

A Digital Clock Drawing Test on Tablet for the Diagnosis of Neurocognitive Disorders in Older Adults

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Abstract. The diagnosis of neurocognitive diseases is an important health issue for patients, families and healthcare professionals. The need to develop rapid, high-performance screening tools would improve access to care. The Clock Drawing Test (CDT) is widely used and validated with the older adults, and its digital version is becoming increasingly widespread. We propose to confirm its validity in a population of old patients hospitalized in a geriatric unit, and secondly to verify its performance in comparison with the reference diagnosis made by a specialized team in a memory consultation. CDTs were collected from older hospitalized patients, both in paper form and digitally on a touchscreen tablet. The results show good agreement between the paper and digital versions (kappa coefficient = 0.81). Sensitivity and specificity of the digital CDT were 0.84 and 0.59 respectively for the diagnosis of major cognitive disorders. The corresponding values were 0.72 and 0.59 for the diagnosis of mild neurocognitive disorders. User questionnaires indicate that older participants find the digital tablet easy to use. However, they prefer to use paper, even if they are open to learning how to use the tablet.

Keywords. digital clock drawing test, digital tablet, diagnosis, neurocognitive disorder, older adult

1. Introduction

The diagnosis of neurocognitive disorders is based on a battery of medical and neuropsychological tests. These require expertise and are carried out in specialized consultation centers. Access to these centers and specialists is still difficult, and waiting times are long. And yet, early detection of neurocognitive disorders enables measures to be put in place for both the person affected and those around them. Providing early cognitive stimulation can enable rapid management of the disease and maintain the person's cognitive abilities.

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The clock drawing test (CDT) is widely used to screen for cognitive disorders: it is quick, inexpensive and easy to administer [1]. It has been shown to detect cognitive disorders in the older adult [2]. However, there are several ways of administering it: with a pre-drawn circle, with a copying task, or simply on command on a blank sheet of paper. Current studies focus on the conversion of paper tests into numerical form, like the CDT, and on the use of digital tools such as tablets or smart pencils to record finer parameters that cannot be observed (number and duration of pauses, finger movements and pressure on the pencil, pressure on the tablet, direction and particularities of the drawing). These more precise data can be combined to detect disease. Machine learning methods applied to healthcare data can be used to develop prognostic tools. Machine learning approaches already exist and have produced interesting results on clock drawings [3]. Efforts to digitize the entire test are underway, and initial results are encouraging [4].

Our study aims to validate digital CDT versus conventional CDT in older adults at a geriatric hospital. We also studied the performance of the digital CDT in relation to cognitive diagnosis in older adults attending a memory clinic. A questionnaire was used to gather the user experience of the participants.

2. Methods

2.1. Participants

We recruited 257 participants; 100 of them were hospitalized in a geriatric hospital and participated in the study that compared conventional paper-and-pencil testing with digital clock testing. One hundred and fifty-seven older adults were recruited from a memory clinic and from the city's seniors' associations and participated in the study that assessed the sensitivity and specificity of the digital CDT for diagnosing neurocognitive disorders. These 157 people received the user experience questionnaire, but only 68 completed it.

2.2. Digital Clock Drawing Test

We used two tablets of the same size to collect the data and a free application available on Android and IOS where we download a circle on which it is possible to draw on.

- *Instructions:* Prior to the test, participants were asked to familiarize themselves with the use of a simple stylus, with no integrated technology, on the tablet by writing a few words. After that, we presented them a pre-defined circle on which they had to draw all the numbers on a clock face by using the stylus. Then they had to draw the hands to indicate 11:10.
- *Scoring system:* Several scoring systems exist for the CDT [5]. We choose two of them, the Greco and the Codex scoring systems [6]. The first is composed of a combination of different clock elements: hand placement, digit placement, gaps, errors, perseveration, unrecognized signs. The total is on 10. The test is considered normal with a score between 7 and 10; 6 is borderline and less than 5 is considered as abnormal. Codex scoring was chosen for its easy-to-use and

the facility to quote. The rating is binary (normal or not) and is based on 4 elements: all numbers are presents, numbers are correctly placed, presence of an hour hand and a minute hand, hands are correctly placed. If any of these criteria is missing, the CDT is considered abnormal.

- *Examiners:* Two qualified healthcare professionals independently assessed the CDT. In cases where their ratings differed, they reviewed them together to reach agreement.
- *Randomization:* In the validation sample, the order of execution of the CDT (paper then digital CDT, or reverse) was randomized.
- *Reference diagnosis of neurocognitive disorders:* For the performance sample, the result of the digital CDT was compared with the presence/absence of neurocognitive disorder and the type of neurocognitive disorder (major or mild) according to DSM-5 criteria.

2.3. User Questionnaire

After completing both conventional and digital CDTs, participants answered a user questionnaire. This self-questionnaire consisted of 9 Lickert questions and 2 open-ended questions on the use of the test on a tablet, its ergonomics, the clarity of instructions, ease of use, as well as the dimensions of the tablet and their preference between the two versions. The aim was to collect their feelings and preferences regarding the use of a tactile tablet for cognitive testing.

2.4. Analysis

We used STATA software to perform the analyses. We used the k-Test (kappa) to evaluate the concordance of conventional and digital CDT findings. We calculated the sensitivity and specificity of the digital CDT for the diagnosis of major cognitive disorder and mild neurocognitive disorders.

3. Results

3.1. Validation Sample

We recruited 100 patients, including 74 women (74%) and 26 men (26%). Their age was 83.7 ± 7 years (range 65 to 95). The contingency table for the Codex scoring version of the CDT is presented in Table 1. Agreement was obtained in 91% of cases. The kappa coefficient is 0.81, indicating almost perfect agreement (very good concordance).

Table 1. Contingency table for the Clock drawing test (CDT) using Codex scoring.

		Conventional CDT	
		Normal test	Abnormal test
Digital CDT	Normal test	33	6
	Abnormal test	3	58

The contingency table for the Greco scoring version is presented in Table 2. The kappa coefficient is 0.71, indicating average to good concordance.

Table 2. Contingency table for the Clock drawing test (CDT) using GRECO scoring

		Conventional version		
		Normal	Limit	Abnormal
Digital version	Normal	36	4	4
	Limit	1	1	3
	Abnormal	5	3	43

3.2. Performance Sample

We administered the digital CDT to 157 participants, including 80 women (76%) and 25 men (24%), Their age was 81 ± 7 years. They comprised 61 patients with major cognitive disorder, 49 patients with mild cognitive disorder, and 47 people with no cognitive disorder. The performance of the digital CDT for the reference diagnosis is shown in Table 3.

Table 3. Sensitivity (Se) and specificity (Spe) of the digital Clock Drawing Test (CDT) for the reference diagnosis (major or mild neurocognitive disorders).

	Se	Spe
Mild vs no neurocognitive disorder	0.72	0.59
Major vs no neurocognitive disorder	0.84	0.59

3.3. User Experience

After completing the CDT, participants were asked to fill in a questionnaire to obtain their feedback on the digital CDT on tablet comparatively to the paper and pencil version. We have collected 68 questionnaires as shown in Figure 1. These participants find the tablet easy to use for 49%. However, they still prefer to use paper version (69%), even if they are open to learning how to use the tablet (45%). The digitization of tests in the healthcare sector leaves them a little perplexed (47%), although they tend to agree (32% agree and 9% totally agree).

4. Discussion and Conclusions

We have found that the digital CDT is equivalent to the conventional CDT in hospitalized very old patients. Its sensitivity is good for diagnosing major or mild neurocognitive disorders, and its specificity is low, as has been shown in other studies. Its performance is interesting for the screening of neurocognitive disorders but does not make the digital CDT alone a diagnostic test for these conditions. We will include this test in a series of digital assessments that could help diagnose neurocognitive disorders in older adults.

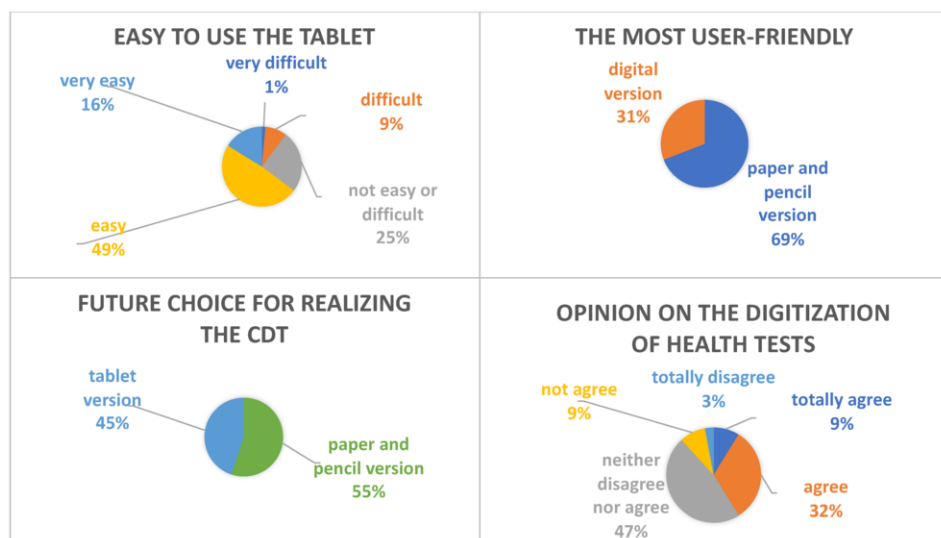


Figure 1. User experience questionnaire

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