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The Efficiency and Efficacy of On-Line Vs. Off-Line Cognitive Rehabilitation Therapies: Can a Wireless Interactive Cognitive Rehabilitation System on Dementia Patients Replace Rehabilitation Therapists?

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Abstract: *There have been increasing attempts to control memory, attention and naming difficulties of the elderly by using game applications on a tablet device. It is necessary to take into account several factors for such attempts to be realized effectively. This study applied the group rehabilitation therapy programs of a wireless interactive cognitive rehabilitation system and of paper-pencil methods to patients with dementia and the elderly with mild cognitive impairment, respectively, and sought to present the factors to be considered in order to achieve both efficiency and efficacy of cognitive rehabilitation therapies. The mild cognitive impairment group had few difficulties in participating in games connected with multi-users, understanding training directions and adjusting a training level of difficulty and speed, whereas the mild AD group, whose cognition fell below -2SD in normative data, had difficulties while a group rehabilitation program was being carried out with only one therapist and a device, and were continually directed one to one on how to use the device. In the therapy program of a paper & pencil method, while the mild cognitive impairment group understood clearly every task, the dementia group could complete the task only under assistant's repeated directions and explanation. The reason why engineering techniques have been applied in cognitive rehabilitation training programs for the elderly with dementia is the advantages of such programs like immediate feedback depending on user's performance and a decreased burden of labor force. It is cognitive functions of the device user that serve as a highly significant variable to predict efficiency and effectiveness of such engineering techniques.*

Keywords: Cognition, Dementia, Elderly, On-Line Rehabilitation, Therapy

Introduction

The elderly with cognitive impairment are likely to have difficulties in memory, executive functions, Visio-spatial functions and the like, which affects [Choi (2003) and Fong et al., 2001] their language competence including speaking, listening, reading and writing abilities. The goal of a cognitive rehabilitation therapy is, thus, to improve one's comprehensive cognitive ability so that one will have an effective communication and perform daily living activities more independently. Although cognitive rehabilitation programs, regardless of administration of drugs to treat cognitive impairment, were reported (Aguirre E et al., 2013) to enhance one's comprehensive cognition, the treatment efficacy of such programs is dependent on in what way a program is realized and presented to patients.

An ever-increasing development of IT-convergence medical devices has made cognitive rehabilitation for the old with cognitive impairment become smarter and smarter. For example, tools like Lip Motion in virtual environments (VEs) (Rose F D et al., 2005) are receiving much attention from cognitive rehabilitation; and artificial intelligent robots have been applied to offer services to care for the old with dementia. New devices where electronic engineering, information and

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communications, and rehabilitation therapy converge are entering the rehabilitation market. Computerized cognitive rehabilitation programs have often been used in clinical settings, and above all, a therapist, a patient and an in-hospital therapy program can be connected through a Wi-Fi network, by which the patient is given immediate feedback on his training performance, and the training data are stored in the server, making it simple and convenient to check the efficacy of treatment. Task performance of inpatients can be stored and made as big data, which will help to evaluate the performance of those patients who have been checked through first assessment and to compare their treatment progress with an average one of other patients. Such merits as 'immediate analysis,' 'uniform contents of programs without frequent changes every time a new therapist comes,' and 'therapy programs available any time and at any place' will create much more attention to computerized cognitive rehabilitation.

Considering that eighty percent of the elderly with mild cognitive impairment have dementia symptoms in six years (Petersen R. C. Et al., 2001), it is really important to apply and manage cognitive rehabilitation therapies for the elderly with decreased cognitive competence. Therefore, a wireless interactive cognitive rehabilitation system that creates a less burden of labor force of therapists and treats a lot of people for a relatively short time has been the focus of attention. It is required to consider several factors in terms of feasibility assessment for a developed device to be used more efficiently and effectively. Actual clinical settings, however, have not been so positive to use those systems. For this study, one medical institution with a wireless interactive cognitive rehabilitation system and one senior welfare center supporting group rehabilitation therapy with paper-pencil methods were selected, and actual group therapies were conducted in order to find out the factors to be considered to achieve both efficiency and efficacy of cognitive rehabilitation.

Methods

Subjects

Twelve inpatients (age = 79.3±2.16 years, Korean-Mini Mental Status Examination (K-MMSE) (Kang Y. W. Et al., 2006) = 22.56±1.08) of the medical institution were divided to mild dementia (N=6) and mild cognitive impairment (N=6) groups, and a wireless interactive cognitive rehabilitation program was conducted for them. Twelve elderly people (age = 78.5±4.76 years, K-MMSE = 26.83±1.60) of the seniors welfare center were also divided to mild dementia (N=6) and mild cognitive impairment (N=6) groups, and cognitive rehabilitation group training of a paper-pencil method was carried out.

Selection of Treatment Tasks

The cognitive rehabilitation program of this study was composed of five categories: orientation, memory, attention and perception, association and language. Orientation means one's ability to recognize time (including past and present), places and persons. Memory means a process by which information is registered, and retained or stored, and after some time, retrieved. Attention and perception is one's ability to concentrate on a certain stimulus without being distracted by other stimuli unrelated with the situation, which is the basic requirement for performing a task or cognitive function. Association means one's capability of establishing a connection between two or more symbols or concepts. Language is a symbol system to be used by auditory-visual means for the purpose of communication and can be divided largely into receptive language and expressive language. (Kim H. Et al., 2012). When organizing the program, this study adjusted its difficulty to a higher level gradually when a new session started. When the subjects showed eighty percent of correct responses on average per area, the difficulty of the next session was adjusted to be higher, and the subjects were previously notified of the

adjustment. Detail examples of five categories in cognitive rehabilitation programs are as Table 1.

Table 1. Examples of Cognitive Rehabilitation

Categories	Examples of Sub-Domains
I. ORIENTATION	- general spatial - general temporal - body awareness - time - environment awareness - Korea geography - familiar person awareness
II. MEMORY	- reminiscence of past events - topics for reminiscence - questions to stimulate reminiscence - sequencing - remembering which came first - word pairs - remembering simple stories - remembering word in the designated time interval - face
III. ATTENTION & PERCEPTION	- letter identification - shape identification - finding the other half of pictures of common objects (high /low freq.) - find the missing - sign comprehension - sign recognition & naming - trail making (sequential numbers) - trail making (alternative numbers/shapes) - trail making (odd/even numbers)
IV. ASSOCIATION	- specifying categorical knowledge - specifying attributes of common objects - mind map (association to stimulus words) - recognizing synonyms - part to whole - free association to stimulus color - identifying categories that don't belong - selecting close associates of common objects - function with object
V. LANGUAGE	- names of famous persons - word retrieval associated with functional activities - completing common phrases (i.e., proverbs, idiom) - free recall (1 min time limits) - describing common objects - answering simple questions - formulating sentences - language reasoning - searching ambiguous sentences - following written instructions - problem solving - making inferences

Procedures

The program was presided over by one examiner, supported by two assistants who helped the subjects in using the devices and participating in group activities. The program was conducted three times a week for three weeks, and the responses the elderly made

during the group training were written on paper in real time by three researchers. With regard to the effectiveness of treatment, a pre-post design was made, and qualitative analysis was conducted. The assessment batteries used in this study included K-MMSE (Kang Y. W. Et al., 2006), Korean-Boston Naming Test (K-BNT) (Kim H. Et al., 1997), digit span test (forward, backward) (Kang Y. W. Et al., 2003) and Geriatric Depression Scale-Short Form Korean version (GDS-SFK) (Ki B. S. Et al., 1996).

Results

In the wireless environment, the subjects of the mild MCI group (N=6) could themselves adjust the training speed and difficulty level and follow directions on the training of various cognition areas including visual perception, memory and orientation, whereas those of the mild Alzheimer's disease group (N=6) could respond to a simple O/X game but were repeatedly helped by assistants in directions on how to adjust the difficulty levels of each training and how to perform tasks, thereby raising an issue on the necessity for assistants who help the elderly to use devices in addition to one examiner.

In the paper-pencil environment, the mild MCI group (N=6) became faster in performing tasks and got better in their ability for reference by, for example, obtaining a cue from the examiner of the group as time went on, and the mild AD group was given directions, and for some of them who forgot how to do activities, an one-to-one intervention strategy was required, but they were not as confused as they felt

Fig. 1 The Training Conducted in the Wireless Environment and Paper-Pencil Environment

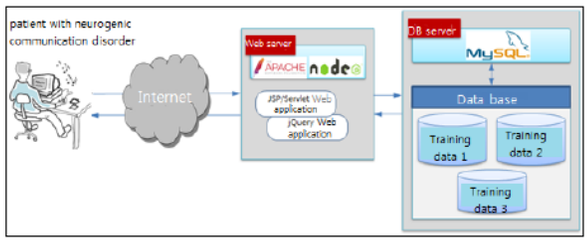

Fig. 2 The Diagram of Web Based Computer Assisted Therapy System

while using the wireless tablet device. The photograph examples of rehabilitation program environments are as Figure 1.

Conclusions

The effectiveness of cognitive training for patients with cognitive impairment is a subject still under debate. Such a genuine behavior therapy that does not include elements like pharmacotherapy and changes in the cortical thickness caused by hormonal change lacks definitive evidence (Clare L. Et al., 2003) because it has a number of variables including ethical issues in verification of its effectiveness. And cognition-oriented techniques such as ROT and memory training are difficult to adjust to a stimulus level or type corresponding to individual patients and are limited in repetitive use. So, software technology like medical aids and automatic medication dispensers has been an issue of importance until recently. These types of software, however, function rather as an aid device for daily life than as practical intervention for improving one's cognition competence and so are limited to be considered in terms of treatment and economical effectiveness. Therefore, a computer-based cognitive training or wireless interactive cognitive rehabilitation system has been in increasing demand as it enables a customized intervention program at a relatively inexpensive cost.

Those attempts to apply engineering techniques to cognitive rehabilitation training have been taken in clinical settings so as to secure

economical effectiveness by decreasing a labor force and increasing those to be treated, whereas the rehabilitation training for the elderly with impaired cognitive functions has a high entrance level because the elderly often have difficulties even in a traditional rehabilitation method where a therapist provides them one to one with training on, for example, swallowing disorder and cognitive-language impairment. Nevertheless, this online rehabilitation program has the advantage of a database allows to accumulate the data of patients. The reason is that, because the accumulated data is also be used to analyze the performance of the other patients (Figure 2).

As a result of this study, the mild MCI group was capable of performing the program regardless of whether it was a wireless environment or not, but the mild AD group with impaired cognition was much worse in the wireless environment in not only understanding the program purpose and tasks but performing them than they were in the paper-pencil environment, and in effect, they required more assistants in the wireless environment than in the paper-pencil one. In other words, the basic goal to reduce the burden of a labor force of therapists and to treat a number of patients did not seem to be met in the group. Therefore, for more effective application of future wireless interactive cognitive rehabilitation systems, it is necessary to closely evaluate user's cognitive competence to judge the suitability of the user as a subject of the service, and such programs that are offered by an application according to user's cognitive functions need to be adjustable in various aspects including a method of program presentation and a difficulty level.

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