A Diagnostic Tool on Time Perception of Children with ADHD

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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).

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).
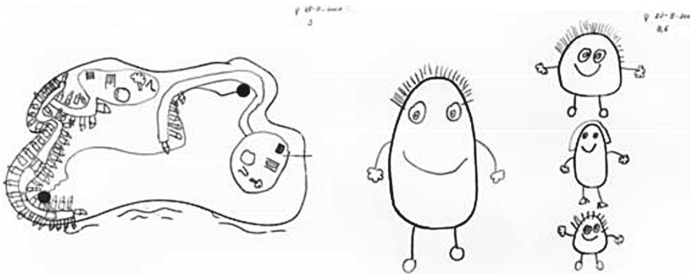

Fig. 1. Sample design of game scene and non-player control characters by a child

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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