capstract:2611.00048v1 [med.CL] 20 Nov 2026

Original Research

Battery withdrawal after a normal clock-drawing assessment: a paired maintenance study in simulated analog clocks

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Abstract

Background: A clock set to ten past eleven satisfies the hand-placement item of a common clock-drawing assessment. The duration of this response in a functioning clock is short. We examined whether battery withdrawal at the time of a normal assessment prolongs the response.

Methods: We screened every whole-minute position of a simulated 12-hour dial. For each position that passed, we followed paired copies for 12 hours, one with continued power and one with the battery withdrawn. The primary outcome was time to first loss of correct hand placement. An independent reference supplied the time for assessments of function.

Results: Five of 720 entry positions qualified. With continued power, median time to relapse was 3 minutes (range 1 to 5). All five unpowered clocks retained the response for 12 hours. At a return visit exactly 12 hours after entry, all ten clocks passed and told the correct time. Over the full interval, the unpowered clocks told the correct time in 5 of 3,600 clock-minutes (0.14%), compared with 3,600 of 3,600 under continued power. Allowing the return visit to run up to 5 minutes early or late produced a 54.5 percentage point advantage for withdrawal on the hand-placement item.

Interpretation: Withdrawal maintained the score at the cost of timekeeping. Punctual follow-up concealed both the relapse of the powered clocks and the loss of function of the unpowered clocks.

Keywords: clock drawing; maintenance of response; withdrawal design; outcome ascertainment; simulation

Introduction

In one widely used clock-drawing procedure, the examiner asks for a face with numbers and two hands set to ten past eleven. The completed drawing earns separate credit for the position of the hands [1]. A drawing can be filed and scored later. An analog clock has the same features available for inspection, but its hands can move between examination and scoring. A clock judged normal at ten past eleven may have lost credit by the time the examiner signs the form.

Maintenance studies recruit participants who have already responded and compare continued treatment with withdrawal [2]. Relapse during follow-up and status on the day of a return visit answer different questions. In clinical withdrawal trials the timing of a first relapse can be ascertained over an interval [3]. In a clock, the hands can be examined throughout the interval, and there is an independent measure of function against which to check the result.

We studied withdrawal of battery power immediately after a clock first presented with qualifying hand placement. We asked how long the response persisted, whether it would be detected at a routine return visit, and how often a clock retaining the response could also be used to tell the time.

Methods

Eligibility and paired follow-up

The sampling frame comprised one simulated clock for each whole minute of a 12-hour dial. At entry each clock agreed with an independent reference. All had a round face, twelve evenly spaced Arabic numerals and two distinguishable hands. The cases

differed only in their time of presentation. Each was screened once. Waiting with an initially ineligible clock until its hands moved into position would have constituted a second screening visit.

We adapted the hand-placement item from the Alzheimer’s Disease Neuroimaging Initiative procedures manual [1]. We assigned the minute hand to the numeral nearest its tip and did the same for the hour hand. A pass required the long hand at 2 and the short hand at 11. We scored a hand exactly between two numerals as incorrect. This angular rule operationalizes the judgment for an ideal dial. We did not administer the command or copy portions of the clinical test, or assign credit for drawing the circle and numbers.

Each eligible case contributed one copy to each policy. In the continuation arm the hands advanced normally. In the withdrawal arm the battery was removed immediately after the qualifying reading, without adjusting either hand. The reference advanced in both arms. In a separate restart analysis the battery was replaced after 6 hours without resetting the clock. This operation distinguishes restoration of movement from restoration of the time. The study used generated dial positions and involved no human participants or patient records.

Outcomes and analysis

The primary endpoint was the first whole minute at which either hand left its qualifying sector. Clocks still passing at 720 minutes were administratively censored for this endpoint. We also measured the proportion of follow-up minutes spent in response, the proportion showing the correct time to the minute, and the proportion meeting both criteria on the same reading. A secondary definition of functional accuracy allowed a

discrepancy of up to 2 minutes in either direction, measured by the shorter distance around the dial.

For a clock displaying minute m after twelve, the hour hand was at $m/2$ degrees clockwise from twelve and the minute hand at $6(m \bmod 60)$ degrees. A hand had to lie less than 15 degrees from the qualifying numeral. We evaluated minutes 1 through 720 after entry, including the return visit and excluding the qualifying reading. In the visit-window analysis we allowed a single return reading at any whole minute within a symmetric interval around 12 hours, with equal weight on each offset. The clocks continued under their assigned policies through the latest possible visit.

We enumerated each eligible entry position under both policies. Percentages describe this finite set. Repeated minutes on a dial do not supply independent observations for a confidence interval. We report counts, paired differences in percentage points and the range across entry positions. No extrapolation to a population of manufactured clocks was made.

Results

Screening and relapse

Of 720 positions screened, 715 failed the entry assessment. Five qualified, from 11:08 through 11:12 inclusive. All five pairs completed follow-up, contributing 3,600 minutes per policy. The first powered clock to relapse had presented at 11:12. The clock that presented at 11:08 remained in response the longest. Their first failed readings occurred at the same displayed time, 11:13 (Figure 1).

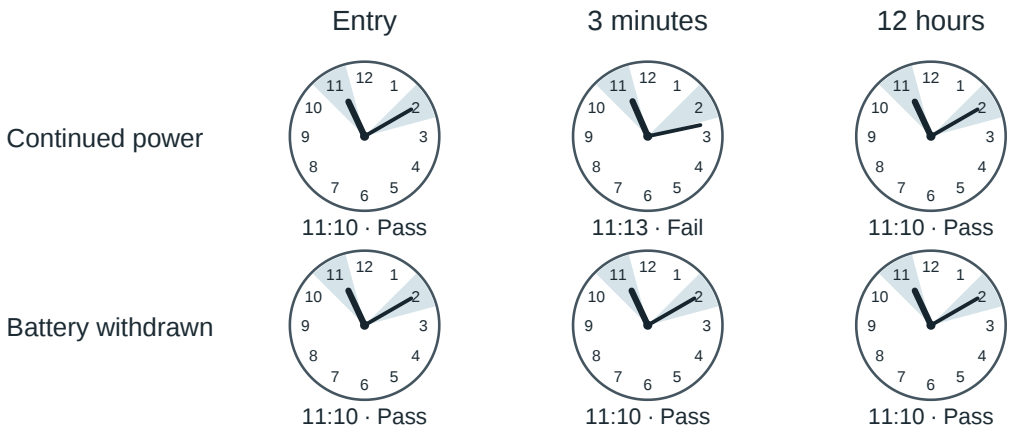


Figure 1. Hand placement for the pair enrolled at 11:10. Shaded sectors delimit the two target numerals. Both clocks were assessed against the same reference at each reading.

Time to first relapse under continued power was 1, 2, 3, 4 and 5 minutes across the five entry positions. None of the clocks from which the battery was withdrawn relapsed. At 12 hours, response was again present in all five powered clocks. An assessment made only at entry and at discharge would have recorded complete maintenance in both arms.

Timekeeping and battery replacement

The withdrawn clocks retained correct hand placement for 3,575 more clock-minutes than their paired controls, but supplied the exact time on only five readings (Table 1). These five readings all occurred at the return visit. With the 2-minute functional tolerance, the two arms spent the same time in joint response. The 25 qualifying minutes in the withdrawal arm fell within two minutes of the entry time on the dial. In the continuation arm they fell within two minutes of 11:10.

Table 1. Outcomes over 12 hours by power policy. Entries are clock-minutes (%) out of 3,600 per column. The restart column is a separate analysis of the same five entry positions.

Outcome	Continued power	Battery withdrawn	Restart at 6 h
Correct hand placement	25 (0.69)	3,600 (100)	1,810 (50.28)
Exact reference time	3,600 (100)	5 (0.14)	0 (0)
Both on the same reading	25 (0.69)	5 (0.14)	0 (0)
Both, allowing 2 min of time error	25 (0.69)	25 (0.69)	10 (0.28)

After battery replacement at 6 hours, all five clocks resumed movement. Each relapsed within 5 minutes of restart. For the remaining 6 hours each ran exactly opposite the reference on the hour hand. Replacing the battery abolished the brief agreement with the reference that would otherwise have occurred at discharge.

Timing of the return visit

A punctual visit yielded a between-arm difference of zero in the proportion passing. A delay of exactly 1 minute was sufficient to produce a 20 percentage point difference. The size of the effect at a fixed offset depended on whether the qualifying positions at entry still overlapped those at follow-up (Figure 2).

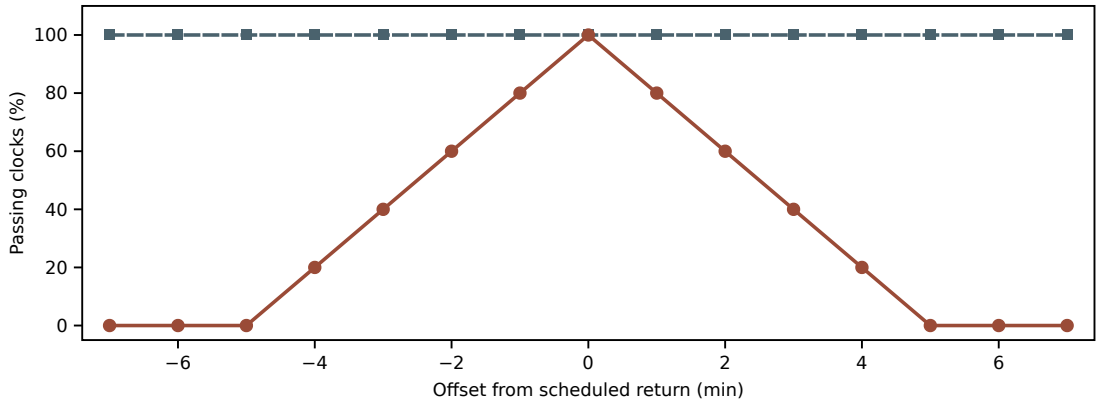


Figure 2. Passing the hand-placement item at a single return visit, by departure from the scheduled time. Circles indicate continued power and squares indicate withdrawal. Each point represents five entry positions. An offset of zero denotes a return exactly 12 hours after entry.

With a visit window of ±5 minutes, 25 of 55 possible readings passed under continued power (45.5%), compared with all 55 after withdrawal. Widening the window to ±15 minutes added 100 possible readings per arm. None of the additional readings passed in the continuation arm. The difference favoring withdrawal rose to 83.9 percentage points.

Discussion

Removing the battery at a qualifying assessment prevented relapse for the full observation period. A clock that continued to run could spend 715 of its next 720 minutes outside the response window and still return with the same score. An investigator reviewing only the two scheduled observations would have little reason to request the intervening record. The time on the wall at discharge would corroborate every reading.

The enrichment step matters. The treatment can preserve any position of the hands. Of the 720 clocks available for screening, 715 would have retained a failing score if treated on presentation. A service accepting referrals throughout the day could make all of them eligible by asking them back at 11:10. The distinction between a response during a run-in and a response to the run-in is material in this design.

Hand placement and timekeeping agreed at recruitment because agreement was required for entry. That observation gives little support for using hand placement as a surrogate for function under withdrawal [4]. A fresh battery alone was insufficient to repair the functional deficit. After replacement, the clocks advanced at the correct rate

from a reading six hours out of date. Resetting them would have been a second intervention.

The scoring rule uses a finished face. Digital drawing studies can distinguish the sequence of strokes in a commanded drawing from that in a copy [5]. Neither trace is available from a manufactured dial. Our analysis is confined to the static hand-placement item. A still image would suffice for that item, although the time of image acquisition would need to be retained. We assumed no gear slip on withdrawal and no drift under power. An offset of a minute mattered near the edge of a qualifying sector. Extrapolation to a worn movement would require measuring both effects.

A 24-hour visit would reproduce the 12-hour result exactly. For a review intended to detect loss of response, moving the appointment by five minutes would be sufficient. For a review intended to establish whether the clock can be returned to service, we would record the reference time as well.

References

1. Alzheimer's Disease Neuroimaging Initiative. ADNI3 Procedures Manual. 2017. Available from: https://adni.loni.usc.edu/wp-content/uploads/2024/02/ADNI3_Procedures_Manual_v3.0.pdf
2. US Food and Drug Administration. Enrichment Strategies for Clinical Trials to Support Determination of Effectiveness of Human Drugs and Biological Products. 2019. Available from: https://www.fda.gov/media/121320/download
3. Lewis G, Marston L, Duffy L, Freemantle N, Gilbody S, Hunter R, et al. Maintenance or Discontinuation of Antidepressants in Primary Care. N Engl J Med. 2021;385:1257–1267. doi:10.1056/NEJMoa2106356
4. Prentice RL. Surrogate Endpoints in Clinical Trials: Definition and Operational Criteria. Stat Med. 1989;8:431–440. doi:10.1002/sim.4780080407
5. Frank B, Bandyopadhyay S, Dion C, Formanski E, Matusz E, Penney D, et al. A Network Analysis of Digital Clock Drawing for Command and Copy Conditions. Assessment. 2025;32:119–129. doi:10.1177/10731911241236336