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Development of a novel computerised version of the Month Backwards Test: A comparison of performance in hospitalised elderly patients and final year medical students ☆

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ABSTRACT

Background and aims: The Months Backwards Test (MBT) is a commonly used bedside test of cognitive function, but there is uncertainty as to optimal testing procedures. We examined performance among hospitalised elderly patients and cognitively intact young persons with verbal and computerised versions of the test.

Participants and methods: Fifty acute elderly medical inpatients and fifty final year medical students completed verbal (MBTv) and computerised (MBTc) versions of the MBT and the Montreal Cognitive Assessment (MoCA). Completion time and errors were compared.

Results: Thirty four participants scored <26 on the MoCA indicating significant cognitive impairment. The mean MoCA scores in the elderly medical group (23.6 ± 3.4; range 13–28) were significantly lower than for the medical students (29.2 ± 0.6; range 28–30: $p<0.01$). For the verbal months backwards test (MBTv), there were significantly more errors and longer completion times in the elderly medical patients (25.1 ± 20.9 vs. 10.5 ± 4.5; $p<0.05$). Completion times were 2–3 times longer for the MBTc compared to the MBTv (patients: 63.5 ± 43.9 vs. students 20.3 ± 4.4; $p<0.05$). There was high correlation between the two versions of the MBT ($r=0.84$) and also between the MBTc and the MoCA ($r=0.85$). The MBTc had higher correlation with visuospatial function (MBTc $r=0.70$, MBTv $r=0.57$). An MBTc cut-off time of 30 s for distinguishing performance (pass/fail) had excellent sensitivity (100%) with modest specificity (44%) for cognitive impairment in elderly medical patients.

Conclusion: The computerised MBT allows accurate and efficient testing of attention and general cognition in clinical populations.

1. Introduction

Automatic word sequences such as days of the week, months of the year and letters of the alphabet are universal to vocabulary [1]. These sequences are established through rehearsal and repetition during childhood [2]. Forward recall is ordinarily easier to perform and thought to test "automatic speech" in conditions with dysphasia or dyslexia [3–5]. Conversely, backward recitation draws upon a wider range of functions including the ability to focus and sustain attention, working memory as well as visuospatial imagery [2,6]. Neuro imaging studies indicate activation of more complex neural networks for backwards versus forwards recall of automatic word sequences [1,7–12] which are especially susceptible to the effects of aging and more likely to be impaired in the early stages of cognitive decline [1,2].

The Months Backwards Test (MBT), also known as the months reversed or months of the year in reverse order test is a brief word sequence production test used to assess cognition [6]. The MBT has been documented as a test of attention [13–15], concentration [16], declarative and working memory [1], non-automatic speech [2], executive function [17], cognitive flexibility [18] mental control [1] and processing speed [19]. The test requires the participant to recite the months of the year in reverse order, starting with December and working backwards until they reach January or

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cannot continue [2]. The test is often undertaken at the bedside or in everyday patient consultations but can also be conducted over the phone [6]. Typically, cognitively intact participants are able to complete the test within 20 s [6].

Performance on the MBT is considered in terms of the ability to complete the test accurately without error and the time taken to reach completion [6]. MBT duration is extremely variable but highly correlated with accuracy [1,2,19,20]. Ostberg and coworkers found that it generally takes twice as long to recite the months backwards than the months forward [1]. MBT performance is impacted upon by educational attainment and age, with peak performance in the 30–60 year age group and thereafter an exponential relationship exists between MBT completion time and increasing age [2,6,19,21].

The MBT is generally a simple test to perform and complete without error, so much so that poor performance or failure to complete the test is highly suggestive of impairment [6]. The MBT has excellent coverage with, for example, the majority of memory clinic attendees able to complete an assessment with the MBT [1]. Other work indicates that 89% of high school athletes and 92% of university athletes could complete the test without error' [19,22]. The test has been applied as a screening tool for delirium to determine the risk of delirium developing in hospitalised patients [23,24], in the assessment of mild cognitive impairment and dementia, in the evaluation of cognition in those with Parkinson's disease and to judge concussion severity in sports [1,12,21,25,26]. However, a recent review [6] highlighted considerable inconsistencies in the administration and interpretation of the MBT in clinical testing and concluded that computer-assisted technology could provide presentation platforms that minimise such effects. As such, we developed a computerised version of the test presented on a touch-sensitive tablet device that focuses upon visual presentation but with the same general rules for performance (i.e. identifying the months of the year in reverse order).

This study examines how this novel computerised version compares with the standard verbal version of the MBT as well as with other tests of cognition in two contrasting groups – hospitalised elderly medical inpatients and cognitively intact young persons.

2. Methods

2.1. Participants

Participants were from two distinct groups; (i) acute elderly medical inpatients aged ≥ 65 at University Hospital Limerick ($n=50$), and (ii) final year medical students undergoing clinical placement at UHL ($n=50$). Patients were recruited by referral from the elderly medical team according to willingness and perceived suitability in terms of morbidity to undertake cognitive testing. Overall, one hundred and six potential participants were approached; of these, 100 provided informed consent, five refused to participate and one was unable to provide informed consent.

2.2. Measures and procedures

All participants completed a 20 min assessment that included screening with the Confusion Assessment Method for possible delirium and a neuropsychological battery which consisted of a verbal and computerised version of months of the year backwards (MBT) test and the Montreal Cognitive Assessment Tool (MoCA) [27]. Baseline data such as age, gender, dementia status and medical morbidities were collected from medical records.

2.3. Confusion assessment method

The presence of possible delirium was assessed using the diagnostic algorithm of the confusion assessment method (CAM) [28]. This requires the presence of (a) acute onset or fluctuating course, (b) inattention and either, (c) disturbed consciousness or (d) disorganised thinking. The CAM is the most widely used screening tool for delirium and has well demonstrated accuracy for delirium detection across clinical populations [29]. Prior to commencing the study, the researcher (L.O'D) underwent formal training in use of the CAM to establish acceptable accuracy and inter-rater reliability with experts familiar with its use (M.L., D.M.) (see below).

2.4. Months forwards and backwards tests

2.4.1. Months forward-verbal test (MFTv)

participants were requested to recite the months of the year in chronological order as quickly as possible (MFTv). This gauges basic contextual awareness and the participant's ability to engage, comprehend and co-operate with testing procedures [1,2,6].

2.4.2. Months backward-verbal test (MBTv)

participants were asked to recite the months of the year in reverse order as quickly as possible without error. MBT accuracy considers participant's ability to complete the test without error. Successful completion of the test involves the ability to correctly recount the months with minimal prompting [23]. It also measures how far each participant can reach without error [6]. Errors can be categorised as omissions, (e.g. "December…November…September") or commissions, (e.g. "August….June….July….June") but for this work, in keeping with recommendations from a detailed review of the MBT [6], only omissions were included as errors. Completing the test within 90 s and with no more than one error is considered a successful performance [6]. Completion time (i.e. the time from commencement to cessation) was recorded in addition to incorrect responses.

The *Computerised version of the Months Backwards test (MBTc)* was presented via a computerised touch-sensitive tablet device. The months were presented in a consistent prearranged format as a series of buttons in a 3×4 grid across an A5-sized screen. The format was chosen from a series of randomly generated examples by virtue of its representation of a variety of separations between the months. Participants were asked to touch each month in reverse order, beginning with December. The tablet automatically recorded performance including time to completion and errors of commission or omission.

The *Montreal Cognitive Assessment tool (MoCA)* [27] was used as a measure of general cognition. This explores 8 distinct cognitive domains including visuospatial skills, executive functioning, memory, attention, language, conceptual thinking, concentration and orientation. The test takes approximately 10–15 min to complete and is scored out of 30. Less than 26/30 is typically considered to be an indicator of impaired cognition. It has a high sensitivity and specificity for cognitive disorders including presence of mild cognitive impairment and early Alzheimer's disease [27].

2.5. Testing

Data was collected over a two week period at the University Hospital Limerick. Raters attended a training day to standardise administration of the CAM, MBT versions and the MoCA. Testing was conducted at the bedside or in a quiet location on the wards. The same sequence of testing was applied for each participant as follows; MFT, MBTv, MBTv, MoCA.