

A working (in a fashion) clock, created by medical students Ben Izakson and Kevin Anderson, as a memento of their time administering the clock drawing test. Reproduced with permission.

The clock drawing test: A useful screening and teaching tool

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Physicians are often asked to assess a patient's knowledge and memory, as well as the patient's ability to use language and numbers, think abstractly, make decisions, and solve problems. This cognitive assessment can be done in a variety of ways, one of which is to ask the patient to draw an analog clock. The clock drawing test (CDT) is often used as part of a larger battery of neuropsychological tests. Poor performance is associated with cognitive impairment, dementia, or other neurological problems.

History of the CDT

The first person to use a clock as part of a medical evaluation may have been English neurologist Henry Head (1861–1940), in 1915.¹ Head wrote a two-volume opus about aphasia, a disorder in which a person with no motor or sensory deficits nonetheless has difficulty speaking, reading, writing, or understanding language.² He asked his patients to carry out a multitude of tasks, such as writing times down in words, reading clocks, and setting the hands of a physical clock following written and spoken commands.

Another English neurologist, Macdonald Critchley (1900–1997) asked his patients to draw a clock on a blank piece of paper and then set the hands to a certain time. This is known as a “free-drawn clock.”^{1,3} Critchley was interested in parietal lobe dysfunction, such as apraxia. The

apraxic person cannot carry out organized movements, despite having the physical ability and intention to do so. Constructional apraxia is the inability to copy, draw, or build an object.

A person may have varying degrees or types of both apraxia and aphasia. The clock drawing test is sensitive to both types of disorders.

Edith Kaplan (1924–2009), a pioneer neuropsychologist working at the Boston Veterans Administration Medical Center, simplified the task. She used pencil and paper, and with respect to a free-drawn clock, asked patients to draw the clock set to only one time, “ten after eleven.” She also asked the patient to copy a drawing of a clock. If she had little time to spend with a patient she would, out of a panoply of neuropsychological assessments, rely on the clock-drawing tests to give her a general sense of the person’s thinking.⁴

Beginning in the 1980s, Ken Shulman in Toronto⁵ and Martin Roth in Cambridge, England,⁶ psychiatrists with expertise in geriatric psychiatry, began to use the CDT as a screen for dementia. The CDT has good sensitivity and specificity, comparing well with the widely used Mini Mental State Examination (MMSE)⁷ with respect to screening for cognitive decline.⁸

Why the clock?

Neuropsychologists and neurologists often ask their patients to draw different objects, such as houses, trees or people to test cognitive functioning. The clock has several advantages over these objects because it has fewer variations, and none of the possibly distracting emotional associations of a person. A person needs no artistic ability to draw a clock. While there is a range of drawing ability in the population, most unimpaired people can draw clocks.

Although drawing a clock is easier than drawing the other objects mentioned above, it still has its share of difficulties, so much so that a successful clock drawing demonstrates that the brain is working well across a range of important tasks. Because it casts such a wide net, the CDT is a good screening test for identifying those people with cognitive dysfunction.

To complete the CDT successfully, patients must first be able to hear and understand the instructions to draw the clock, and be willing to cooperate with what might seem to be an odd request. Next, they must bring a picture of a clock into their minds. They must be able to manipulate a pen or pencil and their vision must be good enough to draw the clock. They must also remember that the short hand denotes hours, and that the long hand denotes minutes.

The most difficult part of drawing the clock is the placement of the hands. Kaplan selected the time “ten after eleven” because it tests patients’ neuroanatomical integrity and functional abilities. The hands showing that time are placed on the left and right sides of the clock, so the task requires the patient to pay attention to both hemispheres of vision. The clock hands are also in the superior half of the clock, and the optic radiations that carry information from the superior visual fields loop from the lateral geniculate nucleus in the thalamus through the temporal lobes to the visual cortex. This long and vulnerable route tests the intactness of the temporal lobes.

This time setting also tests a person’s ability to handle the superimposition of the sexagesimal (base 60) system used to count minutes and the duodecimal (base 12) system used to count hours. This use of dual systems in one clock comes easily to us when we learn it as children, but is quite difficult to explain.

Neurologists sometimes ask patients to draw the clock hands at “twenty after eight.” Because both hands are in the inferior fields of the visual field, this choice of time tests the integrity of the visual pathways that run from the lateral geniculate nucleus in the thalamus through the parietal lobes to the visual cortex. This part of the optic radiation carries information about the inferior fields of vision. However, it is difficult to be certain which brain pathways are activated because the CDT involves so many.

Despite the number of processes involved, most cognitively intact people can draw a clock and place the hands correctly.

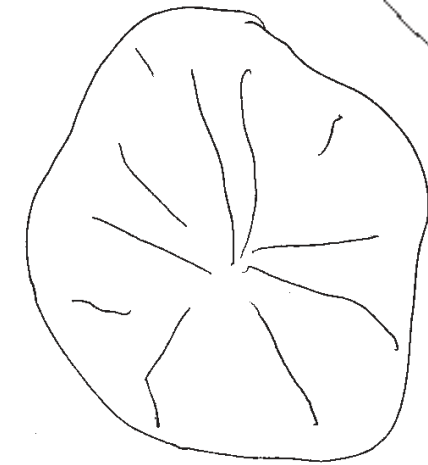
Mistakes in the CDT

A person with cognitive problems can make an array of mistakes in drawing a clock. In most cases of mild dementia the person understands the request and draws a circle without too much trouble. After that, however, the task becomes more difficult. People with dementia may forget some numbers, crowd others together, or get the sequence wrong. Placing the hands is challenging. The time, “ten after eleven,” can be puzzling because of the conjunction of the duodecimal and sexagesimal systems. The person may not be able to recode the spoken 10 to the written two.

People with dementia often place two hands of equal length on the numbers 10 and 11, because of what Kaplan referred to as a “frontal pull,” caused by confusion resulting from the examiner saying two numbers, as though they refer to the same unit. The mistake is a “stimulus-bound response,” in that the person is reacting to the most obvious or concrete interpretation of the word 10, and not demonstrating the usual understanding of the conjunction of the two

systems. If, however, as Kaplan pointed out, the person is asked to put the hands to “twenty after eight,” the task becomes easier since the person will immediately see that there is no “20” on the clock, and they therefore, after some time, understand or remember that the minute hand needs to be set to the number four. As dementia worsens the person becomes unable to include any numbers or to arrange the hands correctly.

Other clock drawing mistakes reveal different types of deficits. Someone with Parkinson’s disease tends to draw a small clock (micrographia), and patients with strokes or other lesions affecting their visuospatial deficits can draw clocks with one side blank. Clocks drawn by patients with tremors often have shaky lines.



Examples of clocks drawn by patients with dementia.

One young woman with unexplained behavioral changes described her own CDT as part of the story of how her diagnosis of anti-N-Methyl-D-Aspartate (NMDA) receptor encephalitis was finally made. She had drawn the numbers one to 12 on the right side of the clock, leaving the left side blank. This unusual clock drawing convinced her neurologist to continue searching for an organic illness. After the diagnosis was made, she was successfully treated and later wrote a book about her illness, using her clock drawing (reproduced in the book) as a compelling demonstration of her illness being due to an organic brain problem rather than a more nebulous psychiatric diagnosis.⁹

Sometimes, the person draws a clock badly and is unaware of his or her poor job, thus demonstrating anosognosia, or a lack of appreciation of one’s deficits. A former mathematician took over an hour to draw a clock and was unable to place the hands correctly; fortunately, but sadly, he was pleased with his drawing.

Some patients and their family members have come to associate the request to draw a clock with a medical visit. If the person, or more often, a family member, recognizes the deterioration in the patient’s clock drawing, the experience can be painful. If the patient or family member becomes upset, the task should be ended. However, a drawing

that becomes more accurate can demonstrate improvement to the patient or family.

Scoring the CDT

The CDT lends itself to complicated scoring systems. Depending on which system is used, the examiner can rate a variety of features of the drawing, including, but

not restricted to, the size of the clock, the placement and size of the hands, the correct sequencing of the numbers, the quality of the circle, and the presence of extra marks. However, the more complicated the scoring system, the more time consuming the entire task becomes.

There is no consensus of how best to score the clock drawing. Perhaps different systems could be used for different purposes. More complex scoring systems may be better at differentiating people with normal cognition from people with mild cognitive impairment.¹⁰ Some authorities suggest that a simple score of normal or abnormal may be just as helpful as a more complex one with respect to screening for cognitive decline.^{11,12}

The CDT and driving ability

In 2001, Barbara Freund, a gerontologist, and her team, suggested using the CDT to predict driving ability in older people.¹³ Because dementia is an age-related disease, and people with dementia have a high rate of driving accidents,¹⁴ physicians may be asked to assess driving ability in their older patients. The decision of whether a person at a certain age or with dementia should or should not drive is momentous. People who stop driving may lose independence, become (or worry about being) a burden on others, and be at risk of becoming depressed and isolated.

Road tests are assumed to be the best way of assessing one’s ability to drive safely, however, it is impractical for all older people to undergo road tests as these tests are not always available and are both time-consuming and expensive.

Freund, et al,¹³ studied 119 older drivers and found that scores on the CDT correlated fairly well with performance on a driving simulation test. David Carr (AΩA, Michigan State University, 1998), et al,¹⁵ showed that the CDT used in a 10-minute screening battery of drivers with dementia accurately predicted subsequent failure on a road test.

The CDT can be correlated with particular types of driving problems. For example, Freund and her team¹⁶ studied people who pressed the gas pedal instead of the brake pedal, thus causing “unintended acceleration.” In the article, “In my car the brake is on the right: Pedal errors among older drivers,” they describe the results of a study in which they asked 180 subjects aged 65 years or older to complete a 30-minute driving simulation test. The subjects also completed the MMSE, the CDT, and Trail Making Tests Parts A and B. Performance on the CDT, but not on the other tests, was significantly correlated with pedal errors.

In Denmark, the CDT is recommended as a cognitive screen for drivers over the age of 70 years, along with questions about orientation and three-word recall.¹¹ In Ontario, drivers over the age of 80 years are asked to take the CDT along with another simple test of cognition, such as the Letter Cancellation Test, to see who might need further cognitive assessment.

The American Medical Association recommends that the CDT, along with the Trail Making Test Part B, be used (as well as tests of hearing, vision, and motor strength, speed, and flexibility) to determine the need for further information gathering. The person who does badly on these tests may need further medical examination, testing, and possible treatment of remediable problems and/or referrals to others including a driving rehabilitation specialist.^{14,17}

Drawing a clock and maneuvering a four-thousand-pound vehicle in traffic each require some degree of physical dexterity, visuospatial perception, and good cognitive functioning. People who perform badly in either area are not always aware of their deficits. However, more research needs to be done in the area of assessment of driving safety. A mediocre clock drawing does not necessarily predict driving disasters, and a well-drawn clock does not guarantee impeccable driving.

The CDT as a teaching tool

Medical students enjoy administering the CDT, even though they often ask if the test will become outdated because so many of them rely on smartphones or digital watches to tell time. But the analog clock, whether as a time-telling device, symbol, or decoration, is omnipresent. The face and hands are integrated into our way of thinking and vocabulary. Thus, when we ask a patient to draw an analog clock, we are asking that person to draw a familiar object. The analog clock is a common meme, and that, along with the presence of so many clocks on our streets, may allow the analog clock to persist as a well-known object.

If the student is observant and engaged, the task can

yield some surprising information. Because the medical examination is usually carried out by an active examiner on a passive subject, the patient may greet the request to do something—in this case to draw a clock—with relief or amusement, and talk with the student about matters that arise from the task.

One of our patients drew, with pleasure, a likeness of a famous banjo clock created by Simon Willard (1753–1848). As he drew the clock he reminisced about his achievements in woodworking and taught the student about the role of the Willard family in the history of clock-making in the United States. The relationship between the patient and student was enriched.

In another case, members of a consultation-liaison psychiatry team (including a medical student) were asked to assess a patient with schizoaffective disorder because of concerns about worsening psychosis. The patient drew a clock accurately, managing to incorporate an hourglass into his drawing. Then he talked about the face of the dial, faces in general, the nature of time, and the clock as a reminder of the inexorable nature of time and our own mortality. His comments led to a discussion with the medical student about the relationship between psychosis, mood disorder, and creativity.

The CDT once demonstrated to a student that a patient was blind. During an interview, the patient turned his face toward the student, leading the student to think that the patient could see him. At no time during the lengthy discussion did the patient refer to his blindness, although he did say that his eyesight was not as good as it used to be. When asked to draw a clock he agreed, but was unable to do so. Had the patient in fact deliberately concealed his blindness? Had he adapted to it? Or did he have a type of anosognosia, making him unaware of the extent of his visual deficit?

The CDT fascinates students, some of whom enjoy the chance to learn about the history of timekeeping and the clock. One undergraduate student working with Shulman developed an interest in the history of the test and became first author of two articles: one on the use of the CDT in the detection of mild traumatic brain injury,¹⁸ and the other a well-researched account of the CDT’s history, including a discussion of the early work of Head and Critchley and the later dissemination of the CDT.¹

The drawings of the patients have inspired some Boston University School of Medicine students to express their own creativity. Two students wrote a poem about the clock, while two others created a working (in a fashion) clock as a memento of their time administering the CDT.

The CDT reminds medical students of the importance of testing a person's cognition, rather than making assumptions. Students and clinicians are often reluctant to diagnose dementia and can be deceived by conversations with articulate or witty patients who retain their conversational skills even when other cognitive skills are lost. When one patient who was uneducated and inarticulate drew a flawless clock the students realized that the patient had strengths and capabilities hitherto unappreciated by them.

A test appreciated by all

The CDT is a quick test of cognition that compares well with other cognitive tests. Both the task assigner and completer often enjoy the test. A clock drawing can illustrate a person's cognitive state vividly and can be kept for easy comparison with later drawings. A mistake-ridden clock is a pictorial representation of a poorly working brain. The cause could be apraxia or aphasia or some combination of the two, or a more common illness such as Alzheimer's dementia. The important point is that an abnormal clock drawing signals the need for further assessment of the person's cognition and ability to perform important tasks such as driving.

The CDT helps the medical student to appreciate the important but sometimes subtle and overlooked difference between verbal fluency and the ability to perform visuospatial tasks requiring planning, some motor skills, and memory.

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