

# What the Digital Clock Drawing Test (dCDT) Tells Us About The MoCA Clock Scoring Criteria

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## Objective

Determine the accuracy of the Montreal Cognitive Assessment clock (M-clock) scoring criteria using the computerized scoring system of the digital Clock Drawing Test (dCDT).

## SUBJECTS

413 Framingham stroke & dementia free subjects were given the dCDT. Two age groups were created consisting of a middle age referent group (FHS-M, n=297) age <60 (47.5 ± 7.8 years) and an older-age cohort (FHS-O, n=116) age >60 (70.4 ± 7.2 years). Groups were equally well-educated and did not differ for gender or handedness.

## METHODS

dCDT software was used to objectively quantify the M-clock 3-point scoring criteria of clock circle (ellipse, circle closure), numbers (all present, no repeats, no sequence error, in correct quadrant) and hands (distance from center, pointing to numbers, hand ratios). To establish the M-Clock hour hand “clearly shorter” criteria, exemplars of clocks with hand length ratios from 0.7 to 0.9 were judged by 2 raters. Hand ratios of 0.85 were the maximum ratios reliably judged “clearly shorter”; higher ratios were unreliable, establishing 0.85 as the MoCA hand length ratio cut score (M-hand). We compared classification accuracy for M-hand, equal length (EQ) and any length (Any) hand ratios. Normative cut scores for the M-Clock were derived on a middle age referent group, FHS-M (n=297; age <60). Based on the skewed distribution, thresholds of 1.64SD were applied to account for 95% of the normal sample. An older-age cohort (FHS-O; n=116; age >60 years) assessed classification accuracy.

Table 1. Performance on component and composite measures for FHS-M (N=295)

	Numbers	Circle: eccen., angle, residual	Hands 0.7	Hands 0.75	Hands 0.8	Hands 0.85	Hands 0.9	Hands 1.0	Hands any
Failed	17	26	127	106	88	79	71	61	41
Pct failed	5.76%	8.81%	43.05%	35.93%	29.83%	26.78%	24.07%	20.68%	13.90%

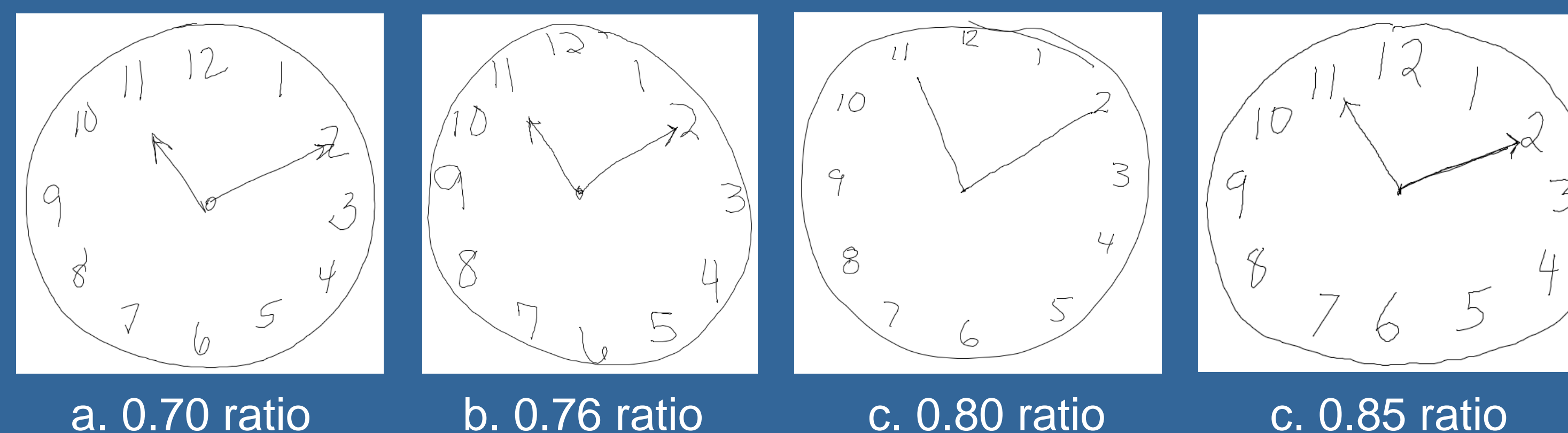
Table 2. Classification of FHS-M on MoCA using various hand ratios (N=295)

	MoCA .7	MoCA .75	MoCA .8	MoCA .85	MoCA .9	MoCA 1.0	MoCA any
Failed	150	131	115	108	101	91	72
Pct failed	50.85%	44.41%	38.98%	36.61%	34.24%	30.85%	24.41%

Table 3. MoCA Scoring Criteria

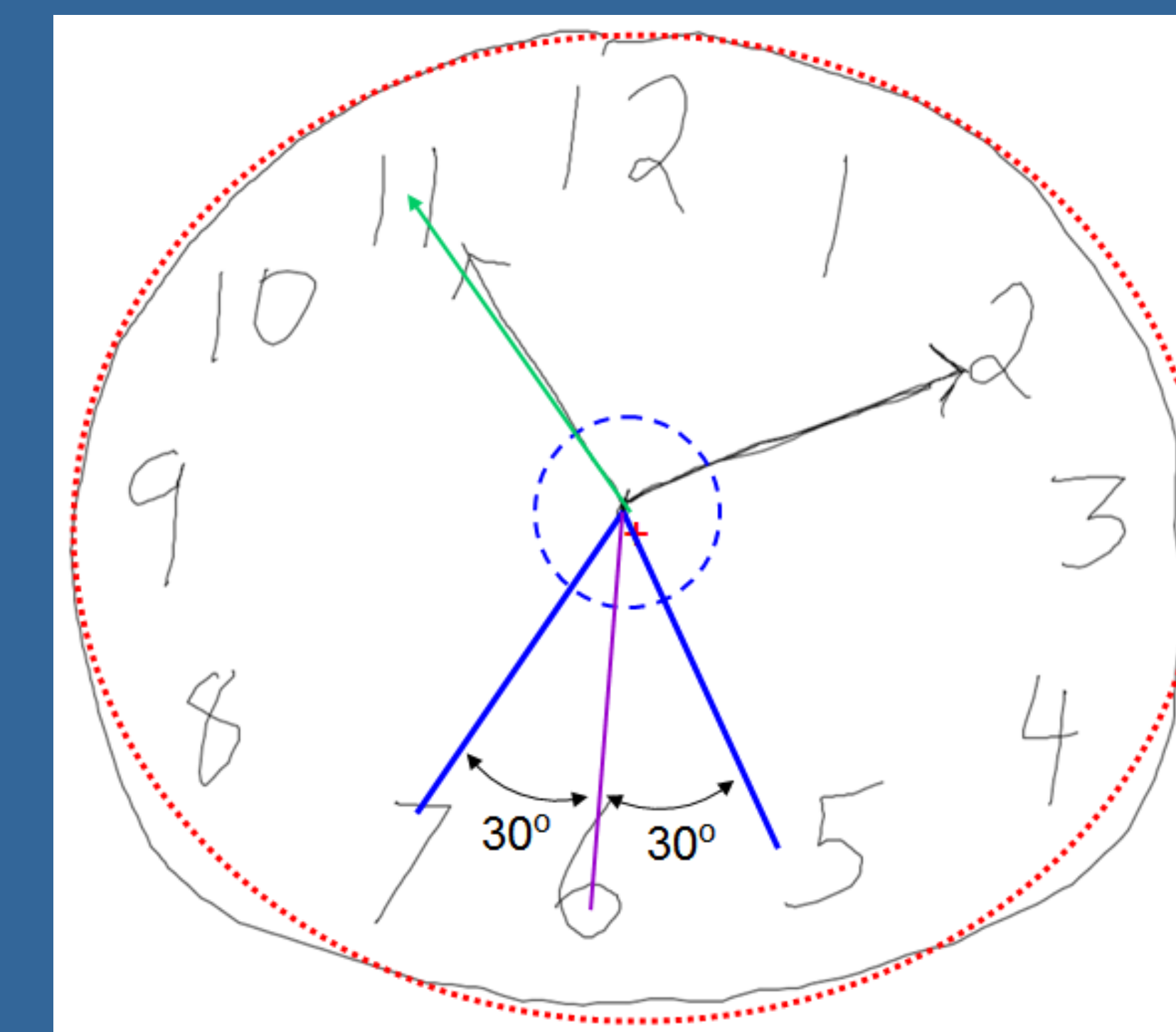
- **Contour (1 pt.):** the clock face must be a circle with only minor distortion acceptable (e.g., slight imperfection on closing the circle).
- **Numbers (1 pt.):** all clock numbers must be present with no additional numbers; numbers must be in the correct order and placed in the approximate quadrants on the clock face; Roman numerals are acceptable; numbers can be placed outside the circle contour.
- **Hands (1 pt.):** there must be two hands jointly indicating the correct time; the hour hand must be *clearly shorter* than the minute hand; hands must be centered within the clock face with their junction close to the clock center.

Figure 1. Which hour hand ratio would you judge “clearly shorter”?



What is your misclassification rate?

Figure 2. Geometry of the dCDT Measurements



Contour: red oval is an ellipse fit to the clock face. Contour distortions measured by: gaps in clock face, eccentricity of the ellipse, and distance from clock face to ellipse.  
Numbers: are judged as in the correct quadrant if they are within 30 degrees of their appropriate angular location.

## RESULTS

Clock circle and number scoring criteria correctly classified healthy FHS-O as normal (5.50% and 1.83% failed, respectively). Mean hand ratios were high for both groups (FHS-M: 0.69 ± 0.27; FHS-O: 0.78 ± 0.31) resulting in hour hands longer than minute hands at the 1.64SD threshold. M-hand misclassified 44.95% FHS-O as not normal. Using EQ hand ratios improved classification accuracy, but failure rate was still high (33.94%). Any hand ratios provided best classification of the normal sample (22.02% failure).

## CONCLUSIONS

Hand ratio errors are common in middle and older aged healthy adults. The M-clock hand length scoring criterion has high classification error rates of impairment. Eliminating the hand ratio component reduces misclassification rates.