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Strategies Classification of the Clock-Drawing Test Construction

Spenciere B and Charchat-Fichman H*

Department of Psychology, University of Rio de Janeiro, Brazil

Abstract

The aim of the study is to propose a new Clock Drawing Test scoring system that classifies planning and organizing strategies of clock drawing construction. Seventy seven healthy older adults (60-90 years), participants of a community center in Rio de Janeiro were evaluated. The construction sequences processes of drawing the clock were analyzed. Then, strategies for the CDT were classified and categorized. The results showed diversity in the patterns adopted by the elderly. The strategies circle-number-center-pointer (general sequence) and quadrant (numerical sequence) associated with measures that evaluate planning. This new classification is a possible method that complements the previous existing quantitative and qualitative scoring systems.

Introduction

The Clock Drawing Test (CDT) is used as a screening test for assessing the evolution of cognitive decline [1].There are several scoring methods for the CDT: quantitative, semi-quantitative and qualitative types. However, recently greater tendency for qualitative analysis has been observed because of its advantages in describing neuropsychological profiles, types of errors committed and dementia subtypes [2,3].

On the other hand, no existing criterion evaluates CDT's planning and organization strategies. Although, planning is an important executive function, is directly related to complex behavior execution [4] and it is directly related to instrumental activities of daily living [5]. That's why the proposal of a scoring system that classifies the different planning strategies of CDT construction emerged. Finally, the aim of the study was to propose the new scoring method and also verify its construct validity.

Method

Participants

The study evaluated 77 (seventy-seven) community-dwelling elderly adults (aged 60-90) that participated in activities offered by the government in the city of Rio de Janeiro. The sample included elderly of both genders and average schooling of 12.77 years (5.22). Inclusion criteria were non-corrected visual or auditory deficit. Those with cognitive decline [6], severe depressive symptoms [7] and neuropsychiatric cases (self-report of clinical history) were excluded from the sample. All participants signed an informed consent form.

Procedures

To verify the feasibility of recording possible organizational and planning strategies, 20 pilot CDT recordings were performed. Subsequently, the complete neuropsychological protocol was performed in the whole sample. To map and classify the CDT construction strategies, two specialists analyzed the videos in phases. First, the CDTs were randomly selected. Then, the sequences of the CDTs construction were described step by step following its construction sequence. So, patterns of sequence could be grouped and classified.

General sequence patterns of construction were observed and encompassed circle, numbers, center and hands. There were also patterns of sequences in numbers distribution and hands positions that could be categorized. Higher specificity in numbers spatial distribution was necessary, so a model of transparent Correction Key (CK) was created. Two other neuropsychologists used the CK and the Record Sheet (RS) and adjustment could be done. Both final models are illustrated in Figures 1 and 2.

All CDT videos were once again watched and the drawing construction sequences performed,

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Correspondence:
Spenciere B, Department of Psychology, University of Rio de Janeiro, Rua Marquês de São Vicente 255 Ed, RJ 22543-900, Brazil, E-mail: barbaraspenciere@gmail.com

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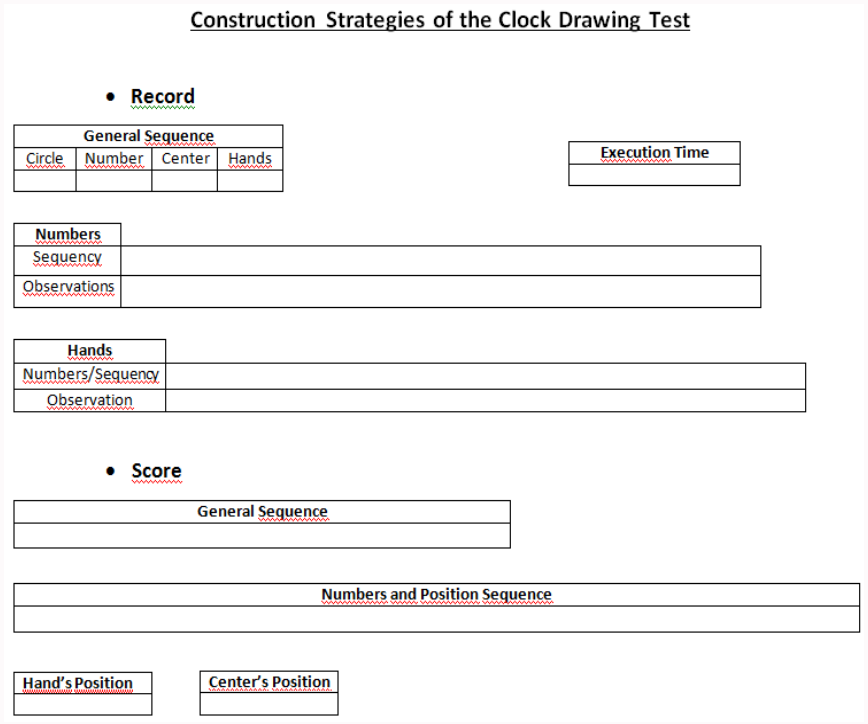

Figure 1: Record Sheet.

Table 1: Sociodemographic, cognitive and functional characteristics of the sample.

Sociodemographic Characteristics	N	M (SD)	Min	Max
Gender (F:M)	72:05:00	-	-	-
Age (years)	77	72.26 (6.76)	60	90
Schooling (years)	77	12.77 (5.22)	0	25
MMSE	77	26.35 (2.43)	18	30
Lawton Scale (pacient)	77	20.55 (0.80)	17	21
Lawton Scale (family)	44	20.09 (1.07)	17	21
Pfeffer Questionnaire	44	0.52 (0.90)	0	3
GDS	77	2.61 (2.53)	0	9

as well as the execution time (in seconds), were registered in the RS. Relevant observations, mainly the occurrence of self-corrections were also noted. After the registration, strategies categories and subcategories could be reached by verifying the most frequent in the sample and criteria for strategies' classification was defined:

General Sequence: Circle-number-center-hand, circle-number-hand, circle-center-number-hand, circle-number-hand-center-hand and atypical.

Numerical Sequence: Sequential (writing the numbers in sequence, either clockwise or counterclockwise), half (refers to the initial arrangement of the numbers corresponding to the midline of the clock (12/6), and then the placement of the numbers of each half), quadrant (corresponds to the placement of the numbers responsible for the subdivision of the circle into four quadrants (12, 3, 6 and 9) first and then to the placement of the other numbers within the quadrants), mixed (self-monitoring in which the participant starts with one strategy and flexibilizes the plan for another strategy during the drawing e.g., Sequential-Quadrant).

Table 2: Frequency of CDT strategies types.

CDT Strategies Types		Percentage (%)
General Sequence	Circle-Number-Center-Hand	32.5
	Circle-Number-Hand	16.9
	Circle-Center-Number-Hand	16.9
	Circle-Number-Hand-Center-Hand	10.4
	Atypical	23.3
Numerical Sequence	Sequential	48.1
	12,1,2,3,4,5,6,7,8,9,10,11 (12 a 11)	27.3
	1,2,3,4,5,6,7,8,9,10,11,12 (1 a 12)	5.2
	12,11,10,9,8,7,6,5,4,3,2,1 (12 a 1)	3.9
	Quadrant	29.9
	12,6,3,9,1,2,4,5,7,8,10,11 (12,6,3,9)	16.9
	12,6,9,3,1,2,4,5,7,8,10,11 (12,6,9,3)	3.9
	6,12,9,3,1,2,4,5,7,8,10,11 (6,12,9,3)	1.3
	12,3,6,9,1,2,4,5,7,8,10,11 (12,3,6,9)	1.3
	Half	15.6
	12,6,1,2,3,4,5,6,7,8,9,10,11 (12,6)	7.8
	Mixed	6.5
	Sequential-Quadrant	1.3
	Sequential-Half	1.3
	Sequential-Sequential	1.3
	Half-Quadrant	2.6

Hands: Number (self-monitoring/perseveration). The come about of self-monitoring of numbers was considered when there was an attempt to correct the positioning of the numbers in the clock, as

well as the change of planning strategy in the numerical sequence. Finally, perseveration was the presence of more than two hands when not related to an attempt of better positioning the hand (self-monitoring).

Instruments

A short identification interview to collect the participant's life history and clinical data, and also a cognitive screening protocol was performed. The cognitive screening protocol was composed of the following tests: Mini-Mental State Exam [6]; Cognitive Brief Screening Battery [8]; Geriatric Depression Scale (GDS-15) [7]; Lawton's Instrumental Activities Daily Living Scale [9]; Pfeffer Functional Activities Questionnaire [10].

The TDR application method was used according to [11]. The scoring methods followed a semi-quantitative [12] and qualitative criteria and also the organizational and planning strategies classification described upon. For construct validity, the following protocol was used: Rey Complex Figure Test (RCFT) [13]; MATTIS - Construction [14]; Block Design Test (BDT) (WAIS-III) [15]; Corsi Block Test [16].

Statistics

A descriptive statistical analysis was performed to characterize the sample and verify the frequency of the types of errors of the CDT and the categories and subcategories strategies as well as self-monitoring and perseveration occurred during the clock drawing construction. Spearman correlation and Chi-square test were used to verify associations between the data.

Results

Table 1 shows the heterogeneity of the sample and some cognitive and functional tests' results. Regarding CDT, the semi-quantitative scale [11] showed a high frequency (68.2%) of score number 5 (numbers in reverse order or concentrated in some part of the clock), and the qualitative scale [17] had a total score average of 12.26 (1.87). The types of CDT construction strategies are shown in Table 2, according to their highest rate (%).

The frequency of self-monitoring (Numbers-50.7%, Hands-24.7%) was higher than the frequency of perseveration (Hands-9.1%, Numbers-3.9%).

The CDT mean execution time was 66.27s (SD=38.26). There was no significant correlation between CDT time and the participants age ($r = 0.06$, $p=0.59$). However, there was an association with schooling ($r=-0.47$, $p<0.001$), as well as with the tests of executive functions: RCFT – copy ($r=-0.38$, $p<0.001$), RCFT - reproduction ($r=-0.24$, $p<0.03$), RCFT strategy ($r=0.29$, $p=0.01$), RCFT – time ($r=0.41$, $p<0.001$), BDT ($r=-0.5$, $p<0.001$), Verbal Fluency ($r=-0.357$, $p<0.001$).

The association between the CDT's Strategies and age showed discrepancies between expected and observed results. Considering age, the higher differences were among older adults (75-90 aged) and General Sequence Atypical (Observed: 8/Expected: 5.5) and circle-number-hand (Observed: 6/Expected: 4.4), as well as Numerical Sequence Sequential Strategy (Observed: 17/Expected: 13.5), and moreover in the Quadrant Strategy and older adults (60-74 aged) (Observed: 19/Expected: 14.6). Regarding schooling data, higher discrepancies were observed only among individuals with 12 and above years of schooling and the following strategies: General Sequences circle-number-center-hand (Observed: 23/Expected: 19.6) and circle-number-hand-center-hand (Observed: 9/Expected: 7.3) and Numerical Sequence Quadrant (Observed: 20/Expected: 16.7).

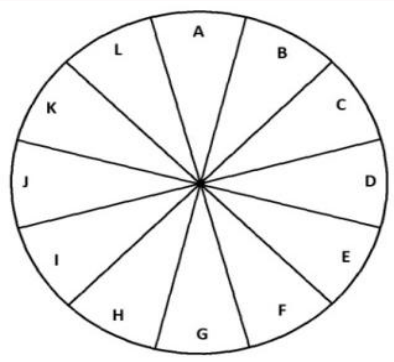

Figure 2: Correction Key.

Table 3 describes the associations between the CDT Strategies and the other cognitive measures. Higher discrepancies were observed between circle-number-center-hand and RCFT construction strategies and BDT.

Discussion

Al though the RCFT also evaluates organization and planning strategies, in contrast with the complexity of the RCFT, the CDT is easy and quick to apply, is well accepted by the elderly and also very useful for community application [18].To our knowledge, this is the first scoring system to classify the planning and organization strategies of the CDT, measure execution time, self-monitoring and perseveration. Organization scoring systems are less influenced by motor and coordination problems and are more sensitive to measure perceptual and organizational skills, if compared to drawing accuracy procedures. It is interesting to use both scales, as they are complementary: the one that evaluates draw's accuracy and the other that evaluates the construction sequence process. Thus, an increase in specificity can be achieved, differentiating perceptual and executive abilities [19]. After all, the process-oriented scoring systems can be considered better planning measures [20]. Considering execution time measurement of CDT, and corroborating with Ferreira and Zanini [21], a significant correlation could be verified between the execution time and the executive functions tests (RCFT, BDT, Verbal Fluency) applied. The execution time in executive functions tests is an important measure, since the processing speed, correlates with a good performance of executive function according to those authors.

There was a greater presence of self-monitoring than of perseveration. While the presence of self-monitoring might evidence poor planning strategy, it also evidences relatively preserved executive, once the error was identified and corrected [22].

Despite the heterogeneity, strategies could be classified regarding higher frequency. When compared to socio demographic data, the circle-number-hand-center-hand, circle-center-number-hand and quadrant strategies were more frequent than expected among the elderly in the younger group. The older adults with more advanced age had higher occurrences of sequential strategy, absence of center (circle-number-pointer) and greater heterogeneity (atypical). The heterogeneity was also observed among elderly with lower schooling. Nevertheless, elderly with high schooling (12 and above years) showed more than likely frequency of circle-number-center-hand,

Table 3: Discrepancies between frequency of observed and expected results' association of CDT's Strategies and Neuropsychological Tests.

Strategies' Types	Rey's Complex Figure construction strategies	Block Design Test WAIS-III									Construction MATTIS		Corsi Block Test	
	1	2	3	4	5	↓	=↓	=	=↑	↑	Pres.	Def.	Pre.	Def.
General Sequence														
Circle-Number-Center-Hand														
Frequency	10	7	4	5	1	0	2	9	9	7	19	8	23	4
Expected Frequency	6	6.3	4.6	8.8	1.4	0	4.6	9.8	6.3	6.3	20	7	23.5	3.5
Circle-Number-Hand														
Frequency	4	3	2	3	0	0	1	5	4	2	7	5	12	0
Expected Frequency	2.6	2.8	2	3.9	0.6	0	2	4.4	2.8	2.8	8.9	3.1	10.4	1.6
Circle-Center-Number-Hand														
Frequency	1	5	2	5	0	0	2	5	1	5	12	1	12	1
Expected Frequency	2.9	3	2.2	4.2	0.7	0	2.2	4.7	3	3	9.6	3.4	11.3	1.7
Circle-Number-Hand-Center-Hand														
Frequency	0	2	4	4	0	0	0	4	3	3	10	0	10	0
Expected Frequency	2.2	2.3	1.7	3.2	0.5	0	1.7	3.6	2.3	2.3	7.4	2.6	8.7	1.3
Atypical														
Frequency	2	1	1	8	3	0	8	5	1	1	9	6	10	5
Expected Frequency	3.3	3.5	2.5	4.9	0.8	0	2.5	5.5	3.5	3.5	11.1	3.9	13.1	1.9
Numerical Sequence														
Sequential														
Frequency	5	8	8	12	4	0	2	9	9	7	26	11	29	8
Expected Frequency	8.2	8.6	6.2	12	1.9	0	4.6	9.8	6.3	6.3	27.4	9.6	32.2	4.8
Quadrant														
Frequency	8	7	2	6	0	0	2	5	1	5	8	4	12	0
Expected Frequency	5.1	5.4	3.9	7.5	1.2	0	2.2	4.7	3	3	8.9	3.1	10.4	1.6
Half														
Frequency	2	3	2	5	0	0	1	5	4	2	19	4	22	1
Expected Frequency	2.6	2.8	2	3.9	0.6	0	2	4.4	2.8	2.8	17	6	20	3
Mixed														
Frequency	2	0	1	2	0	0	5	8	1	1	4	1	4	1
Expected Frequency	1.1	1.2	0.8	1.6	0.3	0	5.5	2.5	3.5	3.5	3.7	1.3	4.4	0.6

circle-number-hand-center-hand and quadrant strategies.

The circle-number-center-hand strategy showed greater results of association with good performance, both with the BDT and with the RCFT construction strategy. An above-expected relation could be observed with strategy 1 of RCFT copy and less association with type 4 [4]. On the other hand, the atypical strategies showed a greater tendency to lower mean results scored in BDT and to RCFT strategies 4 and 5. Therefore, it was inferred that the atypical strategy has the worst planning strategy.

Regarding to the Numerical Sequence, more heterogeneity was verified when comparing BDT. Notwithstanding, higher tendency to association between quadrant strategy and strategies 1 and 2 of RCFT was shown and sequential strategy was more associated to worse planning skills.

Hindmost, it is a first attempt to classify CDT construction strategies. Although the strategy patterns results found were heterogeneous, a largest sample with better age and schooling stratification may clearly present strategy patterns. A clinical validity of the new scoring system is already being developed with a sample of older adults with MCI and AD.

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