

Games for Wireless Cubes in Cognitive Enhancement Therapy

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Abstract. Sifteo Cubes is an interactive tactile entertainment solution with own unique control interface gestures. The aim of the study was the use of games for wireless cubes in the rehabilitation of people with cognitive impairment staying in the neurology department of the hospital. Most of the exercises provided by physiotherapists can be classified into specific groups of tasks using the same way to resolve. During the analysis of sets of exercises, the following main categories of tasks are proposed: anagrams, memory games, and reflex games. As a part of a pilot program of introduction wireless cubes to the rehabilitation of people with brain injuries, three sample games, one from each category were developed.

Keywords: Wireless Cubes, Rehabilitation, Cognitive Impairment.

1 Introduction

Cognitive therapy is one of the fundamental tasks of neuropsychology [1,2]. Improvement of cognitive abilities such as memory, concentration, attention, language functions etc. is an objective of Cognitive Enhancement Therapy (CET) [3]. Impairment of cognitive functions is very often the result of brain damage which the patient suffers as a result of traffic accident or diseases such as stroke, or progressive dementia (i.e. in Alzheimer's disease). Brain injury frequently results in disorders of motor, cognitive, behavioral and social functions. Therefore, an important element of rehabilitation is appropriate diagnosis and therapy adapted to the patient's disorder. Such actions improve the quality of patient's life and extend the period in which he operates autonomously and requires less help from others.

Neuropsychological therapy uses various forms of stimulation from the most popular, using paper and pencil to such aid as boards, blocks, games, or specially prepared computer programs. Attention should be paid to the fact that patients often present motor disorder that prevents them from writing, as well as speech disorder, which does not allow for voice presentation of task solutions. These patients also often have

vision problems. Therefore, it is important to seek a variety of therapeutic methods. Neuropsychological therapy is conducted by a psychologist, and is preceded by a psychological diagnosis that allows evaluating the level of cognitive functions impairment. On the basis of the diagnosis it is possible to select appropriate exercises taking into account additional information on the patient's health status. Stay in rehabilitation centers, both public and private, is limited. But there are patients for whom neuropsychological therapy should be continued after their return home. However, the independent solving of the tasks (without the help of a therapist) often is not possible.

Neuropsychological treatment of neurological patients is conducted, among others, in the Upper Silesian Rehabilitation Center "Repty" in Tarnowski Góry (Poland). The aim of the study was the use of games for wireless cubes in the treatment of people with cognitive impairment staying in the neurology department of the hospital.

2 Related Work

Wireless cubes are not widely used in the rehabilitation of patients. A few therapists are interested in this unique technology.

An example might be Liftacube [4]. Authors realized a pervasive prototype system for training in a physical rehabilitation of person with neurological disorder or spinal cord injuries. The Liftacube prototype is composed from Sifteo cubes and the custom-made sensor board. The Sifteo cubes provide physical objects to handle in the game focusing on the key skill component. The sensor board is used to detect the height of the Sifteo cubes during the game using embedded light sensors and LEDs. The lifting height is really a determining parameter for the quality of the patient's lift movement. A separate board situated on the table with one element is used to detect if a patient lowered his arm after lifting a cube. Liftacube is able to detect the lifting of the patient's arm as well as locomotion interactions of the hands.

Another application of Sifteo cubes is used in a playful technology to engage users' interrelated bodily motions to better productivity [5]. Building interactions inspired by and embodying different mindless activities, authors demonstrate the value of secondary human-computer interactions able to enhance a user's state in primary productivity tasks. There are two games prepared in that project. First game uses the idea of infinite bubble wrap – each Sifteo cube is a single bubble, and its screen shows two bubble states: inflated or popped. Pressing the screen, the user changes the cube state from inflated to popped with an audible pop. Cubes can also be formed in a sheet. Then, the user popping any one bubble starts a chain reaction of the others. Shaking the cube, the user resets the bubble with an inflation sound.

The second game shows classic physics-based toy known as Newton's Cradle. Tilting a cube, the user can simulate. Graphical objects shown on the cubes bounce off one another and screen edges. Collisions generate musical tones.

3 Sifteo Cubes

Sifteo Cubes is an interactive tactile entertainment solution [6]. It is a commercially available game technology, which engages their players through hands-on interactions.

The idea of tangible and graphical user interface platform first time was de-scribed by David Merrill and Jeevan Kalanithi of the MIT lab [7]. They described a Siftables - novel platform that applies technology and methodology from wireless sensor networks to tangible user interfaces in order to yield new possibilities for human-computer interaction. They can be physically manipulated as a group to interact with digital information and media. Then the platform was commercially distributed under the name: Sifteo cubes. The authors noted several patterns of use observed in homes and schools and identified design recommendations for display utilization on distributed interfaces. They also presented the process of commercializing the research prototype to create a marketable game system [8].

Sifteo Cubes platform is composed of a wireless base unit and a wireless 1.5 inch cubes (3-12 units) equipped with a tactile screen, and communicating with each other [9]. Sifteo cubes are so different from other gaming platforms that designing applications for them at the first time, does not seem to be a simple task. Sifteo cubes have own unique control interface gestures. Sifteo cubes are not one device but a few, so designing an application we should think about games with multiple moving screens. It is an impediment in relation to the classical solutions dedicated to computers, and at the same time it is a chance for innovation. Sifteo cubes are characterized by the following features [10]:

- have a relatively small size,
- each cube has its own independent screen, but they can jointly view large image fragments,
- actions can be triggered, if any two dice are neighbored,
- each of the four edges of the cube can be recognized,
- touch screen acts as one big button,
- embedded accelerometer can detect orientation and gestures.

Sifteo Cubes allow developing of games practicing cognitive skills, such as pattern recognition, strategic planning, abstract thinking, language functions, and others. Therefore, it is possible to create the games, which require recognition of colors or patterns, as well as arcade - requiring the analysis of a complex situation.

4 Implementation of Sample Games

During the rehabilitation of people with brain injuries, therapists practice the use of specially designed sets of textual and graphical tasks [11]. Each of these exercises is focused on stimulation of selected cognitive function. Some tasks presented on pages of exercise notebooks can be adapted to wireless cubes. In addition, Sifteo cubes can be used to create innovative games that do not have their counterparts in printed materials.

Most of the exercises provided by physiotherapists can be classified into specific groups of tasks using the same way to resolve. During the analysis of sets of exercises, the following main categories of tasks are proposed:

- anagrams - type of word play, the result of rearranging the letters of a word or phrase to produce a new word or phrase, using all the original letters exactly once; for example orchestra can be rearranged into carthorse. To this group we include also tasks, where we can build words with letters not ordered,
- memory games - card games in which all of the cards are laid face down on a surface and two cards are flipped face up over each turn. The object of the game is to turn over pairs of matching cards. To this group we also include recognition of card order, where at the beginning all the cards with numbers of different values are discovered. Then all the cards are reversed, and the player must indicate the tabs according to the numbers recorded on them.
- reflex games – The user indicates a special card as quick as possible. The card that should be indicated shows something special. A key parameter of the game is the time of displaying this card. Attention and a little bit of dexterity are important while playing the game.

As a part of a pilot program of introduction wireless cubes to the rehabilitation of people with brain injuries, three sample games, one from each category were developed. The first one is based on the idea of anagrams (Fig. 1). The user must build words using cubes lying in a line and contact with each other. Words that can be composed belong to one of selected fields: animals, clothes, flowers, occupations, body parts, food, and countries. In this game a number of cubes in the range 3-12 is used. Each area contains about 40 words. During each gameplay, the sequence of words is drawn, but every time shorter words are guessed at first. The wireless base unit automatically recognizes how many cubes are available in the closest environment. This also limits the possibility of the longest words drawn.

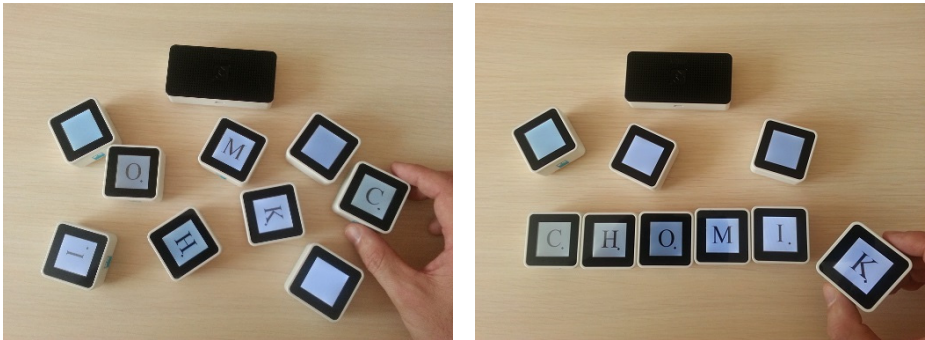


Fig. 1. The beginning and the end of the word building in the anagram game

The second application for Sifteo cubes is a standard memory game (Fig. 2). We need even number of cubes: 4-12. Instead of operation of turnover it is enough to touch a chosen pair of cubes. Cubes can be arranged in columns and rows, which makes them easier to remember. It is also possible to scatter the cubes at random, making the game more difficult. Game level depends on the number of cubes used in the game as well.

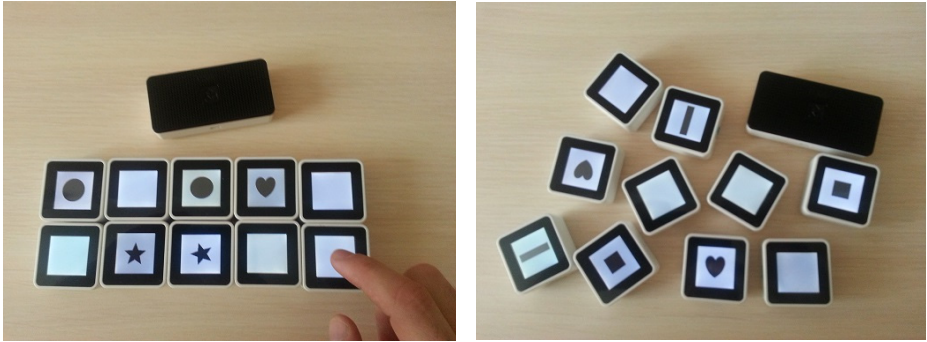


Fig. 2. Aligned and scattered cubes while playing in the memo game

The third game supports training of attention (Fig. 3). There is shown on the one of cube something that the user has to catch i.e. a cockroach. Then a new cockroach is shown on another, random cube. Sometimes, instead of a cockroach, a good-looking bee is presented over the several seconds. It cannot be touched. The gameplay ends when the cockroach is not caught in a certain time or when a player touches the cube showing a bee. During testing, the therapists turned their attention to the fact that the game can be enhanced by the appearance of more cockroaches than just one at a time, and the time on higher level can be shorter.

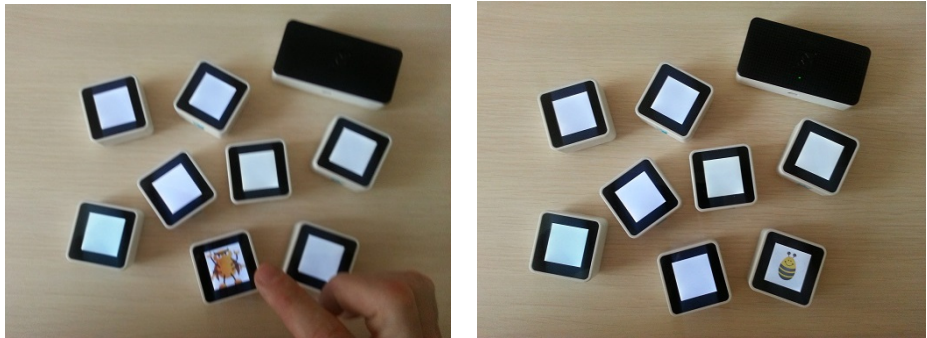


Fig. 3. Different phases of the game during attention training

5 Results

5.1 Study: Game Cubes versus Other Forms of Exercises

Introducing Sifteo cubes to the rehabilitation, we should be aware of the advantages and disadvantages brought by this technology. Over a dozen selected patients were asked about some of the most important aspects of the use of different forms of memory exercises. The study did not show a clear advantage of any of the forms of implementation of the exercise. The table demonstrates collected data. Among the most frequently mentioned disadvantages was the concern about lack of ability to use

a modern technological solution as wireless cubes and the need for help of an assistant, or a therapist. Using Sifteo Cubes can be considered as a good supplement to already used tools.

5.2 Recommendations for Game Developers

Developing applications for the rehabilitation of neurological patients should be realized according to certain strict guidelines. Creators of Sifteo Cubes have published a set of recommendations for application designers [6], however, it is not addressed to specific users, which are patients in rehabilitation centers. These patients, in addition to cognitive deficits may also have motor or visual impairment. Taking into account the expectations and comments given by therapists and patients, we can define basic rules of the rehabilitation game development for Sifteo Cubes. They are:

- use a simple contrast 2D graphics, and optionally allow to select an image inversion mode,
- use of the whole available screen space of a cube to display graphics
- omit animation, effects, flicker and 3D graphics,
- use of sound to confirm the executed action (touch screen, contact ankles, shakes, etc.) and signaling a finish of a task,
- several configuration options, i.e. for memory games: find identical pairs of letters, numbers, symbols, or colors,
- several levels of difficulty to make the game interesting for patients with different levels of impairment,
- levels of difficulty can be related to the number of wireless cubes used in the game,
- measure playing time,
- create a history of previous patient's results.

5.3 Future Work

Wireless Sifteo Cubes have been introduced to rehabilitation in the “Repty” Upper-Silesian Rehabilitation Center so far only as a pilot process. After this step, we must decide which games are correctly implemented, and in what configuration they are useful. Such information allow to use them wider. A questionnaire addressed to patients can certainly be very useful in making a decision. It should contain the following questions:

- Were the displayed graphical symbols recognizable?
- Did you hear generated game sounds?
- Were a feedback signals generated by the cubes useful in the game?
- Was the level of difficulty of the game appropriate?
- Where the configuration options appropriate?
- Would you like to use wireless cubes after leaving the hospital?

The questionnaires should be completed by the patients. Their assistants should be present and provide support when the patients write answers to questions. That is necessary, because sometimes due to paralysis of the patient, writing may not be immediately possible.

6 Conclusions

Researches so far conducted have to be regarded as insufficient, since the number of participated patients is too few. As it has already been mentioned, the exercises improving cognitive functions were used in case of neurological patients. Unfortunately most of them were elderly, who often had no previous contact with new technological solutions, and reluctantly use any electronic devices. However, cognitive therapy is sometimes a very long and hard job, and therefore another form of exercises and new kind of tasks can be more attractive, it can have a positive impact on the patient's motivation to exercise. Thus, the use of wireless cubes may be useful.

Wireless cubes are not widely used in the rehabilitation of patients. Commercial product is relatively young (since 2012), but today (April 2014) the manufacturer has already sold out all the cubes and so far said nothing about the further production. Thus their wider use in the future is questionable.

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