Review

25 years of computerized assessment – where are we now?

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(List three to ten pertinent keywords specific to the article; yet reasonably common within the subject discipline.)

1. Introduction

The goal of this paper is to provide an overview of how computerized cognitive assessments were developed historically and how they have changed since they were first designed in the 80s with the advent of the internet and technologies like small, portable touch screens (iPads). The differences between the existing and commonly used paper-pencil test will be discussed with an emphasis on why computerized tests are particularly advantageous for assessing aging and clinical populations.

2. Cognitive Assessment – Historically

Before computerized assessments, cognitive tests were administered and interpreted by trained neuropsychologists/psychometrists.

Computerized test batteries are highly consistent and reduce experimenter effects that effect validity of test results. For these reasons… discuss the importance of using computerized tests in assessing Dementia. *(Citing Blackwell et al, Chapter 5 from Dementia textbook)*

* Started with CANTAB *(is this really the first computerized test battery?)*
* Describe work by Sahakian and Owen and others on the positive aspects of using computerized batteries in older adult populations/following dementia related cognitive declines
  + Sahakian et al, 1988 *Brain;* 1990 *Neuropsychologia –* Computerized tests in Alzheimer’s & Dementia
  + Sahakian & Owen 1992 *Royal Society of Medicine* – discussion of CANTAB
  + Robbins et al 1994 *Dementia* – CANTAB in large group of older adults (n=787) factor analysis
  + Blackwell et al 2003 *Dementia and Geriatric Cognitive Disorders* – specificity and reliability of computerized tests for detecting dementia/Alzheimer’s
* Discuss work ‘neural validation’ of CANTAB?
  + Owen et al 1995 *Neuropsychologia* – CANTAB and temporal lobe excisions

3. Cognitive Assessment – In the internet age

The internet and proliferation of portable computers provides new opportunities for computerized cognitive assessments (more subjects, can be done at home, can be done without an administrator, etc.)

Example of an online tool: CBS - Describe CBS as a comprehensive battery that is updated for modern technology

* Hampshire 2012 *Neuron –* CBS description
* Can cover a wide range of assessments in a short period of time
* Can be administered to thousands of people – 70 000 people have taken it (8 million test scores) – Figure from Conor showing hundreds of older adult scores on 12 different tests
* Quote CBS materials when describing the advantages to online testing: calculate scores on the fly, tests are adaptive to participant levels, feedback can be given immediately to participants or physicians (refer to example of CBS score report),
* Score reports can interpret scores for the reader of the report – meaningful change (a statistically significant increase in digit span translates to an increase in 0.7 digits – is that meanginful/useful?)

*Is it worth mentioning in this section the use of computerized tests that are used in commercially available brain training programs? E.g. Lumosity – if only to identify how these cognitive assessments differ?*

4. Online testing vs existing alternatives

Online testing vs in lab testing

* Show the unpublished results from young people and PD patients tested at home and in lab – at home testing is just as valid as in lab

Online testing vs MoCA and MMSE

* Summarize Brenkel data and our older adult CBS/Christie Gardens paper – computerized testing does better than existing ‘quick’ assessments

5. Conclusions

**Supplementary Materials:** The following are available online at www.mdpi.com/xxx/s1, Figure S1: title, Table S1: title, Video S1: title.

**Author Contributions:** For research articles with several authors, a short paragraph specifying their individual contributions must be provided. The following statements should be used “conceptualization, X.X. and Y.Y.; methodology, X.X.; software, X.X.; validation, X.X., Y.Y. and Z.Z.; formal analysis, X.X.; investigation, X.X.; resources, X.X.; data curation, X.X.; writing—original draft preparation, X.X.; writing—review and editing, X.X.; visualization, X.X.; supervision, X.X.; project administration, X.X.; funding acquisition, Y.Y.”, please turn to the [CRediT taxonomy](http://img.mdpi.org/data/contributor-role-instruction.pdf) for the term explanation. Authorship must be limited to those who have contributed substantially to the work reported.

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Appendix A

The appendix is an optional section that can contain details and data supplemental to the main text. For example, explanations of experimental details that would disrupt the flow of the main text, but nonetheless remain crucial to understanding and reproducing the research shown; figures of replicates for experiments of which representative data is shown in the main text can be added here if brief, or as Supplementary data. Mathematical proofs of results not central to the paper can be added as an appendix.

Appendix B

All appendix sections must be cited in the main text. In the appendixes, Figures, Tables, etc. should be labeled starting with ‘A’, e.g., Figure A1, Figure A2, etc.

References

References must be numbered in order of appearance in the text (including citations in tables and legends) and listed individually at the end of the manuscript. We recommend preparing the references with a bibliography software package, such as EndNote, ReferenceManager or Zotero to avoid typing mistakes and duplicated references. Include the digital object identifier (DOI) for all references where available.

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1. Author 1, A.B.; Author 2, C.D. Title of the article. *Abbreviated Journal Name* **Year**, *Volume*, page range.
2. Author 1, A.; Author 2, B. Title of the chapter. In *Book Title*, 2nd ed.; Editor 1, A., Editor 2, B., Eds.; Publisher: Publisher Location, Country, 2007; Volume 3, pp. 154–196.
3. Author 1, A.; Author 2, B. *Book Title*, 3rd ed.; Publisher: Publisher Location, Country, 2008; pp. 154–196.
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