Supplementary File 1: Protocol for Systematic Review

Title: Electronic devices for cognitive impairment screening: A systematic review

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Introduction

Recent studies suggest that slowing the progression of dementia by one year would lead to a better quality of life for people living with dementia (1) and a significant cut in the related socioeconomic costs (2). In this context, the early detection of dementia is the first step to initiate timely treatments, to manage the disease and to reduce morbidity (3), as the pathophysiological process of Alzheimer's disease (AD) starts years before diagnosis. There is no evidence to support screening of asymptomatic individuals, but the monitoring and evaluation of persons suspected of cognitive impairment is justified as they have an increased risk for developing dementia (4). A computational model-based prediction found that the reduction in cognitive decline and dementia depends on initial screening age, screening frequency, and specificity (5).

Several markers of dementia have been proposed (neuroimaging, biomarkers, risk factors, cognitive performance in specific domains, etc.). However, Gomar and colleagues have demonstrated that cognitive markers are more robust predictors of conversion to AD than most biomarkers (6). In the neuropsychological assessment field, new screening instruments should capitalize on new technological advances, as they provide standardization of administration, the automatic collection of a wealth of data and a reduction of human error in administration (7).

Information and communication technologies (ICT) is an umbrella term that refers to any communication device or application comprising computer and network hardware and software, radio, television, mobile phones, wireless signals and the various services and applications associated with them (videoconferencing, tele-healthcare, distance learning, etc.). ICT devices have been increasingly used for neuropsychological assessment, with good correlations with well-established paper and pencil assessment tools (8). ICT instruments for

cognitive impairment early detection and assessment can be grouped into four categories: electronic devices (personal computers, laptops, mobile phones, tablets, etc.); internet based devices (electronic devices that need to be connected to the internet allowing online testing and data sharing); monitoring devices (which measure users´ behavior in different areas) and virtual reality (which immerse the user in a more complex and integral sensorial experience). Computerized test batteries have been reported to have advantages compared to paper and pencil batteries in areas such as the standardization of administration and stimulus presentation; accurate measures of response latencies; automated comparison with an individual's prior performance and with age-related norms; efficiencies of staffing and cost; tailoring tests to the examinee´s level of performance; minimizing floor and ceiling effects (9); and their potential to capture time-related information such as spatial planning strategies (10). On the other hand, older adults' limited familiarity with computers (11) and a general lack of psychometric standards (12) have been raised as an obstacle for these kinds of tests.

In a recent review about computerized cognitive testing for older adults (11) 17 test batteries were identified which had adequate discriminant validity and test-retest reliability; however, the authors warn clinicians about the necessity to choose the correct battery for each application considering variables such as its cost, the need for a specialist either for administration or for scoring, and the length of administration. In a previous review (9) the authors identified 18 computerized test batteries, of which 11 were appropriate for older adults; they recommended that test batteries should be evaluated on a one to one basis due to the variability they displayed. In a comparative study of tools for the assessment of cognition in mild cognitive impairment (MCI) the authors reviewed 16 assessment instruments, of which 14 were computer based (7); they collected data directly from technicians, including detailed information about sensitivity and specificity. A review of computerized tests for older adults in primary care settings (13) identified 11 test batteries from which three were

judged potentially appropriate for assessment in primary care based on good test-retest reliability, large normative samples, a comprehensive description of patient cognitive performance, and the provision of an overall score or probability of MCI. Finally, a descriptive review on this subject summarizes the cognitive functions assessed in 19 computerized tests (14).

Usability is a key aspect of ICT programs development. It can be defined as understandability, learnability, operability and attractiveness (15). The necessity of including tests of performance validity in the batteries has been highlighted, as the validity of the assessment relies on the examinee's full motivation and effort to perform as well as possible (16). Consultation with people with dementia (PWD) and their carers is crucial to address the issue of usability in the design of ICT based instruments. Their involvement in all phases of the development process is of great importance to obtain valuable and user-friendly products (17).

Despite the previous reviews of this subject, two fundamental aspects remain conspicuous by their absence: usability and the possibility of home based self-administration. Thus, it is necessary to analyze the state of the art of this area in the available instruments to address this issue if necessary. The aim of this literature review is to analyze the current available ICT based instruments for cognitive decline early screening and detection in terms of validity, reliability and usability.

Method

The systematic review will follow the PRISMA reporting guidelines for systematic literature reviews (18).

Types of interventions

This review will center on ICT based instruments assessing or monitoring older adults with potential cognitive or functional decline. This includes electronic devices (ED) (personal computers, laptops, tablets, phones or mobile phones, etc.), internet (I), monitoring devices (MD) and virtual reality (VR).

Inclusion criteria

— Articles describing ICT based instruments for the screening, evaluation and assessment of cognitive and functional decline in older adults

— Articles published between 2010 and 2015 (previous studies might be based on outdated technologies which would not be comparable to current available ICT).

Exclusion criteria

— Screening and Assessment instruments not validated for older adults (over 60 years old).

— Studies not discriminating results for older adults.

— Studies which do not provide minimum normative data (e.g. mean age of participants, diagnosis, etc.).

— Screening and assessment instruments based on neuroimaging algorithms.

Electronic search strategy and search terms for electronic databases

A search will be performed in July 2015 of the databases Medline and PsycINFO with the search terms (Dementia OR Alzheimer) AND (computer OR ICT) AND (screening OR diagnosis OR assessment OR evaluation). The initial selection criteria will be broad to ensure that as many studies as possible are assessed as to their relevance to the review. Any articles that are obviously unsuitable can be excluded in the early stages or the search (e.g. on the basis of abstracts and titles presented in electronic catalogues), whilst the decision to exclude or include other articles will only be made once the article has been read. The number of articles included and excluded at the various stages will be noted. Further studies might be included through hand search, tracking cited references in other studies and relevant previous literature reviews in this area. A 'search diary' will be kept detailing the names of the databases searched, the keywords used and the search results. Titles and abstracts of studies to be considered for retrieval will be recorded on an Endnote database, along with details of where the reference has been found. Inclusion/exclusion decisions will be recorded on that database. Retrieved studies will be filed according to inclusion/exclusion criteria.

Selection Procedure

The selection procedure is depicted in Figure 1. Studies will be selected for retrieval after abstracts and titles identified in electronic searches have been appraised by the lead reviewer for relevance (note that abstracts and titles that are clearly unrelated to Information and Communication Technologies will be excluded by the lead reviewer). All retrieved studies will be examined by the lead reviewer who will exclude those that make no reference to cognitive impairment screening. Studies that do make a reference to Information and Communication Technologies and cognitive impairment screening will be assessed for relevance independently by three reviewers. Any disagreement about the inclusion of papers will be discussed in a consensus meeting.

Data management

The selected studies will be analyzed with a standardized data extraction form (Annex 1), as suggested by the Cochrane Handbook for Systematic Reviews of Interventions. Tests, early detection tools and screening instruments will be grouped according to their main purpose into cognitive test batteries, measures of isolated tasks, behavioral measures (measures of motor and sensory processes) and diagnostic tools (used by clinicians to help them in the diagnostic process).

Self-administration is defined in the context of this Systematic Review as "*test-taking that is unsupervised after the test platform has been set up, and can occur in the clinic or home setting*" (19). Cognitive domains will be depicted as described by the authors in the article. Concurrent validity will be considered as correlations with other previously validated instruments. Discriminant Validity will be considered as sensitivity and specificity rates and/or capacity to distinguish people with and without cognitive impairment. When discriminant validity is reported as lack of correlation with unrelated measures in the retrieved articles, the information will be also included.

Understandability, even though considered a component of usability, will be reported in a different category as it is the most basic expression of the concept defined as the ability of subjects to understand the instructions and whether a training session was provided before the assessment period.

Usability is defined for data extraction as '*the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use*' (20). It is a multidimensional construct composed of different attributes; a usable system must address the following aspects: learnability, efficiency, memorization, error prevention and satisfaction (21).

Categorizing studies:

We intend to categorize by ICT type into electronic devices (ED) (personal computers, laptops, tablets, phones or mobile phones, etc.), internet (I), monitoring devices (MD) and virtual reality (VR). Three reviewers will do this independently. When the studies themselves do not provide sufficient information to categorize, the authors will consult with each other.

Internet based instruments, usually require a PC, tablet, etc., but we included them under this category when it was compulsory to be connected to the internet to perform the test (online only assessments) or to submit the results. Finally, monitoring devices usually need to be connected to a WIFI network that transmits the monitored information, the instruments included in this category collect information automatically, without any intentional input from the monitored person. Tests, early detection tools and screening instruments will be grouped according to their main purpose into cognitive test batteries, measures of isolated tasks, behavioural measures of motor and sensory processes, surveys (forms and checklists) and diagnostic tools (used by clinicians to help them in the diagnostic process).

When the authors control the confounding variable "education" in their results, either by ensuring their groups are equivalent or introducing it as a covariate in the analyses, it will be stated as "yes" in the data extraction form.

Quality assessment

Schlegel and Gilliland (22) have outlined the necessary elements of quality assurance assessments for computer-based batteries. These authors detailed 20 critical elements that constitute a competent quality assessment grouped in 4 clusters (module information, test functionality, data recording and others). Quality assessment will be carried out analysing

each selected screening instrument for these 20 items with a checklist. Inter-rater agreement will be evaluated using Cohen´s Kappa concordance index and Landis and Koch criteria (23).
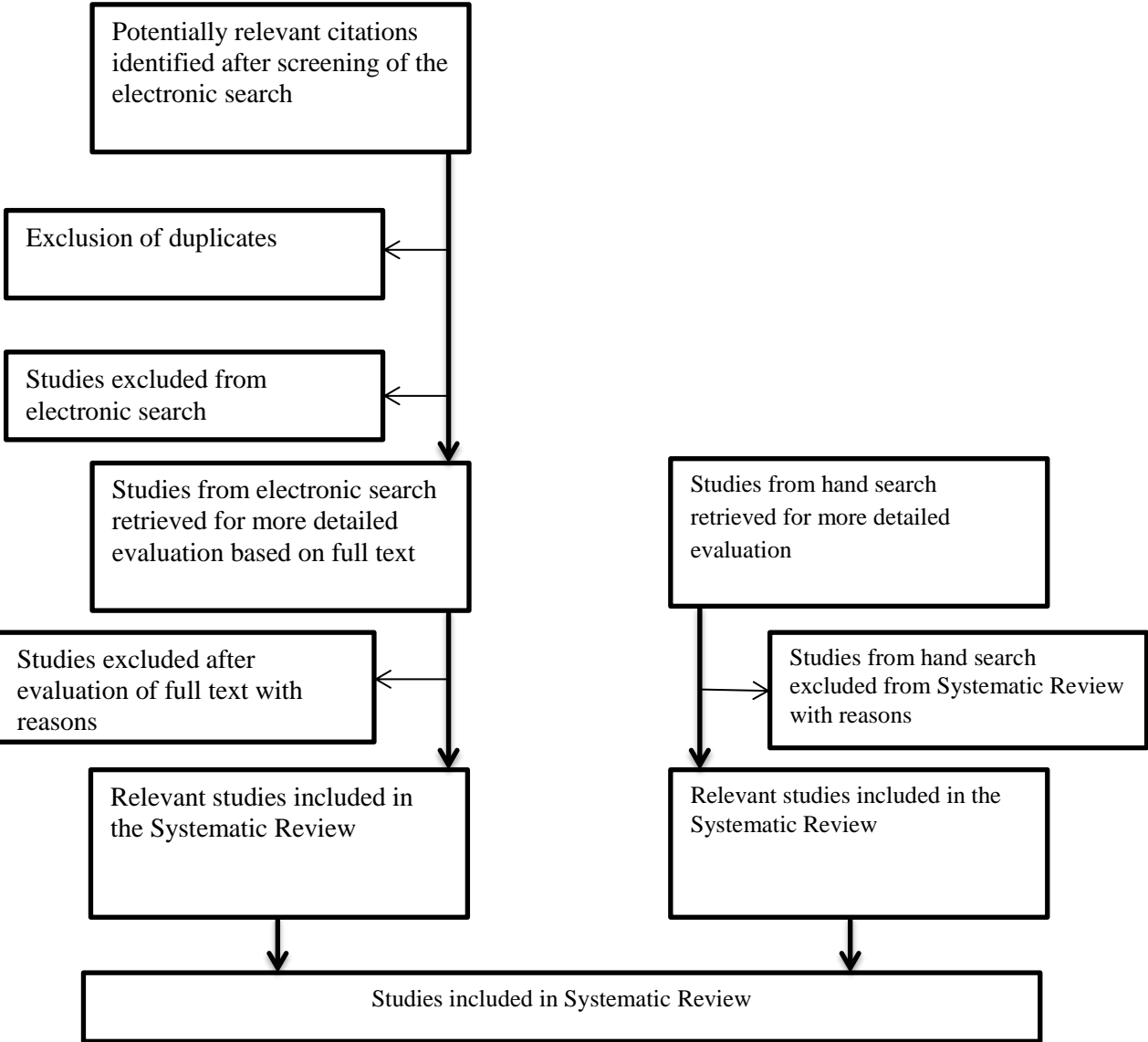
 Timeframe

The review is expected to take 12 months to complete.

Conflict of interests

Reviewers are unaware of any potential conflict of interests.

Figure 1. Flow diagram of study selection procedure

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│ citations identified after  │
│ screening of the electronic │
│ search                      │
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│ Exclusion of         │ ◄────│
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Annex 1

Standardized data extraction form

Table 1. ICT Instruments Descriptive Data:

Name	Author / Year	Technology	Input	Ty	n / diagnosis (mean age ± S.D.)	Ed	SR	T	Adm.	Domains	Usability	Understandability	Home	Lang.

Table 2. ICT Instruments Psychometric Data:

Name	Author / Year	Concurrent Validity	Discriminant Validity	Reliability	Test - Retest Reliability	Factor Analysis	Cutoff

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