

A Process-Aware, LLM-Driven Digital Clock Drawing Test for Scalable Cognitive Screening: Development and Preliminary Validation

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LLM-driven dCDT enables independent, scalable cognitive screening by integrating voice guidance, AI-based clock-face scoring (84.3%–99.8% accuracy), and multimodal process capture—extending beyond traditional CDT without specialized hardware.

INTRODUCTION	METHODS	RESULTS	CONCLUSIONS	REFERENCES
The Clock Drawing Test (CDT) is a widely used cognitive screening instrument. However, existing digital implementations face three key barriers to scalable preclinical deployment: 1. Reliance on human administration: precludes unsupervised, self-directed completion by older adults. 2. Small modeling datasets: prior digital scoring models trained on limited samples may exhibit instability on out-of-sample data [1]. 3. Specialized hardware requirements: requirement for dedicated devices impedes large-scale deployment in community settings [1]. To address these limitations, we developed a process-aware, LLM-driven digital CDT (dCDT).	The dCDT integrates three modules 1. Voice interaction: LLM-driven guidance and real-time Q&A for unsupervised completion. 2. Intelligent scoring: Multi-LLM fusion evaluates seven clock-face indicators from images. No large annotated dataset required. 3. Process capture: Stylus trajectory, digit recognition, and voice metrics (e.g., drawing speed, target-time queries) recorded in real time. Validation: 427 open-access scanned CDT images [2] LLM-powered voice guidance Draw a clock face. It is all numbers, with the time pointing to 11:50. If you have any questions or concerns, feel free to ask me directly. Real-time Q&A You can talk to me or ask questions Start (A) Guidance module Read-time digit recognition & Stylus trajectory metrics recorded Score The time is 11:50. Voice-based behavioral indicator capture (e.g., target-time query frequency) (B) Drawing module	LLM scoring agreement with human annotations (n = 427): - Clock existence: 99.1% - Circle present: 99.8% - Both hands present: 92.3% - Hour hand position: 87.6% - Minute hand position: 84.8% - Digit sequence: 87.1% - Digit completeness: 84.3% Composite score correlated with Shulman total scores (p = 0.613, p < 0.001). Correlation between dCDT composite score and Shulman score $p = 0.613$ $p < 0.001$ $n = 427$	The dCDT represents one of the first LLM-based cognitive assessment tools, demonstrating feasibility for large-scale, unsupervised deployment. The moderate correlation with Shulman scores indicates comparable visuospatial assessment to the traditional CDT. By capturing multimodal data (voice, images, drawing process, touch trajectory), the dCDT extends beyond traditional CDT and holds potential for improved screening efficacy. A prospective clinical validation study using native digital input is currently underway.	[1] Souillard-Mandar W, Penney D, Schaible B, Pascual-Leone A, Au R, Davis R. DCTclock: Clinically-Interpretable and Automated Artificial Intelligence Analysis of Drawing Behavior for Capturing Cognition. Front Digit Health. 2021 Oct 15;3:750661. doi: 10.3389/fdgth.2021.750661. PMID: 34723243; PMCID: PMC8553980. [2] Raksasat R, et al. Attentive pairwise interaction network for AI-assisted clock drawing test assessment of early visuospatial deficits. Sci Rep. 2023;13(1):18113. doi:10.1038/s41598-023-44723-1. CONTACT Zhixing Zhou, MS, DHS zhixing.zhou@bestcovered.com ORCID: 0000-0002-6199-004X ALZHEIMER'S ASSOCIATION AAIC 26