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Using the Quantified Process Approach in Examination of the Five Point Test

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USING THE QUANTIFIED PROCESS APPROACH IN EXAMINATION OF THE

FIVE POINT TEST

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ABSTRACT

The purpose of this study was to collect normative data and test for the reliability of a new strategy index, quantified using a computer-assisted algorithm on the Five-Point Test (FPT), developed by Regard, Strauss, and Knapp (1982). Additionally, the study was aimed at investigating the influence of the new index on the total number of designs and preservative errors. Participants included one hundred and fourteen individuals from Cleveland State University and the community for time one, and sixty two individuals for time two. Participants were administered the Five Point Test and the Delis-Kaplan Design Fluency Test developed by Delis, Kaplan & Kramer (2001) across two time periods approximately two months apart. Total designs and perseveration errors were recorded for both tests. The new index consists of three types of strategy: rotation, addition, and deletion; and was quantified using a computer-assisted algorithm developed by Dr. Amir Poreh. The results of this study show a test-retest correlation of ($r = .755$, $p=.000$) for the new strategy index across two administration periods, and an overall higher reliability for the Five Point Test in comparison to the Delis-Kaplan Design Fluency Test . Furthermore, the study using a stepwise regression analysis showed the new strategy index significantly predicted the number of total designs ($F = 38.39$, $p=.000$), and significantly predicted the number of perseveration errors ($F = 16.33$, $p=.000$).

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CHAPTER I

INTRODUCTION

The purpose of this study was to collect normative data and test for the reliability of a new strategy index quantified using a computer-assisted algorithm on the Five-Point Test. The Five Point Test consists of pages on which are printed 40 contiguous squares in a 5 X 8 array; each square contains five symmetrical and identical arranged dots. The examiner asks the participant to make as many different designs as possible within 3 minutes by connecting any number of the dots with straight lines without repeating.

The Delis-Kaplan Design Fluency Test consists of three conditions each of which are one minute. The first condition is similar to the Five Point Test, but the second condition contains visual distracters (white dots), and the third condition requires the patient to switch between black and white dots when making designs.

Design fluency tasks are a commonly used neuropsychological measure which were first developed as nonverbal analogies to word fluency tasks, and are used to evaluate the ability to initiate and sustain mental productivity, and to self-monitor and regulate responding in the visual-spatial domain. Furthermore design fluency tasks are thought to measure executive function, and are usually sensitive to right frontal lobe dysfunction, although a number of studies have shown that design fluency tasks use both right and left prefrontal cortices (Baldo et al., 2001; Suchy et al., 2003).

There are some differences between Regards Five Point Test, The Delis Kaplan Design Fluency Test and the computer-assisted version. The main differences are the approach to scoring and focus. In Regard's the scoring utilizes the traditional fixed approach focusing on the participants overall performance by adding the total number of designs and errors. The Delis Kaplan Design Fluency scoring again focuses on the overall performance, but additionally compares the combined scores of condition one and two to the score of condition three. The thought here is that condition three involves switching, an executive ability, while the first two conditions do not. This subtraction method is supposed to isolate the executive ability of the participant. The computer-assisted version uses the Quantified Process Approach focusing on the strategy participants utilized by creating new indices quantifying qualitative behavior within the task. Regards original version assimilates too many cognitive components into one overall score. This confuses a neuropsychologist about what he/she is measuring, and causes them to create huge test batteries in order to isolate and separate constructs. The Delis Kaplan version uses three conditions in order to accomplish this, specifically isolating the executive component, but falls short in three ways. First the subtraction method by design involves more than one test, which compounds the error on the side of the participant. Second the switching condition doubles the number of dots, and therefore doubles the number of permutations, which makes the comparison to the first two conditions problematic. Third studies have found that switching in condition three does not measure cognitive flexibility as it does in Trail Making test B (Suchy et al., 2010). The computer assisted version through the creation of new indices separates the constructs executive function within the test, instead of using more conditions to do so. This fixes the compounding of participant error, and the problems of comparing scores across three conditions. Furthermore a study by Elfgren and Risberg (1998) has shown evidence of participant's use of strategy in a design fluency task activating the dorsolateral prefrontal cortex, an area of the brain which is thought to play a heavy role in executive function.

For these reasons the present study is very important. Although the study only used the algorithm from the computer-assisted program, it is setup to run the Five Point Test. This marks a shift in technology, which has the potential to decrease the amount of human error in the administration and scoring of neuropsychological tests increasing reliability. Furthermore as stated above the quantified process approach with the aid of the computer-assisted program allows us to quantify qualitative data separating and giving us a better understanding of the constructs at work in a given task. Finally, and most importantly through this approach we hope to better localize brain dysfunction.

CHAPTER II

LITERATURE REVIEW

2.1 History of design fluency

One of the first design fluency tasks was Jones-Gorman and Milner's Design Fluency Test developed in 1977. This task requires the patient to generate as many different abstract designs as possible. The test is composed of a free-response condition, lasting five minutes, in which few restrictions are imposed on design generation, and a fixed response condition, lasting four minutes, in which the patient must produce designs that contain exactly four lines or components.

The Five-Point Test developed by Regard, Strauss, and Knapp was developed in 1982. In this task patients are asked to make as many different designs as possible within five minutes by connecting any number of the dots with straight lines without repeating. Later in 1994 the time limit was changed to three minutes in order to be analogous to the Controlled Oral Word Association Test (COWAT), a measure of word fluency. Current normative data for adults are 31.95 unique designs (SD=8.4), and 1.39 perseveration errors (SD=1.8) (Strauss et al., 2006).

The Ruff Figural Fluency Test (RFFT) was developed by Ronald Ruff in 1996. This version still asks patients to make as many different designs as possible without repeating, but is broken down into five sections each one minute. Parts two and three involve various distracters increasing the complexity of the task, while one, four, and five contain variations of the original dot pattern analogous to the three letters of the COWAT. Additionally the RFFT measures both rotational and enumerative strategies qualitatively.

The Delis-Kaplan Executive Function System is a test battery developed in 2001. A part of this test battery includes a design fluency test. The test consists of three conditions where by subjects are creating designs by connecting dots in a series of five-dot matrices. The first two conditions are similar to the RFFT where they assess Design fluency with and without visual distracters, whereas the third condition involves switching. Current data for reliability of the design fluency task was rated as low (Strauss et al., 2006)

2.2 Cognitive Components of Design Fluency

Kraybill (2008) used the RFFT and other measures to evaluate the unique contribution of complex motor programming which includes motor control, motor learning, and motor planning to design fluency. These three constructs are thought to involve executive function, specifically motor planning is considered a function of the dorsolateral prefrontal cortex. The study found motor learning and motor planning were significant predictors of performance on the RFFT and account for a unique proportion of the variance.

Suchy (2010) used the Delis Kaplan Design Fluency test to investigate the underlying constructs implicated in design fluency. They found Graphomotor Speed’s contribution was relatively small with less than 5% of the variance. Visual Scanning's contribution was small at first, but accounted for more of the variance as the complexity of the task increased. For example when a task includes distracters or involves switching the complexity is increased. Therefore visual scanning was more of a predictor in condition three compared to condition two or one. The results found that Motor Planning represented the strongest single predictor in all conditions, while Motor Sequence Fluency represented the second strongest predictor. Furthermore cognitive flexibility as measured by Trail Making test B was not found to be a significant predictor of condition three.

2.3 Psychodynamics of Design Fluency and Strategy

Design fluency was first thought to be sensitive to right frontal lobe dysfunction, and was originally created as analogous version of verbal fluency which is sensitive to left frontal lobe dysfunction. Studies early on corroborated with this theory. Jones-Gotman and Milner (1977) reported right frontal lobe lesions were significantly impaired on design fluency tasks, and Ruff et al. (1994) found design fluency was sensitive to right frontal lobe anterior lesions. Recent studies however show design fluency activates the lobes bilaterally (Baldo et al., 2001; Suchy et al., 2003). Intuitively the right hemisphere is needed because design fluency is a visual-spatial task, but for most people who are right handed the left primary motor cortex, including premotor and supplementary motor areas are needed for movement (Kraybill et al., 2008). Therefore when scoring a design fluency task if the total number of designs and errors include all of these areas deficits to any of them would result in a decrease in score.

Ruff (1996) looked at two case studies, and there strategy performance on the RFFT.

Each participant had sustained brain injury, and had undergone Computerized Axial Tomography (CT0 and Magnetic Resonance Imaging (MRI) scans. It was found that case one had sustained an intercerebral hematoma in the left frontal region, where as the second case had sustained a large right frontal hemorrhage. In case one the total number of unique designs generated through application of strategies was significantly higher (12) compared to case 2 (0).

A study by Elfgren and Risberg (1998) investigated regional cerebral blood flow in a normal population in order to elucidate the involvement of frontal and frontotemporal brain regions during performance of both verbal and design fluency tasks when using strategy. The design fluency task included two conditions: In the first condition participants were asked to copy three abstract drawings, in the second condition participants were asked to generate as many abstract figures as possible. The abstract figures were not allowed to represent actual objects or nameable geometric shapes. Participants reported using two strategies in the second condition: The first was classified as a visuo-spatial strategy, and the second was classified as a mixed strategy. The study concluded that compared to condition one in condition two when participants used strategy activation was shown in Brodmans area 10, 11, and 46, which are prefrontal areas.

The dorsolateral prefrontal cortex known as Brodmann's area 9/46 serves as the highest cortical area responsible for motor planning, organization, and regulation. This area has connections to and projects into the premotor and supplementary motor areas, which than project into the primary motor cortex in order to execute movement. Creating an index that focuses on motor planning could differentiate between this area and others when assessing design fluency.

2.4 Problems with previous versions

Starting with Jones-Gorman and Milner's Design Fluency Test problems include lack of published normative data, poor inter-rater reliability, and confusing constructions for cognitively impaired patients. Additionally the test had difficulties in discerning between frontal lobe deficits and confounding motor deficits, and although was sensitive to frontal lobe lesions it was also sensitive to temporal lobe lesions.

Regard developed his Five Point Test as an alternative providing normative data, better reliability, and simple instructions (Lee et al., 1997). Although Regard fixes the problems of Jones-Gorman and Milner, his scores of the total designs and preservative errors include too many cognitive components shown by the studies mentioned above. Because of this, localization of brain dysfunction can be difficult, and can sometimes lead the Five Point Test unable to differentiate between left and right frontal lobe dysfunction (Baldo et al., 2001; Suchy et al., 2003), or to pick up on right frontal lobe lesions at all (Tucha et al., 1999). Furthermore, although the stability overtime for the number of unique designs produced is high, the stability for perseverations is quite modest (Ross et al., 2003).

Ruff created another version of figural fluency with five conditions. Parts two and three involve various distracters increasing the complexity of the task, while one, four, and five contain variations of the original dot pattern analogous to the three letters of the COWAT. Scoring involves adding all five conditions into one total unique design score, and total perseveration score. The problem is the five conditions are not comparable. Parts two and three include distracters and therefore limit response selection and are different tasks. Additionally the

RFFT measures rotational and enumerative strategies qualitatively, and therefore relies on trained raters instead of a standardized algorithm.

The Delis-Kaplan Executive Function System Design Fluency Test involves three conditions. The first two conditions are similar to the RFFT where they assess design fluency with and without visual distracters, whereas the third condition includes switching. Problems include: The subtraction method by design involves more than one test, which compounds the error on the side of the participant, Condition three doubles the number of dots, and therefore doubles the number of permutations, which makes the comparison to the first two conditions problematic, Studies have found that switching in condition three does not measure cognitive flexibility as it does in Trail Making test B (Suchy et al., 2010), which calls into question the executive abilities measured.

2.5 The Quantified Process Approach

The Quantified Process Approaches roots can be traced to a paper by Heinz Werner titled "Process and achievement: A basic problem of education and developmental psychology" (1937). In it Werner argued that the processes by which people arrive at the final solution can give us as much information, if not more, than the test scores (Valsiner, 2005). This idea was later embraced by Edith Kaplan and led to the creation of the Boston Qualitative Process Approach. This approach looks at the qualitative aspects of a participant and their performance on a given test. An example of this can be seen on Block Design a subtest of the Wechsler Adult Intelligence Scale. Here the administrator copies down how a participant forms the design block by block, instead of just measuring whether or not the design was correct and the total time. The

Quantified Process Approach through there composition paradigm attempts to take these qualitative measures and quantify them into new indices for statistical analysis through the use of computerized algorithms (Poreh, 2006).

2.6 The Computer Assisted Version of the Five Point Test

The computer-assisted Five Point test utilizes the composition paradigm of the Quantified Process approach. It takes the original design fluency test format of Regards and coverts it to a computerized version. Additionally it creates a strategy index composed of three types: rotation, addition, and deletion. This eliminates a lot of problems in previous versions outlined above, and allows for a more comprehensive interpretation of design fluency.

2.7 Aims of the Present Study

The present study was aimed at: 1. Collecting normative data for this method of computer-assisted analysis, including a new strategy index. 2. Examining strategy scores and demographic influence on the total production of unique designs and perseveration errors. 3. Testing the stability of the new strategy index through test-retest reliability.

CHAPTER III

METHOD

3.1 Measures and Hypotheses

3.1.1 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.). Although the software includes both the test and the algorithm, in order to test groups of people only the algorithm was used. Test results were entered into the algorithm by the investigator. In this strategy can be recorded and accounted for along with total designs and perseveration errors.

3.1.2 The Five Point Test

The Five Point Test is based on Regards original version. It consists of pages on which are printed 40 contiguous squares in a 5 X 8 array; each square contains five symmetrical and identical arranged dots. The examiner asks the subject to make as many different designs as possible within 3 minutes by connecting any number of the dots with straight lines without repeating.

Predictions for The Five Point Test using the Computer Assisted Algorithm

It is predicted that participants in this sample will perform much like the published normative data stated above. This is primarily because we will not be collecting from a clinical population, and the majority of participants will be young, healthy, and college educated. It is hypothesized that an increase in strategy will significantly predict an increase in designs and a decrease in perseveration errors. Additionally it is hypothesized that strategy will be more reliable than total designs and perseveration errors, and that the Five Point test will be more reliable than the Delis Kaplan.

3.1.3 The Delis-Kaplan Design Fluency Test

The Delis-Kaplan Design Fluency Test includes three conditions. In the first condition the participant is provided pages which are printed 35 squares in a 7 X 5 array; each square contains identically arranged dots. The examiner asks the subject to make as many different designs as possible within 1 minute by connecting any number of the dots with straight lines without repeating. In the Second condition the participant is provided the same material, but within the boxes there are black dots and white distracter dots. The examiner asks the participant to make as many different designs as possible within 1 minute by connecting any number of the black dots with straight lines without repeating, while avoiding the white dots. In the third condition the participant is provided the same material, but within the boxes there are again black and white dots. The examiner asks the participant to make as many different designs as possible within 1 minute by connecting any number of the black dots with straight lines without repeating, but this time when doing so the participant needs to switch from black to white or vice versa when connecting dots.

3.2 Participants

Participants included one hundred and fourteen individuals from Cleveland State University and the community for time one, and sixty two individuals for time two. The average age was 27.69 years (SD=10.5), ranging from 19 to 57 years old. There were 84 females and 31 males. The majority was right handed with a mean education of 15.1 years (SD=1)

The Participants filled out an informed consent and demographics form prior to the test. A copy was kept for the examiner's records and an additional copy was provided to the participant so they would be provided with contact information. Additionally the participant provided his/her age, gender, education level, and handedness prior to testing.

3.3 Procedure

Every participant was give the same instruction and test battery. They first filled out the informed consent and demographics form. Next, he/she completed the Delis Kaplan Design Fluency Test, and then the Five Point Test. Entire time of administration for the informed consent form, demographics form, and two measures was approximately fifteen minutes. After two months the same procedure was used to assess reliability.

3.4 Data Analysis

All data from the demographics form and the Five Point Test was entered into the computer-assisted software. The Delis Kaplan Design Fluency Test was graded by hand. Next, the results were entered into SPSS for analysis. Descriptive statistics were calculated for mean years of education and age, handedness, gender, number of designs and errors, and use of strategy. Pearson's R was used to assess test-retest reliability for strategy, number of designs, and errors. A stepwise regression analysis was used to determine how well strategy predicted the number of designs and errors.

CHAPTER IV

RESULTS

Table I shows the descriptive statistics which were calculated for the indices of Delis-Kaplan Design Fluency and The Computer-Assisted Five Point Test time 1. The Delis-Kaplan condition 1 showed a total design mean of 17.96 (SD=5.1) and a perseveration error mean of .65 (SD=1.4). Condition 2 showed a total design mean of 18.44 (SD=4.8) and a perseveration error mean of .6 (SD=.95). Condition 3 showed a total design mean of 15.39(SD=4.9) and a perseveration error mean of .42 (SD=1.1). The Five Point Test showed a total design mean of 31.8 (SD=7) and a perseveration error mean of 1.8 (SD=2.3). Rotation showed a total design mean of 10.7 (SD=5.7). Addition showed a total design mean of 1.2 (SD=1.8). Deletion showed a total design mean of 2.32 (SD=2.2). Total Strategy showed a total design mean of 14.2 (SD=6.1). The Percentage of strategy used on the Five Point Test showed a total design mean of 43.8 (SD=14.8).

Table I.

Descriptive Statistics for the Delis-Kaplan Design Fluency, The Five Point Test, and Strategy Time 1.

Descriptive Statistics					
	N	Min	Max	Mean	SD
Delis Kaplan Total Designs	115	6	30	17.96	5.124
Delis Kaplan P. Errors	115	0	10	.65	1.396
Delis Kaplan 2 Total Designs	115	7	32	18.44	4.822
Delis Kaplan 2 P. Errors	115	0	5	.60	.953
Delis Kaplan 3 Total Designs	111	7	35	15.39	4.966
Delis Kaplan 3 P. Errors	111	0	8	.42	1.125
FPT Total Designs	114	16	58	31.82	7.028
FPT P. Errors	114	.0	12.0	1.807	2.3532
Rotation	114	0	26	10.70	5.762
Addition	114	.00	9.00	1.2193	1.80343
Deletion	114	0	10	2.32	2.207
TotalStrategy	114	2	28	14.24	6.133
StrategyPercentage	114	9	75	43.76	14.796

Table II shows the descriptive statistics which were calculated for the indices of Delis-Kaplan Design Fluency and The Computer-Assisted Five Point Test time 1. The Delis-Kaplan condition 1 showed a total design mean of 20.2 (SD=3.2) and a perseveration error mean of .51 (SD=.91). Condition 2 showed a total design mean of 19.2 (SD=3.3) and a perseveration error mean of .75 (SD=.1.3). Condition 3 showed a total design mean of 14.8 (SD=4.4) and a perseveration error mean of .26 (SD=.51). The Five Point Test showed a total design mean of 34.7 (SD=6.9) and a perseveration error mean of 1.9 (SD=2.1). Rotation showed a total design mean of 13.08 (SD=6.5). Addition showed a total design mean of 1.1 (SD=1.7). Deletion showed a total design mean of 1.7 (SD=1.8). Total Strategy showed a total design mean of 15.89 (SD=6.44). The Percentage of strategy used on the Five Point Test showed a total design mean of 44.7 (SD=13.01).

Table II.

Descriptive Statistics for the Delis-Kaplan Design Fluency, The Five Point Test, and Strategy Time 2

Descriptive Statistics					
	N	Min	Max	Mean	SD
Delis Kaplan Total Designs	62	11	28	20.19	3.23
Delis Kaplan P. Errors	62	0	5	.52	.92
Delis Kaplan 2 Total Designs	61	13	28	19.2	3.32
Delis Kaplan 2 P. Errors	61	0	5	.75	1.27
Delis Kaplan 3 Total Designs	61	7	25	14.84	4.39
Delis Kaplan 3 P. Errors	61	0	2	.26	.51
FPT Total Designs	62	24	50	34.66	6.94
FPT P. Errors	62	0	8	1.97	2.11
Rotation	62	0	31	13.08	6.52
Addition	61	0	12	1.11	1.78
Deletion	62	0	9	1.74	1.79
TotalStrategy	62	3	33	15.89	6.44
StrategyPercentage	62	10	74	44.68	13.07

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Table III shows the reliability for the Delis-Kaplan Design Fluency Test. Condition 1 showed test-retest reliability of .32 for total designs and .22 for perseveration errors. Condition 2 showed test-retest reliability of .52 for total designs and .16 for perseveration errors. Condition 3 showed test-retest reliability of .63 for totals designs and .04 and for preservative errors.

Table III.

Reliability for the Delis-Kaplan Design Fluency

Time 3

Correlations						
	TD1	R1	TD2	R2	TD3	R3
TD1	.318	.146	.346	.226	.311	.266
R1	-.201	.215	.009	.177	.003	.155
TD2	.480	.083	.515	.121	.435	.338
R2	-.003	.080	.070	.160	-.082	.062
TD3	.324	.058	.408	.180	.626	.286
R3	-.107	-.148	.129	-.015	.181	.035

Table IV shows the reliability for the Computer-Assisted Five Point Test. Totals Designs showed a test-retest reliability of .72 and .67 for perseveration errors. Rotation Strategy showed a test-retest reliability of .65. Addition Strategy showed a test-retest reliability of .10. Deletion Strategy showed a test-retest reliability of .11. Total Strategy showed a test-retest reliability of .76. Strategy Percentage showed a test-retest reliability of .62.

Table IV.

Reliability for the Computer Assisted Five Point Test

Correlations							
	TD1	R1	Rotation	Addition	Deletion	Strategy	Strategy%
TD1	.723	-.139	.520	.144	.199	.658	.420
R1	-.050	.671	-.266	-.119	.051	-.282	-.315
Rotation	.545	-.403	.647	.196	-.002	.716	.588
Addition	.044	.149	-.080	.098	.368	.105	.117
Deletion	.010	.020	-.016	-.076	.111	.002	-.013
Strategy	.572	-.357	.630	.205	.123	.755	.622
Strategy%	.319	-.392	.558	.162	.019	.622	.616

Table V shows the results of a stepwise regression. This analysis revealed that model 2, which included both Rotation and Deletion was the best predictor of Total Designs (F=38.39, p=.000). Table VI shows the results of a stepwise regression. This analysis revealed that Rotation was the best predictor of Perseveration errors (F=16.33, p=.000).

Table V.

Stepwise Regression of Total Designs on the Five Point Test onto the Strategy Index.

Mode	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.47	.22	.212	6.239
2	.64	.41	.40	5.452

a. Predictors: (Constant), Rotation
b. Predictors: (Constant), Rotation, Deletion
c. Dependent Variable: Total Designs FPT

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1221.462	1	1221.462	31.379	.000
	Residual	4359.67	112	38.926		
	Total	5581.132	113			
2	Regression	2282.026	2	1141.013	38.39	.000
	Residual	3299.105	111	29.722		
	Total	5581.132	113			

a. Predictors: (Constant), Rotation
b. Predictors: (Constant), Rotation, Deletion
c. Dependent Variable: Total Designs FPT

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	25.710	1.237		20.787	.000
	Rotation	.571	.102	.468	5.602	.000
2	(Constant)	21.198	1.318		16.078	.000
	Rotation	.685	.091	.562	7.524	.000
	Deletion	1.420	.238	.446	5.974	.000

a. Dependent Variable: Total Designs FPT

Table VI.

Stepwise Regression of Perseveration Errors on the Five Point Test onto the Strategy Index.

Mode	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.36	.13	.12	2.2082

a. Predictors: (Constant), Rotation

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	79.622	1	79.622	16.33	.000
	Residual	546.133	112	4.876		
	Total	625.754	113			

a. Predictors: (Constant), Rotation
b. Dependent Variable: Perseveration errors.

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	3.366	.438		7.689	.000
	Rotation	-.146	.036	-.357	-4.041	.000

c. Dependent Variable: Total Designs FPT

Table VII, VIII, and IX shows the age based norms for Strategy, Total Designs, and Perseveration Errors on the Five Point Test. Ages 20-29 showed a mean Total Design of 32.4 (SD=7.3), Perseveration Errors 1.2 (SD=1.7), and Total Strategy 15 (SD=6.14). Ages 30-39 showed a mean Total Design of 30.6 (SD=6.4), Perseveration Errors 2.2 (SD=2.23), and Total Strategy 11.6 (SD=6.4). Ages 40-49 showed a mean Total Design of 29.6 (SD=6.13), Perseveration Errors 4 (SD=3), and Total Strategy 11.5 (SD=4.9). Ages 50-59 showed a mean

Total Design of 30.9 (SD=6.7), Perseveration Errors 5.7 (SD=2.7), and Total Strategy 10.8 SD (5.6).

Table VII.

Age Based Norms for Strategy

Age	**20-29**	**30-39**	**40-49**	**50-59**
Mean	15	11.6	11.5	12.1
SD	6.14	6.4	4.9	4.7

Table VIII

Age Based Norms for Total Designs

Age	**20-29**	**30-39**	**40-49**	**50-59**
Mean	32.4	30.6	29.6	30.9
SD	7.3	6.4	6.13	6.7

Table IX

Age Based Norms for Perseveration Errors

Age	**20-29**	**30-39**	**40-49**	**50-59**
Mean	1.2	2.2	4	5
SD	1.7	2.23	3	2.7

CHAPTER V

DISCUSSION

The results of the study showed that participants on average generated a total of 31.8 designs (SD=7), while making 1.8 (SD=2.3) perseveration errors on the Five-Point Test. This is consistent with the past published normative data cited above.

The results of the Delis-Kaplan Design Fluency showed that on condition 1 participants on average generated a total of 17.96 designs (SD=5.1), while making .65 (SD=1.4) perseveration errors. On condition 2 participants on average generated a total of 18.44 (SD=4.8), while making .6 (SD=.95) perseveration errors. On condition 3 participants on average generated a total of 15.39 designs (SD=4.9), while making .42 perseveration errors (SD=1.1).

The data shows a trend that participants made fewer errors on condition three than condition one or two. The trend is even more stark in time two where the average number of errors decreased to .21 (SD=.51) again the lowest of the three conditions. This may occur because the number of permutations is increased in condition three since there are a total of ten dots instead of five. That would decrease the chances a participant would repeat a design, and also decrease the need for a participant to plan the task out before hand in order to increase production and decrease error. This trend along with the Suchy (2010) study finding that visual scanning's contribution was greatest in condition three and a measure of cognitive flexibility did not predict scores in condition three may implicate that the Delis-Kaplan Design Fluency condition three may be more of a measure of visual scanning than executive function. This would make the isolation of the executive function component even more problematic above and beyond the previous problems mentioned.

The results of the reliability for the Five Point Test show a test-retest reliability of .72 for total designs and .67 for perseveration errors, .65 for rotation strategy, .10 for addition strategy, .11 for deletion strategy, .76 for total strategy, and .62 for strategy average.

The reliability for the Delis-Kaplan Design Fluency Test showed a test-retest reliability of .32 for total designs and .22 for perseveration errors for condition one, .52 for total designs and .16 for perseveration errors for condition 2, and .63 for total designs and .04 for perseveration errors for condition three.

The overall reliability study showed the Five Point Test to be a more reliable measure than the Delis Kaplan. The Five Point Test correlation coefficients were similar to those found in the literature, accept perseveration errors was much higher than previously published data. It could be just a difference in the sample taken, or it could be that the algorithm is superior to a human grader in locating errors on the test. The Delis Kaplan correlation coefficients were similar to the rating of low found in the literature. Additionally this shows that the total strategy design fluency is a more reliable measure than that of total design.

The stepwise regression analysis revealed that model 2, which included both Rotation and Deletion was the best predictor of Total Designs (F=38.39, p=.000), and Rotation was the best predictor of Perseveration errors (F=16.33, p=.000). This is in concordance with the Suchy (2010) study, and the Kraybill (2008) study, where motor planning significantly predicted performance on the RFFT, and the Delis Kaplan.

Design fluency tasks were originally created as analogous measures of verbal fluency tasks. This was supposed to help differentiate left from right frontal lobe dysfunction. Over the years studies have looked at the cognitive constructs with in design fluency, and brain areas where those constructs originate. The findings sum up to show a more complex picture than what was first thought. Along with this complex picture must come a more complex approach. Neuropsychological tests can no longer just add up the end result and say something meaningful. The quantitative process approach ascertains that the focus of indices should be on how the participant performs the task. In the case of design fluency does the participant utilize a type of strategy? This looks at the mechanisms within the brain that contribute to the performance of the participant on test. A perfect test would have as many indices as there are constructs measured in the task. Shifting neuropsychological tests from paper pencil to computerized versions can help do this, and the results of this study are evidence of it. The computerized version of the Five Point test helps create a strategy index, which on the RFFT was measured quantitatively can now be quantified for analysis. This can help isolate the executive component of the Five Point test, and localize brain dysfunction in the prefrontal cortex.

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