Submission possibilities

<http://jnnp.bmj.com/> -Journal of Neurology, Neurosurgery, and Psychiatry – paper? Short report-1500 words?

<http://www.alzheimersanddementia.com/> - Alzheimer’s and Dementia

Cortex

Both journals have published Moca/MMSE related things

Fine tuning cognitive assessment in the elderly: The added benefits of a computerized test battery

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Abstract (200 words)

**Introduction** -

**Methods** -

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Assessing an individual’s cognitive capacity has become an increasingly large part of caring for the elderly. Cognitive capacity assessments are used to determine the level of care an individual requires and assessment results have legal implications for determining whether an individual is capable of making decisions about property and personal care. Full cognitive capacity assessments are difficult and time-consuming to administer. Shorter versions have been created that can be used to gain a snapshot understanding of an individual’s capacity and to follow cognitive health changes over long periods of time. Currently, the most widely used tests are the Mini-Mental State Exam (MMSE; Folstein, Folstein, & McHugh, 1975) and the Montreal Cognitive Assessment (MoCA; Nasreddine et al., 2005). Both the MMSE and the MoCA are paper-pencil tests that can be administered by a trained individual in under 10 minutes. The MMSE was developed in 1975 as an efficient way to routinely evaluate psychiatric patients (Folstein et al., 1975). Currently, the MMSE is most widely used in clinical and legal settings. However, the MoCA may well replace the MMSE as the gold-standard because it is freely available and recent work has shown the MoCA’s increased sensitivity for detecting mild cognitive impairment (Larner, 2012; Smith, Gildeh, & Holmes, 2007; Zadikoff et al., 2008). The ability to accurately detect cognitive impairment is extremely important for the appropriate care of our aging and elderly populations.

The MoCA and the MMSE are paper-and-pencil tests that determine the presence of cognitive impairment by comparing an individual’s score to a validated cut-off. One shortfall of these tests is an ambiguity in how to interpret scores that fall near or between the cut-off scores. Ambiguity in how to classify these scores can cause misdiagnosis of individuals and result in inappropriate changes to their treatment. Recently, a computerized battery of two cognitive tests was able to further classify individuals with borderline cognitive impairment as determined by the MoCA (Brenkel, Shulman, Hazan, Herrmann, & Owen, 2017). The scores on the computerized tests were used to categorize individuals who achieved a borderline score on the MoCA into the impaired or unimpaired categories indicating that this computerized test battery was capable of a more fine-grained classification of cognitive abilities.

In this study, we wanted to determine whether using a larger computerized battery of 12 tests would better differentiate individuals with ambiguous MoCA or MMSE scores. Specifically, we were interested to see whether a subset of the computerized test battery tasks that best predicted MoCA and MMSE scores could be used to

**METHODS**

**Subjects**

Participants were recruited from retirement homes and the general community. Participants over the age of 50 with the ability to provide informed consent were included in the study. Any participant who was unable to understand the instructions of the tasks was excluded. In total 41 participants (34 female) participated in this study. The study was approved by the University of Western Ontario Research Ethics Board. All subjects gave written informed consent to participate.

**Procedure**

The computerized test battery (CBS battery) consisted of 12 different tasks. Descriptions of each of the tasks can be found in the supplementary materials. The tasks were presented to participants on a tablet computer with a touchscreen and each was preceded by instructions and practice trials. Researchers were on hand to offer further clarification of instructions if necessary. Participants completed all 12 tasks in a random order and took as many breaks as necessary between tasks to prevent fatigue. After the CBS task battery, a MoCA (version 7.1 English) and MMSE (Folstein et al, 1987) were administered on paper in interview format with a researcher. All MoCAs and MMSEs were administered by the same researcher. Participants also completed a demographic questionnaire on paper.

**RESULTS**

Forty-one older adults with an average age of 81 years (62-92 years) completed 12 computerized tests, a MoCA, and a MMSE. Only one participant (90 years old) did not complete all 12 tasks due to fatigue. Scores on the MoCA ranged from 12-30 (mean=24.6) and scores on the MMSE ranged from 16-30 (mean=27.8). A summary of task scores can be found in Table 1.

Table 1. Summary of task scores and relevant population norms from 342 older adults age 70-94. In this study, only 4 participants were younger than 70.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Task** | **Scores** | | **Population norms**  **age 70-94** | |
|  | **Mean** | **SD** | **Mean** | **SD** |
| MoCA | 24.6 | 4.1 |  |  |
| MMSE | 27.8 | 3.0 |  |  |
| Double Trouble | 8.6 | 11.7 | 17.8 | 11.2 |
| Odd One Out | 8.8 | 3.6 | 13.4 | 2.4 |
| Spatial Planning | 11.4 | 6.3 | 14.4 | 7.5 |
| Grammatical Reasoning | 10.4 | 6.0 | 13.8 | 4.6 |
| Digit Span | 4.8 | 1.7 | 6.8 | 1.6 |
| Token Search | 5.7 | 1.8 | 6.3 | 1.9 |
| Paired Associates | 3.5 | 0.9 | 4.3 | 1.0 |
| Spatial Span | 4.2 | 1.2 | 4.9 | 0.9 |
| Feature Match | 69.4 | 26.1 | 95.8 | 24.8 |
| Rotations | 30.2 | 26.6 | 62.4 | 28.6 |
| Polygons | 16.9 | 15.5 | 32.4 | 19.9 |
| Monkey Ladder | 5.7 | 1.9 | 6.6 | 1.3 |

Participants were split into three categories (unimpaired=14, borderline =18, and impaired=9) based on the accepted thresholds of MoCA scores (See Figure 1). To replicate the analysis performed by Brenkel et al, (2017) we further categorized each participant in the mild cognitive impairment group. If the score of a participant in the borderline group on a particular task was less than or equal to the average score of the impaired group (on that task) they were categorized as impaired. If their score on a particular task was greater than or equal to the average score of the unimpaired group (on that task) they were classified as unimpaired. This analysis could not be performed using MMSE scores because only 2 participants were classified into the borderline group (see Figure 1).

Some tasks were better at categorizing participants in the borderline group than others. We partially replicated the results of Brenkel et al (2017) showing that the Feature Match was one of the worst tasks for further categorization while the Double Trouble task was one of the most useful. These two tasks categorized 22% and 72% of participants respectively. Using the same combination of tasks identified by Brenkel et al (2017) (Double Trouble and Odd One Out), 66% of borderline participants were classified as impaired or unimpaired.

To investigate which combination of all 12 computerized tasks best predicted MoCA scores we performed a step-wise multiple regression analysis. The largest amount of variance in the MoCA scores (67%) was explained by the Feature Match, Odd One Out, and Token Search tasks together. Age was included in this regression but did not explain a significant amount of variance over and above the task scores. On its own, age accounted for 13% of the variance in MoCA scores.

A regression was also performed on MMSE scores. Odd One Out and Grammatical Reasoning best predicted MMSE scores and accounted for 41% of the variance. Age was included in this regression but did not explain a significant amount of variance over and above the task scores. On its own, age accounted for 4% of the variance in MMSE scores.

When the MoCA was used on its own to classify participants into the three categories, 59% of borderline participants were classified. The two tasks identified by Brenkel et al (2017) classified 66% of borderline participants. The top three tasks that did the best classification job on their own, when combined, classified 61% of borderline participants. The three tasks identified by the regression analysis (Feature Match, Odd One Out, and Token Search), classified 83% of borderline participants.

**DISCUSSION**

We investigated how a computerized test battery could be used to further identify an individual’s cognitive impairment beyond the scope of a MoCA or MMSE. Using a step-wise multiple regression we determined which combination of tests from the battery best predicted MoCA and MMSE scores. Combining these tasks with the MoCA resulted in classification of 83% of participants as impaired or unimpaired (compared to the MoCA alone at 41%). These three tasks provide additional information about an individual’s working memory and reasoning capabilities allowing for better classification. The two tests identified by Brenkel et al, 2017 were only able to further differentiate 66% of borderline individuals.

The advantage of being better able to classify borderline individuals as implications for their treatment and …

This study also explored the feasibility of using a computerized test battery in an older adult population. With an increasingly aged population SOME STAT ABOUT AGE, the ability to use computerized test batteries is extremely important. Computerized tests do not require a one-on-one interview and therefore reduce the manpower necessary to assess patients. Computerized tests also have the advantage of presenting a novel version of the test each time it is administered. By randomizing the test items, we can guarantee that the patient’s score is related to their abilities and not their memory of the test items. As a result, participants can take these tests many times without fear of practice effects (CITE BOBBY’S PRACTICE STUFF?) which makes the computerized tests a good candidate for monitoring abilities over time.

As with any type of test it is important that the test taker is as comfortable as possible throughout the session. In this study, we were concerned that older adults would have issues completing all 12 tasks due to fatigue, but in fact only one participant (90 years old) was unable to complete all 12 and this was likely due to frustration with the tasks more so than fatigue. The three tasks that we have identified as helping to classify participants can be completed in approximately 5 minutes minimizing any fatigue or effects of frustration. Frustration was also minimized in our study as the tasks were presented on a tablet computer with a touchscreen which removed the need to use a mouse, an unfamiliar skill that may have increased frustration for some older adults.

As the population ages it is important to have a conclusive assessment of cognitive abilities in older adults. In this experiment, we have shown how the inclusion of a short battery of computerized tests in addition to the MoCA can better identify impaired and unimpaired individuals.

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**Competing Interests**

The Cambridge Brain Sciences Battery was created by Professor Owen. Although he has an unrestricted academic license to use this software he stands to gain nothing financially (or otherwise) from its use in this research project. The software was developed in his lab, primarily for research purposes, and is being used currently in numerous academic research studies. There is no conflict of interest.

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