Indian Journal of Clinical Psychology
Vol. 49, No. 4, 98-106 **Review Article**

Digital Cognitive Assessments for Brain Injury– A Systematic Review

Priya Dhandapani[1] and S. Thenmozhi[2]

ABSTRACT

Objectives: Cognitive impairments due to brain injury (BI) are substantial sources of morbidity for affected individuals, their family members, and society. Digital assessments may enhance the efficiency of evaluations in neurology and other clinics. This paper aims to examine the role of digital cognitive assessments for patients with brain injury. Digital neuropsychological assessments for BI patients have long been encouraged to increase their use of experimental designs. However, solid support for such advocacy is lacking, and the present paper fills in this research gap. Method: Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines were followed. This work was pre-registered on the Prospective Register of Systematic Reviews (PROSPERO; CRD42023388370).By using a systematic approach, studies between January 2012 and November 2022 that included Digital cognitive assessments for BI patients were included. This study conducts content analysis based on certain criteria including journal outlets, years of publication, contexts, experimental designs, settings, number of independent variables, research subjects, sample size, subjects per experimental condition, statistical analyses, and provision of effect size. Results: Twenty-six studies were included from an initial N=99 (2 database search) Findings showed that the number of experimental publications has significantly increased over the past decade, especially in digital cognitive publications. Nonetheless, there is still room for improvement in applying the experimental design in using digitalized cognitive assessments for BI patients Conclusion: Digital neuropsychology provides new approaches for measuring and monitoring neuropsychological functioning, informed by an understanding of the limitations and potential of digital technology

Keywords: *Digital, Cognitive Assessment, Brain Injury, Systematic Review*

INTRODUCTION

A brain injury is any injury occurring in the brain of a living organism. Multiple categories exist for classifying brain injuries. Primary and secondary brain injury are terms used to classify the injury processes that occur in brain injury. Specific forms of brain injury include: brain damage, the destruction or degeneration of brain cells traumatic brain injury, damage that occurs when an outside force traumatically injures the brain stroke, a vascular event causing damage in the brain and acquired brain injury, damage to the brain that occurs after birth, regardless of whether it is traumatic or nontraumatic, or due to an outside or internal cause. (McKee, and Daneshvar, 2015)

Brain injury is a major public health issue affecting millions worldwide. Cognitive impairment is a common consequence of brain injury, and it can significantly impact a person's quality of life. (Barman, Chatterjee and Bhide., 2016). Disturbances of attention, memory, and executive functioning are the most common neurocognitive sequelae of Brain injruy at all degrees of severity. Disturbances of attention and memory are particularly problematic, as disruption of these relatively basic cognitive functions may cause or exacerbate additional disturbances in executive function, communication, and other relatively more complex cognitive functions. (Arciniegas, Held, & Wagner, 2002)

A complete neuropsychiatric assessment, to measure the residual cognitive capacities and inabilities of the brain injured person, is important before initiation of cognitive rehabilitation. (Barman, Chatterjee, and Bhide, 2016). Clinical neuropsychologists have traditionally developed and validated parsimonious assessment tools using basic technologies (ie, pencil and paper protocols, general linear model). Advances have predominantly occurred in expanded normative standards throughout the history of this profession (Casaletto, Heaton 2017)

Digital cognitive assessments have emerged as a promising tool for assessing cognitive function in brain-injured patients. These assessments are often administered using computers or mobile devices, and they can provide quick and accurate information about a person's cognitive abilities. (Öhman et., al 2021)

Integrating digital technologies into clinical practise and research has several possible benefits. Digital assessments may reduce the time and cost associated with cognitive testing. If self-administered, there is also potential for reducing costs associated with staffing. This benefit is further increased if testing is performed remotely, rather than in the office or research centre. An automated scoring system is offered by many digital assessments, which can cut down on clinician time and the possibility of scoring mistakes. Some assessments go one step farther and include interpretive reports and recommendations for evidence-based care.(Staffaroni et al., 2020)

[1] Ph.D. Research scholar, University of Madras, Chennai
[2] Professor and Head, Department of Counselling Psychology, University of Madras, Chennai

However, the efficacy of digital cognitive assessments for brain-injured patients has not been thoroughly evaluated. There is a need for a comprehensive and systematic review of the available evidence to determine the effectiveness of these assessments and to inform clinical practice and policy. This systematic review aims to evaluate the evidence on the effectiveness of digital cognitive assessments for brain-injured patients.

The systematic review will include a comprehensive literature search, a critical evaluation of the quality of the included studies, and a synthesis of the data. The review will also investigate the potential moderators of the effect of the interventions, such as the type of brain injury, the severity of the injury, and the patient's age and gender. The results of the review will be communicated in a clear and accessible manner to a wide range of stakeholders, including patients, carers, and policymakers.

Prospero registration: CRD42023388370

Objectives

- To fill the gaps and to provide an updated and comprehensive review of the latest development in cognitive assessments for Brain injury

In particular the primary objectives of the study include categorizing the journal outlets, years of publication, contexts, experimental designs, settings, number of independent variables, research subjects, sample size, subjects per experimental condition, statistical analyses, and provision of effect size

METHODS

The present systematic review was performed according to the Preferred Reporting Items for Systematic reviews and Meta-Analyses guidelines (PRISMA) (Liberati et al., 2009). This systematic review was pre-registered on the International Prospective Register of Systematic Reviews (PROSPERO) – identification number: CRD42023388370https://www.crd.york.ac.uk/prospero/display_record.php?ID=CRD42023388370

Search strategy

The search incorporated related terms and synonyms for the following: Digital, electronic, computer and Cognitive assessment and Brain injury, Head injury, trauma, ABI, TBI or MCI. The electronic databases PubMed and Scopus were searched for publications from the year 2012 to the current date.We decided to search databases from the beginning of 2012 because The field of digital cognitive assessments for brain-injured patients has likely evolved in recent years, and the review may choose to focus on the most recent advancements. By focusing on recent studies, the review may reduce the risk of publication bias and the review may ensure that there is a sufficient body of evidence available to address the research question. Search terms for each database are provided in Table 1.

ELIGIBILITY CRITERIA

Study design

This review includes Randomized Controlled Trials (RCTS) and clinical trials that report on the efficacy of digital cognitive assessments for people with brain injury.

Inclusion Criteria:

Participants of all ages with brain injury (e.g., Traumatic brain injury and Non-traumatic acquired brain stroke).

Studies that used interventions, such as cognitive rehabilitation or pharmacological regimens, were included only when baseline measures were provided

The study should report on the validity, reliability, sensitivity, and specificity of digital cognitive assessments for the evaluation of brain injury.

Exclusion Criteria:

Studies were excluded if normative participants demonstrated severe psychopathology and/or severe intellectual, physical, or neurodevelopmental disability

Industry sponsored Studies of technology were excluded due to the potential conflict of interest.

Bias assessment

Using the Standard Quality Evaluation Criteria (SQAC) developed by Kmet, Cook, and Lee, (2004) two independent raters (P.D. and S.T.) conducted a formal quality assessment. Disagreements were solved via discussion with a third independent rater(J.C).

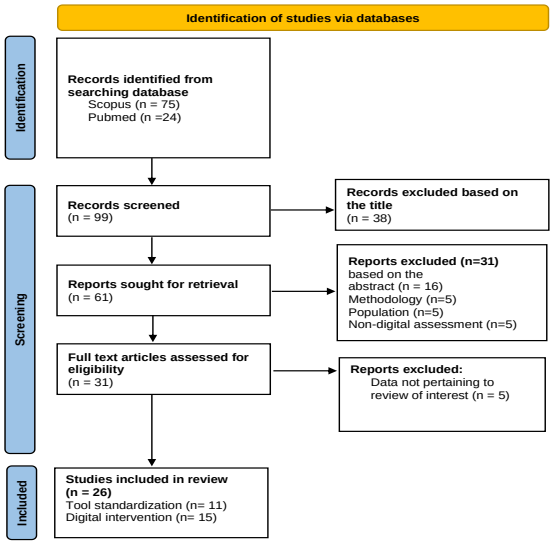

Figure 1: PRISMA flow-chart displaying study selection process. Notes. PRISMA Preferred Reporting Item for Systematic Reviews and Meta-Analyses, Moher et al. (2009) (www. prisma- state ment. org)

Study selection

RESULTS

Results were divided into two sections according to the nature of the study: a) Tool standardization and B) Digital interventions

Table 1: Shows the total no. of articles over the past ten years

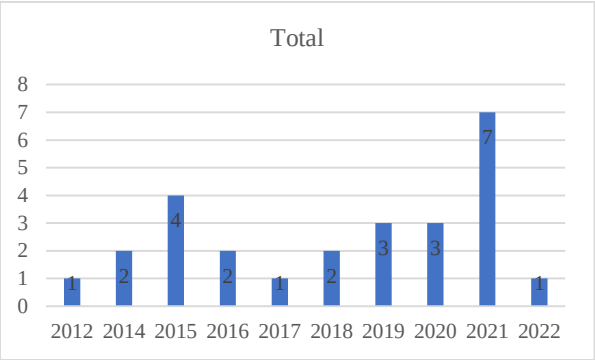

Table 2: Represents the Journal list included in the review

Journal names	Total number
Ann Phys Rehabil Med	1
Aphasiology	1
Applied Psychological Measurement	1
Behavioral Sciences	1
BMC Neurol	1
Brain	1
Brain and Language	1
Clinical Neuropsychologist	2
Cortex	1
Criminal Justice and Behavior	1
Eur J Phys Rehabil Med	1
Health Technol Assess	1
J Neuroeng Rehabil	1
J Neurol Sci	1
Memory	1
Mult SclerRelatDisord	1
Neurobiol Dis	1
Neuropsychological Rehabilitation	7
PLoS One	1
Grand Total	26

Cognitive domains

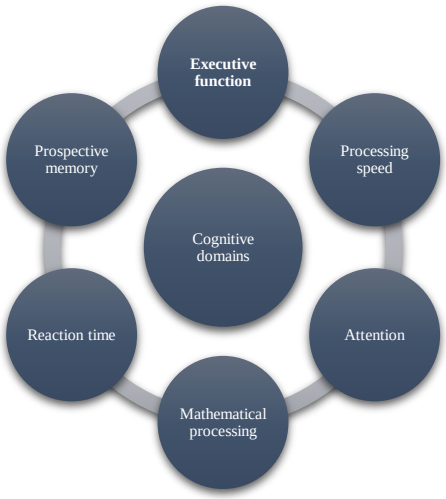

Figure 2: Cognitive domainsindigital neurocognitive assessments for brain injury

Digital cognitive assessments

Assessment	Participants	Modality	Findings		Cognitive domain
Oxford digital multiple errands test (OxMET) (Webb et al., 2022)	124 neurologically healthy controls and 105 stroke survivors	Computer-tablet version	To quickly screen for potential consequences of executive impairments in a virtual environment shopping task on a computer tablet.	High sensitivity and good specificity	Executive function
Interactional Network Tool (INT) (Howell et al., 2021)	Thirty-one video samples of ABI group interactions were independently rated by two rater pairs using the four outcome measures.		INT shows promise as a new method to characterize interactions and detect changes in group communication behavior.	INT initiation frequencies (ICC = 0.83) were moderate to excellent and the INT response frequencies (ICC = 0.69) were poor to good.	Group interactional behaviors
JansariAssessment of Executive Functions for Children (JEF-C©) (Gilboa et al., 2019)	Twenty-nine patients with ABI aged 10–18 years and 30 age-and gender-matched controls were tested.	Computerized	Internal consistency was medium (Cronbach's alpha = 0.62 and significant intercorrelations between individual JEF-C© constructs)		Executive functions

Assessment	Participants	Modality	Findings		Cognitive domain
Virtual Reality-Paced Serial Assessment Test (Parsons et al., 2012)	TBI and healthy controls	Virtual reality	Auditory/Visual Serial Addition Tests (PA/VSAT).		Processing speed, attention, mathematical processing, reaction time
Computer-administered interviewing (CAI) (Wolff et al., 2015)	PTSD scale	Computerized	Test–retest intraclass correlations for the PTSD Checklist (PCL) total score ranging from.774 to.817	Interviewing	PTSD
Automated neuropsychological assessments metrics (ANAM) (Eonta et al., 2011)	Repeated assessments in military populations are necessary to establish stable performance (Eonta et al., 2011). Normative data for assessment of TBI in military population (Vincent et al., 2012).	PC- based	Strong construct validity demonstrated in TBI population (Bleiberg et al., 2000).		Reaction Time (SRT), Code Substitution (CDS), Procedural Reaction Time (PRO), Mathematical Processing (MTH),Matching To Sample (M2S), and Code Substitution Delayed (CDD)

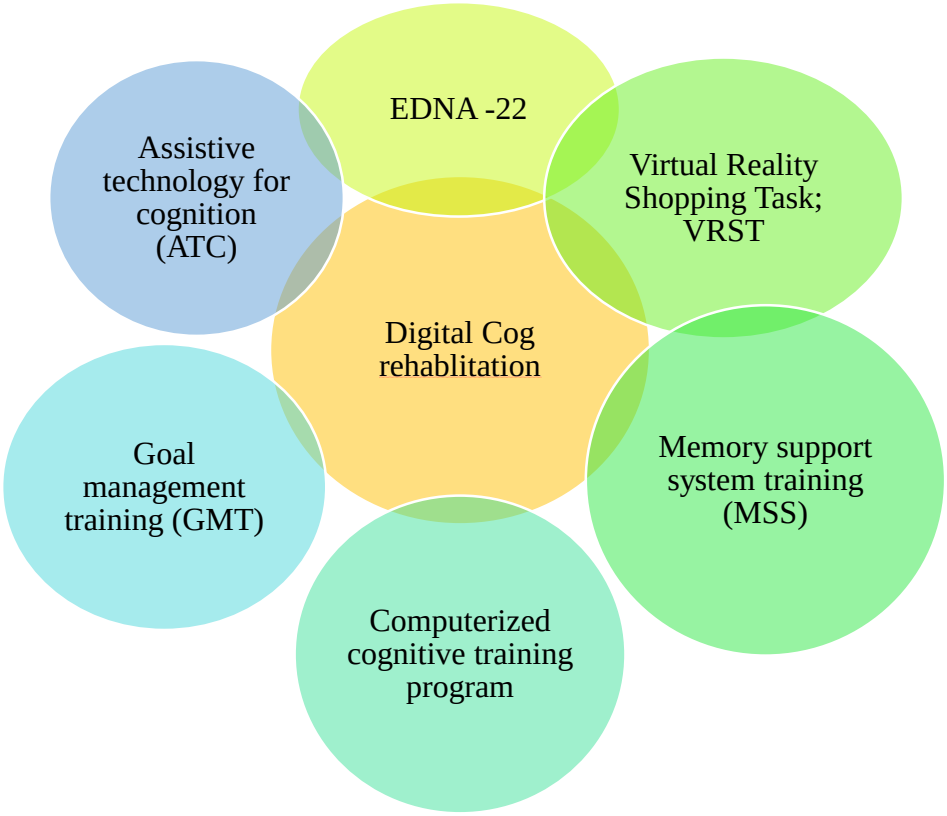

Figure 2: Cognitive Training for Brain Injury

Cognitive training – Digital modality

Assessment	Participants	Modality	Findings	Cognitive domain
Assistive technology for cognition (ATC) Powell et al (2012)	Twenty-nine persons with moderate-severe cognitive impairments due to acquired brain injury	Computerized	Demonstrate that systematic instruction applied to ATC results in better skill maintenance and generalization than trial-and-error learning for individuals with moderate-severe cognitive impairments due to acquired brain injury.	Skill maintenance
Virtual Reality Shopping Task; VRST Canty et al., (2012)	Thirty individuals with severe TBI and 24 uninjured adults matched on age, gender, and education level were administered the VRST	VR - Computerised	For the TBI group, event and total PM performance on the VRST significantly correlated with performance on measures of mental flexibility and verbal fluency, and total PM performance correlated with verbal memory.	Prospective memory task
Memory support system training (MSS) De Wit et al., (2021)	Two-hundred-and-fifteen older adults with aMCI and their study partners (e.g., spouse, adult child) received MSS training one-hour daily for 10 days.	Computerised	Offering compensatory strategies as early as possible for those with MCI might be of the most benefit	Calendar/notebook rehabilitation system
Computerized cognitive training program Kim et al (2022)	A total of 34 patients with cognitive dysfunction after TBI were enrolled. Participants performed 30 sessions of computerized cognitive rehabilitation (Comcog) for 6 weeks. A cognitive evaluation was performed before and after treatment with Mini-Mental State Examination (MMSE) and Computerized Neurophyschologic Test (CNT).	Computerised	The young group showed improvement in MMSE, verbal and visual memory, and visuo-motor coordination tests after computerized cognitive rehabilitation. In contrast, the old group showed significant improvement only in MMSE and visual learning test, one of the visual memory tests.	MMSE and visual learning test
Goal management training (GMT) Cuberos-Urbano et al., (2018)	Sixteen patients with acquired brain injury involving executive dysfunction were randomly allocated to one of the two interventions: seven weeks of GMT (n = 8), or seven weeks of GMT+Lifelog (n = 8)	Computerised	GMT alone was associated with significant changes in overall quality of life. It was concluded that GMT+Lifelog holds promise to optimize the impact of GMT on executive dysfunction and quality of life.	Executive dysfunction
EDNA-22 (Wilson et al., 2021)	Of 19 originally randomized, 17 acute-care patients with upper-extremity dysfunction following unilateral stroke completed training in either the treatment (n = 10) or active control groups (n = 7)	Tablet based	The EDNA group showed moderate (but non-significant) improvement in functional behavior on the SIS (g = 0.57) and NFI (g = 0.49).	Motor, cognitive, and training performance

DISCUSSION

Cognitive assessments for brain injury

The cognitive processes that assist people in organising, planning, and carrying out tasks are referred to as executive functioning. Executive functioning deficits brought on by acquired brain injury (ABI) can significantly affect daily life. However, there aren't many screening technologies on the market that can quickly and reliably determine how executive impairments may affect a person. This gap is intended to be filled by the Oxford Digital Multiple Errands Test (OxMET)Webb et al 2022, a novel instrument that offers a quick and ecologically reliable method of evaluating executive deficits.The Multiple Errands Test, often known as the OxMET, is a condensed form of the task that asks participants to run a number of hypothetical errands in a controlled environment. Both stroke survivors and healthy controls were recruited for the study to complete the OxMET task.

Social communication deficits are frequent following Acquired brain injury (ABI). It has been discovered that group therapies are helpful in enhancing social communication in people with ABI. To quantify group results in this demographic, there aren't many validated tools available. A new digital instrument (INT) created for group interactional behaviours is compared to three well-known social communication measures (PPIC, BRISS-R, and MPC) to assess inter-rater reliability. Using the four outcome measures, 31 video examples of ABI group interactions were independently scored by two rater pairs. Utilizing intra-class correlations, inter-rater reliability was calculated (ICC). The outcomes demonstrated the varying sensitivities of the measurements. On the MPC interaction and transaction scales, there was moderate to good rater agreement. The INT response frequencies ranged from poor to good, and the INT initiation frequencies ranged from mediocre to exceptional. On the BRISS-R PCSS and PDBS scale, poor to moderate reliability was attained, and the PPIC findings were moderate but revealed skew. On

two participation measures, acceptable reliability was attained (MPC and INT).

A computerised test called the Jansari Assessment of Executive Functions for Children (JEF-C) is used to measure executive function in kids and teenagers. The purpose of the study was to evaluate the JEF-validity C's and viability in young patients with acquired brain damage (ABI). 30 age- and gender-matched controls and 29 patients with ABI, ages 10 to 18, were included in the study. The Wechsler Abbreviated Scale of Intelligence (WASI), the Behavioral Assessment of the Dysexecutive Syndrome for Children, and the JEF-C were administered to participants (BADS-C). The Behavior Rating Inventory of Executive Function (BRIEF) survey was filled out by the subjects' parents. Patients with ABI were found to be capable of completing the JEF-C test. The JEF-C task had a medium level of internal consistency, with a Cronbach's alpha of 0.62 and substantial intercorrelations between different JEF-C constructs.

Parsons et al (2015) examined the Two virtual reality-based Paced Auditory/Visual Serial Addition Tests (PA/VSAT) were created to evaluate neurocognitive performance because TBI is a difficult problem for the Department of Defence (DoD) medical health system. In comparison to conventional paper and pencil tests and Automated Neuropsychological Assessment Metrics, the VRPASAT and VRPVSAT have been demonstrated to be more efficient.

Wolff et al (2015) compared the practicality, reliability, and validity of employing computer-administered interviewing (CAI) and orally administered interviewing (OAI) to screen for PTSD among male prisoners. 592 jailed men were randomly assigned to the CAI or OAI screening modality using a 2 2 factorial design. The results showed that CAI was practical and accurate, and gave screening data on PTSD symptoms that was just as dependable as OAI's. The PCL total score's test-retest intraclass correlations ranged from.774 to.817.

Automated Neuropsychological Assessment Metrics (ANAM4) Traumatic Brain Injury (TBI) Battery is used to create individual neurocognitive performance baselines for U.S. military personnel travelling to combat zones, according to Eonta and collegeaues (2011). The ANAM4 TBI Battery was given to two military samples more than once as part of the paper's evaluation of its test-retest reliability. Five of the six performance sub tests in both Studies 1 and 2 exhibit a practise effect, showing that several test sessions are necessary to achieve steady performance on specific computerised activities. These findings have implications for how test administration and data interpretation should account for the practise effects of the ANAM4 TBI Battery

Digital assessments have the potential to improve the lives of individuals with brain injury by enhancing efficiency and accuracy in evaluations. Virtual reality-based tests and computer-administered interviews have been shown to be practical and comparable to traditional methods. Further research and validation studies are needed to establish their effectiveness.

Cognitive rehabilitation for brain injury

The use of assistive technology for cognition (ATC) to offset cognitive impairments following acquired brain damage can be learned through systematic instruction (ABI). The study assessed the efficacy of systematic teaching applied to ATC in a vocational setting using a single-case, multiple-probe methodology across behaviours.

Canty et al., (2012) developed virtual reality prospective memory (PM) task called the Virtual Reality Shopping Task (VRST) for individuals with traumatic brain injury (TBI). The study included 30 individuals with severe TBI and 24 uninjured adults matched on age, gender, and education level. The participants were administered the VRST, a lexical decision PM task (LDPMT), an index of task-friendliness, and a cognitive assessment battery. Performance on the VRST significantly predicted significant others' ratings of patients' occupational activities and independent living skills. Performance on the VRST was rated significantly higher than the LDPMT in terms of reflecting an everyday activity, being interesting, and receiving a higher recommendation. These results provide preliminary but promising evidence of the VRST's sensitivity, convergent validity, and ecological validity.

The study aimed to identify factors that predict the ability of individuals with amnestic mild cognitive impairment (aMCI) to learn and adhere to a compensatory calendar and note-taking system called the Memory Support System (MSS). The study involved 215 older adults with aMCI and their study partners, who received MSS training for one hour daily for 10 days. The results showed that global cognition predicted MSS learning at the end of the training period, and MSS learning at the end of training predicted MSS adherence at 6, 12, and 18 months post-training. The study suggests that offering compensatory strategies like the MSS as early as possible for those with MCI might be most beneficial and have implications for long-term adherence.

The study by Cuberos-Urbano (2016) compared regular goal management training (GMT) with the use of lifelog technology to assess the advantages and effect size. 16 patients with acquired brain damage and executive dysfunction were randomised to either GMT or GMT+Lifelog therapies. Results showed a significant relationship between GMT+Lifelog and changes in

response inhibition, multitasking, DEX Intentionality and Positive Affect subscales, and QOLIBRI Daily Life and Autonomy subscales. However, GMT alone was linked to substantial alterations in overall quality of life. The study concluded that GMT+Lifelog may improve GMT's effects on executive dysfunction and quality of life.

Adult stroke patients have a good choice for at-home arm function rehabilitation using the EDNA-22 tablet. A study comparing the effects of EDNA training with an active control group found that the EDNA group significantly improved both motor and cognitive performance. A brief at-home training session with the EDNA-22 system can enhance motor and cognitive function, but additional research is needed to best use at-home rehabilitation technology for stroke and brain injury patients.

The use of assistive technology for cognition (ATC) can be learned through systematic instruction. Canty et al. (2012) and Cuberos-Urbano (2016) studied the efficacy of systematic teaching applied to ATC in a vocational setting. The results showed that global cognition predicted MSS learning at the end of the training period. EDNA training significantly improved motor and cognitive performance.

LIMITATIONS

- Changes in test format can impact the function
- Device characteristics can introduce systematic measurement bias
- The landscape of digital technology is constantly changing
- currently limited information on psychometric and normative properties for different clinical populations (Bauer et al., 2012)

Strengths

- ✓ Better estimates of typical neuropsychological functioning
- ✓ Variability as neuropsychological indicator
- ✓ Ecological validity and context

Implications

- ➢ Consider device variability in norming and test design
- ➢ Pay more attention to user interface design
- ➢ Treat tests as software

CONCLUSION

The use of technology in neuropsychological assessment is continuing to expand and improve upon traditional approaches of the past. However, along with advantages of using technology-based assessment come challenges. Although some challenges are common across all types of neuropsychological assessment (e.g., establishing psychometric properties and adequate normative data), other limitations are unique to assessments driven by technology

Neuropsychological assessment is strained to maintain pace with the latest technology and determine how these advances influence human cognition. Thus, neuropsychologists should continue to make strides in researching new ways to assess cognitive and functional abilities in order to provide quality assessment and care for future generations of clients.

Digital assessments and rehabilitation can improve the lives of individuals with brain injury by enhancing efficiency and accuracy in evaluations and improve motor and cognitive performance.

FUNDING

No affiliations with or involvement in any organization or entity with any financial interest or non-financial interest in the subject matter or materials discussed in this manuscript.

Table 1: Search Terms for Literature Review: Scopus and PubMed

Database	Search terms
Scopus	(TITLE-ABS-KEY ((digital OR electronic OR computer* OR e-*) AND ("Cognit* assessment" OR test* OR neuropsycholo*)) AND TITLE-ABS-KEY ("Brain injury" OR "Head injury" OR trauma OR "ABI" OR "TBI" OR "MCI")) AND (LIMIT-TO (OA , "all")) AND (LIMIT-TO (PUBYEAR , 2022) OR LIMIT-TO (PUBYEAR , 2021) OR LIMIT-TO (PUBYEAR , 2020) OR LIMIT-TO (PUBYEAR , 2019) OR LIMIT-TO (PUBYEAR , 2018) OR LIMIT-TO (PUBYEAR , 2017) OR LIMIT-TO (PUBYEAR , 2016) OR LIMIT-TO (PUBYEAR , 2015) OR LIMIT-TO (PUBYEAR , 2014) OR LIMIT-TO (PUBYEAR , 2013) OR LIMIT-TO (PUBYEAR , 2012)) AND (LIMIT-TO (DOCTYPE , "ar")) AND (LIMIT-TO (SUBJAREA , "PSYC")) AND (LIMIT-TO (LANGUAGE , "English")) AND (LIMIT-TO (SRCTYPE , "j")) AND (LIMIT-TO (PUBSTAGE , "final")) AND (LIMIT-TO (SUBJAREA , "ARTS") OR LIMIT-TO (SUBJAREA , "SOCI"))
Pubmed	((digital OR electronic OR computer*) AND ("Cognitive assessment" OR test* OR neuropsycholo*)) AND ("Brain injury" OR "Head injury" OR trauma OR "ABI" OR "TBI" OR "MCI") Filters: Abstract, Free full text, Full text, Associated data, Clinical Trial, Randomized Controlled Trial, in the last 10 years, English, Exclude preprints Sort by: Most Recent

ACKNOWLEDGMENTS: We also extend our appreciation to all the researchers whose work we have cited in this review, as they have contributed significantly to the field.

REFERENCES

Arciniegas, D. B., Held, K., & Wagner, P. (2002). Cognitive Impairment Following Traumatic Brain

Injury. Current treatment options in neurology, 4(1), 43–57. doi: 10.1007/s11940-002-0004-6

Barman, A., Chatterjee, A., & Bhide, R. (2016). Cognitive Impairment and Rehabilitation Strategies After Traumatic Brain Injury. Indian J Psychol Med, 38(3), 172-181. doi: 10.4103/0253-7176.183086

Canty, A. L., Fleming, J., Patterson, F., Green, H. J., Man, D., & Shum, D. H. (2014). Evaluation of a virtual reality prospective memory task for use with individuals with severe traumatic brain injury. *Neuropsychological rehabilitation*, *24*(2), 238–265. https://doi.org/10.1080/09602011.2014.881746

Casaletto, K. B., & Heaton, R. K. (2017). Neuropsychological assessment: past and future. J Int Neuropsychol Soc, 23(9-10), 778-790. doi: 10.1017/s1355617717001060

Cuberos-Urbano, G., Caracuel, A., Valls-Serrano, C., García-Mochón, L., Gracey, F., & Verdejo-García, A. (2018). A pilot investigation of the potential for incorporating lifelog technology into executive function rehabilitation for enhanced transfer of self-regulation skills to everyday life. *Neuropsychological rehabilitation*, *28*(4), 589–601. https://doi.org/10.1080/09602011.2016.1187630

Cumpston, M., Li, T., Page, M. J., Chandler, J., Welch, V. A., Higgins, J. P., ... & McKenzie, J. E. (2019). Updated guidance for trusted systematic reviews: A new edition of the Cochrane Handbook for Systematic Reviews of Interventions. Cochrane Database Syst Rev, 10, 142.

De Wit, L., Chandler, M., Amofa, P., DeFeis, B., Mejia, A., O'Shea, D., Locke, D. E. C., Fields, J. A., & Smith, G. E. (2021). Memory Support System training in mild cognitive impairment: Predictors of learning and adherence. *Neuropsychological rehabilitation*, *31*(1), 92–104. https://doi.org/10.1080/09602011.2019.1667833

Dhandapani, P., & S., T. (2023). Digital cognitive assessments for Brain injury– a Systematic review. PROSPERO 2023 CRD42023388370. Retrieved from https://www.crd.york.ac.uk/prospero/display_record.php?ID=CRD42023388370

Eonta SE, Carr W, McArdle JJ, Kain JM, Tate C, Wesensten NJ, Norris JN, Balkin TJ, Kamimori GH. *Automated Neuropsychological Assessment Metrics: repeated assessment with two military samples.* Aviat Space Environ Med 2011; 82:34–9.

Kim SH, Gwak DW, Jeong JG, Jung H, Min YS, Kim AR, Jung TD. Effect of computerized cognitive rehabilitation in comparison between young and old age after traumatic brain injury. Medicine (Baltimore). 2022 Aug 19;101(33):e29874. doi: 10.1097/MD.0000000000029874. PMID: 35984190; PMCID: PMC9388031.

Kmet, L. M., Cook, L. S., & Lee, R. C. (2004). Standard quality assessment criteria for evaluating primary research papers from a variety of fields. Edmonton: Alberta Heritage Foundation for Medical Research (AHFMR).

Liberati, A., Altman, D. G., Tetzlaff, J., Mulrow, C., Gøtzsche, P. C., Ioannidis, J. P. A., ... & Moher, D. (2009). The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: explanation and elaboration. J Clin Epidemiol, 62, e1–e34.

McKee, A. C., & Daneshvar, D. H. (2015). The neuropathology of traumatic brain injury. Handb Clin Neurol, 127, 45-66. doi: 10.1016/B978-0-444-52892-6.00004-0

Moher, D., Liberati, A., Tetzlaff, J., & Altman, D. G. (2009). Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. J Clin Epidemiol, 62(10), 1006-1012.

Öhman, F., Hassenstab, J., Berron, D., Schöll, M., & Papp, K. V. (2021). Current advances in digital cognitive assessment for preclinical Alzheimer's disease. Alzheimers Dement (Amst), 13(1), e12217. doi: 10.1002/dad2.12217

Parsons, T. D., Courtney, C., Rizzo, A. A., Armstrong, C., Edwards, J., & Reger, G. (2012). Virtual reality paced serial assessment test for neuropsychological assessment of a military cohort. Studies in health technology and informatics, 173, 331–337.

Powell, L. E., Glang, A., Ettel, D., Todis, B., Sohlberg, M. M., & Albin, R. (2012). Systematic instruction for individuals with acquired brain injury: results of a randomised controlled trial. *Neuropsychological rehabilitation*, *22*(1), 85–112. https://doi.org/10.1080/09602011.2011.640466

Sam S. Webb, Anders Jespersen, Evangeline G. Chiu, Francesca Payne, Romina Basting, Mihaela D. Duta & Nele Demeyere (2022) The Oxford digital multiple errands test (OxMET): Validation of a simplified computer tablet based multiple errands test, Neuropsychological Rehabilitation, 32:6, 1007-1032, DOI: 10.1080/09602011.2020.1862679

Staffaroni, A. M., Tsoy, E., Taylor, J., Boxer, A. L., & Possin, K. L. (2020). Digital Cognitive Assessments for Dementia: Digital assessments may enhance the efficiency of evaluations in neurology and other clinics. PractNeurol (Fort Wash Pa), 2020, 24-45. PMID: 33927583; PMCID: PMC8078574.

Susan Howell, Rosemary Varley, Emma Louise Sinnott, Tim Pring & Suzanne Beeke (2021) Measuring group social interactions following acquired brain injury: an inter-rater reliability evaluation, Aphasiology, 35:11, 1505-1517, DOI: 10.1080/02687038.2020.1836315

Webb, S. S., Jespersen, A., Chiu, E. G., Payne, F., Basting, R., Duta, M. D., & Demeyere, N. (2022). The Oxford digital multiple errands test (OxMET): Validation of a simplified computer tablet-based multiple errands test. Neuropsychological Rehabilitation, 32(6), 1007-1032. DOI: 10.1080/09602011.2020.1862679

Wilson, P.H., Rogers, J.M., Vogel, K. *et al.* Home-based (virtual) rehabilitation improves motor and cognitive function for stroke patients: a randomized controlled trial of the *Elements* (EDNA-22) system. *J NeuroEngineering Rehabil* **18**, 165 (2021). https://doi.org/10.1186/s12984-021-00956-7

Wolff, N., McHugo, G., Shi, J., Huening, J., & Frueh, B. C. (2015). Screening for PTSD among Incarcerated Men: A Comparative Analysis of Computer-Administered and Orally Administered Modalities. Criminal Justice and Behavior, 42(2), 219–236. https://doi.org/10.1177/0093854814551601