night
10. When I graduate, I prefer to find a job during the	Day	Night

APPENDIX C
(Modified Alertness Questionnaire)

Older Adult Alertness Questionnaire

Please indicate your response to each of the following items by circling either *day* or *night*.

1. I am most alert during the	Day	Night
2. I feel I have the most energy during the	Day	Night
3. I prefer to do housework during the	Day	Night
4. I prefer to read during the	Day	Night
5. I prefer to do work during the	Day	Night
6. I come up with the best ideas during the	Day	Night
7. I enjoy recreation most during the	Day	Night
8. I am most productive during the	Day	Night
9. I am most intelligent during the	Day	Night
10. I prefer to do my errands during the	Day	Night

APPENDIX D
(Mill Hill Vocabulary Scale)

See Raven, J., Raven J., C., & Court J.H. (1998e). Manual for Ravenôs Progressive Matrices and Vocabulary Scales. Section 5: The Mill Hill Vocabulary Scale. Oxford, England: Oxford Psychologists Press/San Antonio, TX: The Psychological Corporation.

APPENDIX E

(Wechsler Adult Intelligence Scale, Digit Symbol Task)

See Wechsler, D. (1981). Manual for the Wechsler Adult Intelligence Scale- Revised. New York: Psychological Corporation.

APPENDIX F
(Instructions for Verbal Fluency)

See Delis, D.C., Kaplin, E., & Kramer, J.H. (2001b). The Delis-Kaplan Executive Function System (D-KEFS). Examinerôs Manual. San Antonio, TX, The Psychological Corporation.

APPENDIX G

(Rules for Verbal Fluency)

See Delis, D.C., Kaplin, E., & Kramer, J.H. (2001b). The Delis-Kaplan Executive Function System (D-KEFS). Examinerôs Manual. San Antonio, TX, The Psychological Corporation.

APPENDIX H

(Instructions for the Color-Word Interference Test)

See Delis, D.C., Kaplin, E., & Kramer, J.H. (2001b). The Delis-Kaplan Executive Function System (D-KEFS). Examinerôs Manual. San Antonio, TX, The Psychological Corporation.

APPENDIX I

(Condition 1 Stimulus for Color-Word Interference Test)

See Delis, D.C., Kaplin, E., & Kramer, J.H. (2001a). The Delis-Kaplan Executive Function System (D-KEFS). San Antonio, TX, The Psychological Corporation.

APPENDIX J

(Condition 2 Stimulus for the Color-Word Interference Test)

See Delis, D.C., Kaplin, E., & Kramer, J.H. (2001a). The Delis-Kaplan Executive Function System (D-KEFS). San Antonio, TX, The Psychological Corporation.

APPENDIX K

(Condition 3 Stimulus for the Color-Word Interference Test)

See Delis, D.C., Kaplin, E., & Kramer, J.H. (2001a). The Delis-Kaplan Executive Function System (D-KEFS). San Antonio, TX, The Psychological Corporation.

APPENDIX L

(Condition 4 Stimulus for the Color-Word Interference Test)

See Delis, D.C., Kaplin, E., & Kramer, J.H. (2001a). The Delis-Kaplan Executive Function System (D-KEFS). San Antonio, TX, The Psychological Corporation.

APPENDIX M

(Instructions for Twenty Questions)

See Delis, D.C., Kaplin, E., & Kramer, J.H. (2001b). The Delis-Kaplan Executive Function System (D-KEFS). Examinerôs Manual. San Antonio, TX, The Psychological Corporation.

APPENDIX N

(Twenty Questions Stimulus)

See Delis, D.C., Kaplin, E., & Kramer, J.H. (2001a). The Delis-Kaplan Executive Function System (D-KEFS). San Antonio, TX, The Psychological Corporation.

APPENDIX O

(Instructions for the Tower Test)

See Delis, D.C., Kaplin, E., & Kramer, J.H. (2001b). The Delis-Kaplan Executive Function System (D-KEFS). Examinerôs Manual. San Antonio, TX, The Psychological Corporation.

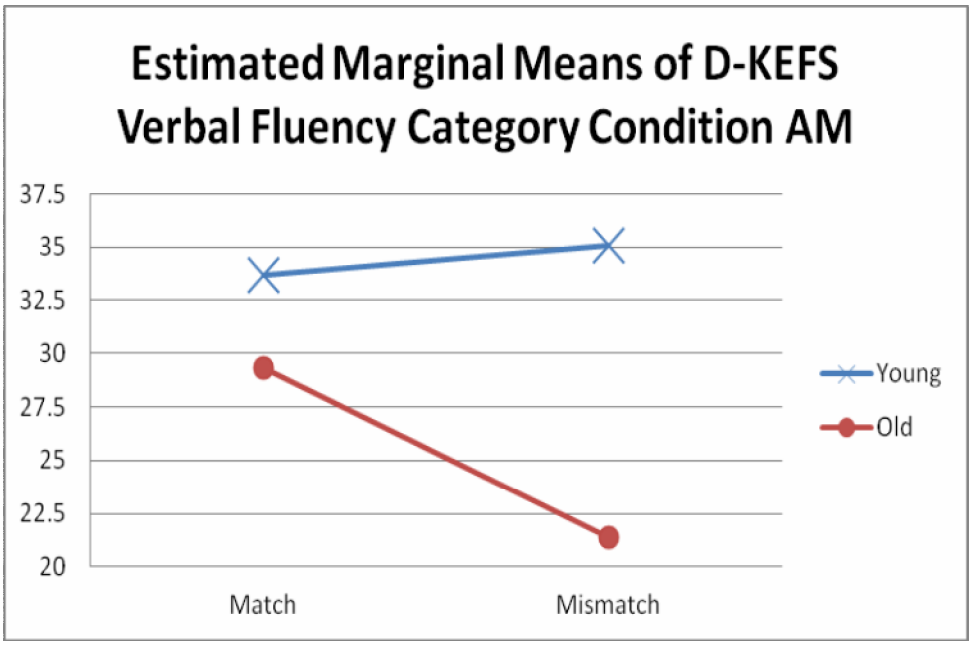
APPENDIX P

(Sample Stimulus for the Tower Test)

See Delis, D.C., Kaplin, E., & Kramer, J.H. (2001a). The Delis-Kaplan Executive Function System (D-KEFS). San Antonio, TX, The Psychological Corporation.

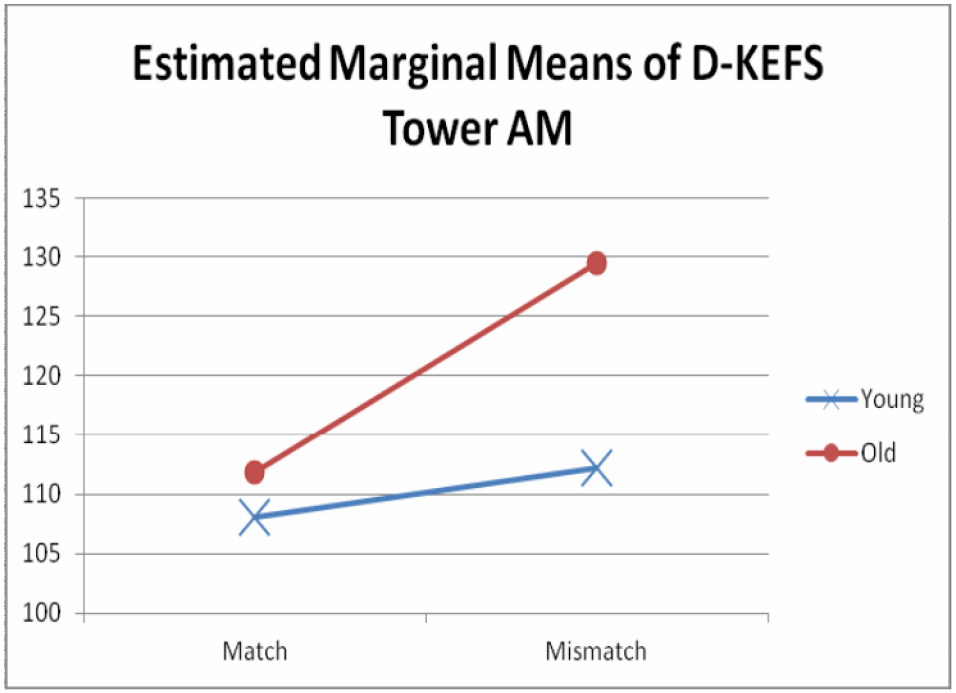
APPENDIX Q

(D-KEFS Verbal Fluency Category AM Interaction)



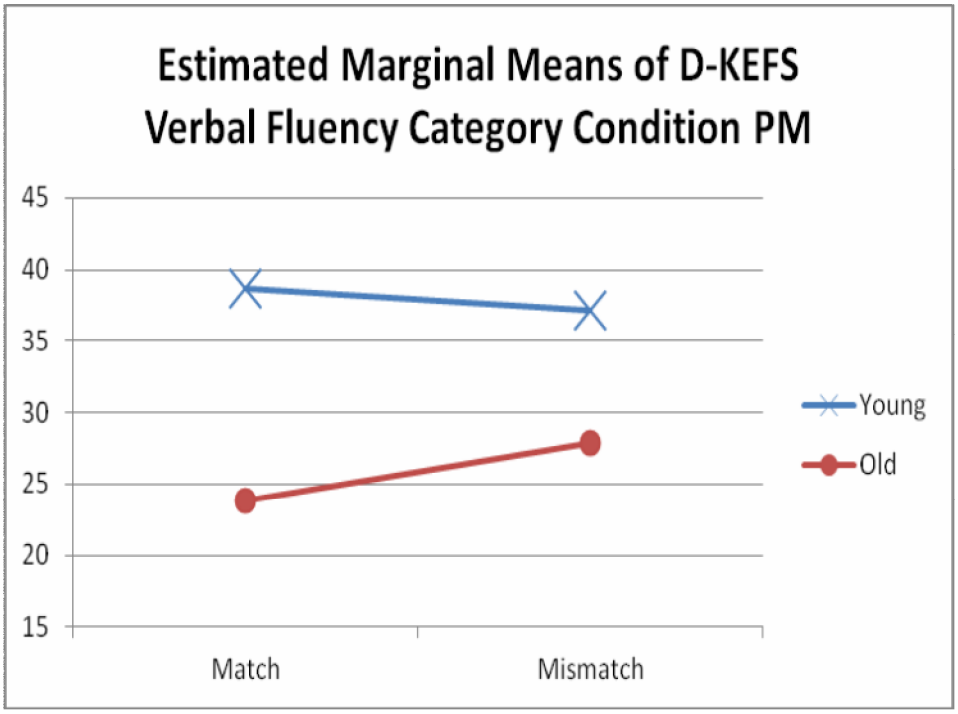
APPENDIX R

(D-KEFS Tower AM Interaction)



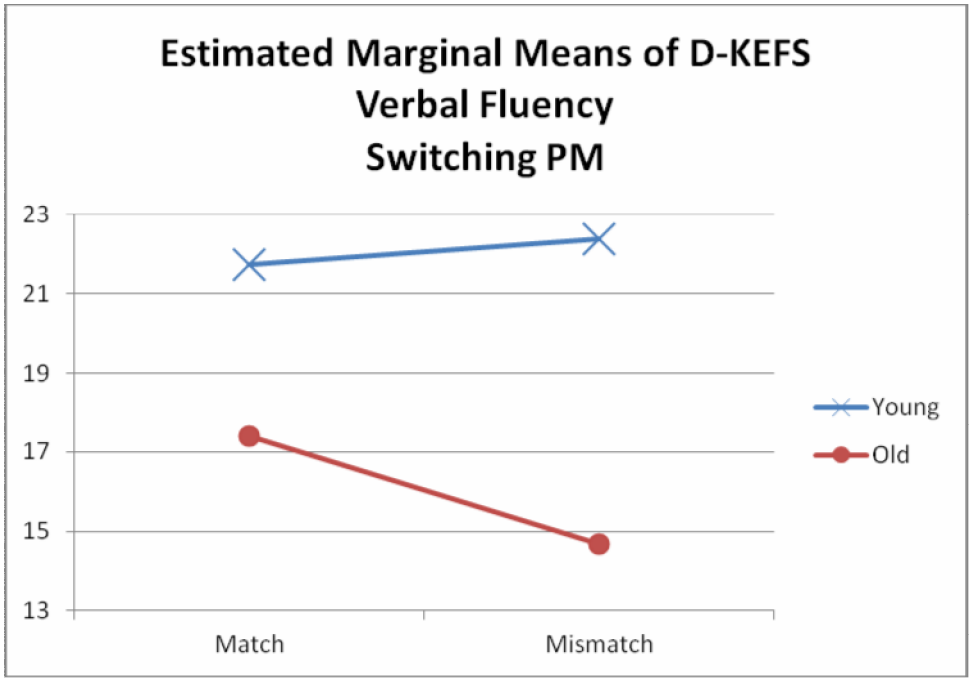
APPENDIX S

(D-KEFS Verbal Fluency Category PM Interaction)



APPENDIX T

(D-KEFS Verbal Fluency Switching PM Interaction)



APPENDIX U

(D-KEFS Tower PM Interaction)