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EMPLOYING STRATEGY IN MEASURES OF EXECUTIVE FUNCTIONING:
YOUNG VERSUS OLD ADULTS

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The research involving human participants that is reported in this thesis was conducted with the approval of the Institutional Review Board of Cleveland State University.

See Appendix H for IRB approval.

This thesis has been approved

for the Department of PSYCHOLOGY

and the College of Graduate Studies by

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ABSTRACT

Although various dementia-related executive deficits have been identified, the functional state of the frontal lobe during healthy aging remains unclear (Raz et al., 2005). The proposed study examines the use of strategy in measures of executive functioning in younger and older adults. Specifically, the strategy types of a nonverbal fluency task are shown to differentially correlate with the actual output generated by participants. The strategies employed here are compared between the two age groups, illustrating that older adults use the best strategy significantly less than younger adults, even when controlling for output differences, which may support the frontal lobe hypothesis of aging. The strategy types were shown to have no linear relationship with education level. Therefore, the possibility of using strategy type in this nonverbal fluency measure as a nonverbal premorbid indicator is not likely.

keywords: neuropsychological testing, executive functions, strategy, aging

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PREFACE

The proposed study seeks to examine older adults' use of strategy in comparison to younger adults. Because aging hypotheses diverge on the process and effects of healthy aging, individual hypotheses may differ on the forecasted outcome of this particular study. Whereas the Frontal Lobe Hypothesis (FLH) (West, 1996) may project that older adults would utilize strategy less than younger adults, global (e.g., Craik & Byrd, 1982) or slowed-processing (e.g., Band & Kok, 2000) theorists might predict that, if one controlled for speed, the use of strategy may very well be the same between the groups. Contrarily, a brain-reserve theorist (e.g., McIntosh et al., 1999) may propose that the results would be based on individual differences; the older participants with higher education would utilize strategy better than those with lower education because they have more "reserves" to rely on for compensatory mechanisms to fight the global decline of aging.

CHAPTER I

INTRODUCTION

The Aging Population

In the proposed study, older adults are defined as those individuals aged 60 years and older. Clinicians need to know more about this age group because the number and proportion of older adults in the population are increasing. Abeles et al. (1997) state that the population of older Americans is in itself getting older, as the oldest old group (ages 85 years and older) is increasing faster than any other group. After age 80, women outnumber men by almost three to one. In the United States, those born between 1946 and 1964, the “baby boomers,” are now growing older, and, at the crest of this demographic phenomenon, 20 percent of the U.S. population will be 65 years old or older.

Older adults experience age-related physical changes, including hearing and visual impairment, and the increasing probability of multiple chronic conditions such as arthritis, hypertension, heart disease, diabetes, and osteoporosis. Furthermore, since older adults often take an average of several medications for such conditions, drug interactions and drug side effects are more common in this population than in younger adults.

However, it is proven that aging yields cognitive change, often impairment, as well. In fact, the previously mentioned physical conditions may also exacerbate cognitive deficits. Due to this, cognitive impairment associated with aging is highly variable among individuals in scope and severity (Brady, Spiro, & Gaziano, 2005; Royall, 2006).

According to Royall (2006), over 4 million elderly persons in the U.S. have some form of dementia. Furthermore, mild cognitive impairment (MCI) turns into clinical diagnoses of dementia at the rate of 10-15% each year (Grabowski & Damasio, 2004). In addition to this cognitive decline, depression is the most common form of psychological illness in the elderly population (Royall), which is known to retard functioning in many of the affected individuals (Taylor et al., 2006). In fact, primary affective disorders, such as major depression, can cause pseudodementia, a reversible dementia that mocks the characteristics of a true dementia; other disorders such as thyroid abnormalities and hypovitaminosis can also cause pseudodementia (Grabowski & Damasio, 2004; American Psychological Association, 2005). This is important because these disorders are common in the elderly population, which puts older adults, who are already at risk for age-related cognitive impairment, at risk for exacerbation of cognitive symptomology. Furthermore, the prognosis of any medical condition is less favorable if Major Depressive Disorder is present, and the prognosis of Major Depressive Disorder is adversely affected as well by other medical conditions (e.g., longer episodes and poorer responses to treatment) (American Psychological Association, 2005), which seems to create a vicious cycle and an increased rate of decline.

In summary, numerous factors affect older adults, some of which are cognitive deficits, many of which cause or exacerbate cognitive deficits. Because the process of

aging is still a debated topic, it is important to examine that process in order to truly understand and, in turn, benefit those individuals fortunate enough to endure that process!

Cognitive Aging

The effects of healthy aging vary in frequency, scope, and magnitude, which may explain the disparity among theories of neurocognitive aging. The basic distinction, however, among these theories lies between the Frontal Lobe Hypothesis (FLH) of aging and the hypotheses that account for the wide range of global changes that occur with aging in lieu of the selective effect of the FLH.

It is difficult to fully understand the healthy aging process for various reasons. First, it is impossible to test healthy aging without including some undetected early dementia process. Since some early stages of dementia go unreported and undetected, it is inevitable that studies of individuals experiencing a healthy aging process will also include some individuals who are in early stages of some dementia process.

However, the FLH of aging is a well-established theory, stating that the prefrontal cortex is more vulnerable to the effects of normal aging than other cortical regions (West, 1996; Hartley, 1993). Support for this theory has been found biologically, cognitively, and neurologically. For instance, Shaw et al. (1984) discovered via a longitudinal study that resting cerebral blood flow (rCBF) was significantly reduced in the prefrontal area of the brain, but not the motor, frontotemporal, occipital, or temporal regions, over a 4-year period. Cognitively, various executive functioning tasks show that older adults display a decline in mastery of this area (for a review, see Band, Ridderinkhof, & Segalowitz, 2002 or West, 2000). Burgess (1997) states, however, that these frontal measures lack

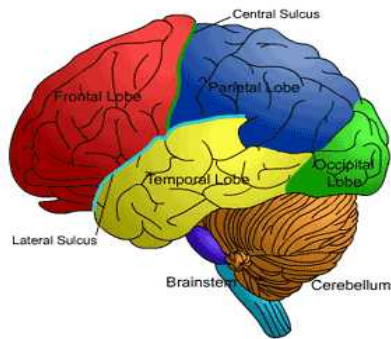
construct validity and are not strongly correlated, which would suggest that they may be sensitive to more deficits than only that of the frontal cortex. In addition, Raz (2000) reports that cross-sectional neuroimaging evidence suggests that age-related volume reduction in healthy adults is more pronounced in gray matter, especially in the prefrontal region. However, cross-sectional studies are incapable of directly gauging rates of change and individual differences in aging which can be examined in longitudinal studies (Raz et al., 2005). Contrarily, longitudinal studies looking at regional change have revealed significant shrinkage of prefrontal regions accompanied by significant declines of other regions, e.g., the hippocampus, the entorhinal cortices, the inferior temporal cortex, and the cerebellum, among others (for review, see Raz et al., 2005). Therefore, longitudinal studies, although stating that prefrontal shrinkage is greater in magnitude than accompanying significant decline in other regions, seem to illustrate global changes in healthy aging.

Craik & Byrd (1982) reported that healthy aging results in a general decline in function. The Brain Reserve hypothesis is related to this general decline theory, stating that higher education will yield more “reserves” to rely on for compensatory mechanisms (McIntosh, 1999). This is based on the fact that more brain regions are activated during various tasks in older compared to younger adults. However, initial global models of cognitive aging were supported by meta-analyses of reaction time data across various task domains (Cerella, 1990; Myerson, Hale, Wagstaff, Poon, & Smith, 1990). These studies examined general slowing and process-specific slowing with healthy aging; it has been agreed that there is a global age effect that overwhelms local processes (Band, Ridderinkhof, & Segalowitz, 2002). Band & Kok (2000) reported that older adults tend

to perform slowly but accurately due to a rigid mode of processing, compared to younger adults' flexible mode of processing. West et al. (2002) argue that this inflexible processing relates to deficits in task-switching which demonstrates frontal lobe deficit, not global or speed decline.

Therefore, the FLH may be the most established hypothesis of aging; however, healthy aging processes are difficult to measure and far from certain.

The Frontal Lobes and Executive Functioning



The uniquely significant roles of the prefrontal and frontal cortices are suggested by their size, structure, and pattern of connectivity. The frontal lobes comprise more than one third of the brain's cortical surface area and weight, as seen in Figure 1 (Royall,

Lauterbach, Cummings, & Reeve, 2002). Furthermore,

Brain Divisions: Figure 1

they are the most phylogenetically recent areas of the brain, and no other animal possesses frontal lobes of such size (Filley, 1995). Thus, it seems evident that the frontal lobes are responsible for capacities that are specific to humans. Anatomically, the frontal lobes are located in a position that parallels their functional significance; they are the most anterior regions of the human brain. Laterally, they occupy all the area anterior to the Rolandic Fissure (Lateral Sulcus) and superior to the Sylvian Fissure (Central Sulcus), and, medially, they extend forward from an imaginary line between the top of the Rolandic Fissure and the Corpus Callosum (Filley, 1995). Of this area, four functionally distinct regions can be distinguished.

The first of the four frontal lobe regions, the primary motor cortex, is responsible for contralateral body movements. Second, the premotor area is just anterior to the motor cortex and controls initiation of movement and the initiation of speech. Third, Broca's area is associated with language fluency in the left hemisphere, while the analogous zone on the right side is associated with language prosody and emotional gesture. Last, the remainder of the frontal lobes is known as the prefrontal cortex; it is connected to more brain regions than other cortical region and is responsible for the highest functions of the frontal lobes, the executive functions (Filley, 1995). It is this executive functioning in humans provide for flexible and autonomous thought that is capable of considering past experience and future goals (MacLean, 1990).

As the name implies, executive functions are high-level functions that enable more basic abilities, such as attention, memory, and motor skills. Due to this administrative quality, executive functions can be difficult to directly assess. Many of the tests that are used to evaluate them were developed to measure other abilities, particularly those that examine complex actions, like divided attention and working memory tasks (Ready, Paulsen, & Stierman, 2001; Miyake et al., 2000). This works because an individual with executive function deficits may perform well on tests of basic skills, such as focused attention, but have trouble with tasks that require divided attention or the ability to hold some stimuli in short term memory and apply some cognitive manipulation to it. For example, a person with such deficit may perform well on a task that requires him to simply look at a computer screen and respond when a particular shape appears but have difficulty with a task that requires him to give a different response depending on the shape presented (Lezak, 1995). In addition, verbal fluency tests can

also reveal executive dysfunction. One commonly used test asks individuals to name as many animals or as many words beginning with a particular letter as they can in one minute. A person experiencing problems in the executive domain may find the animal naming task relatively easy but may struggle to name words beginning with a particular letter because this task requires them to organize concepts in a novel way, which taxes the executive functioning system (Ready, Paulsen, & Stierman, 2001). Executive functions also influence memory by allowing people to employ strategies that can help them to organize information efficiently and, thus, remember the information better. For instance, complex figure tasks ask an individual to copy a design that is presented to them. Executive functions allow the individual to organize the construct efficiently instead of inefficient focus on details, which will aide in memory of the design later, when he is asked to draw the figure from memory after three and 30 minute time intervals. Other tests may present a relatively simple task without instruction on how to complete it. In such cases, executive functions allow people to figure out the task demands through trial and error and through the ability to change strategies as needed (Lezak, 1995; Ready, Paulsen, & Stierman, 2001). However, the executive system is difficult to define because there is no single behavior or anatomical structure that is linked to executive function (Burgess, 1997).

Theories of executive functions have been largely drawn from cases of individuals with frontal lobe damage, but researchers have not yet definitively associated specific neuroanatomical structures with pathology (Stuss & Alexander, 2000). Causing some confusion is the various research which has found that persons with frontal lobe lesions perform within normal limits on some tests measuring executive functioning,

while other research has shown that persons with nonfrontal or diffuse lesions perform as poorly as persons with frontal lesions on these tests (Alvarez & Emory, 2006). Thus, many of the tasks developed to measure executive functioning seem to implicate the frontal lobes, although performance on these tasks certainly rely on other brain regions as well (Miyake et al., 2000).

Stuss and Alexander (2000), in order to address the argued association between executive functions and frontal lobes, conducted a study of patients with focal lesions of the frontal lobes. They measured four cognitive functions of the frontal lobes, including memory, attention, affect, and self-awareness. The data supported the hypothesis that distinct processes are related to different regions of the frontal lobes. In addition, when the complexity of a task was increased, more processes in different frontal lobe regions were required to complete the task and were activated. The conclusion was that the frontal lobes are implicated in these four cognitive functions, but no single brain region can be associated with a specific function. Instead, there is a fractionation of frontal lobe processes that are sorted into different networks as required by task content and complexity.

To summarize, research on the frontal lobes as they relate to executive functions may be somewhat inconsistent or seem inconclusive. However, the executive processes have a large degree of specific anatomical association, while other processes are more adaptable. Within the frontal lobes, there are various processes that cooperate as required by a specific task, and these frontal processes also interact with other brain regions. Thus, instead of thinking of executive functioning as a unitary construct, Zelazo, Carter, Reznick, & Frye (1997) state that it is a macroconstruct in which multiple executive

function subprocesses work in conjunction to solve complex problems and execute complex decisions. Stuss (2006) maintains that the frontal lobes are the best link to the executive functions.

Measures

Various neuropsychological tests have been found reliable and valid for the assessment of executive functions. This study utilized four of these neuropsychological measures to assess executive functioning in young and old adults. Specifically, The Five Point Test, The Poreh Complex Figure Test, The Trail Making Test, and The Verbal Fluency Test were used.

The Five Point Test

The Five-Point Test (FPT; Regard, Strauss, & Knapp, 1982) measures executive functioning and nonverbal fluency, much like complex figure tests. In this test, the examinee is asked to draw as many configurations as possible within a set time limit by connecting up to five points to form unique designs. The examinee is instructed that he can use anywhere from one to eight lines to connect the dots in each rectangle (see Appendix B) therefore making designs as simple or complex as he/she desires, that each line must connect two dots, and that the designs must be different from one another. The scoring assesses the number of original designs, number of repetitions, and number of infractions generated in a three minute interval. The scoring is calculated via QPSS, inc. software (Poreh, 2006); the examiner enters the examinees designs into the FPT program

by clicking on icons that draw the designs. The computer program then generates a report with the scoring information.

Three strategies are used in this task, including addition of an element (Addition), deletion of an element (Deletion), and rotation of a design (Rotation). Addition is the strategy in which a participant adds an additional element to an existing form in a systematic fashion, meaning it is used in at least two consecutive designs. Deletion refers, contrarily, to the strategy in which a participant excludes a single element from an existing form in a systematic fashion. Rotation is the movement of elements around the main axis of the five points. The latter two have no norms and are not validated. However, research has shown this test to be sensitive to frontal lobe damage (Elfgren & Risberg, 1998). Furthermore, this test is desirable because it is only semi-structured, which taxes the executive functions by demanding self-organization, instead of the highly organized complex figure test.

The Complex Figure Test

A second tool that will be used in the proposed study to assess strategy and planning abilities is the Poreh Complex Figure Test (PCF; Poreh, 2006; see Appendix C), similar to the Rey-Osterrieth Complex Figure Test (ROCF; Osterrieth, 1944) and others. These tests assess visual spatial construct ability and visual memory (Strauss, Sherman, & Spreen, 2006). These designs consist of nonrepresentational configurations containing various complex, interrelated spatial components with few common geometric forms (Newman & Krikorian, 2001). The PCF is similar to the other complex figures, only it contains less detail for administration with children and elderly.

Test administration of the complex figure test includes three procedures. There is an initial procedure in which the examinee is instructed to copy the complex figure presented. This is followed by a recall of the figure three to five minutes later, in which the examinee is instructed to draw the figure from memory. This is followed by a delayed recall trial 20-30 minutes after the copy in which the examinee is asked to again draw the figure from memory. The copy trial is used to assess perceptual analytic strategy, and the recall trial is used to assess the amount and quality of information retained. Since the examinee is not informed that there will be additional memory trials, it is thought that any information retained is actually learned during the copy trial (Bennet-Levy, 1984).

Since there are various ways in which the examinee can copy the figure, there is a theory as to how the figure should optimally be drawn (Poreh, 2006). This theory, the planning theory, can be tested by comparing the process by which the examinee copies the figure with the final quality of the copied figure, plus the ability of the examinee to recall the figure immediately and after delay (Poreh, 2006).

The organizational strategies used to copy the complex figure demonstrate an individual's executive abilities (Osterrieth, 1944). Furthermore, research shows that the recall accuracy is contingent upon the strategy used to copy the figure. While some examinees copy the figure piece by piece, known as "piecemeal" copying, other examinees chunk certain elements together; for example they may draw the larger configuration, in this case the square, and then add the inner, more detailed elements. The latter strategy was named "perceptual clustering" by Delis (1989) to equate it with semantic clustering of the verbal fluency test. Research has indicated that those

individuals that draw the complex figure in chunked units show better recall of the figure than examinees that copy the figure in a piecemeal fashion (Shorr, Delis, & Massman, 1992).

The following findings have been confirmed in various studies and are significant to interpretation of results. First, drawing lines in more segments than is necessary is characteristic of poor organization and more common among impaired populations (Bennet-Levy, 1984), as is drawing details before constructural elements (Klicpera, 1983). Finally, organizational scores positively correlate with accuracy of reproduction for both the copy and the delay trials (Bennet-Levy, 1984; Klicpera, 1983). Thus, it seems that individuals who organize the figure in a coherent way will be able to more accurately recall the figure in the immediate and delayed trials.

The scoring for the proposed study was completed using QPSS, inc. software (Poreh, 2006), which recorded process scores for each participant's copy by adding a point for each continuation of a line instead of drawing a line in segments and for each perceptual clustering chunk.

The Trail-Making Test

The Trail-Making Test (TMT; Delis, Kaplan, & Kramer, 2001; see Appendices D & E) is a well-established measure of visual concept and motor tracking and involves motor speed and attention. This speed factor makes it especially desirable for the proposed study because slowing plays such a dominant role in aging.

The TMT involves two parts. The first part examines rote memory and speed as the participant is asked to connect numbered dots in order as quickly as possible without

lifting his pencil and without making any mistakes. This serves as a baseline measure for the second part of the test, which requires the participant to switch between connecting dots with numbers and dots with letters in order (e.g., 1-A-2-B-3, etc.) as quickly as possible without lifting his pencil and without making mistakes.

Part B of this test illustrates an individual's ability to plan and employ divided attention, as he is actively searching for the next target while drawing the line to the current target (Woelwer & Gaebel, 2002).

The Verbal Fluency Test

The Verbal Fluency Test utilized in the proposed study is the Controlled Oral Word Association Test (COWA; Spreen & Benton, 1977), which requires examinees to verbally recite as many words of a certain semantic or phonemic category within a limited amount of time. For instance, phonemic fluency involves naming words beginning with a given letter, and semantic fluency involves naming words that belong to a given category. The production of words on fluency tests is unevenly distributed over time. That is, words tend to be produced in temporal clusters, with a short interval between words and a longer interval between clusters (Troyer & Moscovitch, 2006). Therefore, on fluency tests, the participant will typically generate words within a subcategory and, when this subcategory is exhausted, will switch to a new one.

These two components have been named clustering and switching (Troyer, Moscovitch, & Winocur, 1997). Clustering relies on phonemic analysis on phonemic fluency (e.g., according the phonemes beginning the word) and semantic categorization on semantic fluency (e.g., subgroups of that category). Clustering is thought to require

temporal lobe processes (Troyer & Moscovitch, 2006), while switching requires frontal lobe processes, such as strategic search processes and cognitive flexibility.

In the proposed study, participants are given 60 seconds to name as many words as possible that begin with each of the letters: F, A, and S. Following, they are asked to name as many animals as possible, again in a 60 second time interval. Participants are asked to exclude proper nouns and the same words with different endings. Three scores are obtained from each task. By entering the words generated by each participant for each of the four trials (F, A, S, animals) into the QPSS, inc. (Poreh, 2006) software, the mean cluster sizes, the raw number of switches, and the total number of words generated for each trial are reported by the computer program.

Troyer et al. (1997) define clusters in phonemic fluency as successively generated words that begin with the same first two letters or phonemes. On animal fluency, clusters are defined as successively generated words belonging to the same semantic subcategories, such as pets, zoo animals, birds, etc. The size of the cluster is counted beginning with the second word in each cluster.

Troyer et al. (1997) define switches as the number of transitions between clusters, including single words. The raw score is used here because it has been found that adjusted score and percentages do not capture significant group differences in fluency performance (Epker, Lacritz, & Cullum, 1999; Troster et al., 1998).

Research Purpose

The proposed study intends to examine executive functioning in older adults in order to predict how healthy aging occurs with respect to executive functions. This is

important because, as demonstrated previously, there are confounding aging hypotheses, some of which implicate the frontal lobes and some which take a more global approach. Therefore, the proposed study will look at strategies utilized in the semi-structured, nonverbal fluency task, the FPT, in order to produce the greatest possible number of unique designs.

The first hypothesis is related to these strategies, and it is predicted that the strategies will differentially correlate with number of designs generated, yielding “good” and “bad” strategies. Next, it is predicted that younger adults will generate significantly more designs than older adults because aging does positively correlate with slowed motor speed and processing. Relating to this, the use of strategy by older and younger adults will be compared. It is predicted that, when controlling for slowed speed in older adults by controlling for number of designs generated, younger and older adults will not significantly differ on use of the strategies. This was predicted because of the disparity in evidence for the FLH, especially with neuroimaging studies, along with the well-established knowledge that slowing is associated with increasing age.

Finally, the strategies used on the FPT will be studied against strategies used on other traditional tests of executive functioning. It is predicted that strategies will correlate across tests, demonstrating construct validity of the processes employed in these tasks.

CHAPTER II

METHODS

Participants

Younger Adults

The younger adult sample utilized in this study was a pre-existing data source. No individual demographics are known for the younger adult group (n=46), which is used to compare output and strategy use. However, this group was composed of undergraduate students at a Midwestern college in the same vicinity of the independent-living facilities contacted to gather older adult participants. These students participated in the study in exchange for extra credit in an undergraduate psychology course. It is possible that some small number of these subjects were at or above 60 years of age.

Older Adults

Participants in the older adult group (n=50) were required to be the age of 60 or above and independently-living in order to be considered “healthy” for this study’s purpose. Most of these participants were residents of independent-living facilities for older adults, in which they maintained autonomy in their own apartment and were

responsible for their shopping and bill paying. These independent living sites were located in a suburb of a Midwestern city.

The participants were contacted via a flier sent to each apartment from the community coordinator (see Appendix F for reproduction of the flier) advertising participation for psychological research. Those interested residents contacted their community coordinator, who, in turn, released contact information to the examiner for each interested party. The examiner used this contact information to call participants and schedule an appointment in their apartment for the testing (see Appendix G for telephone script).

Table I: Older Adult Demographics

	Mean	SD	Mdn	Mode	Min	Max
Age	76	10	79	85	60	92
Education	13	2	12	12	6	19

The older adult group (see Table I) ranged from the ages of 60 to 92 and had a mean age of 76, with a standard deviation of about 10 years. The mean education in this group was 13 years with a standard deviation of 2 years; however 56% had a 12-year education. The education ranged from 6 years to 19 years. In addition, 30% of the older adults were male (n=15), and 70% were female (n=35).

Apparatus

All assessments used have specialized scoring systems by QPSS, inc. software (Poreh, 2006). The software was downloaded into the examiner's laptop, which was taken to each participant's assessment. The examiner entered the participants' responses into the program which then yielded a report for each individual.

Procedure

The testing for this study was conducted in each participant's home. Initially, the participant was given the informed consent documentation (Appendix A) to read and sign. A copy of the informed consent was given to each participant. The examiner set up the laptop programming while the participant completed the informed consent. Participant testing was only entered into the programming by a random number assignment; no identifying information was used on any of the assessment materials. The participant was asked to disclose her/his age to the examiner, along with level of completed education.

To begin the assessment battery, a participant was presented with a piece of blank paper and a copy of the PCF stimulus and was asked to replicate the drawing on her/his paper as accurately as possible without a time limit, although the computer measured time to complete the copy. As the participant was copying the figure, the examiner clicked on corresponding lines in the computer program which showed the same design on the computer screen. This is how the computer generated the strategy scores. From here, a three minute interval was spent talking to the participant without insertion of another test, while the examiner "prepared the computer for the next task." At the end of the three minute interval, the participant was asked to draw the design she/he had just copied from memory.

The COWA was given next. The participant was asked to say as many words as possible in a 60 second interval that begin with the letter "F," without using proper nouns and without using the same word with a different ending. The examiner recorded responses into the computer program by typing as the examinee spoke. This was

repeated for the letters “A” and “S.” Next, the participant was asked to name as many animals as possible within a 60-second time interval; these were recorded in the same fashion.

The participant was then asked to complete the TMT, consisting of two parts. In part A, the examinee was asked to connect the dots in numerical order starting with 1, while keeping his/her pencil on the paper and working as quickly as possible without making any mistakes. In part B, the examinee was asked to connect the dots in an alternating fashion, going number to letter to number to letter in order, starting with 1 and drawing a line from 1 to A, from A to 2, from 2 to B, and so forth, until he/she reached the end. The examinee was again asked to leave the pencil on the paper and work as quickly as possible without making any mistakes. As the examinee completed the task, the examiner clicked on corresponding dots on the computer screen, which recorded time and errors. If a participant made an error, the examiner brought him/her back to the previous dot to try again and kept doing so as necessary until the test is complete. The test was discontinued after 5 errors for any participant, which occurred 5 times total out of the 50 older adult participants.

Third, the participant was given the FPT. He/she was instructed to draw as many unique designs or figures as possible by connecting dots in each rectangle using only straight lines and lines that connect dots. However, the examinee was given the freedom to make the designs as simple or complex as they would like by using a minimum of one line and a maximum of eight lines in each rectangle. The objective of the test, to make as many unique designs without repetitions, was again mentioned to the participant directly before the test, and the 3 minute time limit, started. As the participant completed the test,

the examiner entered the designs into the computer program by clicking on dots that draw the designs. Many times, the examiner finished entries after the participant was finished due to inability to keep up with the participant. However, the time limit for participant completion did not change.

Finally, the participant was given a blank sheet of paper and asked to draw one more time from memory the design that they copied when the testing began (PCF). There was no time limit for either recall trial. The examiner entered the scoring for the copy and recalls into the computer after leaving the individual appointment.

Each participant was thanked and given a chance to ask questions after all tests were administered. No scores were given to any participant, although encouragement was given relatively freely in an attempt to optimize test performance and ease of the participant during testing.

CHAPTER III

RESULTS

In order to test the first hypothesis that older adults generate significantly less output than younger adults, a t-test was ran on the total number of designs generated on the FPT for both age groups. A parametric t-test was used because the number of designs, or output, generated by each group did not violate the normality assumption; thus, both age groups demonstrated a normal curve in regard to this output measure.

Table II: Output Across Age Groups

Age Group	N	Mean	SD	SE Mean
Young	46	40.57	9.44	1.39
Old	47	27.28	11.40	1.66

Df	Sig(2-tailed)	Mean Difference
91	<0.001	13.289

The t-test showed that there is a significant difference ($p < 0.001$) between age groups in reference to the actual output generated on the FPT (see Table II); specifically, younger adults generated significantly more designs than older adults. However, we want to see, not just the quantity of output, but how the age groups are generating their outputs, i.e. the processes used. Therefore, we want to find how the age groups used the

three strategies for the FPT: Addition (of an element), Deletion (of an element), and Rotation (of a design).

First, we will address our hypothesis that the strategy types for both younger and older adults will differentially correlate with number of unique designs generated, thus indicating “good” and “bad” strategy types. It was discovered that, indeed, the strategy types differentially correlated with the number of unique designs generated by the participants (see Table III).

Table III: Differential Correlation of FPT Strategies

Strategy	R
Addition	0.45**
Deletion	0.129
Rotation	0.75**

**p<0.01

Rotation was found to have the strongest positive correlation ($r=.75$; $p<0.01$) with output. Addition also had a strong positive correlation with output, although lesser than Rotation ($r=.45$; $p<0.01$). The strategy type Deletion did not significantly correlate ($r=0.129$). Thus, it seems that Rotation and Addition are better strategy types than Deletion, with Rotation having the highest correlation. However, it is unknown whether or not the difference between the significance of Rotation and Addition is significant. Participants seem to gain little from the use of Deletion.

Interestingly, when looking at the age groups separately (not shown), younger adults show a positive but weaker significant relationship between Addition and number of unique designs generated ($r=0.31$; $p<0.05$ in younger adults versus $r=.50$; $p<0.01$ in

older adults). Both age groups showed a strong, positive correlation between Rotation and generated output ($r=0.70$; $p<0.01$ for younger adults and $r=0.71$; $p<0.01$ for older adults). Therefore, this supports the finding that the strategy types do in fact differentially correlate with number of unique designs generated by participants in that Rotation and Addition were significant but Deletion was not, even when looking at the two groups independently.

Because we have found a hierarchy among the strategy types for the FPT, we can now study how the age groups employ these strategies in comparison to each other. Because the strategy use in both groups violates the assumption of normality, we will use nonparametric tests to examine the hypothesis that older and younger adults, when controlling for the amount of output generated (because older adults generate significantly less), will not differ in their use of strategy on the FPT.

In order to control for difference in output, new variables were computed to create a proportion of strategy use to amount of designs produced. Thus, for each participant, the number of times that he/she used a particular strategy was divided by the number of designs he/she generated overall, giving each participant three different strategy proportions. Then, these new variables were used to run a 1X3 Mann-Whitney test. What this showed (see Table IV) was that younger and older adults significantly differ on their use of the Rotation strategy ($p=0.017$) but not on the use of Addition ($p=0.084$) or Deletion ($p=0.235$).

Table IV: Strategy Use Across Age Groups

Strategy	Age Group	N	Mean	SD	Strategy	t	df	p
Rotation	Young	46	.277	.151	Rotation	2.42	91	0.017
Rotation	Old	47	.200	.151	Addition	1.75	91	0.084
Addition	Young	46	.057	.058	Deletion	1.20	91	0.235
Addition	Old	47	.038	.044				
Deletion	Young	46	.019	.025				
Deletion	Old	47	.013	.029				

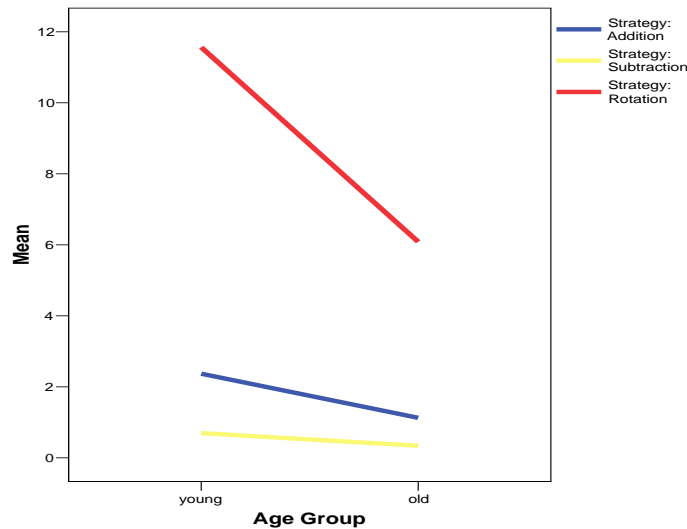
This test illustrates that older adults are employing the strategy Rotation less often than younger adults, even when controlling for differences in generated output. In fact, younger adults are using Rotation an average of almost three times per every 10 designs generated; whereas, older adults are using Rotation on an average of two times per every 10 designs generated (see Table VII for proportional means and Figure 2 for mean use comparison between age groups).

In reference to the strategy of Addition, younger adults are using Addition an average of almost six times per every 100 designs generated; older adults are using this strategy on an average of about four times per every 100 designs generated. Thus, it is evident that younger and older adults do not significantly differ in their use of this strategy (seen in Table IV; $p=0.084$), but they are also using it much less than Rotation.

It turns out that Deletion is used even less often than Addition. For instance, younger adults use this strategy type on an average of about two times per every 100

designs generated, and older adults use it on an average of about one time per every 100 designs generated. Therefore, this strategy type is infrequently used by the participants.

Figure 2: Group Comparison of Mean FPT Strategy Use



Finally, this study examined the strategy types employed on the FPT by the older adults compared to use of strategy types on other neuropsychological tests. For instance, the PCF measures symmetry and continuation, which in essence gives a participant points for working wholistically and not in a piecemeal fashion. Therefore, a participant would get more strategy points (symmetry + continuation) for continuing to draw the large construct of the square in lieu of being drawn out to the semicircle attached to the side of the square, for instance. In addition, the strategies of phonemic and semantic clustering and switching on the COWA were also measured. The TMT was used as a well-established measure of visual-scanning and motor speed and, on Part B, set-shifting ability in order to compare time of completion of parts A and B to the strategy types.

Table V: FPT Strategies and Other Executive Strategies

	Rotation	Addition	Deletion
PCF Strategy	R=0.267	0.074	-0.113
Phonemic Cluster	0.155	-0.156	0.005
Phonemic Switch	0.214	0.049	0.090
Semantic Cluster	-0.095	0.010	0.286
Semantic Switch	0.406*	0.402*	-0.079

*p<0.05

Furthermore, two of the FPT strategies significantly correlate with one of the Verbal Fluency strategies; Rotation and Addition significantly and positively correlate ($r=0.406$ and 0.402 , respectively) with Semantic Switching, although not Semantic Clustering or Phonemic Switching. Possible explanations for this will be discussed later.

Table VI: FPT Strategies and TMT Times

YOUNG				OLD			
	Rotation	Addition	Deletion		Rotation	Addition	Deletion
TMT, A	-0.090	-0.099	-0.067	TMT, A	-0.358*	-0.144	-0.053
TMT, B	-0.211	-0.213	0.136	TMT, B	-0.377*	-0.120	-0.012

*p<0.05

Finally, the TMT (see Table VI) shows significant correlation only with the FPT strategy of Rotation to the $p<0.05$ level on both parts A and B. This means that as the use of Rotation increases, the time it takes for a participant to complete TMT, parts A and B, decreases. This is important because the TMT is a measure of various elements of

functioning, ranging from set-shifting in executive functioning, to psychomotor speed, to visual scanning speed. Therefore, the strategy type Rotation from the FPT shows correlation to a well-established measure of executive functioning and psychomotor speed, validating its utility as a measure of executive function.

Table VII: FPT Strategies and Education Level

Strategy	R	P
Rotation	-0.011	0.944
Addition	-0.122	0.413
Subtraction	0.161	0.279

Our final hypothesis stated that the better strategy type(s) would positively correlate with education, which would yield potential for a nonverbal premorbid indicator. However, our sample demonstrated no relationship between strategy type on the FPT and education level (see Table VII), suggesting no implication for premorbid ability.

CHAPTER IV

DISCUSSION

The proposed study found support for the hypothesis that older adults would generate significantly fewer designs of the FPT than younger adults. This coincides with the proven knowledge that many older adults experience cognitive slowing with age. In addition, the data supported the hypothesis that strategy types on the FPT would differentially correlate with number of unique designs generated, or output, on the FPT, leading to a hierarchy of strategy utility. Rotation was found to be the best strategy, and the one used most often. However, participants of both age groups in this study used the most common strategy on average of about 2.5 times out of every 10 designs, meaning that they utilized a rather small amount of clustering and switching with an average of less than 30% of output being strategically planned in a 3 minute period. One explanation for this phenomenon is that the FPT is a measure of speed as well as strategy use. Thus, participants utilized speed and strategy in combination to optimize performance.

The data did not support the hypothesis that, when controlling for significant differences in output, there would not be a significant statistical difference between the employment of strategy on the FPT in younger and older adults. This tends to support

the FLH because it shows a loss of strategic employment with age. However, this may also be evidence of multiple factors in the FPT. For instance, this test may reliably measure not only strategic employment but also speed. Thus, further research would help to clarify or negate the difference in executive functioning between younger and older adults as was illustrated in this study. Either way, it would be interesting to provide proof for any aging theory, as there is still so much debate among theorists.

Finally, Rotation was the only strategy that correlated with another measure of executive functioning (TMT). This is a step toward verifying the construct validity of this use of strategy as an indicator of executive functioning. It is interesting that Addition did not enter into this construct, especially because it was also significantly correlated with number of unique designs generated. Thus, employment of Rotation and Addition may tax different cognitive systems, implying that using any strategy may not qualify as executive control. Again, increased number of participants may alter the outcome of this correlation since Addition was used much less than Rotation in general.

Further, strategy use demonstrated only a weak relationship with education level, which suggests that organization of novel, unstructured nonverbal stimuli may not be learned through formal education. In addition, this lack of correlation negates implication for strategy use as an indicator of premorbid ability.

In conclusion, younger adults were faster than older adults and generated significantly more output. Younger adults utilized Rotation, the only strategy that seems to be indicative of executive functioning by correlating with other executive measures, statistically more than older adults. Interestingly, though, the use of strategies did not increase with increases in education. This may seem to implicate various issues like an

absence of formal teaching of organization of novel, unstructured stimuli, perhaps specifically nonverbal information; however, it may merely highlight need for a broader range of education levels in further studies.

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APPENDICES

APPENDIX A

Informed Consent

Dear Participant:

Dr. Amir Poreh and I, Amanda Yocum, are asking you to complete the following short tests: the Five-Point test, the Verbal Fluency test, the Complex Figure test, and the Trail-Making test. The purpose of this testing is to assess strategy and planning abilities in older adults and will take approximately 30 minutes to complete. The tests will be labeled with a random number identifier, **WITHOUT** your name. There are no known risks involved in taking these tests, beyond those of daily living. Furthermore, this study may help us to increase the efficacy of results of neuropsychological testing.

Again, you will be assigned a random number identifier that will not be paired with your name. The study is, therefore, anonymous.

Participation is completely voluntary, and you may withdraw at any time. There is no consequence for not participating.

For further information regarding this research please contact Dr. Amir Poreh at (216) 687-3718, email: a.poreh@csuohio.edu or Amanda Yocum at a.yocum@csuohio.edu. 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 letter. After signing them, keep one copy for your records and return the other one. Thank you in advance for your cooperation and support.

Please indicate your agreement to participate by signing below.

I understand that if I have any questions about my rights as a research subject I can contact the CSU Institutional Review Board at (216) 687-3630.

Signature: _____

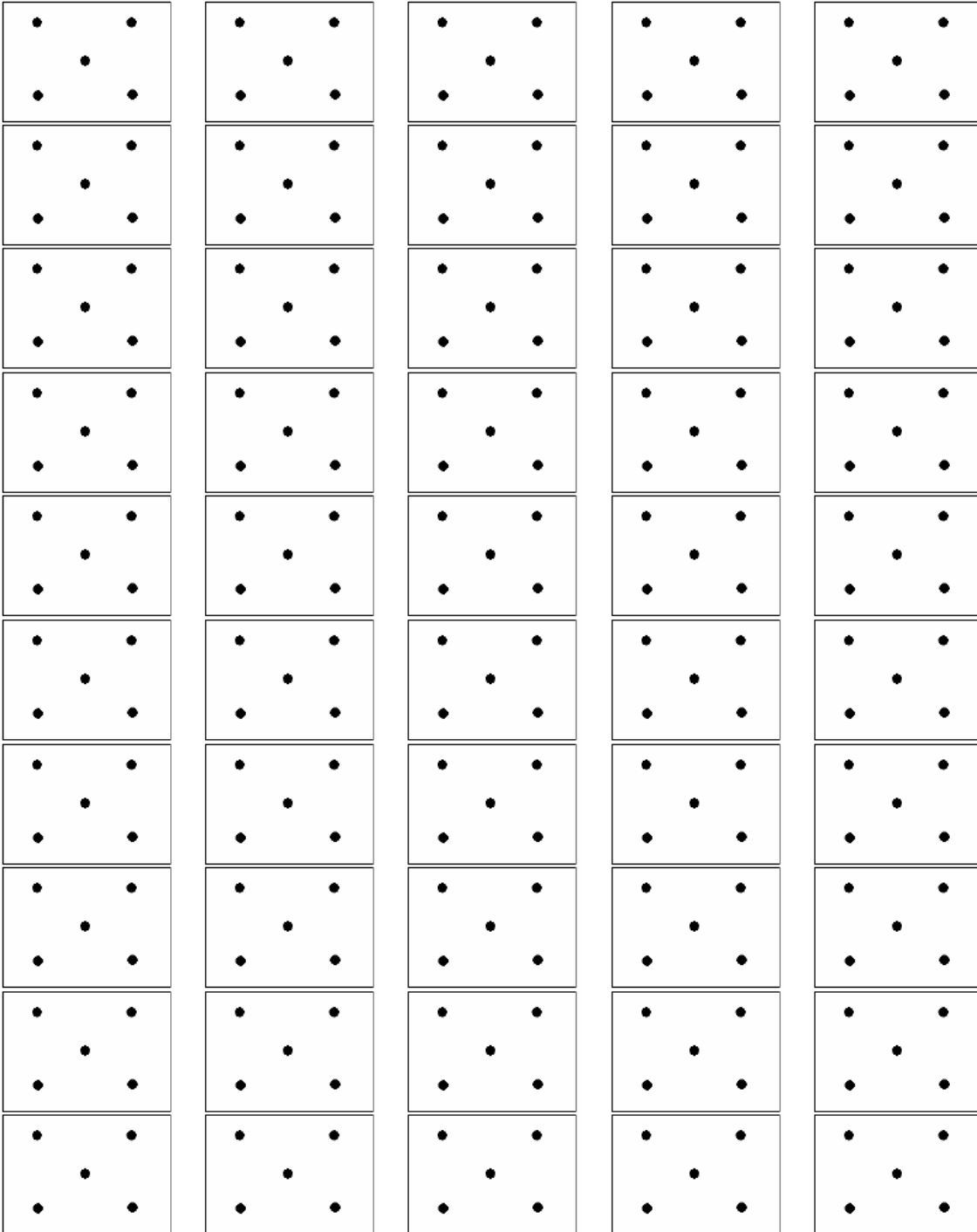
Name: _____ (Please Print)

Date: _____

APPENDIX B

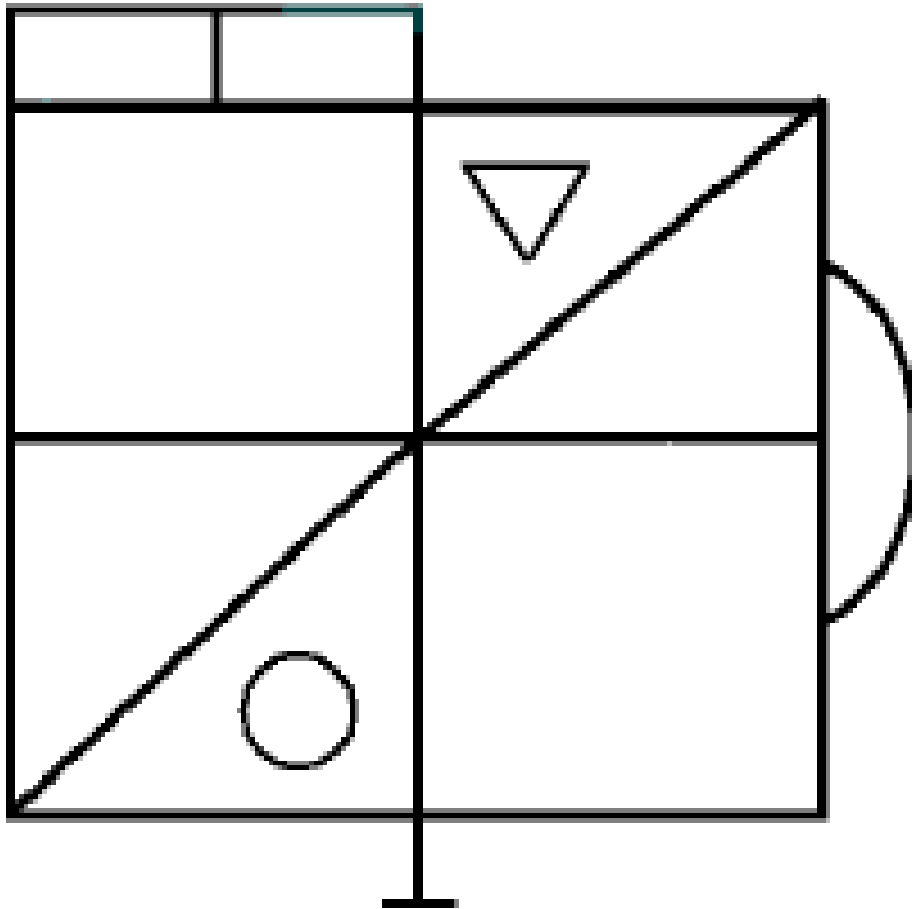
Five Point Test

Name _____ Date _____ Examiner: _____



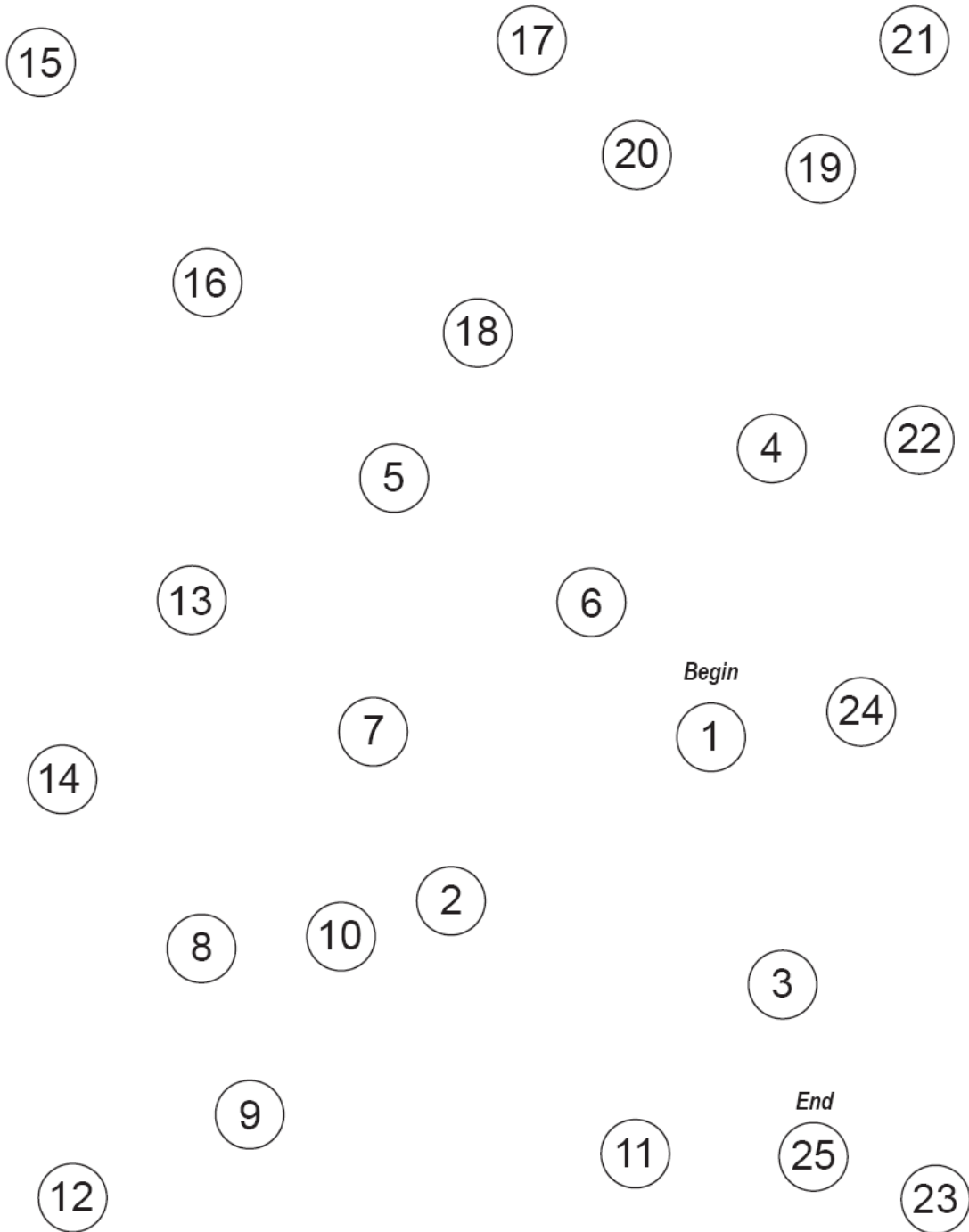
APPENDIX C

Poreh Complex Figure Stimulus



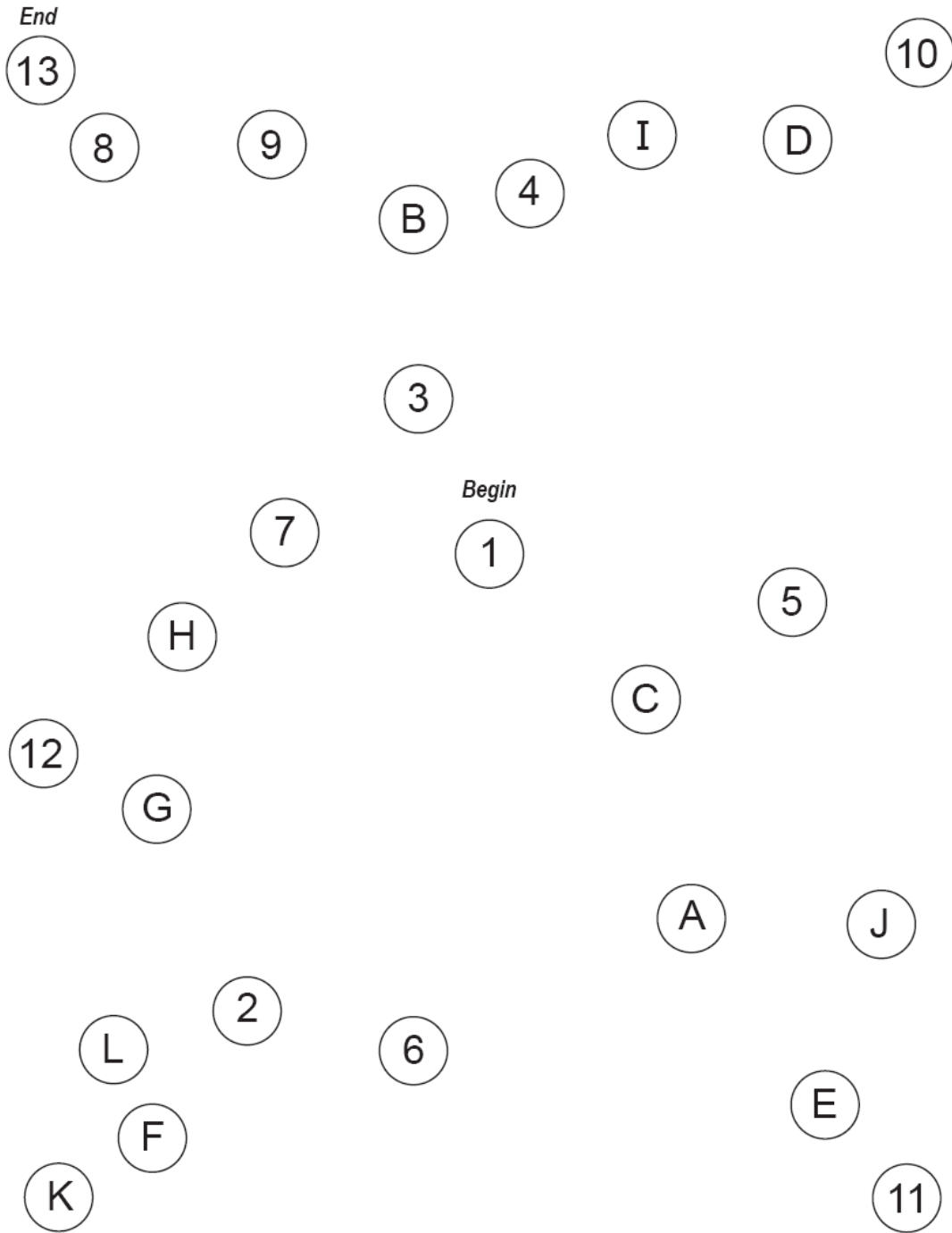
APPENDIX D

Trail Making Test, Part A



APPENDIX E

Trail Making Test, Part B



APPENDIX F

Flier

Can you help us and Cleveland State University by participating in a short (20 minute) research project aimed at determining norms of functioning in the well elderly?

Two Cleveland State graduate students, Amanda Yocum and Daniel Fishman (who lives at one of our NORCs - Huntington Green) are organizing the project.

We are pleased to be asked to help. If you are interested in assisting, please let your resource coordinator know. The research will be conducted at all sites.

Contact Information:

Cathy Weiss

Jewish Community Federation

216-344-8262

cweiss@jfcleve.org

APPENDIX G

Telephone Scheduling Script

Hello, my name is _____, and I am a graduate student from Cleveland State University. Your community coordinator has given me your name because you indicated that you may be interested in participating in a research session that was advertised in your building. If you would still like to help us out and participate, then a clinical psychology graduate student would come to your apartment and conduct some ability tests. These tests are fairly simple, and the session would last approximately thirty minutes. Would you like to schedule an appointment?

APPENDIX H

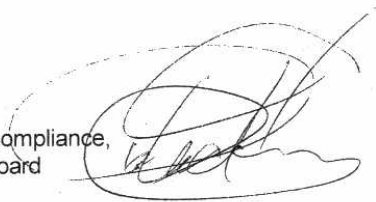
CSU IRB Approval



Cleveland State University
College of Graduate Studies and Research
Office of Sponsored Programs and Research
Institutional Review Board (IRB)

Memorandum

To: Amir Poreh
Psychology

From: Patrick Murray,
Consultant for IRB Compliance,
Institutional Review Board 

Date: 13 March 2007

Re: Results of IRB Review of your project number: 27155-POR-HS
Co-Investigator: Amanda Yocum
Entitled: Executive function of elderly

The IRB has reviewed and approved your application for the above named project, under the category noted below. Approval for use of human subjects in this research is for one year from the approval date listed below. If your study extends beyond this approval period, this office will initiate an annual review of the project. ***This approval expires on 3/8/2008***

By accepting this decision, you agree to notify the IRB of: (1) any additions to or changes in procedures for your study that modify the subjects' risk in any way; and (2) any events that affect that safety or well-being of subjects.

Thank you for your efforts to maintain compliance with the federal regulations for the protection of human subjects.

Approval Category:

Date: 3/8/2007

- Exempt Status: Project is exempt from further review under 45 CFR 46.101 (b)(2)
- Expedited Review: Project approved, Expedited Category
- Regular IRB Approval

cc: Project file

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