The Digital Clock Drawing Test (dCDT) - II: A new computerized quantitative system

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BACKGROUND

The Clock Drawing Test is a widely accepted, safe, and easy to administer neuropsychological test with high sensitivity and specificity useful for cognitive screening. However, significant variability exists in variables measured and scoring systems used. There is clear need for a standardized, operationally defined, automatic scoring system that can measure variables reliably and precisely. The new computerized scoring system (dCDT) will reliably score digitized clock drawings on both standard and novel measures even when employed by different users with varying combinations of computer hardware and operating systems.

SUBJECTS AND METHODS

The dCDT scoring system analyzes clock drawings obtained with a digitizing ballpoint pen (Anoto), producing up to 1012 measurements for each drawing on variables including stroke number, drawing size, and inter-stroke latencies. It was used to analyze 5 clock drawing protocols (each with command and copy drawings), scored by 7 different clinicians, using 9 different computer hardware/ software configurations (Table 1), at 6 geographically distinct sites.

Clinicians were provided written instructions for standardized computer classification of clock test strokes. They were instructed to download the dCDT protocols, hit the classify button to run the automatic scoring and save the results. Test data was anonymized and uploaded to a central database. Stroke classifications, user and site variables for all clock drawings were tabulated using Excel.

Table 1. Operating System Information

Person	Hardware	OS	ClockSketch	Java
1	ThinkPad T60	Windows XP SP2	2.5	Java 6 update 18
2a	Dell Latitude E4300	Windows XP SP3	2.5	Java 6 update 18
2b	Dell Latitude D630	Windows XP SP3	2.5	Java 6 update 15
3	HP Compaq dc 5800	Windows XP SP3	2.5	Java 6 update 13
4	Dell Optiplex 780	Windows XP SP3	2.5	Java 6 update 16
5a	Dell Optiplex GX270	Windows XP SP3	2.5	Java 6 update 20
5b	Dell Latitude D820	Windows XP SP3	2.5	Java 6 update 11
6	MacBook Air	Mac OS X 10.5.8	2.5	Java 2 SE 5.0
7a	Dell Optiplex 760	Windows XP SP2	2.5	Java 6 update 18
7b	Thinkpad Lenovo R60	Windows XP SP2	2.5	Java 6 update 11

Table 2. Values were identical for 1112 computerized measurements

Drawing Type	COMMAND	COPY	COMMAND	COPY
Drawing Total Strokes	42	40	42	40
Drawing Total Time (sec)	192.077	85.115	192.077	85.115
Clock face 1: total strokes	1	1	1	
Clock face 1: total time (sec)	4.773	3.04	4.773	3.04
Clock face 1: total length of strokes (mm)	142.689	107.168	142.689	107.168
Clock face 1: pen speed in first quarter (mm/s)	32.814	48.160	32.814	48.160

Table 3. Variable differences due data transmission method

	Drexel		MIT		UIC		UND	
PtNameF	R	R	R	R	CIN1220912665	CIN1220912665	CIN1220912665	CIN1220912665
PtNameL	C	C	C	C				

Table 4. Variable differences due clinician selected variables

PtDiagnosis1	Indeterminate	Indeterminate	ADHD-inattentive	ADHD-inattentive
PtDiag1Cert	High confidence	High confidence	Low confidence	High confidence

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RESULTS

All computerized measurements were identical for all protocols, testing sites, operating systems, and users (i.e., 100% consistency on computerized measurements, Table 2).

Program output differed only on 7 user and site variables, including clinician name and scoring time, which are intended to differ, for site and user identification purposes. Differences in sites were obtained for variables of Patient First Name (PtNameF), Last Name (PtNameL) and Medical Record Number (Medical Rec) based on the method of transmission of data to the PI: subject identification data uploaded to the website was correctly anonymized (Table 3 UIC & UND anonymized).

The dCDT requires a patient diagnosis and certainty value prior to saving. These values were not specified in the study instructions, resulting in site differences on these variables . All users selected either the first (ADHD-inattentive) or last (Indeterminate) diagnosis and certainty values (High or Low confidence) from the dropdown list (Table 4).

CONCLUSIONS

The dCDT is a reliable computerized system producing unprecedented objective, precise, reproducible quantitative measurements that can operationally define a wide collection of cognitive constructs. These data could be used for differential diagnosis and outcome treatment efficacy.

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