Research in Education and Rehabilitation 2021; 4(2): 165-180. DOI 10.51558/2744-1555.2021.4.2.165

THE POTENTIAL UTILITY OF THE CLOCK DRAWING TEST IN SPECIAL EDUCATION AND REHABILITATION

MOGUĆNOSTI PRIMJENE TESTA CRTANJA SATA U SPECIJALNOJ EDUKACIJI I REHABILITACIJI

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Professional Article

Received:05/10/2021
Accepted: 14/12/2021

ABSTRACT

This article aims to at analyze and point out the importance of the use of the Clock Drawing Test for cognitive screening in special education and rehabilitation with reference to early identification and adequate intervention for children and adults at risk, as well as to prevent the occurrence and intensification of disabilities. Through the simplicity of the test administration and scoring, as well as the great value of qualitative data based on the observation of participants' behavior while performing the given task this test has gained popularity in research and clinical practice. On the other hand, in order to perform the given task, it is necessary to activate complex cognitive functions such as visuospatial / visuoconstructive skills and executive functioning. Given the difficulties in performing, the Clock Drawing Test may be indicative of a potential cognitive inefficiencies in the specified domains and/or executive dysfunctions, such as those related to the temporoparietal and frontal lobe structures. In this regard, the present article aims to present and discuss the utility of the Clock Drawing Test in children of different ages and types of developmental challenges (attention deficit hyperactivity disorder, learning disabilities) as well as in adults with multiple sclerosis, traumatic brain injury and dementia.

Keywords: Clock Drawing Test, children, developmental disorder, multiple sclerosis, traumatic brain injury, dementia

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SAŽETAK

U članku je analiziran Test crtanja sata, sa ciljem da se ukaže na važnost njegove primjene kao dela kognitivnog skrininga u specijalnoj edukaciji i rehabilitaciji, a radi prepoznavanja djece i odraslih u riziku kako bi se sprečio nastanak/pogoršanje invaliditeta i primenile odgovarajuće intervencije. Jednostavnost njegovog zadavanja i skorovanja, kao i dragocenost kvalitativnih podataka koje nam pruža posmatranje ponašanja ispitanika tokom izvođenja datog zadatka, učinili su ovaj test veoma popularnim u istraživačkoj i kliničkoj praksi. Sa druge strane, da bi se navedeni zadatak ispunio neophodno je angažovanje složenih kognitivnih funkcija kao što su vizuoprostorne i vizuokonstruktivne sposobnosti i egzekutivne funkcije. Poteškoće prilikom izvođenja Testa crtanja sata mogu već ukazati na potencijalnu slabost u pomenutim domenima i/ili disfunkciju struktura koje su za njih odgovorne, kao što su temporoparijetalni i frontalni režanj. Biće dati i prodiskutovani primjeri upotrebe Testa crtanja sata kod djece na različitim uzrastima sa različitim izazovima u razvoju (poremećajem pažnje i hiperaktivnošću, smetnjama u učenju), kao i kod odraslih sa multiplom sklerozom, traumatskim povredama mozga i demencijom.

Ključne reči: Test crtanja sata, djeca, razvojni poremećaj, multipla skleroza, traumatska povreda mozga,demencija

THE CLOCK DRAWING TEST: WHY IS IT SO POPULAR AND WHAT DOES IT ASSESS?

The utility of the Clock Drawing Test for cognitive screening has been gaining increasing popularity among researchers and clinicians due to its numerous advantages (Müller et al., 2017; Rogers & Panegyres, 2007). Given that it requires only minimal testing materials, based on paper and pencil, as well as it can be administered in less than 5 minutes relatively free from educational, language and/or cultural bias and typically well accepted by respondents. Although the simplicity of the Clock Drawing Test performance may suggest that it has only limited utility, the way in which it is solved by respondents, problem-solving strategies and potential failures such as errors related to the time-setting instructions may yield valuable diagnostic information (Ghanizadeh et al., 2013; Kibby et al., 2002). Moreover, it has been found that both hemispheres of the brain contribute to the activation of most cortical, subcortical, anterior, posterior skills during the Clock Drawing performance, suggesting in particular the contribution of the frontal, temporal and parietal regions (Aprahamian et al., 2009). Specifically, the posterior parietal cortex and the dorsal premotor area appear to be the main constituents of the frontal-parietal cortical networks associated with performance on the Clock Drawing tasks (Figure 1; Eknoyan et al., 2012). Hence, a performance of this complex task requires a wide range of cognitive domains, including planning, problem-solving, abstract thinking, visuospatial and visuoconstructive skills, motor programming, and executive functioning (Kibby et al., 2002; Müller et al., 2017; Schulman, 2000).

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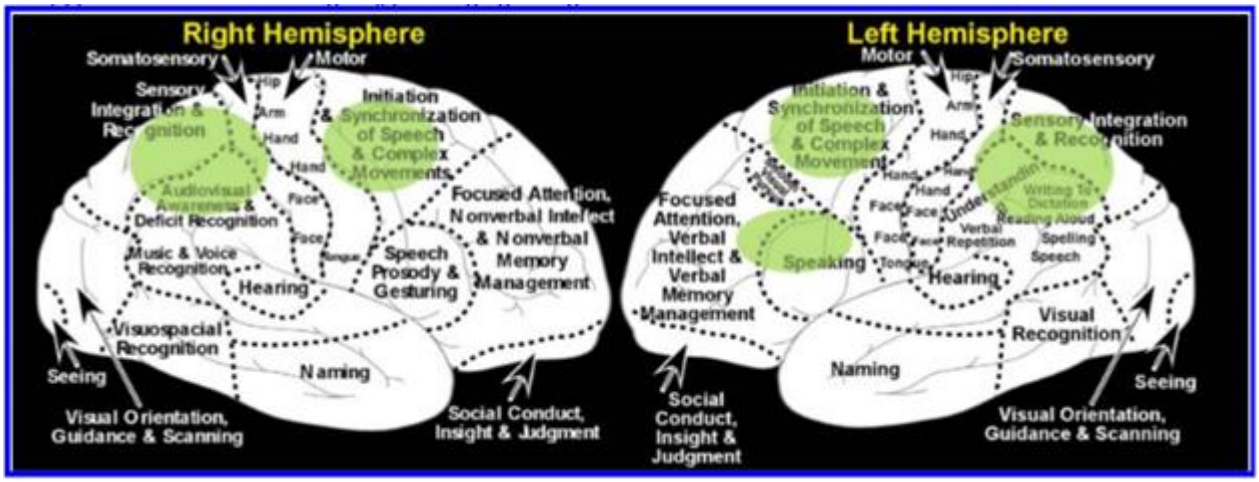

Figure 1. Illustrations of the left and right hemispheres in healthy individuals, mapping the major cortical regions activated in the Clock Drawing task; approximate areas are marked in green (Eknoyan et al., 2012)

Versions of the Clock Drawing Test Instructions

According to the free-drawn method, the respondent is asked to draw a clock from memory, while according to the method of pre-drawn circle (pre-drawn method) the respondent is asked to place all the numbers on the clock. Sometimes the respondent is required to draw the clock hands indicating 10 min past 11 o'clock. Also, there is the method in which the respondents are only asked to set the hands at a fixed time on a pre-drawn clock, whereas a circular contour and numbers are given. Furthermore, there are versions with and without performance time limit. Scoring varies depending on various test based methods (Agrell & Dehlin, 1998; Schulman et al., 1993; Spenciere et al., 2017). Clock Drawing errors typically include deficits in the spatial arrangement of numbers, omissions, repetitions, number rotation or reversal, incorrect placement of hands to a specific time, and incorrect placement of hour and minute hands (Figure 2; Eknoyan et al., 2012).

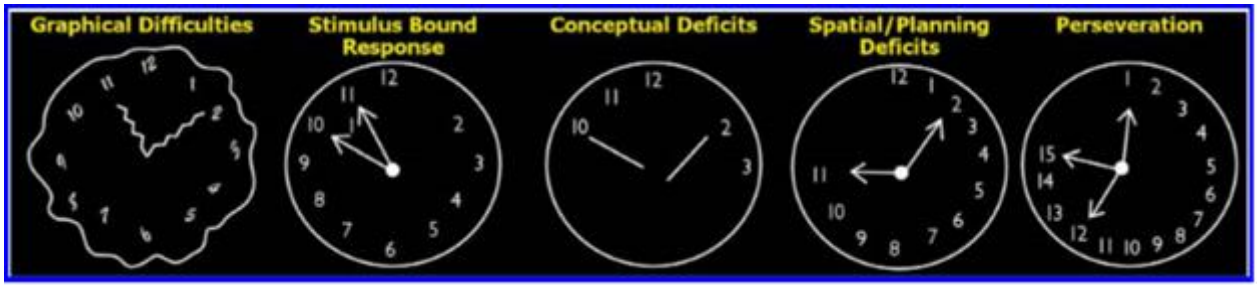

Figure 2. Common types of Clock Drawing errors (Eknoyan et al., 2012)

Although there are guidelines about what a well-drawn clock looks like, it is, however, important to note that if a subject's Clock Drawing shows an error, it does not necessarily mean that the subject's cognitive abilities are impaired. Likewise, if a Clock Drawing falls into the range of "normal" performance, this does not necessarily implicate that the subject's

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cognitive abilities are preserved (Figures 3-6; Diagnostic value - time-on-surface is displayed in black color and time-in-air movements are displayed in red color; Müller et al., 2017).

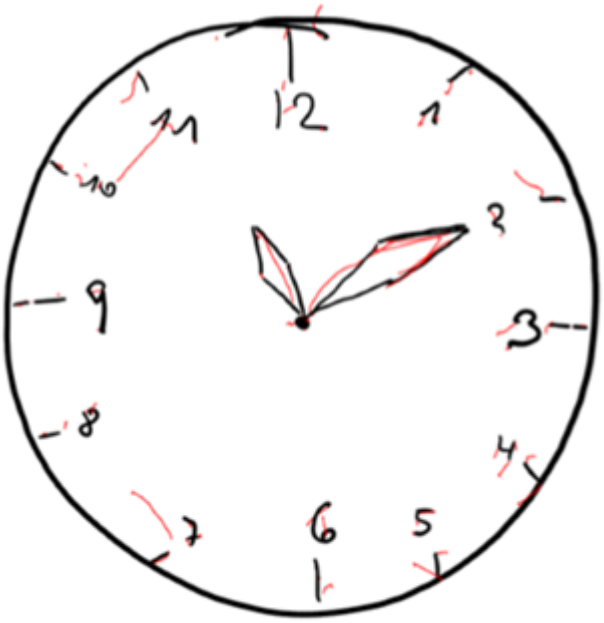

Figure 3. Unimpaired Clock Drawing performed by a healthy individual (Müller et al., 2017)

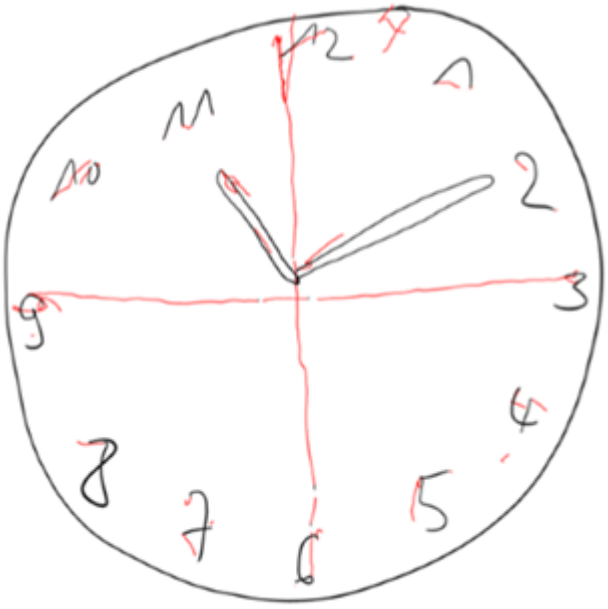

Figure 4. Unimpaired Clock Drawing performed by an individual with a mild cognitive impairment (Müller et al., 2017)

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Figure 5. Visually distorted Clock Drawing by an individual with a mild cognitive impairment (Müller et al., 2017)

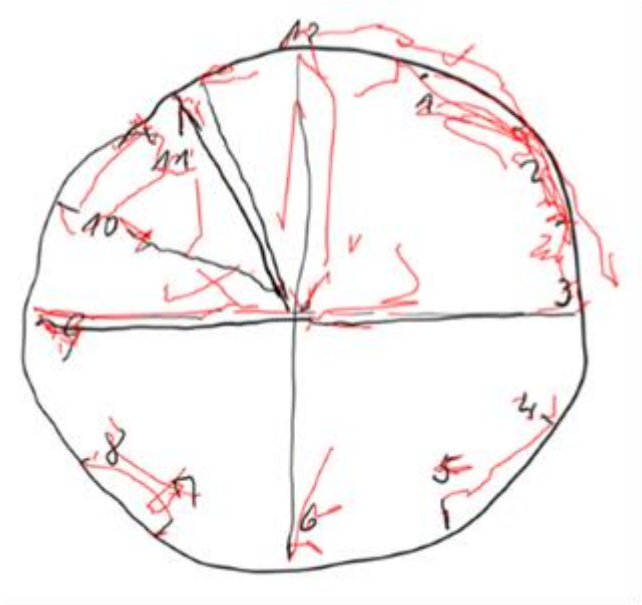

Figure 6. Visually distorted Clock Drawing by an individual with early signs of Alzheimer's dementia (Müller et al., 2017)

In the examples of the Clock Drawings given below, participants were allocated 75 seconds to put in the numbers on a given clock contour (pre-drawn clock), and set the hands at 11:10 (Figure 7). It was used the 10-point scoring system. Also, a special transparent foil was used

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for placing over the drawing, with a drawn circle divided into eight equal parts serving as a scheme for evaluating (Figure 8).

One point is given if the numbers are in the proper octant of the circle, one point if the hour hand is set towards the number "11" and one point if the minute hand is set towards the number "2" (Manus & Wu, 1994).

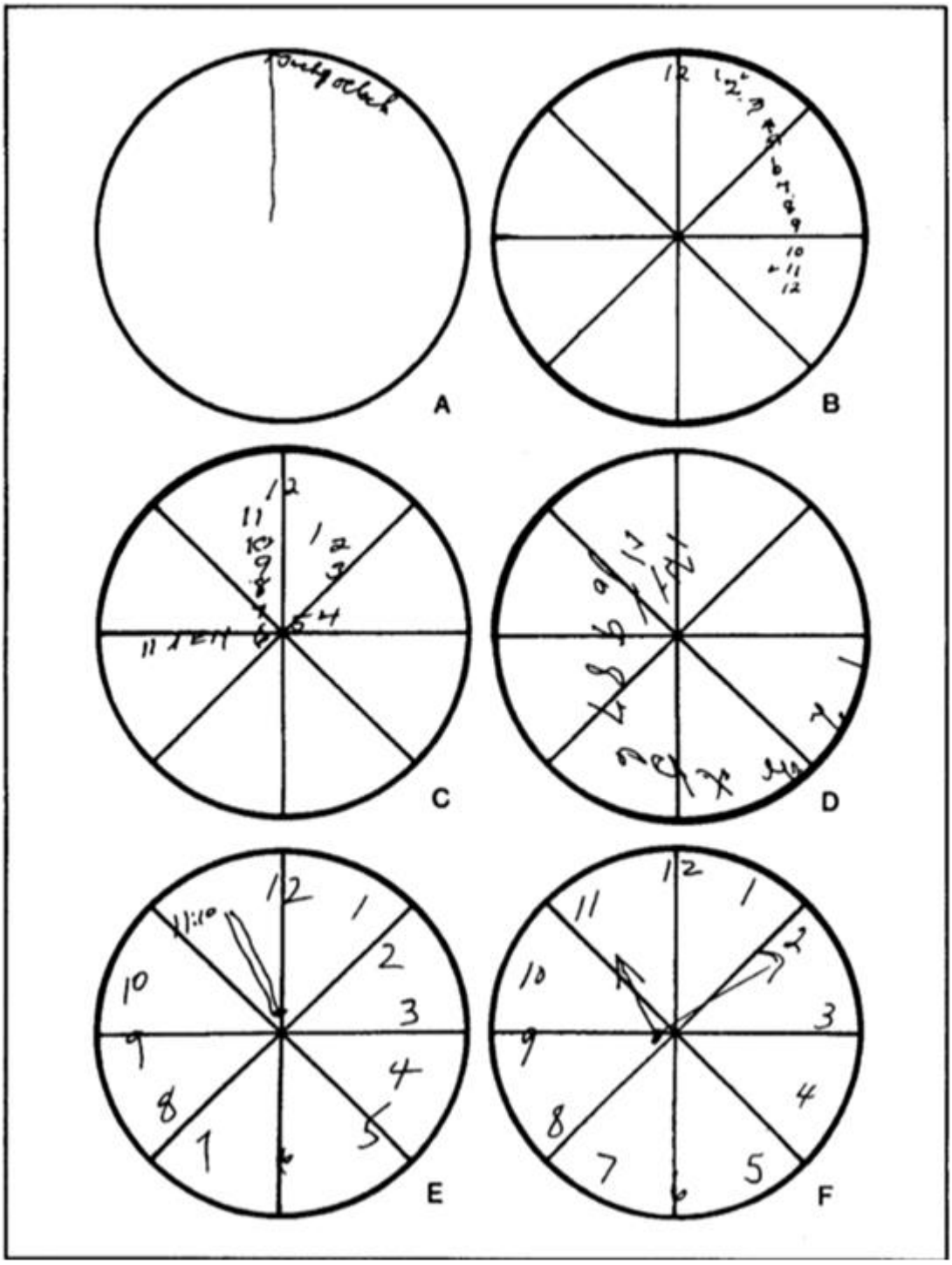

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Figure 7. Scoring examples of the Clock Drawing Test: (A) number of points given is 0; (B) one point is given for the correct placement of number 1; (C) two points are given for the correct placement of numbers 1 and 11; (D) four points are given for the correct placement of numbers 7, 8, 10 and 11; (E) eight points are given for the correct placement of numbers 1, 2, 4, 5, 7, 8, 10 and 11, and zero point earned due to the equal length of the clock hands; (F) 8 points are given for the correct placement of numbers 1, 2, 4, 5, 7, 8, 10 and 11, one point each is given for the correct placement of the hour hand at 11, and minute at 2, the maximum number of points earned, i.e. a total of 10 points (Manus & Wu, 1994).

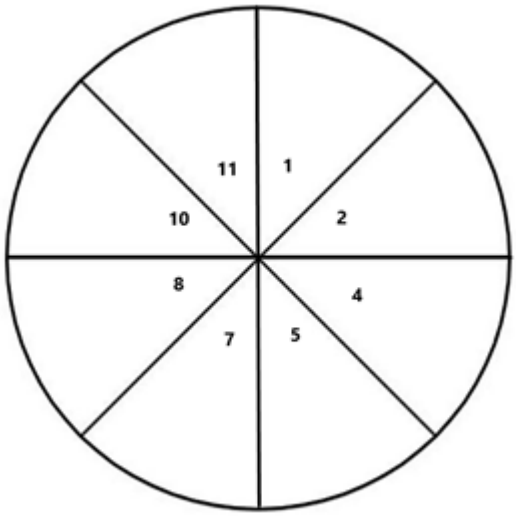

Figure 8. Transparent foil used for a simplified scoring of the Clock Drawing Test (Manus & Wu, 1994)

The Clock Drawing Test in children of different ages

It is therefore suggested that both clock construction and the concept of time are developmental in nature since most 6-year-olds have a basic conceptualization of a clock, most 8-year-olds have been able to successfully set the time while most 10-year-olds have been able to successfully construct and draw a clock face (Figure 9), although spacing of numbers on the clock face was incorrect (Cohen et al., 2000). However, many children ages 11 and 12 continue having errors in the placement of numbers around the clock, which indicates that the Clock Drawing Test is sensitive to the frontal lobe function, and further reveals the trend of gradually increasing the planning skill development after 12 years of age. Thus, this task should be used in assessing school-age children as an integral part of routine evaluation (Kibby et al., 2002; Yousefian et al., 2015).

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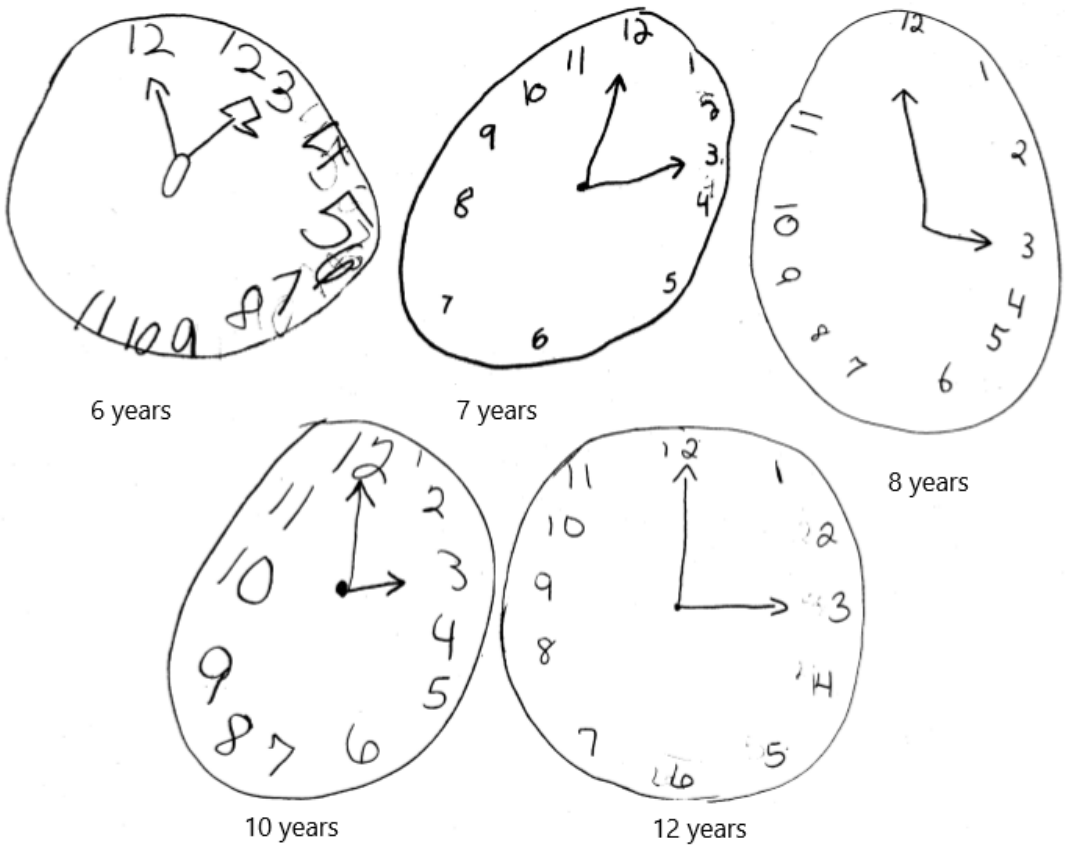

Figure 9. Illustration of Clock Drawings performed by children at 6, 7, 8, 10, and 12 years old (Cohen et al., 2000)

The Clock Drawing Test in children with attention deficit hyperactivity disorder (ADHD)

Deficits in executive function has been considered as the main problem in children with attention deficit hyperactivity disorder in terms of planning, inhibition, working memory and cognitive control, whereby it is expected that they would present with planning and organizational difficulties during the construction of a clock face. Moreover, executive function deficits interfere with the behavioral self-regulation in everyday life, i.e. these children often have poorer adaptive behavior (Ghanizadeh et al., 2013). Results revealed that with regard to putting numbers and hand setting children with ADHD showed poorer performance on the Clock Drawing Test in comparison to children without ADHD (Figure 10), in spite of their adequate visual-spatial and visual-motor integrative abilities. (Kibby et al., 2002). Most common types of Clock Drawing errors included planning deficits in the placement of numbers around the clock face, whereas if children were subsequently provided with a pre-drawn clock that had the numbers 3, 6, 9, 12, that means, if planning/organizational requirements were reduced, their clock construction improved significantly, validating that errors in their original drawings were due to planning as opposed to visuospatial deficits.

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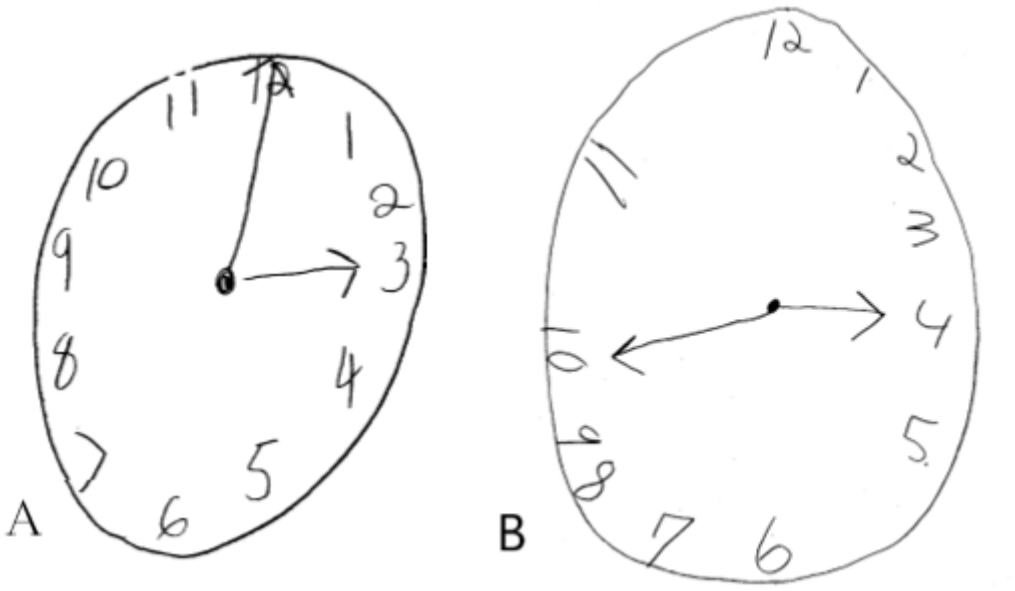

Figure 10. (A) An example of the clock face drawing in children with and without attention deficit hyperactivity disorder, the clock with numbers showing 15:00; (B) An example of the clock face drawing in children with attention-deficit/hyperactivity disorder, the clock with numbers showing time 10:20 (Kibby et al., 2002)

The Clock Drawing Test in children with learning disabilities

Symptoms of learning disabilities include difficulties with reading, writing and/or math problem-solving skills, attention, poor coordination, and time-related concepts. These symptoms alone are not sufficient to identify an individual with a learning disability. Therefore, professional assessment is required for diagnosis of some of the learning disabilities (Pezeshk et al., 2017).

In comparison to individuals with the normal function, individuals with dyslexia showed increased activation in the right hemisphere posterior and inferior frontal regions to compensate for the dysfunction in their left hemisphere posterior regions (Im et al., 2015; Quercia et al., 2013). In a typically developing population, the brain regions responsible for word analysis and recognition include parietotemporal and occipitotemporal regions (Pezeshk et al., 2017). Developmental dyslexia is a dysfunction of the left hemisphere associated with the impairment of skills, such as verbal working memory and phonological processing, which are largely dependent on this hemisphere. However, deviations can be found in the physiology of the right hemisphere brain regions. There is a research-based evidence that children with dyslexia can neglect the left side of the image when they draw clock faces, suggesting a dysfunction of the right-hemisphere mechanisms in spite of dysfunctions in the left hemisphere associated with dyslexia. Figures 11 and 12 provide insight into the achievement of the Clock Drawing Test performance in children with dyslexia and those with typical development (Eden et al., 2003).

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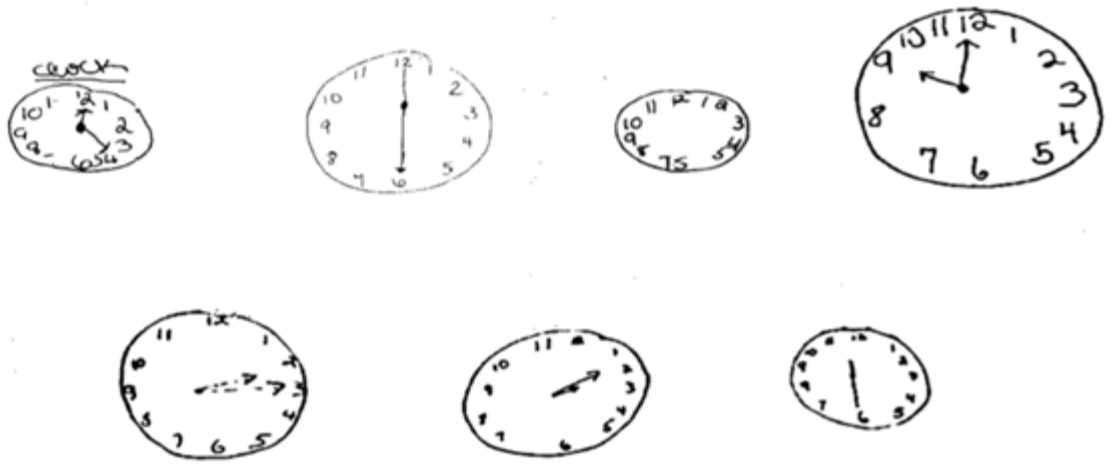

Figure 11. Illustrations of the Clock Drawing Test by children without dyslexia and other disorders aged 10 to 11 years (Eden et al., 2003)

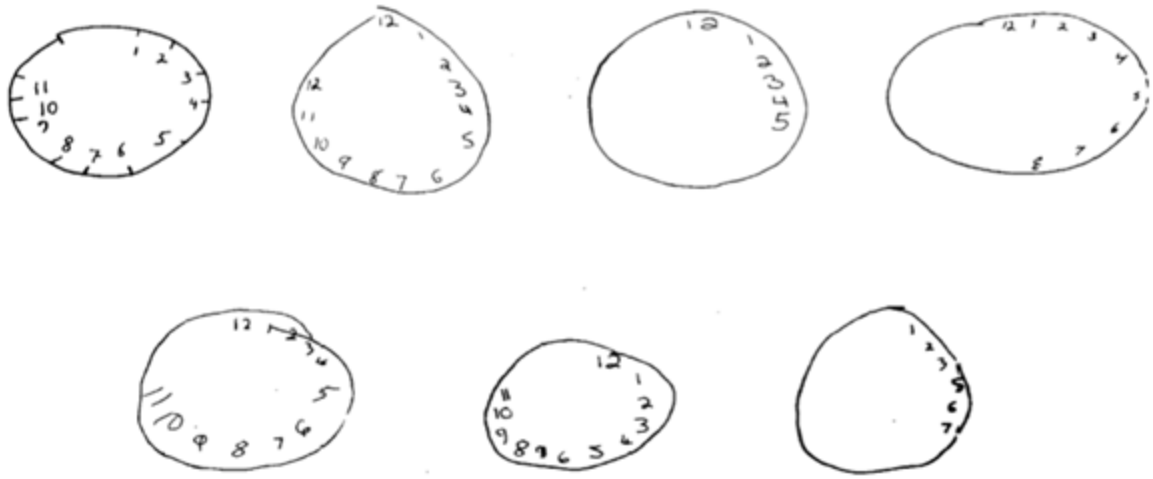

Figure 12. Examples of the Clock Drawing Test by children with dyslexia aged 10 to 12 years (Eden et al., 2003)

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Apart from the left side neglect, there were no differences in clock size or number sequencing in children with and without dyslexia. The study found that apart from the left side neglect there were no significant differences between clock size and number sequencing in children with and without dyslexia.

The Clock Drawing Test in adults with multiple sclerosis (MS)

In addition to the most common sensory and motor deficits related to multiple sclerosis, it is estimated that cognitive impairment is present in 40-70% of patients (Rogers & Panegyres, 2007). Factors associated with MS-related cognitive impairment include brain lesion localization, duration and form of the disease, neurological deficits, fatigue, drugs affecting the central nervous system, and affective disorders (Amato et al., 2001; Kujala et al., 1997; Thornton et al., 2002). Considering that the disease most often occurs between 20 and 40 years of age, i.e. in the working-age population, with the emphasis on the importance of cognitive screening for early detection in these individuals. In addition, the Clock Drawing Test can be used to evaluate cognitive changes over time which can be used in monitoring treatment progress (Barak et al., 2002).

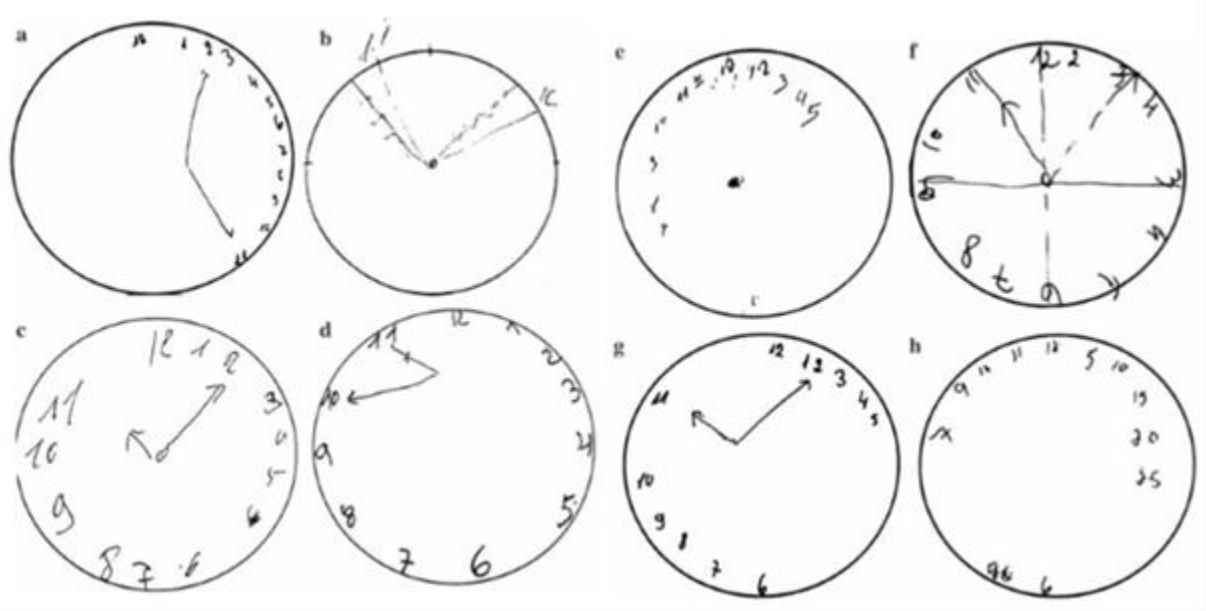

Figure 13. Examples of the Clock Drawing Test by individuals with multiple sclerosis: (a) a 46-year-old woman who was diagnosed with MS 14 years ago; (b) a 67-year-old woman diagnosed with MS 13 years ago; (c) a 57-year-old man diagnosed with MS 12 years ago; (d) a 52-year-old woman diagnosed with MS 3 years ago; (e) a 47-year-old woman diagnosed with MS 24 years ago; (f) a 60-year-old man diagnosed with MS 39 years ago; (g) a 46-year-old woman diagnosed with MS 23 years ago; (h) a 40-year-old woman diagnosed with MS 15 years ago (Barak et al., 2002)

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The Clock Drawing Test in adults with traumatic brain injury

The most common acute cognitive impairments after traumatic brain injury include confusion and disorientation, problems with short-term and long-term memory, attention deficit, problems in communication, organization and planning, and diminished cognitive flexibility (de Guise et al., 2011; Ino et al., 2003). The Clock Drawing Test should help to clinicians gain initial insight into patients' cognitive status and opt for further testing (de Guise et al., 2010). Functional magnetic resonance imaging studies (de Paula et al., 2013) suggest bilateral frontal lobe activation during the Clock Drawing Test, although other regions are also involved. The Clock Drawing Test shows a different error pattern in subjects with right hemisphere lesions (mild left spatial neglect, incorrect placement of hands and reversal of clock numbers) compared to the left frontal lobe lesions (difficulties with understanding the test instructions, incorrect placement of numbers and writing numbers beyond "12"). Difficulties with the Clock Drawing Test performance are more common in patients with right hemisphere lesions than in patients without such lesions. Consequently, numbers are often omitted from the left side of the clock, all the numbers are aligned on the right side and the clock drawing shows only the numbers 12 to 6 (Figure 14; de Guise et al., 2010). Further, they also had a problem with gaps in number spacing and deficit in spatial layout of numbers. Typically, neglect on the lower left quadrant of the clock has been more frequently observed following right parietal lobe lesions.

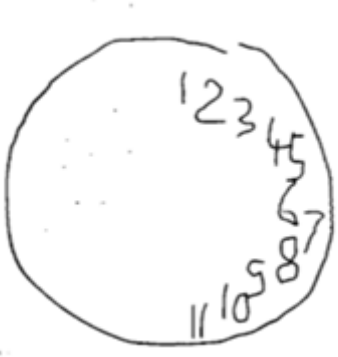

Figure 14. An example of the Clock Drawing Test by an adult patient with a right parietal lobe lesion (de Guise et al., 2010)

Patients with traumatic subarachnoid hemorrhage, swelling in the brain or the presence of bilateral brain injury were found to perform significantly poorer on the Clock Drawing Test compared to those without brain injuries. It is about the difficulties in construction of the clock face and the placement of clock hands and numbers in the correct position. Also, older and less educated patients with traumatic brain injuries have shown worse results in the Clock Drawing Test.

The Clock Drawing Test in people with dementia

Common Clock Drawing Test errors in individuals with dementia include errors in setting clock hands at number "10" and " 11"on the clock face instead towards "11" and "2", setting time (both in letters/numbers) not just in numbers, omission of clock hands, neglect of the left

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or right half of the clock, incorrect placement of the anchor numbers (12, 3, 6, 9), errors in the spatial layout of numbers, numbers written outside the clock face, numbers written counter – clockwise, repeating numbers or duplicating the clock hands. The omission of numbers or hands, errors in number placement and hand proportion, and errors in spatial layout of numbers are more associated with decline in cognitive functions than other errors (Ricci et al., 2016). Sensitivity of the Clock Drawing Test has been shown while comparing groups of patients with Alzheimer's disease, Parkinson's disease and vascular dementia, whereby the group of Alzheimer's disease patients committed more errors related to a loss of semantic knowledge while the impairment of executive functioning seemed to be more pronounced in the other two groups than in the group with Alzheimer's disease (Allone et al., 2018). Further, the errors in placing the clock hands were taken into account for distinguishing patients with mild cognitive impairment, who are more likely to develop dementia (Ehreke et al., 2011). In addition to the patient's condition itself, the educational attainment and literacy status of older people influenced performance on the Clock-Drawing Test significantly (Figure 15; Kim & Chey, 2010).

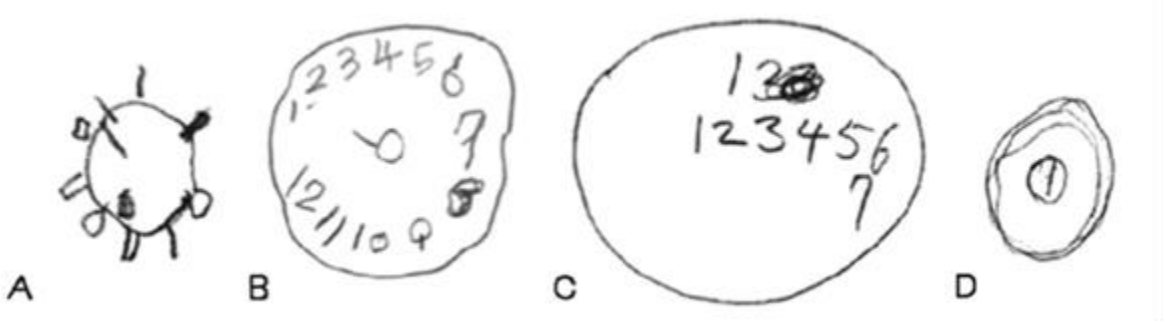

Figure 15. Examples of conceptual errors observed most frequently in the illiterate individuals with no education and in the dementia of the Alzheimer's type: (A) 82-year-old woman, uneducated, illiterate; (B) a 69-year-old woman, uneducated, illiterate; (C) 70-year-old woman, Alzheimer's dementia, 6 years of schooling, literate; (D) 57-year-old woman, Alzheimer's type dementia, uneducated, illiterate (Kim & Chey, 2010)

Less educated participants had lower Clock Drawing Test scores. The effects were most dramatic in the illiterate individuals. It has been observed that illiterate and/or less educated older individuals have made mistakes similar to those made by people with Alzheimer's dementia. The conceptual deficits observed in patients with dementia of the Alzheimer's type have been interpreted as stemming from the loss of semantic knowledge evoked by the word "clock' and the graphic representation of a clock. However, this interpretation assumes that everyone has developed semantic and visuospatial representations of the clock and a constructive ability to translate these mental representations into drawing before the development of dementia.

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CONCLUSION

It is therefore recommended to use the Clock Drawing Test as an integral part of a cognitive screening in both children and adults because it can provide insight into valuable qualitative and quantitative data, which would serve as guidelines for continuing the work with patients in the field of special education and rehabilitation, aiming at recognizing persons at risk and preventing the occurrence and intensification of disability. Given the impact of cognitive domains on the task performance, domains that have a significant impact on test performance are relevant to performance of activities of daily living, and it is essential to assess performance on these cognitive domains.

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