

Automated analysis of figure drawing and recall

Background:

Figure drawing and recall tests (e.g., Rey–Osterreith; Benson Complex Figure Test, etc.) are sensitive behavioral measures of visuospatial construction, organizational strategy, and episodic memory. Performance on these tasks declines early in neurodegenerative disease and predicts functional outcomes. However, traditional figure drawing tests rely on manual test delivery and scoring that are labor-intensive, require specialized training, and exhibit substantial inter-rater variability. Moreover, conventional scoring—with subjective categorical measures of element presence and spatial placement—ignores potentially useful data such as motor dynamics, temporal organization, drawing sequence, shape fidelity, and geometric distortion. As a result, much of the information about the drawing process itself is lost, limiting clinical sensitivity. Here, we describe the automated analysis results from the two-minute figure drawing test of the California Cognitive Assessment Battery (CCAB) administered remotely in participants' homes.

Methods:

Participants first copy a target figure presented on a touch-screen display and are asked to reproduce it from memory after a 30-minute delay. During drawing, finger position is sampled continuously and analyzed to derive temporal (e.g., pauses, segment durations, total drawing time) and motor measures (e.g., velocity, acceleration, jerk, tortuosity). Resulting drawings are then homographically aligned in template space to enable element identity and location to be scored by computer vision using Vertex AI which concords 97% of the time with manual element identification. Figure 1 shows the overlap of a copied drawing from one subject (drawing color reflects latency). Subsequent analysis yields both categorical and continuous measures of element presence and location, as well as metrics of drawing organization (e.g., large structural elements drawn first), perseveration (duplicate elements), shape fidelity (Hu moments), and geometric distortion.

Results:

Normative data from a demographically sample of 1,750 diverse participants (mean age 63.4 years; 31% male; 65% non-White) demonstrated expected age-related declines in performance, particularly in recall conditions (Figure 2), and cognitive reserve effects, e.g. of vocabulary measures of pre-morbid verbal intelligence (Figure 3).

Conclusion:

By comprehensively quantifying visuospatial, motor, and organizational performance the CCAB enhances the sensitivity of figure drawing tests to early cognitive decline and neurodegenerative disease.

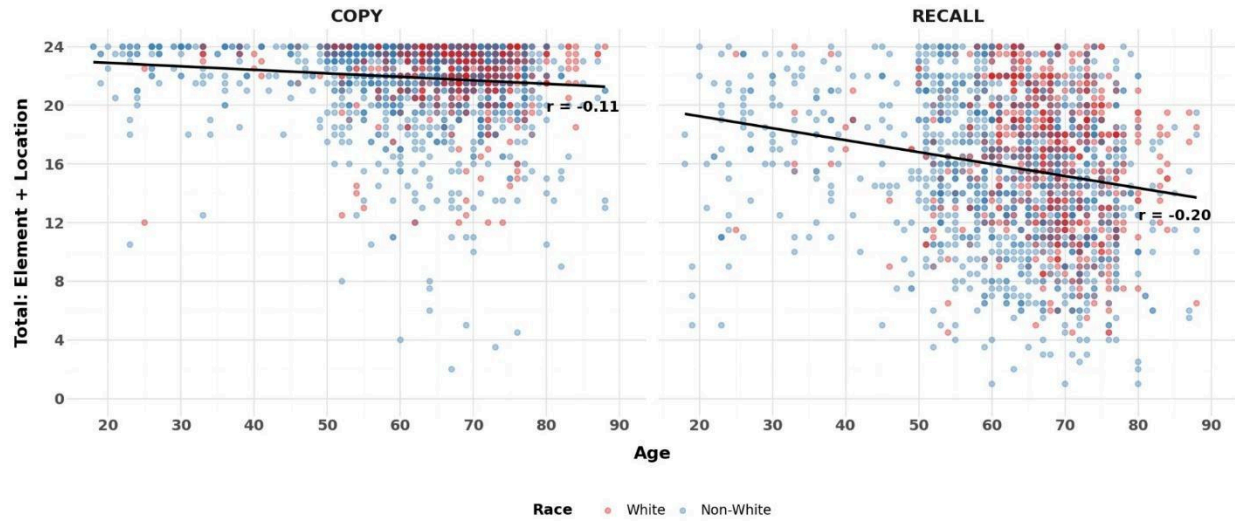


Figure 2. Age effects on Element + Location total correct scores. Age had a larger influence on Recall than Copy performance.

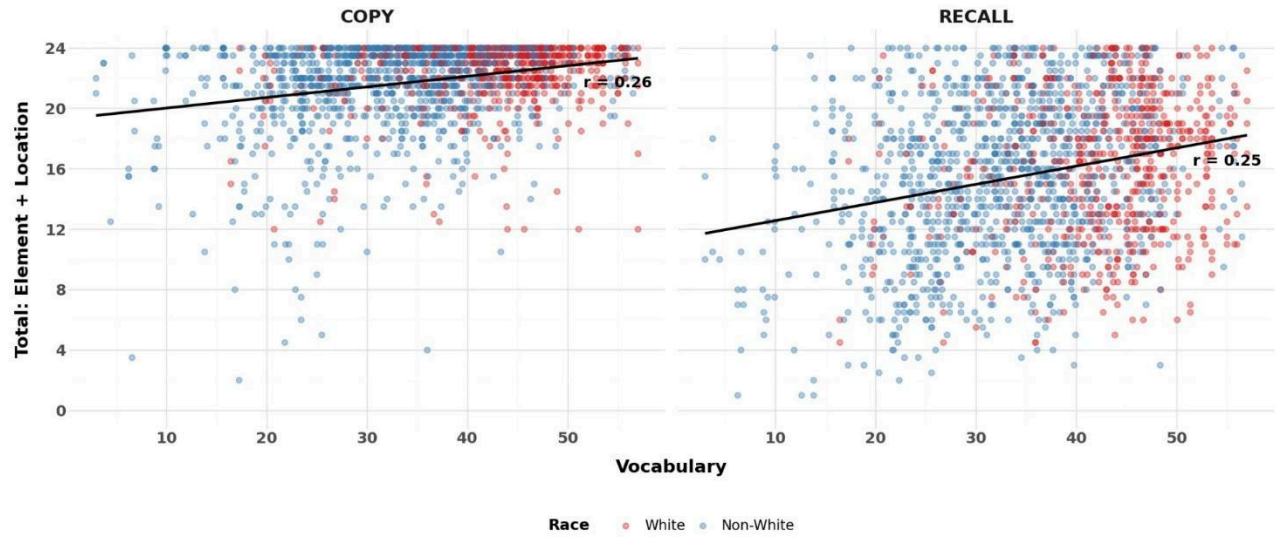


Figure 3. Larger vocabulary was associated with improved Copy and Recall performance.