DECLINE OF NONVERBAL EXECUTIVE FUNCTIONS ACROSS THE LIFESPAN –
DISTINGUISHING BETWEEN OUTCOME AND PROCESS

ANNA KRIVENKO

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Ohio Northern University
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We hereby approve this thesis for

Anna Krivenko

Candidate for the Master of Arts in Psychology degree for the

Department of Psychology

and the CLEVELAND STATE UNIVERSITY

College of Graduate Studies

_________________________________________________________________

Thesis Chairperson, Amir Poreh, Ph.D., ABAP

_________________________________________________________________

Thesis Committee Member, Christopher France, Psy.D.

_________________________________________________________________

Thesis Committee Member, Boaz Kahana, Ph.D.

_________________________________________________________________

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ABSTRACT

Numerous studies have attempted to validate nonverbal fluency tests but none have examined construct validity, particularly the correlation of measures and self-reported executive functioning deficits. The current study examined this issue by correlating the results of the Five-Point Test (5PT) and the Delis Kaplan Executive Functioning System (D-KEFS) Design Fluency Test with the Barkley Deficits in Executive Functioning Scale – Short Form (BDEFS-SF) in 306 English speaking adults. Participants were volunteers from undergraduate classes and those serving jury duty in a large urban city. The mean age was 36.89 ± 18.08 with an average of 14.65 ± 2.85 years of education. The majority was female (70.3%), Caucasian (76.0%), and had a primary language of English (97.7%). Results were unable to confirm the previous literature showing adequate test-retest reliability across all scores for the 5PT and for the D-KEFS Design Fluency Test as only rotation of the 5PT ($r_{s}=.84$) as having good reliability. In analyzing the scales of the BDEFS-SF, the study found only a few inconsistent meaningful correlations between the summary and strategy scores of the 5PT and scales of the BDEFS-SF. When controlling for age and education, repetitions for the 5PT and the DKEFS Design Fluency Test correlated significantly with most of the scores on the BDEFS-SF, supporting repetitions on nonverbal fluency tasks as measures of executive
dysfunction. A mediation analysis was significant such that education mediated the relationship between age and number of unique designs on the 5PT, $b = .086$, 95% BCa CI [.035, .138], as well as for the relationship between age and strategies used on the 5PT, $b = .069$, 95% BCa CI [.014, .122]. In general, small insignificant correlations were found between the summary scores of the two nonverbal fluency measures and the self-report measure of executive functioning, further suggesting the link between self-report of such deficits and actual deficits is tenuous at best. These findings also indicate that higher education is neuroprotective against cognitive decline.
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CHAPTER I

INTRODUCTION

1.1 The Frontal Lobes

Carl Wernicke’s work on aphasia and apraxia in the 1800s is often considered the genesis of neuropsychology as a field of study. Neuropsychology developed as a synergy between neurology and psychology, as Wernicke’s early works on functional anatomy revealed key connections between localized brain regions and behavior. Eventually, neuropsychology and medicine split into separate entities in the 1940s. The disciplines that contribute to the understanding of the interaction of the brain and human behavior, namely behavioral neurology, neuropsychiatry, and neuropsychology, take on the underlying notion that certain aspects of human behavior are hard-wired in the brain (Stuss & Levine, 2002). Though interconnected, each brain region has been associated
with a particular set of functions. The region of the brain referred to as the frontal lobes have consistently been of focus of neuropsychology brain-behavior research. The frontal lobes make up about twenty percent of the neocortex and are separated into right and left lobes and each lobe is even further divided into prefrontal, premotor, and motor cortexes. Though both lobes play a role in all behavior, verbal movements, such as speech, are localized to the left frontal lobe, while non-verbal movements, such as facial expressions, are generally localized to the right frontal lobe (Kolb & Whishaw, 2011).

Often the neuropsychological literature of the frontal lobes subdivides the lobes according to function. Filey in 2011 proposed to break down the frontal lobes into four functionally different regions: (a) the primary motor cortex which is responsible for contralateral body movements, (b) the premotor area which is responsible for the initiation of movement and speech, (c) Broca’s area which lies within the left hemisphere premotor and motor cortex and which is responsible for language fluency, and (d) the prefrontal cortex which is responsible for the most integrative functions of the frontal lobes. The prefrontal cortex can be further subdivided in relation to three different prefrontal syndromes: the orbitofrontal, dorsolateral, and medial frontal syndromes. The orbitofrontal syndrome is characterized by disinhibition, inappropriate affect, impaired judgment and insight, and distractibility. The dorsolateral syndrome is characterized by executive function deficits, perseveration, stimulus-bound behavior, and diminished verbal fluency. The medial frontal syndrome is characterized by apathy, mutism or transcortical motor aphasia, lower extremity paresis, and incontinence (Filey, 2011).

Despite differences, most characterizations of frontal lobes consider the prefrontal cortex as its own area of specialized abilities (Filey, 2011; Kolb & Whishaw, 2011;
Risberg & Grafman, 2006; Stuss, 2011). Once thought of as the root of intelligence, the prefrontal cortex is now more closely associated with the construct of executive functioning. This area of the brain receives information from almost every other brain region and as such is involved in numerous functions (Risberg & Grafman, 2006). Functions of the prefrontal cortex include the control of cognitive processes and the integration of sensory input, temporal and working memory, context, as well as experiences and goals (Kolb & Whishaw, 2011). Similarly, executive functioning is believed to be essential for analyzing the environment, establishing new ways of thinking or adapting previously established ways of thinking, introspection, empathy and self-monitory, inhibitory control etc. Thus, it can be inferred that executive dysfunction can be detected from a number of symptoms, examples of which are impulsivity, poor planning, aggression, poor decision-making, distractibility, etc. (Halligan, Kischka, & Marshall, 2003).

1.2 Executive Functioning and Aging

A substantial amount of neuropsychological literature focuses on the cognitive decline associated with aging; with a significant portion of research exploring how executive functioning is affected. The frontal lobes are particularly affected by aging, with an individual losing approximately 10-17% of the prefrontal cortex over the lifespan. Part of the literature even indicates that tests of executive functioning are better predictors of daily living capabilities of older adults than other cognitive domain tests. Additionally, it has been purported that a person can live productively and independently
if executive functioning skills are intact despite other cognitive domain impairment (Jurado & Rosselli, 2007). Some tasks that are affected by aging are those that utilize simple and choice reaction times, working memory, episodic memory, spatial ability, reasoning ability, mental rotation, and visual-search. The weakened performance on many cognitive tasks has been related to changes in the prefrontal cortex and as such are reported as indicative of executive functioning decline (Verhaeghen, 2011). Additionally, Andres, Guerrini, Phillips, and Perfect, (2008), found that age significantly affected executive but not automatic inhibition.

Age-related differences have also been found in working memory, inhibitory control, long-term memory, and processing speed. Even in tasks that do not reveal age-related differences, such as item recognition, the area of prefrontal cortex activation during the completion of tasks changes with age. In regards to inhibitory control, it has been shown that older adults are more vulnerable to distraction and interference. Processing speed also declines with age, and such decline has been correlated with white matter volume and microstructure. The greatest age-related affects, however, have been seen in long-term memory which has been related to less activation in parts of the prefrontal cortex in some studies (Reuter-Lorenz & Park, 2010). Prefrontal cortex white matter volume has also been linked to increases in perseverative errors with age on a measure of executive set-shifting and strategy generation (Gunning-Dixon & Raz, 2003). Conversely, in a series of meta-analyses by Verhaeghen, it was found that though age-related cognitive decline is the rule, decline in executive functioning plays a minimal part in cognitive decline (Verhaeghen, 2011). This however, may indicate that the processes underlying executive functioning decline are separate from those in cognitive decline.
A known mediator of the effect of aging on cognitive decline is education. Numerous studies have found that education appears to be neuroprotective. Many have found that higher educated individuals perform significantly better on tests of cognitive functioning than their younger counterparts, particularly in older adults (Farmer, Kittner, Rae, Bartko, & Regier, 1995; Ganguli et al., 1991; van Hooren et al., 2007). Effects of education on executive functioning, however, are ambiguous as some research shows this effect to be restricted to specific aspects of executive functioning. In an effort to clear up this ambiguity, an experiment run by Dorbath, Hasselhorn, & Titz, (2013), found that education was protective for performance related to focus-switching for older adults as opposed to younger participants. Yet another study found an age education interaction such that executive functioning declines with age and this decline is perpetuated in those with lower education (Van der Elst, Van Boxtel, Van Breukelen, & Jolles, 2006). Studies such as these highlight the need to understand the relationship demographic characteristics, such as education, have with executive functioning changes over the lifespan.

1.3 Assessments of Executive Function

Executive functioning includes a number of higher order cognitive processes, and researchers have attempted to effectively assess those processes in healthy and clinical populations (Sharma et al., 2014). Because executive functioning is a term that is usually associated with deficits in the frontal lobes or frontally interconnected subcortical regions (Lyon & Krasnegor, 1996), assessments of executive functioning are often used in
clinical populations where such deficits are present, such as neurodevelopmental, neurodegenerative, and neuropsychiatric disorders, as well as in those with acquired brain insults and medical conditions. With all of these populations, it is important to note that multiple components of executive functioning may be affected and for some, the specific ones are not clear, though this does not point to an absence of executive functioning deficits (Y. a. Suchy, 2016). Neurocognitive assessments have also been used with gifted children. Gifted children have been thought to have more executive functioning skills whereas children with intellectual disabilities seem to lack in these skills (Lyon & Krasnegor, 1996).

A number of different assessment methods have been developed to characterize executive functioning. One of the simplest methods is behavioral observation of actions that have been linked to executive functioning such as aggression and dysregulated affect. Similarly, medical record review and clinical interviews that focus on indicators of executive functioning have also been used (Y. a. Suchy, 2016). However, the aforementioned qualitative measures have distinct limitations. Qualitative research has often been criticized as being biased, small scale, anecdotal, lacking rigor, and reliability and validity are often not available (Anderson, 2010).

Numerous measures of executive functioning have been developed to address limitations of qualitative assessment. Gold standard executive functioning measures include the Trail Making Tests and versions of the Stroop Color-Word Interferences Tests (Y. a. Suchy, 2016). The Barkley Deficits in Executive Functioning Scale is another, newer, empirically developed self-report measure of five components of executive functioning that is also offered as another report measure (Barkley, 2011).
Verbal and non-verbal (or figural) fluency tests are also commonly used measures of executive functioning. With all assessments of executive functioning, it is important to keep in mind that because these assessments are measuring the components of the overall construct, executive functioning, any disruption in any one or more component can mimic an issue in executive functioning. To accommodate for this potential problem, it is recommended to use multiple assessments of executive functioning or to administer assessments of other neurocognitive processes in conjuncture. Furthermore, given the integrative nature of human executive functioning, each assessment of executive functioning inevitably reflects multiple components of executive functioning (Y. a. Suchy, 2016).

1.3.1 Verbal Fluency Tests

Verbal Fluency tests are one of the most frequently administered neurocognitive tests and are considered a staple in clinical evaluations of executive functioning (Y. a. Suchy, 2016). Originally developed by Thurstone, they were adopted by Arthur Benton to assess language deficits in head injured patients (Benton, 1968; Thurstone & Thurstone, 1943). Verbal fluency assessments consist of a patient identifying as many words as they can according to specific rules in an allotted amount of time (Van der Elst, Hurks, Wassenberg, Meij, & Jolles, 2011). There are typically two different types of parameters in verbal fluency assessment, semantic and phonemic. On a semantic fluency trial, the individual is tasked with generating words within a particular category. During the phonemic fluency trial, the examinee must generate words that begin with a specific
letter (Shao, Janse, Visser, & Meyer, 2014). Many cognitive processes are activated during these tasks, so a score generated by one of these measures often represents the activation of several brain regions (Tyburski, Sokołowski, Chęć, Pelka-Wysiecka, & Samochowiec, 2015; Weiss et al., 2003). The executive functioning components that verbal fluency tests measure include working memory, goal-directed retrieval, mental flexibility, discrepancy detection, inhibition, initiation, maintenance, and effort mobilization (Y. a. Suchy, 2016). Within the neuropsychology field, verbal fluency tasks are often used to supplement a diagnosis of attention-deficit/hyperactivity disorder, traumatic brain injury, or a neurodegenerative disease such as Alzheimer’s disease or Parkinson’s disease (Shao et al., 2014).

Verbal fluency measures do have known limitations. If used to test individuals with primary speech problems, verbal fluency assessments should be interpreted as measures of language because the speech problems can mimic executive functioning problems on the assessment (Y. a. Suchy, 2016). Because verbal fluency tasks utilize both verbal ability and executive functioning, a poor score can reflect an impairment in either cognitive domain (Shao et al., 2014). Furthermore, in addition to the attention, and inhibitory components of executive functioning that are assessed via verbal fluency tasks, they also tap into semantic memory and vocabulary size (Van der Elst et al., 2011) which may confound interpretation. Despite limitations, verbal fluency measures are still considered a staple in neuropsychological testing.
1.3.2 Figural Fluency Tests

Figural, or design, fluency tests are considered the nonverbal analogues to tests of verbal fluency. They may even be preferential to verbal fluency tasks given their particular sensitivity to frontal lobe damage (Ross, Foard, Hiott, & Vincent, 2003). Tests of figural fluency have been described as tests of initiation, divergent reasoning, and planning that are not susceptible to language, motor or memory deficits (Y. Suchy, Kraybill, & Gidley Larson, 2010). Originally used for the assessment of creativity, figural fluency tasks involve the individual’s generation of novel abstract designs within a limited time (Van der Elst et al., 2011). The specific neurocognitive domains that figural fluency tests measure include working memory, goal-directed retrieval, mental flexibility, discrepancy detection, inhibition, initiation, maintenance, and effort mobilization (Y. a. Suchy, 2016). As such, figural fluency assessments are often regarded as assessments of executive functioning. However, as with any assessment, nonverbal fluency assessments are not without their limitations for use as executive functioning measures though. Nonverbal fluency tests inherently assess additional cognitive constructs beyond executive functionings that include visuoconstruction, visuomotor, and motor planning abilities (Van der Elst et al., 2011).

One of the first tests of design fluency, the Design Fluency Test, was developed by Marilyn Jones-Gotman and Brenda Milner in 1977 to be a nonverbal analogue of Thurstone’s Word Fluency Test. The Design Fluency Test was comprised of two parts. In
the first, participants were asked to invent novel drawings for five minutes, while in the second, participants were asked to invent novel drawings only using four lines for four minutes (Jones-Gotman & Milner, 1977). This test, however, lacked clinical application due to a lack of available normative data, instructional vagueness, and difficulty in scoring (Ruff, Allen, Farrow, Niemann, & Wylie, 1994). Following the development of the Design Fluency Test, several more structured measures were developed. Two of these structured measures are the Five-Point Test and the Ruff Figural Fluency Test.

The Five-Point Test (5PT) developed by Regard, Strauss, and Knapp in 1982, requires the generation of unique figure drawings in a three-minute span by connecting five dots with one or more straight lines. See Figure 1 for illustration of the 5PT.

![Figure 1: Example of the Five Point Test](image)

Scores are comprised of the number of novel designs as well as the percentage of perseverative errors (Fernandez, Moroni, Carranza, Fabbro, & Lebowitz, 2009). The Five-Point Test has demonstrated high interrater reliability, test-retest reliability, and construct validity (Tucha, Aschenbrenner, Koerts, & Lange, 2012). The literature has also
shown that this assessment is sensitive enough to discriminate between psychiatric disorders, non-frontal neurological disease, and frontal lobe dysfunction in patients (Fernandez et al., 2009). Based on clinical studies, there is also evidence that it is sensitive to impairments associated with Alzheimer’s (Bartos, Raisova, & Ripova, 2014) and Parkinson’s Disease (Goebel, Atanassov, Köhnken, Mehdorn, & Leplow, 2013; Tucha et al., 2012). The Ruff Figural Fluency Test was developed by Ronald Ruff as a modification of the Five-Point Test (Izaks, Joosten, Koerts, Gansevoort, & Slaets, 2011). While the first trial is similar to the Five-Point Test, the second and third trial incorporate distractors, and the fourth and fifth trials have a different arrangement of dots (Ross et al., 2003). Thus, the Ruff Figural Fluency Test is longer than the Five-Point Test, and, as such, increases demands on concentration and attention. Therefore, patients with deficits in executive functioning and attention may be stressed and experience difficulty (Tucha et al., 2012). Among individuals with Parkinson’s disease, researchers demonstrated that the 5PT was superior to the Ruff Figural Fluency Test in detection of perseverative and strategic deficits (Goebel et al., 2013).

Another widely used nonverbal fluency test is the Delis Kaplan Executive Functioning System Design Fluency Test (DKEFS Design Fluency Tests) which was developed as part of a neuropsychological test battery to test executive control functions (Delis, Kramer, Kaplan, & Holdnack, 2004). The DKEFS Design Fluency Test consists of three one-minute trials during which the participant must generate as many unique designs as possible. Unlike the Five-Point Test, the DKEFS Design Fluency Test includes two trials of distractors, trials two and three of the measure include both filled and open
dots (Y. Suchy et al., 2010). See Figure 2 for an illustration of the two types of dot layouts on the DKEFS Design Fluency Test.

![Figure 2: Two Dot Layouts on the Delis Kaplan Executive Functioning System Design Fluency Test](image)

The DKEFS Design Fluency test has been normed in numerous samples, including male criminal offenders, teens with diabetes mellitus type 1, community-dwelling older adults, and children with high-functioning autism. Internal consistency reliability among the various samples ranges from .13 to .73 (Y. a. Suchy, 2016). In their findings, Suchy et al., suggest that the last trial of the DKEFS Design Fluency Test be considered separately from the other first two trials, as it may rely more heavily on attentional resources and less on executive functions (Y. Suchy et al., 2010).
1.4 The Quantified Process Approach

Until the 1970s, clinical neuropsychology as a field focused on a strongly empirical approach (Grant & Adams, 2009). In the 1970s, a group of American neuropsychologists adopted a method of assessment scoring and interpretation previously only employed in Europe. Known as the process approach, it involves an examination of the method and strategies an examinee utilizes while completing a test or task. Proponents of the process approach suggest that the process by which people arrive at their conclusion is at least as important as their calculated score. The Boston Process Approach was one of the first attempts to integrate the European process approach in the United States (Poreh, 2006). The basis of the Boston Process Approach is the integration of qualitative, quantitative, and behavioral information provided by psychometric assessments (Grant & Adams, 2009). This approach allowed clinicians to quantify behaviors, as well as operationally define clinical thresholds, such that clinical studies could be repeated. However, the Boston Process Approach has not been subjected to empirical systematic documentation and research, and it remains a highly subjective approach to neuropsychological process interpretation. As such, the need to improve objectively and reliability over the Boston Process Approach brought about the Quantified Process Approach. The Quantified Process Approach attempts to emirate qualitative measures into new indices so as to provide a quantified measure of a participant’s process (Poreh, 2006). An individual’s process, and how these processes change in the presence of executive functioning deficits may provide enhanced
assessment of executive functions and therefore greater insight into executive dysfunction among clinical populations.

Process research for verbal fluency tasks is abundant. Researchers have revealed the primary strategies associated with verbal fluency performance and characterized process changes within clinical samples. The two strategies in verbal fluency tests are thought to be clustering and switching. Clustering involves the application of semantic conceptual clusters, which are two or more consecutive words that are associated with one another. Switching is defined as the ability to switch between clusters. Among healthy individuals, research has indicated that switching is the primary process associated with phonemic fluency performance, whereas semantic fluency performance involves both switching and clustering strategies. In a sample of schizophrenics, strategy use was impaired in comparison to the healthy individuals (Robert et al., 1998). In a comparison study of normal aging and Alzheimer’s, it was found that individuals with Alzheimer’s disease produced less words and utilized switching less frequently for semantic fluency than the healthy control group. For phonemic fluency, the individuals with Alzheimer’s disease produced less clusters, but the two groups did not differ in number of switches or the size of the clusters (Haugrud, Crossley, & Vrbancic, 2011). Additionally, it has been found that when comparing younger and older healthy adults, that older adults switch less frequently on semantic fluency and produce larger clusters on phonemic fluency than younger adults. This provides support for the idea that the strategy of switching on verbal fluency measures, is indicative of executive functioning (Trorey, Moscovitch, & Winocur, 1997).
While a more mature literature base exists for examination of verbal fluency process, figural fluency process research is sparse. Moreover, process research for figural fluency within clinical populations is even more scant. In a study of HIV-positive individuals, it was found that cognitive impairment was associated with poor organizational strategy on the Rey Complex Figure Test (Gouse et al., 2016). In a study comparing individuals with Parkinson’s disease with normal controls, Jaywant et al. (2014) found that strategy use on figural fluency measures correlated with responses with both left-body onset and right-body onset Parkinson’s disease but not in normal controls. Studies such as these provides support for the use of strategy scores in assessment, although more research is needed.

1.5 The Present Study

Although separate studies have considered the reliability and validity of the Five-Point Test and the D-KEFS Design Fluency Test, these tests have yet to be directly compared to one another and little is known about the differences in these tests’ sensitivities to executive functioning. In particular, the reliability and validity of the strategy scores of the Five-Point Test are unclear. Because of this, one of the primary focuses of this study was to compare the psychometric properties of the Five-Point Test and the D-KEFS Design Fluency Test. Also, the sensitivity of the Five-Point Test and D-KEFS Design Fluency to detect executive dysfunction will be explored by correlating performances on these tests to the Barkley Deficits in Executive Functioning Scale – Short Form (BDEFS - SF).
Additionally, frontal lobe functioning, and in turn executive functioning, prioritize strategies which makes it important to look at strategy rather than just process scores of assessments of executive functioning. Because evidence suggests that the quantified process approach is more insightful into actual functioning, another primary focus of this study is to explore whether strategies used on the Five-Point Test are better correlated to executive functioning than the summary score. Specifically, as there is indication in the literature that the switching strategy is correlated with executive functioning, it is foreseeable that switching will correlate better with the summary score of the BDEFS-SF. This is especially important when considering that executive functioning is an unstable construct and thus the reliabilities of most summary scores are unstable (Y. a. Suchy, 2016).

Furthermore, because little is known on how figural fluency is affected by the normal aging process, another primary focus of this study was to examine the effects of age on both strategy and summary scores, with a specific focus on how these effects are different according to age of onset of decline as well as how these effects are mediated by education. Verbal and nonverbal fluency assessments are thought to utilize similar components of executive functioning and as such, research into age-related changes on verbal fluency tests can provide insight into how age effects figural fluency.

It is also foreseeable that normative data was gathered for both the Five-Point Test and the D-KEFS Design Fluency Test.
1.6 The Purpose of the Present Study

The proposed study has three specific aims:

**Specific Aim 1:** To compare the reliabilities and sensitivities to executive functioning of different scores on the Five-Point Test and the D-KEFS Design Fluency Test.

**Hypothesis 1:** The Five-Point Test will be more reliable and sensitive to executive functioning deficits than the D-KEFS Design Fluency Test.

**Specific Aim 2:** To correlate the different strategies used on the Five-Point Test with executive functioning.

**Hypothesis 2:** The strategies used will correlate better with executive functioning than summary scores for the Five-Point Test, specifically the switching strategy will be correlated better with executive functioning.

**Specific Aim 3:** To assess the relationship between age, gender, education and nonverbal fluency.

**Hypothesis 3:** Number of unique designs will show an age-related decline that will be mediated by education level. The type of strategy used will be different for younger and older healthy adults and overall strategy scores will decline with age. Education will be neuroprotective in terms of onset of decline.
**Exploratory Aims:** A normative sample will be compiled for the Five-Point Test and the D-KEFS Design Fluency Test.
CHAPTER II

METHOD

2.1 Participants

One hundred and thirty participants from Cleveland State University were recruited from two undergraduate psychology courses. These participants were given participation credit for their participation. Another one hundred and seventy-six participants from the community were recruited from those serving jury duty in Cuyahoga County.

Participants had a mean age of 36.89 (SD = 18.08) and mean years of education was 14.65 (SD = 2.85). The majority of the sample was female (70.3%), white (76.0%), and with a primary language of English (97.7%). Demographic characteristics can be seen in Table I.
**Table 1: Demographic Characteristics of a Normative Sample of 306 Individuals**

<table>
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<th>N (%)</th>
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<tr>
<td><strong>Sex</strong></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>89 (29.7)</td>
</tr>
<tr>
<td>Female</td>
<td>211 (70.3)</td>
</tr>
<tr>
<td><strong>Race</strong>&lt;sup&gt;a&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>225 (76.0)</td>
</tr>
<tr>
<td>African-American</td>
<td>54 (17.6)</td>
</tr>
<tr>
<td>Other</td>
<td>17 (5.6)</td>
</tr>
<tr>
<td><strong>Primary Language</strong></td>
<td></td>
</tr>
<tr>
<td>English</td>
<td>297 (97.7)</td>
</tr>
<tr>
<td>Other</td>
<td>7 (2.3)</td>
</tr>
</tbody>
</table>

<sup>a</sup>Participants endorsed identification with only one category; race categories were mutually exclusive.

2.2 Instruments

2.2.1 The Demographic Survey

Participants were given a short demographic survey to eliminate any participants that have previously undergone tests of fluency to control for potential test retest bias. The demographic survey included questions about age, race, gender, highest level of schooling achieved, and primary language. See *Figure 3* for illustration of demographic survey.
2.2.2 Computer Assisted Software

The computer assisted version of the Five-Point Test was developed by Dr. Amir Poreh and Quantified Process Scoring Systems (QPSS Inc.). The software includes both the test and a scoring algorithm. The Scoring algorithm provides scores for the following: process, errors, overall strategy, rotation, addition, and subtraction. See Figure 4 for illustration of the software printout.
Figure 4: Page Two of the QPSS-FPT Software Printout
2.2.3 The Five-Point Test

Participants were administered the Five-Point Test, devised by Marianne Regard and her colleagues, following methods described in previous research (Regard, Strauss, & Knapp, 1982). The test consists of pages with 40 contiguous 5 X 8 squares, each with five symmetrically and identically arranged dots. Participants were asked to create as many designs by connecting two or more dots with straight lines as possible in a three-minute period of time. Number of unique designs as well number of errors were scored. The possible errors are perseverative, repetition of a design, and rule, designs with lines that fail to connect dots (Tucha et al., 2012).

2.2.4 The Delis Kaplan Executive Functioning System Design Fluency Test

Participants were administered the Delis Kaplan Executive Functioning System Design Fluency Test (D-KEFS Design Fluency Test) following methods described in previous research (Y. Suchy et al., 2010). The D-KEFS Design Fluency Test consists of three one-minute trials. The three trials are Filled dots, the participant makes as many unique designs as they can by connecting filled dots with four lines, Empty Dots, the participant makes as many unique designs as they can by connecting empty dots with four lines, and Switch, participants make as many unique designs as they can by connecting both empty and filled dots in a switching pattern with four lines. Number of unique designs were scored (Y. Suchy et al., 2010).
2.2.5 The Barkley Deficits in Executive Functioning Scale - SF

Participants were administered the Barkley Deficits in Executive Functioning Scale for Adults – Short Form (BDEFS-SF), a test devised by Russell A. Barkley, as a self-report measure of executive functioning. The original test consists of 89 items which take approximately 15-20 minutes to administer, each inquiring the frequency of certain behaviors in the past six months. The short form (SF) of the test consists of 20 items from the original test and takes four to five minutes to administer. Each item is measured on a four point Likert-type scale ranging from never to very often. The test contains five subscales: Self-management to time, self-organization/problem solving, self-restraint, self-motivation, and self-regulation of emotion (Barkley, 2011).

2.3 Procedure

2.3.1 Classroom

Participants were randomized into one of two groups based on which test of figural fluency was administered first. The first group received the Five-Point Test first, the second the D-KEFS Design Fluency Test. This was to ensure a randomized block design.

Participants were first passed out a consent form to be signed prior to the start of test administration. After signed consent forms were collected, participants were given a short demographic survey, see Figure 3. Afterwards, participants were given either the
Five-Point Test or the D-KEFS Design Fluency Test. After the first figural fluency test, participants were administered the second test. Following both tests of figural fluency, the BDEFS-SF was administered. The process took approximately 30 minutes.

Participants were contacted approximately two and a half months after completion and those who were willing to retake the Five-Point Test and the D-KEFS Design Fluency Test were asked to come in again. Scores were compared to establish test-retest reliability.

2.3.2 Community

Participants serving jury duty in Cuyahoga County were first introduced to the co-investigator and the thesis project as part of their introduction to serving as jurors. Each participant was given the option to go to a conference room set up by the Justice Center for the co-investigator to participate either as a group or individually. Only the Five-Point Test was administered to the jurors to save time.

Participants were first passed out a consent form to be signed prior to the start of test administration. After signed consent forms were collected, a short demographic survey was given to the participants, see Figure 3. Afterwards, participants were given the Five-Point Test. Following the test, the BDEFS-SF was administered. The process took approximately 15 to 20 minutes.
2.3.3 Data Analysis

All the tests except the Five-Point Test were graded by hand to grade for total scores, and number of errors were calculated for the D-KEFS Design Fluency Test. The computer assisted software was used to grade the Five-Point Test for summary and strategy scores as well as errors. The results of the Five-Point Test were entered manually into the SPSS software.

General descriptive statistics, including mean, standard deviation, skewness and kurtosis, were analyzed. For all tests, participants that indicated a race other than White or African American were consolidated into an “other race” category due to the very small sample size, see Table 1. To test the test-retest reliability of the Five-Point Test and the D-KEFS Design Fluency Test, bivariate correlations were conducted on the total scores and the number of perseverative errors of each assessment and the strategy scores of the Five-Point Test at the two different time points. To determine which assessment’s test-retest reliability is significantly better, Fishers Z-transformation was conducted. To test whether the validity of the Five-Point Test and the D-KEFS Design Fluency Test, bivariate correlations were conducted between total scores and the number of perseverative errors on the tests and the total score on the BDEFS-SF. To test which validity is significantly better, Fishers Z-transformation was conducted. To test whether strategy scores correlate better than total scores on the Five-Point Test, bivariate correlations were conducted between the strategy scores and the summary scores of the Five-Point Test and the total score on the BDEFS-SF. To test which correlates better,
total score or strategy score, Fisher’s Z-transformation was conducted between the
correlations for total score and strategy score for the Five-Point Test. To assess how the
different nonverbal abilities, as measured by the different scores on the figural fluency
measures, are affected by the normal aging process as well as by education, each score
was correlated with age and education. Mediation tests were run to analyze the effect of
education on the relationship between age and nonverbal fluency decline. All statistical
analyses were performed using IBM SPSS Statistics 22, G*Power 3.1.9.2, and Microsoft
Excel 2016.

The study was approved by the Cleveland State University Institutional Review
Board and all study participants provided written informed consent. Data were collected
between June, 2016 and October, 2016.
CHAPTER III

RESULTS

Independent samples t-tests with the demographic variables of age, \( t(296) = 1.86, p = .064 \), \( d = .46 \), and education, \( t(298) = 2.90, p = .004, d = .83 \) being the dependent variables and gender being the independent variable found that men in the sample were older and that men possessed significantly more years of education than women. Pearson correlations were significant between age and education confirming the presence of a cohort effect, \( r_s = .448, p < .001 \). ANOVA analysis race as an independent variable and age as a dependent variable revealed significant race effects on age, \( F(2,292) = 5.30, p = .005 \), and on education, \( F(2,292) = 4.98, p = .007 \). Post hoc comparisons using LSD indicated that participants from the other race category (\( M=24.06, SD=7.51 \)) were younger than both white (\( M=38.11, SD=18.61 \)) and African American participants (\( M=34.74, SD=16.55 \)), but white and African American participants did not differ significantly in age. Post hoc comparisons for education using LSD indicated that white
participants (M=14.92, SD=2.79) had more years of education than African American participants (M=13.71, SD=2.15), while participants in the other race category (M=14.00, SD=2.47) did not differ significantly from either white or African American participants.

3.1 Hypothesis 1

Retests were conducted approximately two months apart in a subsample of 22 undergraduates who had a mean age of 20.55 (SD = 6.20) and mean years of education was 13.41 (SD = 1.82). The majority of the subsample was female (86.4%), white (59.1%), and with a primary language of English (95.5%).

The test-retest reliabilities were calculated utilizing non-parametric correlations of the various scores of the 5PT and scores of the DKEFS Design Fluency Test are presented in Table II. Fisher’s Z-transformation found that the reliabilities for unique scores, $Z(22) = .84, p = .20$, and for repetitions, $Z(22) = .21, p = .42$, between the 5PT and the DKEFS Design Fluency Test were not significantly different.
Table II: Test-Retest Pearson Correlations for the Five Point Test and the Delis Kaplan Executive Functioning System Design Fluency Test

<table>
<thead>
<tr>
<th>Test</th>
<th>rs (p-value)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Five-Point Test</strong></td>
<td></td>
</tr>
<tr>
<td>Designs</td>
<td>.50 (.019) *</td>
</tr>
<tr>
<td>Repetitions</td>
<td>.53 (.010) *</td>
</tr>
<tr>
<td>Rule Break</td>
<td>-.07 (.760)</td>
</tr>
<tr>
<td>Unique Designs</td>
<td>.58 (.005) **</td>
</tr>
<tr>
<td>Addition</td>
<td>.48 (.024) *</td>
</tr>
<tr>
<td>Subtraction</td>
<td>-.12 (.585)</td>
</tr>
<tr>
<td>Rotation</td>
<td>.84 (&lt; .001) **</td>
</tr>
<tr>
<td>Strategy</td>
<td>.73 (&lt; .001) **</td>
</tr>
<tr>
<td><strong>Delis Kaplan Executive Functioning System Design Fluency Test</strong></td>
<td></td>
</tr>
<tr>
<td>Unique Designs</td>
<td>.69 (&lt; .001) **</td>
</tr>
<tr>
<td>Repetitions</td>
<td>.02 (.934)</td>
</tr>
</tbody>
</table>

* trend level findings. * p < .05. ** p <.01

Non-parametric correlation analyses between the self-report measure of executive functioning, the BDEFS-SF and the 5PT are presented in Table III.
Table III: Summary of Non-Parametric Intercorrelations for the Five Point Test Scores and the Barkley Deficits in Executive Functioning - SF

<table>
<thead>
<tr>
<th>Five Point Test</th>
<th>Barkley Deficits in Executive Functioning - SF</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Self-Management</td>
</tr>
<tr>
<td>Designs</td>
<td>.05</td>
</tr>
<tr>
<td></td>
<td>(.205)</td>
</tr>
<tr>
<td>Repetitions</td>
<td>-.04</td>
</tr>
<tr>
<td></td>
<td>(.273)</td>
</tr>
<tr>
<td>Rule Break</td>
<td>.03</td>
</tr>
<tr>
<td></td>
<td>(.282)</td>
</tr>
<tr>
<td>Unique Designs</td>
<td>.03</td>
</tr>
<tr>
<td></td>
<td>(.306)</td>
</tr>
<tr>
<td>Addition</td>
<td>-.03</td>
</tr>
<tr>
<td></td>
<td>(.279)</td>
</tr>
<tr>
<td>Subtraction</td>
<td>.03</td>
</tr>
<tr>
<td></td>
<td>(.282)</td>
</tr>
<tr>
<td>Rotation</td>
<td>-.04</td>
</tr>
<tr>
<td></td>
<td>(.244)</td>
</tr>
<tr>
<td>Strategy</td>
<td>-.02</td>
</tr>
<tr>
<td></td>
<td>(.365)</td>
</tr>
</tbody>
</table>

P-values for correlations are reported in parenthesis. T trend level findings. * p < .05. ** p < .01

To control for the effects of age and education, partial correlation analyses were conducted between the self-report measure of executive functioning, the BDEFS-SF and the 5PT are presented in Table IV.
### Table IV: Summary of Partial Intercorrelations for the Five Point Test Scores and the Barkley Deficits in Executive Functioning - SF

<table>
<thead>
<tr>
<th>Five Point Test</th>
<th>Barkley Deficits in Executive Functioning - SF</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Self-Management</td>
<td>Self-Organization</td>
<td>Self-Restraint</td>
<td>Self-Motivation</td>
<td>Self-Regulation</td>
<td>Total</td>
</tr>
<tr>
<td>Designs</td>
<td>.06</td>
<td>-.04</td>
<td>.08</td>
<td>-.02</td>
<td>-.03</td>
<td>.02</td>
</tr>
<tr>
<td></td>
<td>(.145)</td>
<td>(.267)</td>
<td>(.081) T</td>
<td>(.372)</td>
<td>(.289)</td>
<td>(.386)</td>
</tr>
<tr>
<td>Repetitions</td>
<td><strong>.10</strong></td>
<td><strong>.12</strong></td>
<td><strong>.10</strong></td>
<td><strong>.13</strong></td>
<td>.06</td>
<td><strong>.15</strong></td>
</tr>
<tr>
<td></td>
<td>(.043) *</td>
<td>(.021) *</td>
<td>(.038) *</td>
<td>(.011) *</td>
<td>(.157)</td>
<td>(.005) **</td>
</tr>
<tr>
<td>Rule Break</td>
<td>.02</td>
<td>-.02</td>
<td>.05</td>
<td>-.03</td>
<td>-.07</td>
<td>-.02</td>
</tr>
<tr>
<td></td>
<td>(.378)</td>
<td>(.348)</td>
<td>(.213)</td>
<td>(.300)</td>
<td>(.103)</td>
<td>(.374)</td>
</tr>
<tr>
<td>Unique Designs</td>
<td>.03</td>
<td>-.08</td>
<td>.05</td>
<td>-.07</td>
<td>-.05</td>
<td>-.04</td>
</tr>
<tr>
<td></td>
<td>(.315)</td>
<td>(.074) T</td>
<td>(.216)</td>
<td>(.122)</td>
<td>(.187)</td>
<td>(.264)</td>
</tr>
<tr>
<td>Addition</td>
<td>.05</td>
<td>-.05</td>
<td><strong>.10</strong></td>
<td>.05</td>
<td>-.08</td>
<td>.00</td>
</tr>
<tr>
<td></td>
<td>(.200)</td>
<td>(.203)</td>
<td>(.047) *</td>
<td>(.176)</td>
<td>(.097) T</td>
<td>(.497)</td>
</tr>
<tr>
<td>Subtraction</td>
<td>.00</td>
<td>-.01</td>
<td>-.02</td>
<td>.01</td>
<td>-.01</td>
<td>-.018</td>
</tr>
<tr>
<td></td>
<td>(.479)</td>
<td>(.457)</td>
<td>(.358)</td>
<td>(.415)</td>
<td>(.450)</td>
<td>(.380)</td>
</tr>
<tr>
<td>Rotation</td>
<td>-.06</td>
<td>-.07</td>
<td>-.02</td>
<td>-.10</td>
<td>-.04</td>
<td>-.08</td>
</tr>
<tr>
<td></td>
<td>(.141)</td>
<td>(.129)</td>
<td>(.355)</td>
<td>(.041) *</td>
<td>(.236)</td>
<td>(.087) T</td>
</tr>
<tr>
<td>Strategy</td>
<td>-.03</td>
<td>-.09</td>
<td>.03</td>
<td>-.06</td>
<td>-.09</td>
<td>-.08</td>
</tr>
<tr>
<td></td>
<td>(.302)</td>
<td>(.058) T</td>
<td>(.279)</td>
<td>(.141)</td>
<td>(.072) T</td>
<td>(.093) T</td>
</tr>
</tbody>
</table>

P-values for correlations are reported in parenthesis. T trend level findings. * p < .05. ** p < .01

Similar correlations between the BDEFS-SF and the DKEFS Design Fluency Test are presented in Table V.
Table V: Summary of Non-Parametric Intercorrelations for the Delis Kaplan Executive Functioning Systems Design Fluency Test and the Barkley Deficits in Executive Functioning -SF

<table>
<thead>
<tr>
<th>DKEFS Design Fluency</th>
<th>Barkley Deficits in Executive Functioning Scale - SF</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Self-Management</td>
</tr>
<tr>
<td>Repetitions</td>
<td>-.02 (.431)</td>
</tr>
<tr>
<td>Unique Designs</td>
<td>-.03 (.369)</td>
</tr>
</tbody>
</table>

P-values for correlations are reported in parenthesis. \( ^\dagger \) trend level findings. * \( p < .05 \). ** \( p < .01 \)

To control for the effects of age and education, partial correlation analyses were conducted between the BDEFS-SF and the DKEFS Design Fluency Test are presented in Table VI.

Table VI: Summary of Partial Intercorrelations for the Delis Kaplan Executive Functioning Systems Design Fluency Test and the Barkley Deficits in Executive Functioning -SF

<table>
<thead>
<tr>
<th>DKEFS Design Fluency</th>
<th>Barkley Deficits in Executive Functioning Scale - SF</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Self-Management</td>
</tr>
<tr>
<td>Repetitions</td>
<td>.08 (.189)</td>
</tr>
<tr>
<td>Unique Designs</td>
<td>-.04 (.342)</td>
</tr>
</tbody>
</table>

P-values for correlations are reported in parenthesis. \( ^\dagger \) trend level findings. * \( p < .05 \). ** \( p < .01 \)
Repetition rate per design was calculated for repetitions made on the 5PT by dividing number of repetitions by number of designs created. Repetition rate per minute on the 5PT can be seen in Figure 5.

![Figure 5: Repetition Rate on the Five Point Test as a Function of Minutes on the Five Point Test](image)

Paired samples t-tests were significant for the 5PT repetitions per designs created in minute one (M=.01, SD=.03) versus minute two (M=.02, SD=.04) and versus minute three (M=.03, SD=.04) such that participants made significantly more repetitions per design created in minute two and in minute three than in minute one, \( t(134) = -3.14, p = .002, d = .88 \) and \( t(134) = -4.83, p < .001, d = .998 \), respectively. Paired samples t-test were also significant for the 5PT repetitions per designs created minute two versus minute three such that participants made significantly more repetitions per design created in minute three than in minute two, \( t(134) = -2.28, p = .02, d = .62 \).
3.2 Hypothesis 2

As presented in Table 2, only the unique design ($r_s$=-.10, $p$=.040), addition ($r_s$=-.13, $p$=.013) and strategy ($r_s$=.10, $p$=.048) of the 5PT correlate significantly with the self-organization subscale of the BDEFS-SF; only the addition ($r_s$=-.12, $p$=.018) of the 5PT correlate significantly with the self-regulation subscale of the BDEFS-SF; and only the rotation ($r_s$=-.10, $p$=.045) of the 5PT correlate significantly with the total score on the BDEFS-SF.

Fisher’s Z-transformation found that the correlations for the unique design score and strategies used on the 5PT were not significantly different with the BDEFS-SF total score, $Z(298) = .61$, $p = .271$; the BDEFS-SF self-management score, $Z(302) = .61$, $p = .271$; the BDEFS-SF self-organization score, $Z(302) = 0$, $p = .500$; the BDEFS-SF self-restraint score, $Z(302) = .37$, $p = .356$; the BDEFS-SF self-motivation score, $Z(301) = -.12$, $p = .452$; and the BDEFS-SF self-regulation score, $Z(298) = .61$, $p = .271$.

3.3 Hypothesis 3

ANOVA analysis revealed significant race effects on number of unique designs on the 5PT, $F(2,292) = 3.93$, $p = .021$, and on strategy used on the 5PT, $F(2,292) = 8.89$, $p < .001$. Post hoc comparisons using LSD indicated that white participants (M=35.32, SD=10.52) created more unique designs than African American participants (M=31.22, SD=10.52).
SD=8.42), while participants in the other race category (M=32.12, SD=11.55) did not differ significantly from either white or African American participants. Similarly, post hoc comparisons for strategies used on the 5PT using LSD indicated that white participants (M=16.04, SD=7.75) utilized more strategy than African American participants (M=11.22, SD=7.43), while participants in the other race category (M=13.24, SD=8.48) did not differ significantly from either white or African American participants.

Pearson correlations were significant between age and number of unique designs on the 5PT, $r_s = -0.21$, $p < 0.001$ but only a trend level correlation between age and strategies used on the 5PT, $r_s = -0.11$, $p = 0.051$. A mediation analysis was significant such that education mediated the relationship between age and number of unique designs on the 5PT, $b = 0.086$, 95% BCa CI [.035, .138]. This relationship is illustrated in Figure 6.

![Figure 6: Unique Designs on the Five Point Test as a Function of Age](image)

**Figure 6: Unique Designs on the Five Point Test as a Function of Age**

*Range Separated by Education Level*
A mediation analysis was significant as well for the relationship between age and strategies used on the 5PT, $b = .069$, 95% BCa CI [.014, .122]. This relationship is depicted in Figure 7.

![Figure 7: Strategy Use Rate Per Unique Design on the Five Point Test as a Function of Age Range Separated by Education Level](image)

ANOVA analysis revealed significant primary language effects on repetitions made on the DKEFS Design Fluency Test such that those with a primary language other than English made significantly more repetitions, $F(1,128) = 5.60, p = .019$. 

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3.4 Exploratory Aims

Means and standard deviations for the 5PT in healthy adults with at least high school education (12+ years of education) are presented in *Table VII*.

*Table VII: Normative Data for the Five Point Test for Healthy Adults With at Least 12 Years of Education*

| Age Range (N) | Unique Designs | | | Repetitions | | | Strategy | |
|---------------|----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
|               | M              | SD              | M              | SD              | M              | SD              |
| 18-22 (N=113) | 35.25          | 10.78           | 2.31           | 3.43            | 15.21          | 8.75            |
| 23-29 (N=27)  | 37.63          | 12.18           | 2.22           | 2.93            | 16.52          | 8.43            |
| 30-39 (N=30)  | 37.97          | 10.50           | 2.30           | 3.29            | 17.20          | 7.46            |
| 40-49 (N=28)  | 35.25          | 9.66            | 3.50           | 8.15            | 15.00          | 8.07            |
| 50-59 (N=46)  | 33.65          | 8.31            | 2.89           | 2.59            | 14.65          | 6.53            |
| 60-69 (N=38)  | 28.95          | 10.01           | 2.24           | 2.25            | 12.97          | 6.64            |
CHAPTER IV

DISCUSSION

The present study aimed to test the reliability and validity of various scores of the 5PT and the D-KEFS Design Fluency Test, compare the summary and strategy scores of the 5PT, and assess the extent to which age and education affect nonverbal fluency. In addition, normative data for the 5PT in an adult population with at least 12 years of education were collected.

Our findings were unable to replicate the high test-retest reliability for the 5PT demonstrated by Tucha et al., 2012. Significant test-retest reliabilities for designs, repetitions, unique designs, addition, rotation, and strategy scores of the 5PT were found and indicate fair test-retest reliability. However, only the rotation and strategy score test-retest reliabilities of the 5PT exceed the minimum of acceptable reliability of .7 and only rotation exceeds the minimum of good reliability of .8 as has been shown in the literature.
Conversely, only the unique design score of the D-KEFS Design Fluency Test was significant and was near acceptable reliability. Though it could be argued that only the reliabilities of the 5PT can be considered acceptable or good, the reliabilities of the 5PT and the D-KEFS Design Fluency Test were found to not be significantly different, inconsistent with what was hypothesized.

Individuals made more preservative errors in minute two than in minute one and the most in minute three on the 5PT. Such findings suggest that the one minute trial administration of the D-KEFS Design Fluency Test is not enough time for participants to make meaningful perseverative errors. Though not replicated in this data, repetitions on figural fluency tasks have been linked to executive functioning. As such, it is important that a test of nonverbal fluency provide adequate time for participants to commit clinically meaningful mistakes. This finding could further indicate that the 5PT is a better measure of nonverbal executive functioning overall.

Review of the scores for the 5PT and the D-KEFS Design Fluency Test and their correlations with the self-report measure of executive functioning revealed several meaningful correlations. Total unique designs is a commonly utilized summary score on the 5PT, and it correlated with the self-organization scale on the BDEFS-SF. Addition and strategy scores on the 5PT also correlated meaningfully with the self-organization scale of the BDEFS-SF. The addition score also correlated with the self-regulation scale on the BDEFS-SF and the rotation score correlated with the total score on the BDEFS-SF. In analyzing the D-KEFS Design Fluency Test, only unique designs correlated with the self-motivation scale on the BDEFS-SF. Taken together, strategy scores appear to correlate better with self-reported executive functioning symptoms, thus providing
support for the Quantified Process Approach. However, strategy scores did not correlate significantly better than unique designs on the 5PT. The finding further supports the use of the 5PT over the D-KEFS Design Fluency Test due to option of strategy scores on the 5PT. A possible alternative explanation for the insignificant results in correlating figural fluency to the BDEFS-SF is that the self-report measure is not a good indicator of actual executive functioning. Indeed, the present findings are consistent with the literature which indicates that self-report measures of cognitive functioning rarely correlate with actual performance on neuropsychological tests.

Because age and education have been found to affect the summary and strategy scores on both the 5PT and the DKEFS Design Fluency Test, partial correlations were run between the 5PT and the D-KEFS Design Fluency Test with the self-report measure of executive functioning. When controlling for age, repetitions on the 5PT were significant correlates with all scores on the BDEFS-SF except for the self-regulations scale. In other words, the more repetitions made on the 5PT, the more self-reported executive functioning problems were reported on the BDEFS-SF. Previous research has demonstrated that repetitions are representative of the dysexecutive symptom of perseveration. Of the strategy scores on the 5PT, addition correlated meaningfully with the self-restraint scale and rotations correlated meaningfully with the self-motivation scale on the BDEFS-SF. This provides evidence against the hypothesis that strategy scores would provide a more meaningful insight into executive functioning. Furthermore, repetitions on the DKEFS Design Fluency Test correlated meaningfully with all the scores on the BDEFS-SF, except for the self-management and self-restraint scales. Again, the more repetitions made on the DKEFS Design Fluency Test, the more self-reported
executive functioning problems reported on the BDEFS-SF. The unique designs on the DKEFS Design Fluency Test also correlated meaningfully with the self-organization and the self-motivation scales on the BDEFS-SF. Taken together, these findings indicate the sole use of repetitions scores as being most representative of executive functioning deficits.

The effects of race on nonverbal fluency were explored, and white participants created more unique designs and utilized more strategy on the 5PT than African American participants. Such a finding may suggest race differences in executive functioning. Conversely, socioeconomic and minority statuses may have contributed to differences. A strong correlation exists between ethnic minority status and socioeconomic status, and previous research demonstrated that socioeconomic status predicts working memory, income changes correlate with executive functioning changes, and income and maternal education predict executive functioning (Silvia M., 2015).

Primary language was also found to have significant effects on perseverations on the D-KEFS Design Fluency Test such that participants with a primary language other than English made significantly more repetitions. This effect was not seen in the 5PT, possibly due to the increased instruction on the D-KEFS Design Fluency Test as opposed to the 5PT. The 5PT may therefore have greater generalizability to other cultures.

As the literature into verbal fluency indicates education to be neuroprotective, education was analyzed as a potential mediator of the significant correlation between age and unique designs and the nearly significant correlation between age and strategies used on the 5PT. Consistent with the literature, education was found to be significant mediator, despite problems with underrepresentation of lower education participants. Additionally,
this could mean that education is also neuroprotective for nonverbal fluency. As such, when thinking about the data presented by the current study, executive functioning performance at a given age should be thought of as being a function of maximum performance and the exponential value of decline after the threshold education level is achieved.

LIMITATIONS OF THE STUDY

There are several limitations to the current study which may impact the generalizability of the results. Namely, the very small subsample that made up the test-retest group and thus the negative results may be a result of a lack of power to detect differences between groups. Additionally, this small subsample was taken from a group of undergraduates which brings into question the motivation of this sample to take the research process seriously. The sample was also made up largely of highly educated individuals, and as such though education was found to be a significant mediator of the relationship between age and nonverbal fluency decline, the threshold of this mediation effect is yet to be determined. Additionally, age and education were highly correlated in this sample, indicating a need for a more normative sample. Future research might look to collecting profession in addition to education level as a way to control for education type as well.

Another limitation of the current study, that has been noted in the literature as well, is that with nonverbal assessments of executive functioning, other cognitive constructs are also being assessed at the same time. In the current study, performance
may be effected by graphomotor speed, a component not controlled for by the current study. Future research might look to creating a pre-trial to the 5PT, such as a trial requiring participants to connect dots in a specific manner in an allotted amount of time.

Self-report measures of neuropsychological performance have also been found by previous literature to be a poor representation of actual neuropsychological functioning. As such, future research may look to correlate measures, such as the 5PT and the DKEFS Design Fluency Test, with other well-known non-self-report measures of executive functioning, such as the Trail Making Test: Trail B or with measures of components of executive functioning.
CHAPTER V

CONCLUSIONS

In summary, given the extensive importance of executive functioning combined with the widespread decline seen with normal aging, the results of the current study may provide useful information to advance understanding on the effects of other demographic variables, such as education, on this process. In addition, when looking to nonverbal fluency measures as assessments of executive functioning, the findings in this study support the previous literature that repetitions on nonverbal fluency measures are indicative of executive functioning and as such should hold more weight. High education appears to have a neuroprotective effect on the decline of nonverbal executive functioning over the lifespan. Future studies might look into the exact threshold of neuroprotective education level as well as the effects of other demographic variables.
REFERENCES


Silvia M., H. G. (2015). *The Impact of Ethnicity on Executive Functioning in Youth.* (Doctor of Philosophy), DePaul University, College of Science and Health Theses and Dissertations. (118).


Thurstone, L. L., & Thurstone, T. G. (1943). *Chicago tests of primary mental abilities.* Chicago.


