A Diagnostic Tool on Time Perception of Children with ADHD

Pongpanote Gongsook[1(✉)], Janneke Peijnenborgh[2], Christian Sallustro[1], Erik van der Spek[1], Jun Hu[1], Francesco Bellotti[3], Matthias Rauterberg[1], and Jos Hendriksen[2]

[1] Department of Industrial Design, Eindhoven University of Technology, 5600 MB Eindhoven, The Netherlands
{p.gongsook, c.sallustro, e.d.v.d.spek, j.hu, G.W.M.Rauterberg}@tue.nl

[2] Kempenhaeghe, Center for Neurological Learning Disabilities, 5591 VE Heeze, The Netherlands
{PeijnenborghJ, HendriksenJ}@kempenhaeghe.nl

[3] ELIOS Lab – DITEN, University of Genova, Via Opera Pia 11/a, 16145 Genoa, Italy
franz@elios.unige.it

Abstract. ADHD is among the most common childhood developmental disorder which may affect the school achievements. Children with ADHD may show symptoms of time perception problems. Although ADHD is a clinical diagnosis with several approaches, no diagnostic tool has been designed to detect the symptoms of time perception problems in ADHD children. A computer game can be a powerful tool to be used as part of the psychological assessment and yield better accuracy in ADHD diagnosis. In this paper, we present our concept of a diagnostic tool on time perception for children with ADHD-symptoms.

Keywords: ADHD · Diagnostic tool · Serious game · Time perception

1 Introduction

Attention Deficit Hyperactivity Disorder (ADHD) has been widely researched in the past decades. Several hypotheses have been formulated on the causes of this disorder, as it could be derived both genetically and environmentally [1]. Some researchers have already proposed a tool targeting the cognitive functions for ADHD diagnosis [2–4].

Children with ADHD may have difficulties in processing, reading and telling time [5, 6] and a diminished functioning of reaction time and information processing speed [7]. Therefore, for an alternative to general cognitive measurements, we are interested to investigate the question on whether a computer game on time perception may contribute to a diagnostic process for children aged 4-8 years old. In this paper, we briefly describe what ADHD is and approaches to the diagnosis (Sect. 2), as well as why the diagnosis on time perception using computer games is of importance for our current design and development (Sect. 3).

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2 Attention Deficit Hyperactivity Disorder (ADHD)

ADHD is a behavioral and developmental disorder identified by the Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (DSM-IV) [8]. Its symptoms must be present before the age of seven, persist for at least six months, must be maladaptive for the development of the child, inconsistent with the person's developmental level, and severe enough to impact daily functioning across several environment settings [9]. They reveal subtle but clear impairments in several complex functional systems such as selective attention, memory, motor speed and visuomotor ability, inhibitory control, and working memory [2].

Despite that we have DSM-IV guidelines for ADHD, no absolute methods for diagnosis have been defined. Moreover, it is difficult to diagnose ADHD since this developmental disability can not be diagnosed until children are six years of age, when they are exposed to classroom learning of academic tasks [10]. There are some computer games designed for ADHD diagnosis for example IntegNeuro [11], and Groundskeeper [12]. IntegNeuro is designed to assess people aged 6–96 years old, while Groundskeeper has been designed to target people from 6–17 years old.

We agree with Greenberg [13] that there is no such game that fits all age groups, the diagnostic game should be tailored to match the specific age group. The target age group of children in our project is 4–8 years old, the reason for choosing this age range complies with what Kalff [14] stated: (1) there is a limited amount of research conducted with children 4–8 years old, and (2) The symptoms that can be diagnosed as belonging to ADHD are not obviously shown but will gradually emerge when the children grows up.

3 A Diagnostic Tool on Time Perception

Time perception is a conceptual understanding that enables us to predict, anticipate, and respond to events occurring in the environment [15]. Children with ADHD may have deficits in working memory, that is related to time perception [16]. In addition, we know that children with ADHD may have brain abnormalities in some regions such as the pre-frontal cortex, basal ganglia, striatum, corpus callosum, nucleus caudatus, globus pallidus and cerebellum [17]. Those regions relate to the conceptual understanding of time [18]. Moreover, unlike other symptoms that could decline when the child grow up, time perception problems still remain even when the child becomes an adult [19]. This makes time perception a suitable factor for diagnosis. Therefore, we contend that if we have a better understanding of time perception in children with ADHD, we can train time perception, which contributes to the treatment of attention problems in children with ADHD.

3.1 Game as a Diagnostic Tool

Computer games offer players with intense and often relentless action, immediate rewards, challenging, and appealing stories, which seems to be something the brain of children with ADHD eagerly desire, and they hardly get from the everyday life outside the digital world [20]. The game we are creating is well fitted to the term of serious game [21]. It is designed specifically for diagnostic purposes with immersive environments, and multimodal interaction.

We aim at giving them the feeling that they are playing instead of being tested. Computer games could give an advantage over a plain psychological test because it does not induce a type of the Hawthorne effect [22], where kids behave differently when they know they are being studied. Using a game could therefore improve the ecological and external validity of ADHD diagnosis.

3.2 Current Project Approach

We have formed a collaborative and multidisplinary working team of computer scientists and designers from Eindhoven University of Technology, and psychologists from Kempenhaeghe, center for neurological learning disabilities. The development of the diagnostic tool is roughly divided into three phases in each iteration: design, implementation, and evaluation, with a spiral model [23, 24]. In the design phase we applied participatory design model (PD) [25] and user-centred design (UCD) [26]. We working with psychologists for their requirement, and re-design the diagnostic tool regarding to their feedback and comments. Children have been involved and observed do they understand our designed user-interaction, and asked how the non-player control characters in the game should looks like (see Fig. 1).

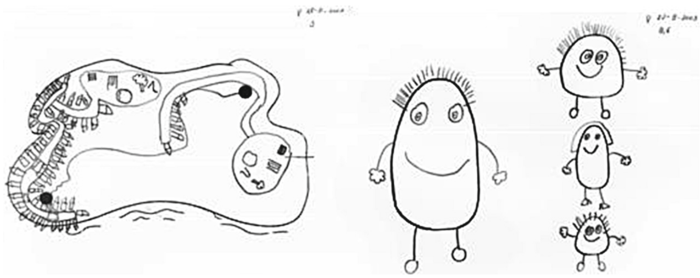

Fig. 1. Sample design of game scene and non-player control characters by a child

According to Zapata-Rivera and Bauer [27], there are some important items that should be taken into account when designing the game: (1) avoid to construct irrelevant content which need knowledge or skills on the player's side that are unrelated to our assessment goal, (2) limit other types of user interaction, but do not make the game boring or repetitive, (3) if we need more cognitive processing in working memory, we must introduce high interactivity and engagement, (4) players need support from in-game tutorial to become familiar and know how to interact with the game environment, and (5) provide formative feedback to the players.

Fig. 2. Sample screenshot of the diagnostic tool

The diagnostic tool will be used with a supervision from a psychologist. It is a single player game display in first person view using 23 inch LCD touch screen. Duration for diagnosing with our tool is set to the maximum of 30 minutes per session so the child will not feel too much fatigue. The diagnostic tool has a controlled linear story to secure that every child who plays our diagnostic tool will experience the same story progression. We have designed mini games to test specific aspects of time perception and related aspects such as time estimation, reaction time, and waiting time behavior.

Figure 2 shows one of the mini games which testing on children inhibition with go-nogo signals, the child has to clean banana peels from the pathway but the cleaning will be successful only when the monkey is hiding behind the leftmost banana trees. We believe that children who perform worse in the mini games have more possible deficits in the relevant executive functions. We already had a small evaluation test with normal children and received very positive feedback.

4 Future Work

We would like to explore whether information of time perception does contribute to an understanding of children with ADHD. Before going to conduct a clinical experiment with children, we will conduct a pilot test to get qualitative data and observations from children's behaviors to assess key game features such as usability, usefulness playfulness and attractiveness.

5 Conclusion

ADHD is a developmental behavior disorder which impedes the learning achievements of children. Psychologists use a combination of various approaches to diagnose ADHD. But there is no existing computer game which is designed extensively to diagnose possible deficits in time perception which we know is associated with ADHD.

In this paper we present our concept of a diagnostic tool, and mini games. We strongly believe that a computer game on time perception will definitely contribute to the diagnostic process for children aged 4–8 years old. We are not yet receiving the confirmation, but from the evaluation feedback we consider that we are getting closer to receive the answer soon.

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Preface

The second GALA Conference was held during October 23–25 at the Dassault Systèmes (Paris). The Serious Games Society supported and organized the conference along with the Games and Learning Association, the Network of Excellence on Serious Games funded by the European Union under the Seventh Framework Programme. The conference has been devoted to Serious Games (SGs) and aimed at gathering, building, and nurturing an expert community on SGs which involves academic, industrial developers, teachers, and corporate decision makers, to promote knowledge share, technology transfer, and business development. SGs aim at improving learning processes by providing attractive, motivating, and effective tools. So far, effectiveness of SGs has been shown by recent studies (e.g., [1, 2]), but the potential of SGs in education is still far to be fulfilled. Furthermore, there is a growing need for scientific and engineering methods and tools for efficiently building games as means that provide effective learning experiences (e.g., [3–5]). An effective application of SGs for education and training demands appropriate metrics, analytics, tools, and techniques for in-game user assessment. This can be achieved in particular by measuring elements such as learning outcomes and engagement, considering the twofold nature of SGs as compelling games that achieve precise educational goals (e.g., [6, 7]). Recent technological advances have brought what was once expensive, specialized Human–Computer Interaction (HCI) equipment located in research labs, to our family rooms and classes at an affordable cost. Devices such as stereo cameras, eye trackers, tablets and smartphones, pointing devices, motion sensors, sensors related to the central and peripheral nervous systems (e.g., galvanic skin response, heart rate, neuronal activity) [8, 9], amongst others, not only provide innovative interaction methods and techniques, but also present opportunities to develop innovative solutions for continuous user monitoring and assessment (e.g., [10–12]). All in all, design of SGs is a very complex activity, involving different constraints, targets, and disciplines, which is being investigated but is still far from maturity [13–15]. This book reports the studies presented during the conference, addressing the above-mentioned call for paper indications. The book is divided into two parts. The first and main part includes three SG research tracks: design, technology, and application. The second part reports the results of the Workshop "Acquiring 21st Century Skills: gaining insight in the design and applicability of a serious game with 4C-ID" and presents short papers describing the posters exhibited during the conference.

The first research track is dedicated to SG design. The first paper describes the gamification process in a safety and energy-efficiency application context, while the second describes a location-based SG for promoting citizens' preparedness to flooding situations. The third article presents two case studies of SGs for supporting music research, while the fourth gives an overview of the conceptual development and technical implementation of an early staged prototype combining a business simulation and an SG. Learning analytics (LA) are discussed in the next two papers, the first paper devoted to a practical experience on using LAs in educational games and the second stressing the importance of the game log files for developing LAs. The last paper of the track deals with the relationship between entertainment games and SGs and what SG designers may learn from entertainment game design. The second research track is devoted to the technology applied in SGs. The first paper presents an accessible multiplatform game engine for a new version of the eAdventure educational game authoring platform. The second paper proposes an agent paradigm as a methodological tool to guide the design of SGs in the social field. The next article presents the F1 game, used to demonstrate how learning takes place in the domain of the Formula 1. An additional paper shows the learning path for solving learning difficulties in the use of money and other basic business activities by kids with cognitive disabilities. Two studies deal with significant enabling technologies. The Haptic technology is presented as a provider of a physical control layer that could enhance the immersion of virtual reality. Voice emotion recognition, on the other hand, is presented in the context of improving learning through webcams and microphone. The flow experience and how it can facilitate the game evaluation and design process is discussed in another paper, while the last article in the track presents the perspective of executive functions and discusses how they can help provide a more coherent approach to understanding the cognitive benefits of playing games. The third track of the research part is dedicated to SG applications. The first paper presents a business simulation game with an agent-based deliberative model of consumer behavior, while second paper deals with the evaluation of team collaboration in digital entertainment games. A cultural heritage application is considered in the next paper, presenting the key features, design solutions, and game mechanics of the Fort Ross Virtual Warehouse SG, while a subsequent study presents a Game-Based Learning MOOC for entrepreneurship. A case study presents how to deal with cultural awareness in a game concerning deployment of troops in Afghanistan. Another study provides a handy toolkit for evaluating the effectiveness of a SG for cultural awareness and heritage. The next paper investigates the gambling interactive experience, understanding how games of chance are structured and how they are related to cognitive errors and biases that occur in both frequent and infrequent gamblers. Another article describes a player-specific conflict handling ontology. The last paper in the track presents a compelling case for the use of games as a method for carrying out useful computational work by players in order to define new tools for designing SGs.

The second part of the book starts with the presentation of a workshop exploring how a widely applied instructional design model, 4C-ID, can ease the uptake of SGs by offering teachers a model fitting their background to assess games on the applicability in their learning contexts. The final part of the book collects short papers describing the exhibited posters, addressing a wide range of topics, from user profiling to knowledge convergence measure and from design to description of new SGs in different application fields.

In summary, as the above description may have shown, we are confident that a variety of stakeholders in the field of SGs—industrial developers, researchers, teachers, corporate decision makers, etc.—may find in this book a rich material for their work and inspiration for their activities.

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