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Considerations and Design on Apps for Elderly with Mild-to-moderate Dementia

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Abstract—Many elderly people suffer from dementia in their daily life. The symptoms of dementia include impairments in thinking, communicating and recalling things of the past. Dementia can be caused by brain damage incurred from stroke (brain infarct), injury or other diseases. Recently, research has indicated a potential rehabilitative role for touchscreen technology in dementia. Elders can use apps to aid recall in order to support activities of daily living. Memory and activity apps can be developed for people suffering from early dementia. This paper presents the current state of development in the field of cognitive tests. It has also presented the many considerations and design issues related to the development of apps for people with dementia.

Keywords—dementia, elderly, application software, cognitive test, cognitive stimulation therapy.

I. INTRODUCTION

Aging population is increasing. Elderly with dementia is also increasing. According to World Health Organization, the worldwide population with dementia is 35.6 million, with an increase of 7.7 million new cases every year [1]. It is projected that this number will be double by 2030 and triple by 2050. With the deterioration in memory, thinking and the ability to perform daily activities, the dementia patients have important physical, psychological, social and economic impact on caregivers, families and society [2].

On the rates of dementia, between 2% to 8% of the general population aged 60 or above has dementia. Although the prevalence of dementia is increased with age, it is not a normal part of aging. Dementia is one of the major causes of older people’s disability and dependency. The major feature of dementia is cognitive decline. There are early, moderate and severe dementia with different levels of decline in cognitive function. Cognitive function is a broad construct that includes a number of domains including attention span and concentration, intelligence and judgment, learning ability memory, orientation, perception, problem solving and psychomotor ability. According to these cognitive domains, some valid and reliable cognitive tests were developed to measure cognitive function, dementia and stages of dementia which would be described below.

Cognitive stimulation therapy is considered as effective for improving or delaying deterioration of cognitive function among older people with early to moderate dementia. Recent research has indicated the potential on the use of touchscreen technology for cognitive stimulation therapy to help demented older people to improve on their cognitive functions. There is a potential rehabilitative role for touchscreen technology in dementia [3]. This paper would introduce cognitive test and discuss on cognitive therapy. The main is on the considerations and design of the apps on cognitive stimulation activities. It is believed that such new touchscreen technology is opening a new door on improving quality of life and also contributing to cognitive function of demented older people.

The demand for simple and reliable tests for cognitive impairment is clear. The need for cognitive stimulation therapy is obvious. In this paper, we aim to provide a background on the current state of development on cognitive tests for dementia. A brief discussion on cognitive therapy is given as well. The main content of the paper is on the development of apps for elderly with mild-to-moderate dementia. The paper is organized as follows. In Section 2, a review on cognitive tests is given. Section 3 introduces the cognitive stimulation therapy. Some recent apps related to cognitive testing are given in Section 4. In Section 5, the development of apps for cognitive stimulation therapy is discussed. Section 6 discusses the many considerations when developing apps for people with dementia. The design issues are given in Section 7. Finally, conclusions are given in Section 8 of the paper.

II. COGNITIVE TESTS

There are a number of methods to carry out cognitive test on a potential patient. Below is a brief history of development on cognitive tests.

A. Abbreviated Mental Test

An early development of the test is the Abbreviated Mental Test [4] originated in UK. A series of ten questions are put to the potential patient and one point is awarded to each question correctly answered. A low score below 7 would suggest cognitive impairment. A more complete version of the test has 26 questions, but still no further analysis was carried out. The test has a very strong British flavor and many adaptations are needed when used in other countries.
B. Mini Mental State Examination

The Mini Mental State Examination (MMSE) [5] originated in the US and is used by specialist psychiatrists. Nowadays, the test is brief and can also be easily carried out by GPs. In a longer standardized version, the test has 12 questions and the total test score is 30. It would take 10 minutes to administer. A score of 23 or less would indicate dementia. Versions in other languages are common. The nature of the questions is complete and covers six areas:

- test on orientation (both time and location);
- test on registration;
- test on attention and calculation;
- test on recall;
- language;
- visuospatial ability.

C. GPCOG

The General Practitioner Assessment of Cognition (GPCOG) [6] is also a common and more recent screening test/detection for cognitive impairment or dementia. It was developed by a team in Australia and UK, and it is designed for use by GPs. It is simple to administer and the test takes just around five minutes. It is consisted of a number of cognitive test items and historical questions for the potential patients. The tests include memory recall, time orientation, visuospatial functioning and recent news/event description.

D. MoCA

Another recent test is called Montreal Cognitive Assessment (MoCA) [7] which is a sophisticated test for mild cognitive impairment and dementia. It provides an assessment on different cognitive domains. The test takes around ten minutes to administer and the possible maximum score is 30. The ranges for grading severity is as follows: mild cognitive impairment 18-26; moderate cognitive impairment 10-17; severe cognitive impairment is less than ten.

E. ACE-R

Addenbrooke’s Cognitive Examination, Revised (ACE-R) [8] is a more extensive validation tool for determining the severity of dementia. It was developed by the UK mental health professionals. It is a 100-point test and assesses on six cognitive domains (orientation, attention, memory, verbal fluency, language, visuospatial ability). Some components are the same as in MMSE. The revised version claims to have better sensitivities and specificities for the diagnosis of dementia. However, the test takes longer to administer (15-20 minutes). Unlike other assessments, ACE-R does not require specialized equipment or trained assessors. In this test, the factors like age, level of education or gender does not influence the predictive outcome, whereas in MMSE it is known that both age and gender have influential power.

III. COGNITIVE STIMULATION THERAPY

For elderly with dementia, especially in their early stage, the potential for mental activities and exercises to maintain and improve on their cognitive functions is indisputable. Psychological therapies for these patients have been developed for several decades. They are delivered by trained staff and mental health nurses [9]. The therapies may involve personalized cognitive rehabilitation [10] for the enhancement of the remaining cognitive skills. They may also involve cognitive training to improve on memory and attention capability through practice. Very often, the therapies are conducted either individually or in small groups, which are organized by the memory clinics.

Specialized sessions to address different cognitive functions such as memory and language are possible, but the overall aim is to engage the participants in a stimulating and learning environment, which is best provided in a group setting. This portion of the population is mainly living in nursing homes, where they communicate less and tend to close up themselves. Many of them are not connected to the current technology: computer, tablet computer, smartphone. In other words, many of them live in isolation and loneliness. Computer technology and touchscreen devices has the potential to ameliorate their lives by providing answers to their needs.

IV. APP FOR COGNITIVE TESTING

The well-known Clock Face Test [11] can be downloaded for iPhone/iPad. Recently, researchers in UK and Australia have developed an app for dementia assessment based on Addenbrooke’s Cognitive Examination (ACE) [12]. The app is now available for free download (since July 9, 2014). The official site of The General Practitioner assessment of Cognition (GPCOG) also provides a screening tool for cognitive impairment [13].

V. APP FOR COGNITIVE STIMULATION THERAPY

Around one-third of the cognitive stimulation therapies in UK are delivered in groups [9]. Hence, it is obvious that the majority of the people with dementia are not in group therapy. They may be unwilling or unsuitable to participate in groups. Also, there may not be local groups, and they are unable to get to groups. As suggested in [9], individual cognitive stimulation training should be considered seriously, and if possible, should be made widely available.

The conventional delivery of individual cognitive stimulation training to a patient with dementia is provided by family carer/members. Yet, there is potential to use tablet computer technology to provide the service. Specialized application softwares (apps) can be developed for these touchscreen devices that may enhance reminiscence and recall for elderly with mild-to-moderate cognitive impairment.

There is no evidence that mild cognitive impairment can be successfully treated once it is diagnosed [14]. Yet, it is hoped that the appropriate use of app for cognitive stimulation therapy can slow the rate of progression or the conversion to
Alzheimer’s disease. Further research should be carried out in the future on this aspect.

In a recent study with report published in UK [15, 16], iPad touchscreen devices were provided for older adults with dementia in residential and nursing homes. The report concluded that the touchscreen device can make a positive contribution to helping people with dementia. It can support reminiscence of an elder with an app called Life journal, which records a life history. Also, through the use of the app YouTube, the elderly can search for music and movies that they recognize from their youth, which further support reminiscence.

Researchers have started to develop apps for the cognitively impaired. One example is “Alive Inside” [17], which has version for both the Android and iOS platforms. It is a mobile app developed to stimulate the memory of those suffering from Alzheimer and dementia through music of their youth. It is a music streaming app which provides a personalized music listening list defined by the user.

In another effort to develop mobile app to help dementia and Alzheimer patients [18], an app was developed to help an elder to navigate the web, provide the weather information as well as pill reminder alerts. Another app was developed to allow families to electronically send photographs, video clips, and favorite music from anywhere to their loved ones for enjoyment.

In our research, a number of apps are being developed and brief descriptions of them are given next. The first type of app is like a photo album of family members and friends. It is designed as a high level tool for the organization of photos provided by the user, or by his friends or family members. The display can be synchronized with music or various artistic display of the photos. The app is designed for reminiscence exercises, memory prompts and other mental exercises. The display of kaleidoscopic images is another interesting app. The aim is to allow an elder to tap on some selections on brush, color and pattern. The software would then show some interesting images which can vary with time, and the display can be synchronized with music and nice melodies.

In addition to the above, another category of apps are games designed for the enhancement of various cognitive domains:

- attention and concentration;
- executive functions;
- memory;
- language;
- visuoconstructional skills;
- conceptual thinking;
- calculations;
- orientation.

A. Apps on Managing Real Daily Living Activities

The idea is on developing an app to engage a patient in managing his daily activities. The objective is to maintain or enhance his/her functional capabilities, rather than taking a passive role in daily living. The app is designed for the elderly to carry out a series of activities, which are routines in his daily lives. There is a lot of flexibilities in the setup of the routines and tasks, and the schedule is personalized individually. Below is a table showing a list of potential activities in the app.

<table>
<thead>
<tr>
<th>Activity</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Communications</td>
<td>Look up of number from a contact list, dial a call, receive and make calls without help. Reminders to contact family members or friends can be setup.</td>
</tr>
<tr>
<td>Taking Medicine</td>
<td>Reminder to take medicine Know the dosage and reason for the medication</td>
</tr>
<tr>
<td>Information Gathering</td>
<td>Watching daily news, reading newspaper from the Internet</td>
</tr>
<tr>
<td>Schedule</td>
<td>Reminder on daily exercise, weekly social meetings, occasional visit to physician etc.</td>
</tr>
</tbody>
</table>

B. Apps on Managing Virtual Daily Living Activities

The idea is on developing an app to engage a patient in some virtual activities. The design of the app is like a game. The app is designed for the elderly to carry out a series of virtual activities, like fishing and hiking. There is a lot of creativities in the setup of the activities. Below is a table showing a list of potential activities.

<table>
<thead>
<tr>
<th>Activity</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traveling</td>
<td>Virtual planning of places to visit, both local and overseas. Information on the places of visit/cities and their culture and history is contained in the app.</td>
</tr>
<tr>
<td>Fishing</td>
<td>Virtual fishing; Information on fish is contained in the app.</td>
</tr>
<tr>
<td>Gardening</td>
<td>Virtual growing of flowers or plants; Information on various plants and flowers is contained in the app.</td>
</tr>
<tr>
<td>Hiking</td>
<td>Virtual hiking, scenes of nature.</td>
</tr>
<tr>
<td>Shopping</td>
<td>Browsing of items, finding details on the sale items; this activity can be combined with managing money.</td>
</tr>
<tr>
<td>Managing money</td>
<td>Virtual pocket and bank account</td>
</tr>
<tr>
<td>Preparing meals</td>
<td>Virtual planning and cooking of meals; Information on different cuisines is contained in the app.</td>
</tr>
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</table>
VI. CONSIDERATIONS ON THE APPS

The design of apps for cognitive testing is radically different from apps for cognitive stimulation therapy. A cognitive test is designed to be administered around five minutes. It is designed to provide rapid screening, and further test can be carried out to determine the severity of dementia. On the other hand, apps for cognitive stimulation therapy are designed with a specific purpose in mind. The aim is to enhance one or more cognitive functions of the user, which may include attention and concentration, memory, language, visuoconstructional skills, calculations, orientation etc.

The app for cognitive stimulation therapy is also designed to be used for a prolonged period of the day. It is anticipated that the touchscreen device is personalized for an individual and the elder can use the device throughout the day for various purposes. For example, the device may have to be switched to a communication device for making phone calls or for messaging to friends. In another instance, it becomes a device which would remind the user to carry out a certain task, or to remind the user to take medical prescription. It is a multimedia device with various functions: music player, video/movie player, game playing, organizer (with personalized calendar), communication device (phone/messaging) etc.

Every effort should be made for the touchscreen device to be a personalized device for the elder. One emphasis of “Alive Inside” [17] is the provision of a personalized music listening list. The various setting of the display should also be personalized.

It must also be emphasized that there is a lot of information on the user and his activities in the device. In fact, the device contains a continuous record of the performance/scores on the use of the apps (e.g. a memory game). The enhancement (or deterioration) on a cognitive function of the user can be evidenced by the record of activities. Hence, data protection and security issues should be considered so as to respect the rights of the elder. Only authorized personnel should be allowed to access the data contained in the touchscreen device other than the user.

VII. DESIGN ON THE APPS

It is desirable to have separate app for the enhancement of a specific cognitive function. As the user is expected to use the app for a prolonged period, the app should be designed with many interesting graphics and variations. The app should be developed for both iOS and Android devices. Both types of device are very popular, and can be quite different in price as well.

When an app is designed as a game activity, it is desirable for the game to have different levels of difficulty or challenge. Each elder has different background on his experience on the use of software. With different level of usage, a new user should be able to find a suitable entry point to the software. This will also ensure that the app can provide continuous stimulation to the user, as he progresses when using the app.

On the issue of Graphical User Interface (GUI) design, it must be emphasized that most elders are not familiar to the standards of mobile applications. Conventional interface design such as drop-down menus or icons may already cause problems. Hence, careful instructions should be provided on each page. Each app should have a simple and easy-to-understand interface, with bigger fonts and large buttons, which are clearly labeled. The GUI should be optimized for elderly people with bad eyesight. It should not depend on good motor skills of the user as well. As far as possible, colors should be used to further distinguish the different meanings of a button or a region.

The design of software for elderly users is very important for it can lead directly to the success or failure of the device [20-21]. A good design can greatly reduce the barrier between the elders and computer devices. It would increase the confidence of the elders to use the technology for their benefits. With the many cognitive declines of the elders including eye vision, color, sound, lack of attention, motor decline etc., many considerations should go into a careful design of the software for use by elders [22]. Below is a list of principles [23-29] into the design of the apps for elders with the aim of improving their cognitive functions with daily usage.

A. Reduction of complexity
- The functions that are rarely used should be removed.
- Try to reduce items per working page to between 2 to 5 items.
- Avoid the use of complex interactions.
- Simplify the text into short/simple sentences.
- No multi-touch gesture due to the lack of motor skill.

B. Clear structure of tasks
- Key function unity (one key is for one function).
- Page function unity (one page is for one task).
- Use of hypermedia structure with limited options for selection.
- Use step by step wizard for complex tasks.
- Place confirmations whenever possible.

C. Consistency of information
- Make use of color to support information presentation, not to communicate meaning (a color can be interpreted differently in different cultures).
- Make use of Labeling: information presentation should be clear and distinct.
- Make use navigation bar/menu.
- Consistency on interface even for different software versions.
D. **Rapid and distinct Feedback**

- Provide feedback continuously.
- Distinct feedback from each action, every feedback should be easily recognized, use specific, constructive words in error messages.
- Button clicks: Visual aural feedback within 50 milliseconds
- Action taking between 1/2-2 seconds: Wait/hourglass icon.
- Action taking more than 2 seconds: Message and animated progress bar.
- Return from long process: Visual indication such as a message.

E. **User support**

- Minimize Errors
- High Recoverability: provide undo facility.
- Exploit forcing functions to constrain people to use a limited range of operation.
- On screen help.

F. **Interface optimization**

- Make use of proper size interface components.
- Avoid using scroll bar, use of icons with text description.
- Present text the simplest way, pay attention to size and font size.
- Make use of black font on white background and avoid using fancy text (moving, non-horizontal orientation, splash etc.).
- Keep operation area in the center of working page.
- Make use of multi model communication.
- Make use of real object-liked interface.

The design of an app called “Golden Journal” is described next. The objective is to help record the life of the elder, together with a photo album. The setup would resemble an e-book autobiography for the elder to map out his life. The app would facilitate him to write out his life timeline. He can identify the main characters in his life, and include photos to the software. He has write out the stories that he would like to communicate with others “in his own voice”. With regular usage of the app, an elder is expected to have the following advantages:

- To help the elder on recall of early memories; to support reminiscence.
- To reduce anxiety and depression, bring out positive emotion.

- Quick and easy access of photos/videos of relatives and friends.
- The nurse or caretaker can know about the past history and preference/favorites of the elder, and hence provide more understanding of the person. Better decision making and tailored care can be given to the elder as a result of this better understanding.

Part of the design of the app is shown in Fig. 1 below.

![Fig. 1. Design of the app called “Golden Journal”](image)

**VIII. CONCLUSIONS**

Many elderly people suffer from dementia in their daily life. The symptoms of dementia include impairments in thinking, communicating and recalling things of the past. Dementia can be caused by brain damage incurred from stroke (brain infarct), injury or other diseases. Recently, research has indicated a potential rehabilitative role for touchscreen technology in dementia. Elders can use apps to aid recall in order to support activities of daily living. Memory and activity...
apps can be developed for people suffering from early dementia. New touchscreen technology is opening a new door on improving the lives of elderly people. This paper has reviewed some recent developments in the field. It has also presented the many considerations, design issues and principles related to the development of apps for people with dementia.

REFERENCES