

# Predictive Value of the Clock Drawing Test

## A Review of the Literature

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### Key Words

Cognitive decline, early diagnosis • Cognitive tests •  
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### Abstract

**Background/Aims:** The Clock Drawing Test (CDT) assesses cognition focusing on executive function and praxis in contrast to the more language-based Mini-Mental State Exam. The CDT may allow early identification of cognitive decline.

**Methods:** A systematic review of the literature was used to identify studies that had used the CDT to predict future cognitive impairment. **Results:** Five studies were found with the CDT as a predictor. The data were too disparate for meta-analytic techniques. **Conclusion:** The CDT may be a useful tool to identify decline before more traditional screening tests; however, further studies are needed as the data are sparse and heterogeneous.

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### Introduction

Dementia is a common form of illness and cause of disability in the very elderly [1] and we live in a globally ageing society [2]. Treatments to ameliorate the effects of dementia are available [3] and advance warning of this disease may allow time to implement treatment strategies and to plan ahead. There are many cognitive tests and

diagnostic criteria for the identification of cognitive decline, mild cognitive impairment (sometimes thought of as a preclinical phase of dementia) and dementia itself [4, 5]. Probably the most widely used is the Mini-Mental State Exam (MMSE) [6, 7], a tool which is fairly easily administered with relatively little training and takes approximately 30 min to complete [6]. The disadvantages faced by the MMSE are that it is language based [4] and if not administered in the first language of the individual could result in a lower score. This might be of particular relevance when assessing the elderly from ethnic minority groups, although multiple language versions are available to help surmount this problem. The MMSE is also thought to be influenced by education [4], such that lower levels of education result in lower scores especially for the language-based items. High levels of education also have an impact as this can contribute to ceiling effects with the educated individuals able to use their cognitive reserve to perform well on the MMSE despite having a decline from normal functioning [4, 8, 9].

Supplementing the standard MMSE with the Clock Drawing Test (CDT) has been proposed [10]. This may help compensate for these disadvantages as the latter requires less language ability and performance in executive function and praxis may be less protected by cognitive reserve. The CDT has been in use since the 1950s [4] and is easy to administer [7]. It is also considered to be less influenced by depression or dysphoria [11, 12]. The clock test is thought to require the use of a variety of mental

**Table 1.** The papers identified in the literature

Authors	Study details	Participant details	Time delay	Screening tools used	Dementia diagnosis
<i>Studies with information on the CDT as a predictor</i>					
Ferrucci et al. [21], 1996	to evaluate the CDT as predicting cognitive decline; observational	247 followed for 4 years	baseline for this analysis = 1991; follow-up = 1995	at baseline 1991: MMSE, CDT, Dementia Rating Scale; in 1995: MMSE, Dementia Rating Scale	N/A, just assessed cognitive function
Chen et al. [22], 2001	prospective community-based study; case control methods used to compare	551 participants; 68 cases developed symptomatic Alzheimer's disease and had full testing data	assessment at '3.5 (T1) and 1.5 (T2) years before onset'	neuropsychological battery, CDT	standard criteria
O'Rourke et al. [23], 1997	prospective	59 recruited from a clinic for Alzheimer's disease	average time between baseline (T1) and later (T2) assessments = 22 months	clock tests (scoring system Tuokko), CDT administered at first visit (T1)	standard criteria
Brodaty and Moore [24], 1997	cross-sectional case control study	subset 8/28 subjects had Alzheimer's disease and MMSE $\geq 24$	none	MMSE	standard criteria
Ratcliff et al. [25], 2003	prospective observational study	425 completed tests in all assessment years	10 years assessments every 2 years	MMSE, neuropsychological battery, CDT	none
<i>Studies without information on the CDT as a predictor</i>					
Lee et al. [26], 2003	prospective pilot survey	50 consecutive referrals to an outpatient ophthalmology clinic aged $>64$ years	not clear; only 1 patient accepted referral after screening	clock drawing (plus depression and functional impairment screen)	none
Nishiwaki et al. [27], 2004	prospective trial	13,557 participants $\geq 75$ years; community-based sample	median follow-up = 4.7 years	MMSE, CDT – scored using a 4-point method	none
Ganguli et al. [28], 1996	prospective observational study	follow-up sample (n = 1,017; mean age = 74.3 years, standard deviation = 5.4)	first follow-up (mean = 23.8 months, standard deviation = 2.8)	MMSE, neuropsychological battery, CDT	none

skills; visuo-perceptual and visuo-motor abilities to internally represent the clock face and to translate the mental representation into a motor program, and visuo-perception also guides the ongoing layout of the clock and monitors the output. Hemi-attentional processes are needed to produce features on both sides of space, the linguistic system must provide the graphomotor representation on numbers and executive function must coordinate the planning, organisation and simultaneous

processing. This includes corrections and inhibition of incorrect responses such as perseveration [13]. Memory is needed to remember the instruction to set the time and retrieve it once the clock face is complete, and finally the time setting of 10 past 11 with the 2 recoded as 10 min past the hour 'cannot be stimulus driven but must rely on executive function' [13]. There are several methods for administering the clock test, but most authors agree that the clock draws primarily on visuo-spatial and executive

Outcome
The CDT was scored according to the system of Wolf-Klein; pathological clocks correlated with follow-up MMSE score ( $p < 0.01$ ); when analysis was restricted to those with an MMSE score $>21$ at baseline, people with a pathological clock at baseline were 5.4 times more likely to have an MMSE score $<21$ at follow-up (confidence interval = 2.1–14.2) and 5 times more likely to have an MMSE score $<18$ at follow-up (confidence interval 1.6–19.6)
Mean change between cases and controls: for the MMSE cases declined from 26.68 to 25.94 ( $p = 0.2$ ), controls from 27.76 to 27.61 ( $p = 0.52$ ), the difference was significant ( $p = 0.04$ ); difference in decline/change between cases and controls: for the CDT, when the changes in cases and controls were compared directly, the $p$ value was 0.11; the participants were not demented at their second assessment
Predrawn circle; the participants were not suffering from dementia at their first assessment; 18 had a diagnosis of dementia at follow-up assessment; the 2 groups differed in their baseline CDT score; when each error type and clock setting/reading errors were entered into a MANCOVA (adjusted for age) substitution ( $p = 0.006$ ) and clock setting ( $p = 0.001$ ) remained significant
The Shulman scale identified 7/8 using a cut-off of 2/3; the Sunderland scale identified 3/8 with a cut-off of 5/6 or 5/8 using a cut-off of 8/9; the Wolf-Klein scale identified 1/8 using a 6/7 cut-off or 7/8 with a cut-off of 8/9
The participants included in this analysis were cognitively intact at baseline; factor analysis identified several factors, although there was some change in the loading as the assessments progressed; the factors included constructional praxis (including clock test); the authors recommend caution regarding the praxis data as these tests are subject to ceiling effects
10 participants had abnormal clock scores, but only 1 accepted further assessment, so judgement of predictive value was not possible
CDT associated with mortality from cerebrovascular disease, respiratory disease and malignant neoplasm; incident dementia not assessed
The participants included in this analysis were cognitively intact at baseline; cognition showed a slight decline; the mean clock scores fell from 7.4 to 7.1; no information is given on the predictive status of the clock scores, although the participants who dropped out of the study before follow-up assessment were more likely to have been impaired at baseline

functioning, particularly with regard to the inhibition of incorrect responses [14–17].

The CDT then may focus differently to the standard MMSE, and this be especially relevant as the earliest deficits that are manifested in Alzheimer's disease, the commonest form of dementia, may be visuo-spatial [14] or visuo-spatial and executive functioning, even in those with high MMSE values [15]. Preclinical Alzheimer's disease has been associated with attention and executive function

deficits [16]. Similar findings with deficits in memory and executive function were shown in a further study [18].

A variant of the CDT, 'Clox', was able to distinguish between Alzheimer's disease and mild cognitive impairment, finding that subjects with mild cognitive impairment had worse verbal, visuo-spatial and executive function skills than control subjects [19]. A further study also found impaired executive function Alzheimer's disease and scores unaffected by dysphoria, although apathy caused them to fall [20].

Vascular dementia, the second most frequent diagnosis, and frontotemporal dementia are also thought to show deficits in executive functioning [17, 14].

The CDT may then be an apt means of measuring early cognitive decline, possibly before MMSE or other screening tests.

The objective of this review was to systematically examine the literature to discover any evidence that the use of the CDT had been assessed as an early screen for possible dementia, before the more usual tests had identified a problem.

## Method

Three databases were searched for the terms 'Clock drawing test' or 'clock drawing task' or 'clock test' or 'clock drawing' or 'CDT' or 'clock' with 'cognitive decline' or 'cognitive impairment' or 'executive function'. The searches were restricted to subjects  $\geq 65$  years, human sources and in English, French, Spanish, Italian and Portuguese languages.

Psychinfo was searched from 1967 to January 2006, Medline from 1966 to January 2006 and Embase from 1980 to January 2006. In total 288 records were identified. The number of abstracts selected for further examination was 138. Abstracts were selected if they used the clock test or a variant of this to assess cognitive function (i.e. not as a proxy for physical function, etc.) and if the participants were not suffering from any additional psychiatric disorders which may affect performance on cognitive testing. Letters, conference proceedings and case studies were not included.

The 2 authors assessed the abstracts independently. There were no discrepancies between them and 73 papers were selected for more detailed examination. Of these, 8 (reporting on 7 studies) were selected as relevant to the research question. This required participants to have no diagnosis of dementia at baseline, a CDT score at baseline and some form of longitudinal follow-up.

## Results

Eight papers were identified, reporting on 7 studies. Of these, only 5 studies provided sufficient information to allow evaluation of the CDT as a predictor. In the one

that had produced 2 papers, these were based on different populations at different lengths of follow-up, but only 1 provided follow-up data with regard to cognitive decline. All 8 papers are included in table 1.

Three studies had longitudinal data showing that the performance on the CDT was worse in a non-demented population at baseline who went on to develop dementia/cognitive impairment than in those who did not [21–23]. Ferrucci et al. [21] followed their population for 4 years and found that when the analyses were restricted to people with an MMSE >21 at baseline, pathological clocks were significantly more likely to predict an MMSE <21 (5.4 times more likely) or <18 (5.5 times more likely) at follow-up. Similarly, Chen et al. [22] observed a difference between baseline CDT scores when comparing those who went on to receive a diagnosis of dementia with those who did not, although it did not achieve statistical significance ( $p = 0.11$ ). O'Rourke et al. [23] found errors in substitution and clock setting were significantly more likely in the group that went on to have dementia.

Two further studies provided limited information [24, 25]. Brodaty and Moore [24] reported that the CDT identified Alzheimer's disease cases in those with MMSE scores of  $\geq 24$ . In the Movies study, Ratcliff et al. [25], writing about 425 survivors followed for 10 years, found that constructional praxis (including the CDT) was one of the aspects identified by a factor analysis as impacting on cognitive decline, but they did not relate the CDT to incident dementia or cognitive decline. One further study identified 10 out of 50 subjects as having abnormal clocks. However, only 1 participant accepted later cognitive evaluation [26].

Of the other papers, one, Nishiwaki et al. [27], did not assess dementia as an endpoint, although they found that the CDT score was related to subsequent mortality from cerebrovascular disease, respiratory disease or malignant neoplasm. Another was a second publication using the data from the Movies project, with long-term follow-up but without predictive information [28].

Of the 5 studies with outcome data, only 1 published an odds ratio, 2 provided significance values for comparisons between the cases and controls at follow-up, 1 presented the number of cases identified by each scoring system and 1 considered praxis as a feature emerging from a factor analysis. Meta-analyses using the data identified in the review were therefore not possible as the data were too few and too disparate (table 1).

## Discussion

A systematic review of the literature found 5 useful studies with regard to the application of the CDT as an early test for cognitive decline or dementia prior to more traditional screening tools identifying a problem. The evidence that is available suggests that the CDT may well function in this role, but the data are currently insufficient to allow any firm conclusions. There were many studies identified in the literature showing that the CDT correlated with other tests and with diagnoses, but in total, only 7 investigations could be found that followed a population for a period of time and/or had CDT data at baseline with later outcome. Of these 8 papers (7 studies), only 4 clearly specified the follow-up time and the lack of cognitive decline or dementia at baseline [21, 22, 25, 28], with 1 further study including only MMSE scores >21 at baseline [21], a level that may well be indicative of an already present dementing process. The analyses reported in the papers vary too widely to allow a meaningful comparison. The methods used to administer and score the CDT differed, as did the other assessments of cognitive function, the population and the length of follow-up. The identification of cases was not standardised and this may have impacted on the study results and means that drawing conclusions is hard even with the available data. The results were also reported in a variety of ways and there was insufficient statistical information to allow formal comparison, meta-analysis or the production of a forest plot. Despite this, the limited data available do seem to indicate that the CDT may show deficit before the MMSE falls to the usually defined category of 'mild dementia', that is a score <24. Certainly, performance on the CDT is likely to be predictive of decline and that in itself may merit its use at least alongside the MMSE, with abnormal performance prompting further assessment even if the MMSE score does not seem to give cause for investigation. Certainly, it is not time-consuming and can be incorporated into general practice assessments [27]. As the data currently available in the literature are disparate and unable to be combined, it is argued that it is time for a large robust study to answer this question clearly.

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