Examining the Efficacy of a Novel Self-Administered Tablet-Based Application for Assessing Cognition in Mild Cognitive Impairment, Neurodegenerative Disorders and Stroke

Rachel L. Fabian, MS, CCC-SLP, Kelly L. Sloane, MD, Amy Wright, BA, Colin M. Stein, BA, Darek Sikorski, Zafer Keser, MD, Shenly Glenn, Argye E. Hillis, MD

Introduction

Clinical management of neurological disorders depends greatly on effective tools to assess behavioral performance, especially in cognitive domains that can be impacted by these conditions, such as attention, memory, and language. Comprehensive batteries comprised of traditional neuropsychological tests are currently considered the gold standard [1-7]. However, these batteries are time-consuming for clinicians, inaccessible for many individuals, and can induce fatigue and anxiety in patients. Given the increasing prevalence of cognitive impairment, especially in the aging population, and the importance of implementing early and diseasespecific therapies, it is valuable to investigate more sensitive and easily-administered tools for accurately characterizing these populations. The current global pandemic underscores the need for accurate and reliable remote testing options and highlights the critical need for exploring computerized assessment options for individuals with neurological disorders. Self-administered, remote, tablet-based cognitive assessments would be accessible, efficient, cost-effective, and clinically valuable if they are shown to detect and classify cognitive deficits as effectively as traditional in-person neuropsychological testing.

Recently, tablet- and computer-based programs have been developed as screening and assessment tools, including Cognitive Assessment for Dementia (CADi2), Computerised Cognitive Screening (CCS), and CogState Battery [8-10]. However, many of these tools were not as comprehensive as neurocognitive testing (CADi2, CCS) and demonstrated significant variability such that no one application was appropriate for all patient conditions [11-12]. Thus, there is a great need to explore tablet-based assessment options further. The Miro application is a novel comprehensive tablet-based battery of neurocognitive assessments based on versions of common tasks from the domains of neuropsychology and cognitive psychology. They include game-like versions of Digit Span, Spatial Span, Verbal Fluency, Design Fluency, Symbol-Digit Coding and Trail Making Tests. These tests assess performance across the domains of memory, cognitive flexibility, speed of processing, attention, working memory, and speech and language.

Aims

Our study aims to evaluate the feasibility and effectiveness of Miro, a novel tablet-based neurocognitive mobile application, featuring a series of tablet modules designed to assess cognitive skills (Table 1). We tested whether these modules sensitively measure the same cognitive domains as traditional pencil-and-paper tests. Our hypothesis is that tablet-based modules with a neurocognitive focus will: (1) provide reliable and objective scoring; (2) offer greater ease of use for patients; and (3) capture and analyze informative data types, like speech, fine motor function and eye movements, that are not typically used in traditional testing due to the specialized skills needed to analyze the data and the time-consuming nature of the analysis.

Method

We tested whether the tablet-based modules of the Miro application sensitively measured the same cognitive domains as traditional pencil-and-paper neuropsychological tests. In this ongoing study, participants complete Miro tablet-based testing and traditional pencil-and-paper neuropsychological testing at each of three total visits over one year. This abstract presents analyses of data from the first visit of these participants. Seventy-nine patients and 29 agematched healthy controls were enrolled. Inclusion and exclusion criteria are listed in Table 2. Participants were randomly assigned to undergo tablet modules before or after the pencil-andpaper testing. We performed pencil-and-paper testing with the participant and supervised, but did not guide, the participant in completion of the tablet-based testing.

We used t-tests to evaluate the effectiveness of each tablet module in distinguishing between patients and controls. The correlations between the tablet and pencil-and-paper performances of cognitively impaired subjects were tested with Pearson correlation coefficient tests in the entire cohort and for each disease group. STATA version 14 was used for statistical analyses, and a pvalue of <0.05 was considered significant.

Results

Seventy-nine participants with cognitive impairments

were assessed during their first study encounter. Mean age was 62.9 years old (SD 11.8) with 62% of participants being between the ages of 60 and 79 years old. Men accounted for 61% of the subjects; 70% of subjects had at least college education (Table 3). Participants included cognitively impaired subjects with right and left hemispheric strokes, MCI, and various neurodegenerative disorders such as Alzheimer's dementia, Parkinsonism related cognitive impairment, or Primary Progressive Aphasia (PPA).

Statistically significant Pearson correlations were noted for Digit Span Forward and Backward, Spatial Span Forward and Backward, Letter Fluency, Category Fluency, Coding, Design Fluency, Trails A and B, Picture Naming, Finger Tapping of the Left Hand, Verbal Learning Immediate Recall, Verbal Learning Delayed Recall, and their tablet equivalents (i.e., all except Finger Tapping of the Right Hand; Table 4). Subgroups per diagnosis showed similar correlations, but they were underpowered to show statistical significance (p >0.05; Fig 1). All subtests of the tablet-based application differentiated healthy controls from patients by t-tests except for the Spatial Span Forward and Finger Tapping modules (Table 5). When analyzing results among different diagnoses using analysis of variance (ANOVA), we found 11 of 14 Miro tablet modules differentiated between different patient groups.

On the post-testing survey, most patients did not experience anxiety with tablet testing (Table 6). Regarding modality, paper versus tablet, 48% of participants preferred the tablet; 18.8% preferred the paper-and-pencil tests; 33% had no preference. Averages were similar across diagnostic groups. Age positively correlated with "enjoy" and prefer scores; the older the patient, the less they enjoyed it or preferred it. However, all groups, on average, enjoyed the tablet modules and preferred it to paper and pencil.

Discussion
Our study indicates that tablet-based approaches are feasible and comparable with traditional paper-and-pencil-based assessments. Patient experience surveys from our study indicate that most participants enjoyed using the tablet modules. Hesitation to utilize technology-based assessments has been largely due to difficulty translating traditional neuropsychological testing to a tablet-based platform and concern for ease of use. Our study suggests that the tablet-based format is achievable, efficient, and effective.

Limitations of this preliminary analysis include the relatively small number of participants and the cross-sectional design. More participants are being recruited to further validate individual tablet modules in different patient cohorts with adequately-powered sample sizes over multiple timepoints.

References
Benedict, R. H. B., Schretlen, D., Groninger, L., & Brandt, J. (1998). Hopkins Verbal Learning Test-Revised: Normative Data and Analysis of Inter-Form and Test-Retest Reliability. The Clinical Neuropsychologist, 12(1), 43–55. https://doi.org/10.1076/clin.12.1.43.1726

Delis, D.C., Kaplan, E. , & Kramer, J. (2001). Delis-Kaplan Executive Function System. San Antonio, TX: Psychological Corporation.

Kaplan, E., Goodglass, H., & Weintraub, S. (2001). Boston naming test-2 (BNT-2). Austin TX: Pro-Ed.

Kertesz, A. (2007). Western Aphasia Battery-Revised. San Antonio: The Psychological Corporation.

Ruff, R. M., Light, R. H., Parker, S. B., & Levin, H.S. (1996). Benton Controlled Oral Word Association Test: Reliability and updated norms. Archives of Clinical Neuropsychology, 11(4), 329-338. https://doi.org/10.1016/0887-6177(95)00033-X

Tombaugh, T. N. (2004). Trail Making Test A and B: Normative data stratified by age and education. Archives of Clinical Neuropsychology, 19(2), 203–214. https://doi.org/10.1016/S0887-6177(03)00039-8

Wechsler, D. (2008). Wechsler Adult Intelligence Scale-Fourth Edition: Administration and scoring manual. San Antonio, TX: Psychological Corporation.

Onoda, K. & Yamaguchi, S. (2014). Revision of the Cognitive Assessment for Dementia, iPad version (CADi2). PLoS One, 9(10): e109931. https://doi.org/10.1371/journal.pone.0109931

Scanlon, L., O'Shea, E., O'Caoimh, R., & Timmons, S. (2016). Usability and validity of a battery of computerised cognitive screening tests for detecting cognitive impairment. Gerontology, 62, 247-252. doi: 10.1159/000433432

Mielke, M. M., Machulda, M. M., Hagen, C. E., Edwards, K. K., Roberts, R. O., Pankratz, V.S., … Petersen, R. C. (2015). Performance of the CogState computerized battery in the Mayo Clinic Study on Aging. Alzheimer's & Dementia, 11(11), 1367–1376. doi:10.1016/j.jalz.2015.01.008

Wild, K., Howieson, D., Webbe, F., Seelye, A., & Kaye, J. (2008). Status of computerized cognitive testing in aging: a systematic review. Alzheimer's & Dementia, 4(6), 428-437.

Zygouris, S., & Tsolaki, M. (2015). Computerized cognitive testing for older adults: a review. American Journal of Alzheimer's Disease & Other Dementias®, 30(1), 13-28.