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A mobile application for cognitive screening of dementia

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ABSTRACT

Neuropsychological assessment tests have an important role in early detection of dementia. Therefore, we designed and implemented a test battery for mobile devices that can be used for mobile cognitive screening (MCS). This battery consists of 33 questions from 14 type of tests for the assessment of 8 different cognitive functions: Arithmetic, orientation, abstraction, attention, memory, language, visual, and executive functions. This test battery is implemented as an application for mobile devices that operates on Android OS. In order to validate the effectiveness of the neuropsychological test battery, it was applied on a group of 23 elderly persons. Within this group, 9 (of age 81.78 ± 4.77) were healthy and 14 (of age 72.55 ± 9.95) were already diagnosed with dementia. The education level of the control group (healthy) and dementia group were comparable as they spent 13.66 ± 5.07 and 13.71 ± 4.14 years at school respectively. For comparison, a validated paper-and-pencil test (Montreal Cognitive Test – MoCA) was applied along with the proposed MCS battery. The proposed test was able to differentiate the individuals in the control and dementia groups for executive, visual, memory, attention, orientation functions with statistical significance ($p < 0.05$). Results of the remaining functions; language, abstraction, and arithmetic were statistically insignificant ($p > 0.05$). The results of MCS and MoCA were compared, and the scores of individuals from these tests were correlated ($r^2 = 0.57$).

1. Introduction

Average life expectancy has recently increased due to the improvements in medicine and technology. As a result, incidence and prevalence of dementia have also increased. According to Alzheimers Disease International's 2014 report, it is estimated that there are 44 million people living with dementia wordwide, and this number is expected to almost double by 2030 and to reach more than triple by 2050 [1]. As there is no effective treatment for dementia, studies are focused on slowing the progress and alleviating the symptoms of dementia. Hence early diagnosis of dementia is of critical importance. Early diagnosis can be possible by screening the cognitive abilities of the population over a certain age. Dementia is characterized by memory impairment,

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progressive decline in daily activities, a variety of psychiatric symptoms and behavioral problems. Cognitive screening can be performed by neuropsychological tests. These tests are composed of simple questions that evaluate certain cognitive abilities. Therefore, there has been vast amount of research to design test questions which can accurately assess the cognitive abilities. In early applications, paper and pencil were used in these tests. The advantage of these tests was the ease of using pencil by the elderly people. However, the spectrum of the possible questions on a paper was quite narrow. With the development of digital technologies cognitive tests were computerized. Computers enhanced the variety of questions due to the use of rich multimedia components. In addition, computerized test results can be stored on digital media which makes storing, retrieving, and analyzing easy. On the other hand, elderly people typically have difficulty using PC interface (i.e. computer mouse). This disadvantage limited the use of computerized neuropsychological test for screening dementia. Mobile devices bring the power of multimedia with the ease of user interface together. They can offer almost all multimedia components of personnel computers, and their touch screen interface is much easier than using a computer interface especially for elderly people. Hence, it was immediately adopted as a medium of neuropsychological tests.

In this study, we aimed to design a test battery that is applicable on mobile devices (i.e. tablet computers, mobile phones, etc.). Our objectives were; (a) an easy user interface for elderly people, (b) to design a variety of questions for testing different cognitive functionalities, (c) data analysis for comparing individual results against total population.

The paper organized as follows: Section 2 summarizes similar neuropsychological tests that are widely used. In Section 3, the design and details of the proposed test questions are described. The test is applied to a group of elderly people, and the results are explained in Section 4. The results are analyzed and discussed in Section 5. Section 6 summarizes and concludes this study.

2. Background

In this section, we introduce the neuropsychological tests in the literature (see Table 1). Some of these tests are based on paper and pencil (Section 2.1), personnel computers (Section 2.2). A systematical review can be found in [2].

2.1. *Paper-and-pencil based neuropsychological tests*

2.1.1. *Montreal Cognitive Assessment (MoCA)*

Montreal Cognitive Assessment (MoCA) is a screening test which is developed for the evaluation of cognitive impairment's first stage [3]. The abilities that are evaluated with this test are memory, visual–spatial processes, attention, concentration, abstraction, orientation and language functions. Duration of the test is about 10 min and the total score is 30 points. If the participant gets at least 21 points, it is considered as a state with normal cognitive abilities. MoCA has been validated and used in many neurological diseases.[1]

2.1.2. *Mini Mental State Examination (MMSE)*

Mini Mental State Examination (MMSE) was developed to rapidly assess the mental functions in terms of cognitive aspects [4]. Test is consisting of 11 questions and its total score is 30 points. The duration of the test is approximately 5–10 min. MMSE includes evaluation of cognitive abilities about orientation, record memory, attention, mathematical operations, recall and language tests.

2.2. *Computer-based neuropsychological tests*

2.2.1. *Automated Neuropsychological Assessment Metrics (ANAM)*

ANAM is a test library in which cognitive, computer-based evaluations may be carried out, such as attention, concentration, reaction speed, memory, mathematical ability, managerial function and decision-making [5,6]. ANAM consists of 22 different performance evaluation tests which are sensitive in terms of cognition.

2.2.2. *Computer-Administered Neuropsychological Screen for Mild Cognitive Impairment (CANS-MCI)*

CANS-MCI was developed for the detection of mild cognitive impairment, and it is used for the assessment of memory, language and executive functions [7]. Tests in CANS-MCI are administered by computer with a touch-screen and speakers. Completion time of the tests is about 30 min.

2.2.3. *Cambridge Neuropsychological Test Automated Battery (CANTAB)*

The battery aims to impair 3 cognitive abilities: working memory and planning, visuospatial memory and attention [8,9]. The tests are applied via a touch screen.

2.2.4. *CNS Vital Signs (CNVS)*

The battery includes 7 tests focusing on 5 cognitive abilities: memory, cognitive flexibility, psychomotor speed, time, reaction and complex attention [10,11]. The duration of the battery is approximately 30 min and the tests are applied via a computer keyboard.

2.2.5. *Computerized Neuropsychological Test Battery (CNTB)*

The battery includes 11 subtests which evaluate information processing, motor speed, verbal and spatial memory, attention, language and spatial abilities [12,13]. The tests are applied by using a single key, pointing, or spoken responses that are entered by the technician.

2.2.6. *CogState (CGS)*

In the subtests of CGS there are simple, choice, and complex reaction times, matching, working memory, continuous monitoring, incidental learning and associative learning [14,15].

[1] See http://www.mocatest.org/references.asp for a complete list of fields where MoCA was validated and used.