Co-StiCap: System based on Distributed and Tangible User Interfaces to Improve Skills in Children with ADHD

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Abstract. The attention deficit disorder with hyperactivity (ADHD) has increased considerably in recent years. People who have it experience behavioral problems, learning and self-control in their lives. The therapies performed are based on activities to improve cognitive abilities. Nowadays technology is becoming a tool to facilitate the cognitive stimulation and work of therapists, family, etc. In this paper we present Co-StiCap (Stimulating Collaborative Cognitive Capabilities) is a multi-device system based on Distributed User Interfaces and games aimed at improving the communication and cognitive capabilities in children with ADHD. The system consists of a projector running the main game interface, tangible interfaces based on common objects that we use to interact through a mobile device (which integrates NFC reader) with the main interface. Moreover it has another mobile device application for therapists, which aims to control the process of children and assist in the collaboration and cooperation among them. It has carried out an assessment in order to check the effect of the system and the new technique of interaction among children and families and therapists.

1 Introduction

Diagnosis of Attention Deficit-Hyperactivity Disorder (ADHD) has increased considerably over the last decade [1]. ADHD is defined as a behavioral disorder characterized by moderate to severe distraction, difficulty attending, restlessness, emotional instability and impulsive behavior [13]. Often people suffering from this disease have social problems, between 50 and 60 percent of children with ADHD have difficulty getting along and interact with other children. Brain-training programs are high-tech therapies that sharpen working memory and improve focus in children and adults with ADHD.

In recent years interactive games have been widely accepted by the society, these can be used as a learning tool and help to strengthen cognitive skills in an amusing and pleasant way. According to a study published in [5] among the effects of the games we emphasize that cooperative games improve the participation and integration of users, also improving their communication skills, self-confidence, self-awareness and ability to work with others.

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Technological advances in miniaturization of microprocessors have opened new possibilities for user services. The user has multiple devices such as smartphones, tablets, netbooks, laptop, etc. We find multi-device environments that offer us many advantages, but also require a new type of user interfaces and interaction mode. In this case we use Distributed User Interfaces (DUIs) and Tangible User Interfaces in order to offer a multi-device usable and intuitive to the user, thus taking advantage of all the opportunities offered by technology.

Co-StiCap is a system based on games that uses NFC and Web technology to carry out the distribution of user interfaces and to provide a intuitive interaction with the system. The main objective of the system is to provide cognitive stimulation games for the ADHD affected conduct their therapy in a fun and develop skills such as memory, attention, communication, and so on.

The paper is organized as follows. The following section describes the most important concepts related to the project, then explained how it was designed and developed the system. The next section describes in detail the system Co-StiCap and finally we explained the conclusions and future work.

2 Related Works

We are witnessing the integration of new environments, also called multi-device environment (MDE). These scenarios are going to find consist of multiple, heterogeneous devices distributed in the environment along with screens and surfaces where user interfaces can be executed. Example of such environments we find the following: *i-Land*, [11] is an interactive system for facilitating collaboration between users through devices such as: an interactive electronic wall; a chair and an interactive table that allows interacted with her through 'touching' technique. *WallShare* [6] is a collaborative system that allows distributing the interfaces between different devices such as mobile phones, PDAs, laptops, and etc. In addition, it is composed on an open space to be displayed through a projector on a surface such as a wall. *E-conic* [10] is an application that supports multiple devices sharing information among them. These new scenarios offer multiple advantages over the computers. However, we have the necessity of distributing information in different and heterogeneous devices. For this reason, It is necessary take into account the design of Distributed User Interfaces (DUI). This term is defined by Niklas Elmqvist in [4] as a user interface in which its components can be distributed across one or more dimensions such as input, output, platform, time and space. Distributed user interfaces can be displayed on different devices: phones, computers, screens, objects , and etc. The interfaces that are distributed in objects are called Tangible User Interfaces (TUI) [8]. These are physical objects used as representations and controls for digital information.

There are games focused on improving cognitive abilities of people affected with ADHD disease. Then, we will describe them. *Memotiva* [12] is a program that includes exercise to improve the visual and spatial abilities. *Caza_Cosas* [2] is a suite of games designed for visual memory. *Luminosity* [9] is a program designed to train the mind. It is based on the concept of 'neuroplasticity', ie the mind's ability to learn and adapt to receive the right stimuli. *SMART BrainGames* [3] is a game focused on educating different cognitive abilities. There are also virtual reality environments

developed to improve the attention and concentration in children with ADHD [14] [15]. Currently online games are having a high acceptance by the ability to interact with the therapist so remotely [17]. There are even video games offer the possibility of developing cognitive skills and improve learning in children such as *Interactivemetronome*[18] and *Cogmed*[19]. However, the way they interact is still based on the classical methods of interaction via mouse and keyboard, or in the case of virtual reality through hulls (Head Mounted Device, HMD). Furthermore, these systems enhance user's individual development but do not allow that multiple users to collaborate.

3 System Requirements

In order to design and develop an MDE scenario we considered an interactive triangle (Figure 1). This is based on the following factors: Users and tasks to be performed, new technologies and devices available in an MDE scenario and tangible distributed user interfaces as an intermediary between users solutions.

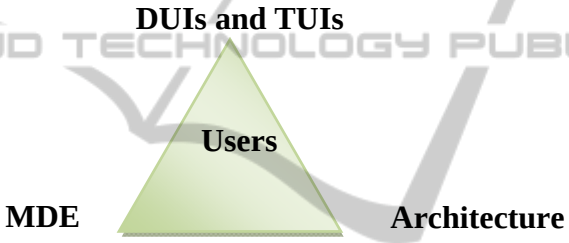

Fig. 1. Interactive Triangle.

The most important component of the system is the user. The design corresponds to your needs and the task to be performed. Then we define the vertex of the triangle in more detail:

Vertex 1: MDE refers to the devices and the communication among them. In the design we have to keep in mind that all available devices should be easy to use. For example the following devices: Laptop, Smartphone, Kinect, Wii, Tablet, and Projector.

Vertex 2: The architecture to communicate all devices. This kind of architecture must allow to integrate different types of technologies, such as Web technologies, identification RFID, NFC.

Vertex 3: DUIs and TUIs are the link among MDE environments, the architecture and the user together with the task (the latter is an implicit factor that will be present to design and develop the system).

Combining these types of interfaces offers the following advantages:

-The system can have a private interface (tangible interfaces, each user has their own) so this makes users more confident . Moreover, it provides a shared interface.

-Tangible interaction is more natural for users. They only have to bring the objects closer to the mobile device. In this way we provide flexibility in the space, you can work in the same room and o remotely interact with the system.
-It offers the possibility for multiple users to interact simultaneously, thus facilitating participation and communication.
-In a collaborative environment we can distribute and maintain collaborative interface users' private spaces with their own device. Considering Streng study [16] and the importance of working with individual space, our conclusion is that users are more confident when interacting and working with the system.
-The distribution of user interfaces in the environment allows us to simulate the way people usually work. In order to improve human-computer interaction in multi-device environments that support DUIs it is necessary to know and take into account how mental models and the cognitive system of users work. The study described in [7] provides a guidelines to distribute traditional user interfaces (GUIs) in MDE
-Direct interaction with the objects provides a better understanding of the task. The tangible interfaces emphasize the connection between the body and the cognitive process, thus facilitating thinking through physical actions.
The disadvantage is the scalability of tangible interfaces. These are stationary and designed to engage five users. One of the future works would be to allow users to edit the games and tangible interfaces easily.

4 Co-StiCap System

Co-StiCap (Stimulating Collaborative Cognitive Capabilities) is a learning and collaborative multi-device environment designed to stimulate the memory, attention, concentration, so on in people with ADHD disease. The collaborative system is based on the distribution of interfaces and device mobility; it offers the possibility to be used individually or by multiple users. It integrates a new form of human-computer interaction. The user can interact with the system through everyday objects. The functionality of the system is as follows. In the main game an interface is projected on the wall. Users with tangibles interfaces, i.e., the objects that integrate NFC tags, can interact with the main interface; this requires the mobile device that incorporates the NFC reader to interact with the main interface and this is necessary to bring objects to the mobile device. For example, if in the game an object must be associated with another, the user only has to bring the corresponding object closer to the mobile device, and then the system recognizes it and displays the outcome of the game. The system includes a part for teacher or therapists. This module allows to control the games, the results, and the users. In addition ,the system also monitors the user data to coordinate the multi players in the game (see Figure 2).

4.1 Design through Interactive Triangle

In order to design and develop the system we have considered the three vertices as explained in the previous section.

Fig. 2. Main scenario: it consists of tangible interfaces, mobile device and the computer.

4.1.1 MDE

Multiple devices are networked in an MDE. In this system we have used the following:

-*Smartphone*. It is used to interact with the system, because of the small screen size it has just been used as an interaction device, the relevance of this device is that it offers a more natural tangible interaction style which is easy to use any size tablet could also be used, being the only requirement to incorporate NFC technology .

- *Tablet* has been used for application of the therapist, in this case the application shows data, graphs, monitoring users and user data. Besides, it offers functions to control the game. This device was chosen because of the complexity of the task and the need for a larger screen than any Smartphone.

-*Laptop*. It is responsible for showing the main game interface. It has been chosen due to its computing power that allows us to execute quality graphics and multi-modal factor as well as offering sound, text, graphics.

-*Projector*. This device expands the size of the main interface easily. It also allows multiple players to play at the same time

-*Resources interaction*, i.e. common objects that facilitate interaction with the system.

-*Tangible Menu*, (this is an alternative to tablet) which has been used by therapist, parents, teachers, etc. In this case the interface allows them to control the game remotely.

4.1.2 System Architecture

The architecture is client-server mode. It allows any type of device to communicate with others through NFC and Web technologies. Tangible user interfaces incorporate an NFC tag that has written a web address that identifies the object. When the interface approaches the NFC reader (built inside the mobile device) it reads the tag information and executes the corresponding mode on the server. The server is responsible for interpreting the data sent by the mobile device and simultaneously executing the required action in the other interfaces. In this type of scenario the server is the main component responsible for communication among devices through an access point. This component is also responsible for the control logic, i.e. contains all services and tools necessary for the rest of devices which make up the system.

4.1.3 Duis and Tuis

The main task of the system is to provide collaborative games. Taking into account the distribution of user interfaces according to the users' mental models [7]. We has divided collaborative interface main games on a projector to be displayed more clearly, mobile device interface has been used as device interaction between the main interface and tangible interfaces. In the next section we describe in more detail the distribution of the interfaces.

4.2 Interfaces Distribution

The system divides and distributes the following interfaces:

4.2.1 Main Game Interface

It refers to the interface that is distributed and displayed on the wall thanks to the projector that which is responsible for extending it. The main reason has been to facilitate the visualization of the main game screen. In this way the children can interact remotely with the game. The information displayed on the interface has been designed keeping in mind that children with ADHD have a too limited working memory that may cause limitations in performing daily activities. Cognitive stimulation games is taking place in therapy with children with ADHD to exercise your memory and improve concentration and attention. In this system we have focused on games memory, calculation and language in order to improve the cognitive abilities of users, the communication between them and their self-esteem.

The shared interface allows users to pay attention to the image, because the projection of the interface allows the size is larger, and allows all users to concentrate on the information displayed in the interface and share it with other users (Figure 3).

Fig. 3. Main Game Interface.

4.2.2 Tangible User Interfaces

Tangible interfaces are based on common objects such as cards. It contains a NFC tag inside with a web address that is responsible for identifying the card and the user who has it. Each user is identified by a color and using the cards as interactive resource. The advantages of this type of interface is that we allow for simple and intuitive interaction for the user. In this prototype we take physical manipulation for educational purposes has always been the basis of cognitive development in education, so the user does not need a prior learning to interact with objects, he/she does unconsciously (See Figure 4).

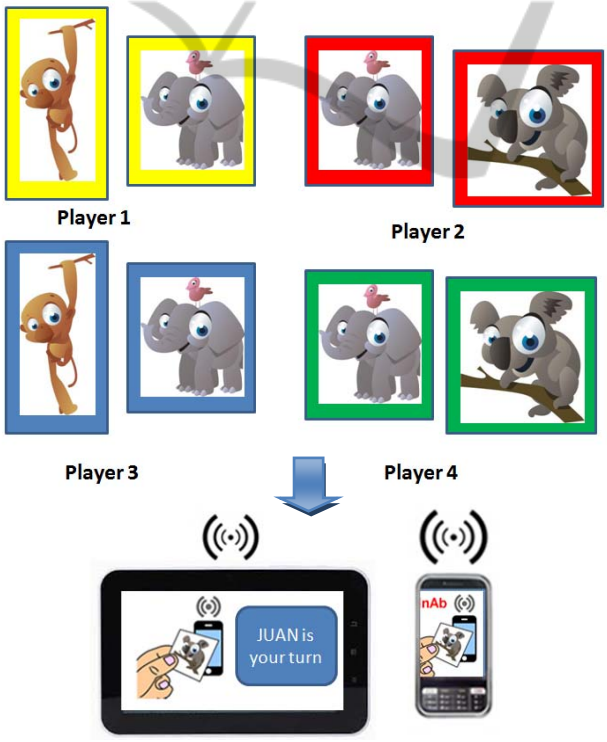

Fig. 4. Tangible Interfaces collaborative games (top) Mobile devices that incorporate an NFC reader in order to communicate tangible interface with the system (down).

4.2.3 Mobile User Interface

In this system we have two different mobile devices: the *Smartphone* and *Tablet*. The Smartphone has been used as a device for interaction between the main game and tangible interfaces. Due to the limited screen size of your mobile interface based on graphic description of the interaction to be performed by the user with the game.

The Tablet in the system can have two different functions. If it contains inside NFC reader can be used as a communication device between tangible interfaces and the game (same as a mobile device). In our case has been used to show the application made for therapists, family, and etc. This application is responsible for displaying the data that monitors the game, i.e. the child has played, the results, and etc. among the existing games depending on the cognitive capacity that is intended to improve. Internally the application monitors the user process, when you have a user wearing several games without playing warns the therapist and the therapist can change the turn, simultaneously show a message in the game interface by encouraging the user to participate. This will get better communication and coordination among the users. It also offers the opportunity to shy and introverted children to integration with other children. The program allows the therapist to control the data and those who play. It also includes an automatic option which coordinates to the users depending on the improvements in the games.

4.2.4 Interaction Style

The new style of interaction with tangible interfaces attempts to simulate the way the user interacts with his environment. This will try to eliminate the need for prior knowledge of the user. In order to interact with the system only need to bring tangible interface (depending on the type of game to be shown on the main interface) to the mobile device (see Figure 5).

a) **b)**

Fig. 5. (a) Tangible User Interfaces with NFC tag, (b) Interaction style.

5 Conclusions

This paper describes a multi-device and collaborative environment which support tangible and distributed user interfaces. It has been developed with NFC and Web technologies. In order to design and develop the system has emphasized how to distribute the interfaces that device and how they communicate between them, taking into account the human factors of users. The main objective of the system is to facili-

tate stimulation cognitive and communication in children with ADHD. The mechanism of interaction based on tangible interfaces, known as objects offered a simple and intuitive interaction in a way that helps to eliminate the technological barrier in people who have limitations. We did an evaluation, the results have been very positive, users have enjoyed using the system and it was found after several iterations cognitive and communicative improvements among users.

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References

1. Craig F. Garfield, E. Ray Dorsey, Shu Zhu, Haiden A. Huskamp, Rena Conti, Stacie B. Dusetzina, Ashley Higashi, James M. Perrin, Rachel Kornfield, G. Caleb Alexander . Trends in Attention Deficit Hyperactivity Disorder Ambulatory Diagnosis and Medical Treatment in the United States, 2000–2010. Academic Pediatrics - March 2012 (Vol. 12, Issue 2, Pages 110-116, DOI: 10.1016/j.acap.2012.01.003)
2. Caza-Cosas game http://www.edicinco.com/
3. Cromley, J. (2006) Control a car with your thoughts – it's therapeutic. Los Angeles Times, May 15, 2006.
4. Elmqvist, N. Distributed User Interfaces: State of the Art .Workshop on Distributed User Interfaces2011 (DUI) at the 29th ACM CHI Conference on Human Factors in Computing Systems 2011, ISBN: 978-84-693-9829-6, Vancouver, Canadá, May 7-12, 2011.
5. Garaigordobil, M. (1996). Jugar, cooperar y crear: Tres ejes referenciales en una propuesta de intervención validada experimentalmente. FAISCA. Revista de Altas Capacidades, 4, 54-75.
6. González,P.,Gallud,J.A.,Tesoriero,R. WallShare: A Collaborative Multi-pointer System for Portable Devices. PPD10: Workshop on coupled display visual interfaces. May 25, 2010: Rome, Italy.
7. Guía,E. Lozano,M.D. Penichet.V.M.R. Interaction and Collaboration Supported by Distributed User Interfaces: FromGUIs to DUIs. In Proceedings of of the 13th International Conference on Interacción Persona-Ordenador. ACM, Article No. 53. ISBN: 978-1-4503-1314-8 doi>10.1145/2379636.2379688Elche, Alicante, Spain, Oct. 3-5, 2012
8. Ishii, H. Tangible bits: beyond pixels, Proceedings of the 2nd international conference on Tangible and embedded interaction, February 18-20, 2008, Bonn, Germany [doi>10.1145/1347390.1347392]
9. Luminosity game. http://www.lumosity.com/
10. Nacenta, M. A. Sakurai, S. Yamaguchi, T. Miki, Y. Itoh, Y. Kitamura, Y. Subramanian, S. and Gutwin. C. E-conic: a perspective-aware interface for multi-display environments. In Proceedings of the ACM Symposium on User Interface Software and Technology, 279–288,2007.
11. Norbert A. Streitz , Jörg Geißler , Torsten Holmer , Shin'ichi Konomi , Christian Müller-Tomfelde , Wolfgang Reischl , Petra Rexroth , Peter Seitz , Ralf Steinmetz, i-LAND: an in-

teractive landscape for creativity and innovation, Proceedings of the SIGCHI conference on Human factors in computing systems: the CHI is the limit, p.120-127, May 15-20, 1999, Pittsburgh, Pennsylvania, United States.
12. MeMotiva game http://www.rehasoft.com/tdah/memotiva/
13. Ramos-Quiroga JA, Bosch R, Nogueira M, Castells X, Escuder G, Casas M. Trastorno por déficit de atención con hiperactividad en adultos. Current Psychiatry Reports. Edición en Español. 2005a; 2:27-33.
14. Rizzo, A. G. Buckwalter, T. Bowerly, A. van Rooyen, J. McGee, C. van der Zaag, U. Neumann, M. Thiebaux, L. Kim and C. Chua. Virtual environment application for the assessment and rehabilitation of attention and visuospatial cognitive process: an update, in Proc. 3rd Intl Conf. Disability, Virtual Reality and Assoc. Tech., Alghero, Italy, pp. 197-207, 2000
15. Rizzo, A. J. G. Buckwalter, T. Bowerly, C. van der Zaag, L. Humphrey, U. Neumann, C. Chua, C. Kyriakakis, A. van Rooyen and D. Sisemore. The virtual classroom: a virtual reality environment for the assessment and rehabilitation of attention deficits, Cyberpsychology and Behavior, no. 3, pp. 483-499, 2000
16. Streng, S. Stegmann, K. Boring, S. Böhm, S. Fischer, F. Hussmann. H. Measuring effects of private and shared displays in small-group knowledge sharing processes. NordiCHI 2010: 789-792
17. Wilkinson, N., Ang, R.P., &Goh, D.H., (2008) Online Video Game Therapy for Mental Health Concerns: A Review. International Journal of Social Psychiatry, 54(4) p.370--382.
18. Interactivemetronome https://www.interactivemetronome.com/
19. Cogmed http://www.cogmed.com/