Stimulating Capabilities: A Proposal for Learning and Stimulation in Children with ADHD

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Abstract. Children with ADHD (Attention Deficit Disorder and Hyperactivity) experience behavioral and learning problems at home, at school and a lack of self-control in their lives. We can take advantage of the evolution of new technologies to develop applications with the aim of enhancing and stimulating the learning process of children with ADHD. In addition these applications may help teachers and therapist to monitor and control the children improvements. In this paper we present a software system based on games to improve the memory and language abilities in children with ADHD. The collaborative games are developed in a Multi-Device Environment applying the Distributed User Interfaces (DUI) paradigm. The interaction with the system is very intuitive and simple. The user only has to bring physical objects, with RFID technology integrated inside closer to a mobile device. In this way children can play from anywhere in the room and interact with the games projected on the wall.

1 Introduction

Attention problems are the most frequent at school. In epidemiological studies with normal population, teachers stated that among the inattentive children almost half of them were boys and quarters were girls. In the clinical setting, attention problems have prevalence between three and five percent [1], but just half of the children are diagnosed through clinical evaluation. Providing special education is a key factor to tackle this problem.

The Attention Deficit Hyperactivity Disorder or ADHD is a developmental disorder of self-control, which includes hyperactivity and the difficulty of maintaining the attention. In addition, these problems cause deterioration in the child's ability to control their behavior over time and to keep in minds the goals or future consequences.

Information and Communication Technologies (ICT) are ideal for educational proposes. Indeed, they can contribute to motivate children. In addition, ICT may be also good for teachers, parents and therapists who through a computerized material can carry out different tasks and control the evaluation of children. The advantages of using software systems and educational games in the therapy of children with ADHD are that they give children more independence from the teacher who does not need to be present all the time. Besides, it improves socialization through the use of collabo-

rative applications, the concentration is also improved as children have to focus on concrete contents, and the appealing and motivating interfaces make products designed for this purpose, an excellent choice in educational processes. The main stimulus for children is the motivation and attraction of using games that make children enjoy and learn without being aware of the fact that they are being evaluated and controlled. In order to exploit the advantages offered by multimedia resources and new technologies, the system we present in this paper aims to improve and stimulate the learning process of children with ADHD. To enrich the games we have applied technologies such as RFID and WiFi. This scenario also involves concepts such as IoT (Internet of Things), MDE (Multi-Device Environments), and DUIs (Distributed User Interfaces) to improve the user experience during the performance of the different activities as explained hereafter in the paper.

2 Related Works

In this section we describe the main works and concepts related to the system we propose in this paper.

Some games for children with ADHD are the following: *MeMotiva* [11] is a program that includes visual and spatial exercises. It includes a reward system to motivate and encourage them during the performance of these exercises and it is designed so that teachers, parents and children themselves can manage the results. *Caza-Cosas* [10] is a fun set of games designed exclusively for the development of visual memory. *Lumosity* [9] is a program designed to train the brain. It is based on the concept of "neuroplasticity", the ability of the brain to learn and adapt when receiving an appropriate stimulus. The different games and exercises are designed to train and improve memory, attention, processing speed and cognitive control. *SMART Braingames* [2] are interactive videogames that are intended to simulate real events in order to stimulate and educate different cognitive capacities.

A virtual environment simulating a regular classroom is described in [4], [5]. The user sits on a real desk, and immerses within the environment with the use of a Head Mounted Device (HMD). 58 typical classroom distracters (classroom noise, movement of students, outside events on the street, etc.) were systematically controlled and manipulated in the Virtual Environment. The tasks were focused on improving the attention of children.

Recently, there has been a growing interest in the use of online games. These are a good tool for those children who need to have remote interactions with the therapists [3].

These are some of the solutions that have been developed for the improvement and stimulation of children with ADHD. However, the system we present in this paper provides the flexibility to play collaboratively and individually. The users use common physical objects, such as cards to interact with the game interface. These objects are more familiar to users and thus the interaction becomes more simple and easy as it does not need prior learning. Besides, it is low cost and the devices (cards and mobile device) are less heavy than helmets, gloves, HDMs and other typical devices for virtual reality.

In school settings, Hengeveld described in [12] the value of designing intelligent interactive games and learning environments for young children with multiple disabilities to increase their language and communication skills. In [8] we can find a proposal that digitalizes toys to help deaf children to learn sign language.

We have also used the concept Internet of Things (IoT) in our proposal. This concept refers to a network of daily life objects being all of them digitalized and interconnected [14]. These new scenarios also support DUIs (Distributed User Interfaces). According to Niklas Elmqvist in [6] DUIs can be defined as a user interface whose components can be distributed through one or more dimensions. These dimensions are: input, output, platform, space and time.

3 Description of StiCap System

StiCap, Stimulating Capabilities, is an interactive system to improve attention and learning in children with ADHD. It is addressed to psychological therapies, in schools, allowing supervision by professionals, parents, and teachers.

The system consists of three games: two oriented to memory improvement and another one oriented to vocabulary enrichment. It is composed of the following devices: cards integrating RFID tags used as interactive resources which allow one-way transfer of information between a user and the system; mobile devices are interaction devices incorporating a RFID reader which provides the communication among cards and the system; and a projector or whatever big display showing the game interface which is running on any PC or laptop.

This section will briefly describe the StiCap system through the system requirements, the different devices, the interaction style, the main modules and the architecture.

3.1 System Requirements

One of the main requirements to be considered for de development of such a kind of application is simplicity and easiness. In this way, StiCap does not provide excessive unuseful animation. Children with ADHD lose their concentration easily, for this reason, it is necessary to motivate them through amusing but simple user interfaces.
Another important requirement is avoiding frustration because of failure. Appropriate applications show positive and encouraging messages when the user fails. In this way, the user is motivated to continue playing and learning. Additionally, the degree of difficulty to learn is considered. Educational programs should offer different difficulty levels so that the children can exploit their potential effectively. Verbal messages facilitate the use of the game and get the attention, enthusiasm, and concentration of children, who are driven through the interface. Activities performed by using the application are required to provide tranquility. Some kind of music and characters with too much action and troublemakers might increase hyperactive and impulsive reactions. Lastly, playing dynamics encourage ADHD children. These activities reinforce and enhance children's abilities through the games.

3.2 Multi-devices Environments

An amount of devices are used altogether on the environment where the games run: digitalized objects, mobiles devices, laptop, projector, and so on. These devices communicate each other through identification (RFID) and wireless (WiFi) technologies. The application user interface is distributed in such a way that interaction becomes more natural. The user do not need to know anything about computers or any kind of devices, but using the system naturally moving cards, approaching them to other places and so forth. These movements lead to the performance of task in the system.

Fig. 1. Multi-Device Environment that support Distributed User Interfaces.

The environment includes different types of interaction depending on the function of the device.

-IR (Interaction Resources) are the devices that can help the user to interact with the system. In this project are the cards that integrate RFID or what is the same physical user interfaces.

-ID (Interaction Devices) are computing devices that handle the input or send output to IR in order to shows the task executed and its results. This includes devices such as: desktop computers, tablet PC, mobile phones. In our case the mobile devices is responsible for interconnecting the physical interfaces (digitalized card) with the main game- user interface.

3.3 Interaction Style

The user interacts with the system through cards that integrate RFID technology inside (see Figure 2). Cards show images corresponding to the running game.

The interaction style consists of getting a card close to the mobile device which incorporates an RFID reader, then tasks are performed. A common flow of actions that a user may perform may be the following one:

a)   b)

Fig. 2. (a) Cards with RFID tags attached are used as interaction resources. Through them, the user can play. Every card has an image representing something in the game. (b) New style interaction, to interact with the system the user must bring closer the cards to mobile devices.

- Updating the results internally in the system and it creates a history of children's development.
- The system automatically generates the corresponding game interface. The projector displays it. According to the action carried out, different messages might be shown.

    - The answer is right a message indicating the outcome of the play. This user interface congratulated and encourages to the children to continue playing. A few seconds later appear the interface related to the game that is running, but a higher level than before.

    -The answer is wrong a message indicating the outcome of the play. This user interface motivates and encourages them to try again. The next user interface is related to the game that is running at the time, but in the same level as before.

Voices and motivating messages sound in every interface to make the user feel actively accompanied and encouraged. Exit and pause the game is an option always available.

3.4 Management and Administration of the Games

Therapist, psychologist, teacher or parents are in charge of saving a game and the evolution of children. This module of the system is focused on supporting the person responsible for children who can check the improvements of them. In addition, statistics and charts regarding the evolution of the children are provided. This part runs in mobile devices, but also may be shown on any other device.

3.5 Game Management

The system consists of three games, each with three levels of difficulty. Each level increases the difficulty of the game. If a child wins the game, then he/she moves to the next level, otherwise, he/she continues at the same level. The interfaces of the games are displayed on the projector, allowing different players to play at the same time. When the game starts, the instructions appear simultaneously in sound and text. The user can omit this step. Each user has his/her cards. In order to play they bring
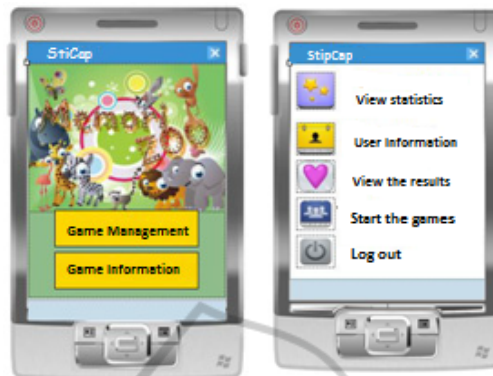
Fig. 3. Mobile user interfaces to manage profiles and evolutions.

the cards closer to the mobile device that recognizes the chosen card and checks if it is the correct one or not. Then, the result is shown in the projector. .

Children with ADHD have low self-esteem and may be easily frustrated; therefore, when the children lose the game, the displayed messages have to be motivating for the children to try again. The idea is not to give importance to the fact of having lost. Hence, the messages designed are as follows. When children win the game, the message displayed is "You've got it!" and when children fail then the message displayed is "Try again", as depicted in figure 4. The features of three games composing the system are detailed hereafter.

Fig. 4. Messages when winning or losing the game to encourage and motivate users.

- Memory and Vocabulary Stimulation Game

The aim of the system developed is to improve the memory and increase the abilities and attention of children with ADHD. Working memory is Working memory is regarded as a complex mechanism that permits the performance of complex cognitive tasks such as learning, understanding or reasoning.

Therefore, it is very important to work this capacity because this memory is the one that helps us in our daily activities, especially in the school years. For this reason, it is important that children with ADHD train their working memory as it helps them

to improve their daily life. Below we describe the different games composing the system.

- **Game 1.** This game consists on identifying a missing card among a set of cards previously displayed. As depicted in Figure 5a, the procedure is as follows. Three or four cards, depending on the level, are displayed on the projector for a limited time and children have to concentrate and memorize the set of cards. After ten seconds, the cards disappear and appear again with one card missing. Children must remember what the missing card is. Then, they have to identify it among all the cards they have physically on the table and bring it closer to the mobile device, which is responsible for checking if it is the correct one or not and then the success or failure message is shown accordingly.

- **Game 2.** This second game consists in identifying the order in which different animals appear in the screen. Every 3 seconds an animal appears on the screen. The number of animals can be three or four, depending on the level of difficulty. The children have to concentrate and memorize the order in which animals appear. After ten seconds, all the animals disappear, and then the children have to remember the order in which they had appeared, and bring the appropriate card representing the correct animal closer to the mobile device.

Fig. 5. (a) Main User Interface corresponding to the first game. (b) Main User Interface of the second game.

- **Game 3.** This game aims to improve linguistic and vocabulary. First, a letter is shown to the children and then, they have to identify the animal whose name starts with that letter. They have to choose the card representing the correct animal and again, bring it closer to the mobile device.

3.6 System Architecture

The StiCap system is a client-server system, designed as follows.

- Client System. The client system runs on the user mobile device. It is connected to the server application through a wireless network and it is communicated with objects via RFID when the user approaches the object to the mobile device. A tag (or more) is integrated inside the object or card depending on the size of the object; each tag describes a unique identifier. When the RFID reader in the mobile device is ap-

proached to the chosen metaphor, the RFID tag inside is excited by electromagnetic waves sent by the RFID reader, then, the component controller, explained below, sends the identifier to the server. The server maps this information in the database and executes the steps necessary to return the information to the mobile device. The games which are running in the PC are shown in the projector.

- Server System. The server system runs on a desktop computer that is connected to a wireless network via Wi-Fi connection. The server system contains the control logic and its function is to check whether the interacting objects are correct or not and displays the results on the projector.

- Software Components. The software components we have implemented are the following: *Controller* is located in the mobile devices and its main function is keeping waiting until an event occurs, like reading a tag ID and then the controller send it to the web service to execute a specific operation. The *Web Service* receives the identifier previously read and check the database to return the information corresponding to the game displayed. *Mobile Games* runs on the mobile device and displays the interaction mode. It also shows the status and feedback of the game and finally *Game system* runs on the PC and checks if the user has some interaction with the system. If an event has occurred, it checks the event and shows the corresponding interface.

4 Conclusions and Discussion

In this paper we present the StiCap (Stimulating Capabilities) system, based on games to improve cognitive abilities such as memory and vocabulary in children with ADHD. The games have been developed in a Multi-Devices environment, in such a way that users interact with different elements in a natural and intuitive way. The concepts related to the different games, that the users have to handle, are represented in physical cards with RFID technology inside, so that users interact with the game by using these cards. The game interfaces are projected on the wall to allow working in groups and promote collaboration as cards are easily handle for more than one user at a time. To carry out this new form of interaction, users have to bring the cards containing an RFID tag inside closer to a mobile device with the RFID reader. Therefore, the game interfaces are distributed in physical objects, mobile devices and a laptop, PC or Tablet. Besides, the system is portable and flexible as the user may handle the games remotely from anywhere in the room. It also offers the possibility of playing the games individually or collaboratively with other users. Another benefit to highlight is that the system has a low deployment cost since the RFID tags are quite cheap.

In order to check the benefits of the system, we evaluated it involving ten users in the experimental study (6 men and 4 women). There were two groups with three players and four players that played individually. The method used for evaluation was direct observation [15]. The test was repeated four times to check if some results improved when using certain cognitive abilities such as memory, attention and vocabulary. The results were as follows. Six out of ten participants enjoyed the games and wanted to repeat the activities. Four users played individually. They were more

introverted and unable to interact with more people. However, when playing alone, they were motivated and enjoyed the games. The results were positive in children. They collaborated with each other and when they got a correct answer, they celebrated it. However, when they failed, they encouraged each other and wanted to continue playing. When repeated the session, the results were even better than before; they were more satisfied and motivated. Users considered the use of the system easy. The new interaction way was nice and attractive for them and they were able to feel themselves immersed in the game.

Acknowledgements

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