The Effect of Usability of Mobile Applications on the Attention-Span of Children with ADHD

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Abstract

The aim of this study is to investigate and identify the influence of the usability of mobile applications on the attention-span of children with ADHD. This study also explores how the implementation of different game elements in applications or games affect the effectiveness and efficiency of these applications. With an upcoming trend of using mobile applications in everyday lives, the focus is on whether or not mobile applications can be used for children with ADHD for improving their attention span. The study is conducted within a regular primary school in Bergen op Zoom and a special primary school in Cuijk. To control for biases, the study used a control group of children from the regular primary school in Bergen op Zoom. For both the test group and the control group the usability score of three existing applications was measured as well as the attention-span of the children. Based on the results it can be suggested that usability of mobile applications does influence the attention-span of children with ADHD. Furthermore, the results show that the control group (regular children) and the test group (children with ADHD) appreciate different (design) elements of applications in very different ways and that there is a need of designing more customized applications for children with ADHD

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1. Introduction

ADHD (attention-deficit/hyperactivity disorder) is a common disorder. ADHD is a diagnosis that is given to children, adolescents, and adults, which is characterized by very high levels of inattention, over-activity, and impulsivity (Sowerby & Tripp, 2009). In the past few years, ADHD diagnosis has received quite some attention in the scientific community and a good amount of research has been conducted on ADHD in general (Rief, 1998; LeFever, Butterfoss, & Vislocky, 1999; Klingberg, T., Forssberg, H., & Westerberg, H., 2002; Ota & DuPaul, 2002; Sowerby & Tripp, 2009). Overall these studies indicate that ADHD is a growing problem and affects children in multiple ways. These children suffer in different situations of everyday lives and one important context is educational or school environment (Ota & DuPaul, 2002).

Several studies indicate that ADHD negatively affects educational outcomes, because of the high levels of inattentiveness (LeFever et al., 1999; LeFever, Villers, Morrow and Vaughn, 2002; Ota & DuPaul, 2002; Loe & Feldman, 2007). Because of these high levels of inattentiveness, it is even argued that children with ADHD are substantially more limited in their daily functioning than children without ADHD (Ota & DuPaul, 2002). This high level of inattentiveness in children demands for extra care by teachers or caretakers in the school environment but unfortunately, this demand is not always possible to fulfill, especially in regular educational environment. It is therefore interesting and of great importance to look further into possible alternatives to support the children with ADHD in their daily activities and in educational settings as well.

In the past decade, use of computer technology within educational (Dickey, 2006), not only for skill development but for personality development as well, has dramatically increased. A more recent development is the increasing use of mobile applications (Li & Liao, 2002) for similar purposes. Mobile applications have become an important part of children's lives. Most of the mobile applications designed for children are designed for serious aims i.e. playful games with a serious purpose. These applications are not only restricted to regular children. Children with special needs e.g. children with ADD or with ADHD are also benefiting from this new wave. In the case of children with ADHD, these applications can help them in numerous ways, from increasing attention-span to reducing hyperactivity. Although it is a recent trend to design special applications for children with ADHD, it is not an easy task. It becomes even more difficult when children are required to use these applications in a more independent manner i.e. without the supervision of teachers for easing out their workload.

Children with ADHD differ from regular children in many ways and it is not clear which criteria of designing a good application for them are needed. Are all the design principles valid for regular children, suitable for children with ADHD as well? If not, what changes do we need to make for designing a more customized application for children with ADHD?

The focus of this study is on the attention-span of children with ADHD. This study particularly explores how different mobile solution should be designed in a usable manner for assisting children with ADHD in everyday routine i.e. in school as well as in home environment. Although a number of mobile applications are available as off-the-shelf solutions for improving the attention span of children with ADHD, it is not clear which features or design elements make one application a good one and another one a bad one. Furthermore, the core purpose of such applications is either to increase the attention span of children or keeping them involved and motivated. It is therefore important to know how different design elements and the usability of the application affect the overall attention span and task performance. This is what we try to explore in this study.

A decent criteria to evaluate a mobile application is to measure the usability and engagement of the application using standard methods and frameworks. It is argued that when the mobile application scores high on usability and engagement, the aim of the application will be reached easier than when these scores are low (Zhang & Adipat, 2005). This statement suggests that the usability and associated engagement elicited by the application affects the achievement of the goal of the mobile application.

The rest of the thesis is structured as follows. In chapter 2, ADHD and ADD will be further explained and defined. Furthermore, the link between ADHD and its role in the educational context will be discussed. In chapter 3, mobile applications will be discussed. In chapter 4, usability testing of mobile applications will be explained. In this chapter, usability testing for mobile applications for children and for children with ADHD will be specified as well. After that, in chapter 5 the state of the art of mobile applications within education will be discussed. Within this chapter, there will be looked further into mobile applications for educational purposes for children and after that, into mobile applications for educational purposes for children with ADHD. In chapter 6, a framework of game elements will be shown. Chapter 7 is about those game elements linked to this study. Chapter 8 links the theoretical framework as a whole to the research conducted for the current study. In chapter 9, the methodological aspects of the study will be discussed and chapter 10 shows the results. Finally, in chapter 11, a conclusion and discussion will be presented.

2. ADHD and ADD explained

Attention-deficit/hyperactivity disorder (ADHD) is a well-known disorder. Sowerby and Tripp (2009) define ADHD as "The diagnosis given to children, adolescents, and adults who display developmentally inappropriate levels of inattention, over-activity, and impulsivity" (Sowerby & Tripp, 2009, p.210). Ota and DuPaul (2002) complement this definition and state that children with ADHD exhibit developmentally deviant levels of inattention or have hyperactivity-impulsivity that significantly impair functioning in different areas. Therefore, Ota and DuPaul (2002) suggest that ADHD is considered one of the most common childhood behavior problems in western societies. Given this information, it becomes clear that ADHD has become a major public health issue (LeFever et al., 1999).

To narrow down the type of ADHD, which will be focused in this study, it is important to explain the current and official types of ADHD. The term ADHD is seen as an umbrella for three types of the disorder: the predominantly inattentive type (ADHD-I), the predominantly hyperactive and impulsive type (ADHD-HI), and the combined type (ADHD-C) (Rief, 1998). According to the American Psychiatric Association (Sowerby & Tripp, 2009), the predominantly inattentive type (ADHD-I) is characterized by six or more symptoms of inattention, but fewer than six symptoms of hyperactivity/impulsivity. The predominantly hyperactive and impulsive type (ADHD-HI) is distinguished by six or more symptoms of hyperactivity and impulsivity, but fewer than six symptoms of inattention. Finally, the third type of ADHD, the combined type (ADHD-C), is known for six or more symptoms of inattention and six or more symptoms of hyperactivity and impulsivity.

Because all three of the types of ADHD include inattentiveness, even ADHD-HI includes few symptoms of inattention, they will all be used for our study. Furthermore, attention-deficit disorder (ADD) is most compatible with type ADHD-I, since this type lacks hyperactivity, but is still characterized with inattentiveness (Rief, 1998). In this review, the term ADHD will be used as an overarching concept for all types of ADHD and ADD as well.

2.1 ADHD within the field of education

A good amount of research already has been conducted within the field of ADHD (Barkley, 1997, LeFever, et al., 1999, Klingberg et al., 2002). In this previous research on ADHD, researchers focused on the effect of ADHD on children and most importantly how ADHD affects children in the educational environment. Loe and Feldman (2007) state that longitudinal studies show that the academic underachievement and poor outcomes associated with ADHD are persistent. Ota and DuPaul (2002) agree with this statement and argue that

children with ADHD experience more difficulties with academic achievement in comparison to average children. Also, Loe and Feldman (2007) acknowledge these facts and state that ADHD is associated with bad results at school, increased grade detention, expulsion and low rates of graduation. Furthermore, LeFever et al. (2002) state that children with ADHD are four to five times more likely to use special educational services than children without ADHD. They also argue that children diagnosed with ADHD often suffer from low self-esteem and poor academic self-image.

LeFever et al. (2002) acknowledge that children with ADHD must be treated looking at the consequences the disorder may cause in especially educational fields. In their study, they divide treatments for children with ADHD into "medical management" and "behavioral treatment". According to LeFever et al. (2002), the parents of the children with ADHD that were examined for their research, reported negative results from medical management. Pelham et al. (1999) support this result and even argue that 30% of treated children respond negatively to medication. These facts show that the benefits of medical management are not always encouraging and attention should be also be paid to the behavioral treatment. In this study, the focus will only be on behavioral treatment because it has been shown that this treatment cannot be underestimated.

Since ADHD can have major consequences in educational systems (Loe & Feldman, 2007; Ota & DuPaul, 2002; LeFever et al., 1999; LeFever et al., 2002), behavioral treatment is not only offered at special institutions, but in regular schools as well. LeFever, et al. (2002) argue that effective and efficient use of school-based interventions will contribute to the child's development in primary school. Also, children with ADHD are characterized by inattention (Luman, Oosterlaan & Sergeant, 2005; Ota and DuPaul 2002; Prins, Dovis, Ponsioen, ten Brink & van der Oord 2011; Rief, 1998) and it is therefore important that the children are stimulated to focus on the available resources which can help them.

Especially when tasks are extremely boring, or need to be performed without supervision, the attention-span of children with ADHD tends to be very limited (Luman et al., 2005). Prins et al. (2011) support these facts and therefore argue that by making tasks less boring, the motivational state of the child will be optimized, which results in better performances. Nevertheless Prins et al. (2011) argue that helping children with ADHD throughout school-based interventions takes much time and effort from the facilitators within the school. It is therefore important to look at alternatives that can provide a helping hand, but merely on the effects of the usability of mobile applications on the attention-span of children with ADHD.

3. Mobile applications

With the continuous advances and developments in the widespread use of mobile devices, such as smartphones and tablets, many innovative mobile applications are emerging (Li & Liao, 2002). Mobile applications, referred to as software systems operating on mobile devices, are therefore evolving rapidly according to Zhang and Adipat (2005). They also argue that, because of the fast growth of mobile applications, this market has attracted extensive interest of research (Zhang & Adipat, 2005).

Mobile applications evolve over time and, as traditional software systems, are required to be maintained (Minelli & Lanza, 2013). According to Minelli and Lanza (2013) it is unclear whether or not the program comprehension used for software systems can be ported to applications. It is therefore interesting to examine what is needed for designing mobile applications in general.

According to Harrison, Flood and Duce (2013), it is important to consider several aspects in designing mobile applications. They argue that the limited screen sizes, the limited connectivity and limited input modalities are issues which need to be evaluated in the designing process (Harrison et al., 2013). Moreover, they stress out the importance of the context in which the application will be used (Harrison et al., 2013).

Adams (2007) acknowledges the importance of the context in designing mobile applications. Furthermore, he states that the usability is determinative for the application's success. Harrison et al. (2013) demonstrate that cognitive overload influences usability. Linking this to the most important characteristic of ADHD, inattentiveness, it is of great importance that mobile applications developed for children with ADHD do not cause cognitive overload which results in an increase in distractors. Hence, usability can affect the outcome of mobile applications in general (Zhang & Adipat, 2005). Especially for children with ADHD, the usability can affect outcomes in a more negative way than for children without ADHD.

4. Usability testing of mobile applications

The usability of a mobile application, sometimes also referred to as appropriateness of a mobile application, can differ based on context factors and personal preferences (Gong & Tarasewich, 2004). Usability testing is a well-known method that is used to evaluate the usability of a mobile application during the design- and developmental process (Kaikkonen, Kekålåinen, Cankar, Kallio, & Kankainen, 2005). Zhang and Adipat (2005) argue that usability testing of mobile applications is a mandatory process, because it can ensure that the

application is practical, effective and easy in use. Nevertheless, usability testing of mobile applications faces various challenges due to unique features of mobile devices, unreliable networks, limited bandwidth and changing contexts (Zhang & Adipat, 2005).

Ideally, usability testing is conducted in usability test laboratories with a monitoring area and a one-way mirror (Kaikkonen et al., 2005). Kaikkonen et al. (2005) argue that the laboratory environment should be a peaceful space where a test user can concentrate on their performance. However, with the increase in mobile application usability testing, researchers and practitioners are concerned that the ideally looking test laboratories do not comply enough with realistic user environments (Tamminen, Oulasvirta, Toiskallio, & Kankainen, 2004). Kaikkonen et al. (2005) share this opinion, because they too argue that the laboratory environment does not simulate the context in which mobile devices are used. Therefore, it is seen more useful when participants are observed within an actual environment or the one that does not look like laboratories (Kaikkonen et al., 2005; Tamminen et al., 2004).

Looking at the information mentioned above, one can argue that usability testing of mobile devices brings challenges for researchers in general. However, for this study, the usability testing of mobile applications will be performed by children, which is an even more challenging task.

4.1 Usability testing for children

When thinking about usability testing of mobile applications for children, it is necessary to consider the goal of the application. Moreover, it is of great importance to take the age of specific target group of the application into account (Carusi & Mont'Alvão 2012).

As mentioned before, usability testing of mobile applications for children involves numerous challenging situations (Markopoulos and Bekker, 2003).The children are required to do much more than just evaluate the use of the technology. Kaikkonen et al. (2005) and Tamminen et al. (2004) argue that children have to step out of their comfort zone when testing mobile applications, because they have to test and evaluate the applications within an unknown environment. Druin (2002) support these findings and state that testing with children is multifaceted activity. It is not only complex for researchers to perform the test but also very complicated for children to follow the process. The children need to adapt to the testing environment, follow several processes and guidelines, report their experiences, and they have to interact with the facilitator.

Although the above mentioned information suggests that usability testing with children may be too challenging, it is also found that children are useful and active

participants in usability testing (Markopoulos & Bekker, 2003) and we should not ignore them while designing products for them. Furthermore, children are known for their creativity, which can provide major advantages for designers while designing innovative products for them (Markopoulos & Bekker, 2003). Another advantage of usability testing with children is that children do not tend to provide desirable answers which results in honest views (Druin, 2002; Khanum & Trivedi, 2012). Finally, previous research has consistently shown that testing applications should be performed by the target group itself, because they know exactly what is needed in a successful application (Carusi & Mont'Alvão 2012).

Elaborating on performing usability testing for mobile applications by the users itself, the user can fulfill different roles. Druin (2002) describes four main roles that the children in usability testing can fulfill: "user", "tester", "informant", and "design partner". The roles have been defined according to the relationship to adults, the relationship to the technology and to the goals for the research with children. For this study, only the role of user will be used, since this study will not focus on the actual development of mobile applications, but merely on the effects of the usability of mobile applications on the attention-span of children with ADHD.

In order to involve children in the usability testing process, it is essential to create a clear and structured testing plan (Khanum & Trivedi, 2012). Firstly, it must be clear what the aim and the objectives of the test are (Khanum & Trivedi, 2012). Secondly, the children must know which role they are going to fulfill on forehand (Druin, 2002). Thirdly, there are guidelines concerning the testing environment, which should feel natural for the children (Hanna, Risden, & Alexander, 1997). For younger children (up to 7- or 8- years old) there should be a tester in the room (Khanum & Trivedi, 2012). Hanna et al. (1997) also emphasize the importance of discretely placed testing tools like cameras. Finally, the testing sessions should not take any longer than 30-40 minutes per day. In this way, the sessions are said to be more effective (Druin, 2002).

4.2 Usability testing of mobile applications for children with ADHD

Usability testing with children is challenging at itself, but when taking the information about children with ADHD into account, usability testing with children diagnosed with ADHD becomes even more challenging. Children with ADHD are said to be inattentive, overactive, and impulsive (Sowerby & Tripp, 2009). Ota and DuPaul (2002) even state that these characteristics cause impairment in functioning in different areas. This suggests that it will be difficult to test usability of mobile applications with ADHD children, because of their limited attention-span.

However, Pfiffner et al. (1998) suggest that the ADHD children's interest and motivation increases when performing computerized tasks. Furthermore, the possibilities of direct feedback and interactivity leads to more attentiveness than when the ADHD children need to perform a non-computerized task (Prins et al., 2011; Frauenberger, Good, & Alcorn, 2012).

Taken all the challenges and advantages into account, it is important that the usability testing of mobile applications for children diagnosed with ADHD is performed by the target group itself: children with ADHD. Naturally, only children with ADHD can indicate their needs and suggest what works or does not work for their disorder. Especially, when looking at the lack of personalization in interactive technology, and thus in mobile applications as well, working with the target group in usability testing has major benefits.

An important issue in working with children with ADHD is that the whole testing process needs to be customized for their needs and that the testing is very well planned (Daley & Birchwood, 2009). Khanum and Trivedi (2012) emphasize the importance of structure and plans even for children without ADHD. Without the clear structure, the children will not be as involved in the testing process as needed (Sowerby & Tripp, 2009).

5. State of the art of mobile applications within education

With an upcoming trend of mobile applications, it is seen more and more often that mobile applications for children are primarily designed for educational purposes (Amory, Naicker, Vincent & Adams, 1999; Dickey, 2006; Wideman et al., 2007). This thesis also focuses on the use the mobile applications in the educational context by children with ADHD. Mobile applications within education can provide numerous benefits such as time-saving within classrooms, the possibility for home study, development of different skills and so forth. In this chapter, the existing mobile applications with educational purposes for children in general will be discussed. After that, the small amount of available mobile applications with educational purposes for children with ADHD will be handled.

5.1 Mobile applications for educational purposes for children

Most mobile applications that are offered for educational purposes contain different game elements. According to Amory et al. (1999), playing games is very important for the development of our social and mental capacities. Amory et al. (1999) even state that play is a universally accepted learning method. In the literature, two main trends are seen:

"edutainment" and "serious gaming" (Charsky, 2010; Denis & Jouvelot, 2005; Dickey, 2005). To provide a clear view of both trends, a definition for both trends will be presented.

Firstly, Charsky (2010) defines edutainment as "the combination of one of the lowest forms of education (drill and practice) with less than entertaining game play" (p. 178). Denis and Jouvelot (2005) support this statement, but argue that the technology that is used for video games is increasingly used for educational purposes. Nevertheless, they also state that the edutainment software is not well designed to be playable and that it is more static than video games. In this way, the edutainment software is not much entertaining and challenging (Denis & Jouvelot, 2005).

Secondly, serious gaming builds on the basic elements of edutainment, but adds what is lacked in edutainment. Thus, in serious gaming, the educational aspect is present and in addition, it also uses specific game elements to enhance interactivity and motivation. In this way, serious games tend to be more fun and better playable that edutainment.

It would be ideal that all games with educational purposes are developed as serious games (Charsky, 2010). Although this is becoming a more common trend, still most games are missing depth of learning and sophistication (Dickey, 2005). Nevertheless, the elements within a game can be used for analyzing games and designing phases of edutainment and serious games (Charsky, 2010). To prevent confusing for the next chapters, both edutainment and serious games will be further referred to as (mobile) applications.

As mentioned before, little research has been done on the existing mobile applications designed for children with ADHD. Nevertheless, there is already a small number of existing applications for people with ADHD in general. Though, the major part of the available applications in the market, is focused on toddlers, adolescents, or adults. The applications available primarily focus on creating to-do-lists, improving productivity, keeping track of goals and tasks, or simply contain information about ADHD. However, applications that focus on both enhancements in attention and applications that can be used for children with ADHD within the educational field are less common. One should therefore look at what is available within the field of attention enhancement instead of browsing the educational field only.

In chapter 6, a framework of game elements developed by Charsky (2010) will be discussed. This given framework provides the core game elements of games. He argues that every mobile application has these elements, but that those elements are seen in different ways. These core elements will be discussed in the following chapter, since these game elements will be used later in the evaluation of the observations and interviews. The

framework is of great importance for this study, because it is very useful to look into the different elements that could enhance the attention-span of children with ADHD

6. Charsky's framework for game elements

As mentioned before, most mobile applications designed for educational purposes contain different game elements. Researchers and designers use different frameworks for designing and evaluating the game play of such applications. One famous framework of game elements is proposed by Charsky (2010). He argues that every mobile application has these elements, but that those elements are seen or implemented in different ways. He also argues that skipping one more elements while designing playful applications, can affect the level of engagement elicited by that application. The core elements of his framework are: "competition & goals", "rules", "choice", "challenges", and "fantasy". This framework is very important for our study because it will be used for evaluating the usability and gameplay of different applications designed for children with ADHD and therefore we will discuss these elements in detail.

Competition and goals

Competition and goals are, according to Charsky (2010), often similar and intertwined in games. Alessi & Trollip (as cited in Charsky, 2010) also state that in mobile applications, the game goals match the learning goals and to make the learning more joyful, a competition element is added. Some goals are based on competition which involves competing with other players, one player against another or one player against the computer.

Another competing element is racing against the clock (Alessi & Trollip, as cited in Charsky, 2010). Charsky (2010) argues that competition leads to more motivation to complete the game activities, because the learners want to win. He also states that in mobile applications, the game goals and competition have expanded beyond conditions of winning and losing. Nowadays, gamers can often decide their own conditions for winning of achieving success i.e. improvement of their avatar (the user's character), city, and etcetera.

Rules

Rules are defined as the limitations that constrain the actions a player can or cannot take (Charsky, 2010). Especially rules that are fixed are of great importance, since they can represent reality (Alessi & Trollip, as cited in Charsky, 2010). According to Charsky (2010), fixed rules are also good for learning, because it requires much practice on a skill set. On the

other hand, when there is no "right way" in gaming, students can learn more because of the various ways to succeed (Denis & Jouvelot, 2005).

Choice

Choice can be defined as the total amount of decisions a player must make and the total amount of possibilities a player has during and prior to playing games (Charsky, 2010). Charsky (2010) distinguishes three types of choice in his framework, namely: expressive, strategic, and tactical.

First, expressive choices are choices that do not have a major effect on learning, but still can improve a learner's motivation. Motivation is characterized by the reasons that explain or justify actions made by a user (Denis & Jouvelot, 2005). Examples of expressive choices are choosing an avatar, picking a location on a map, choices in audio etcetera. According to Dickey (2005), expressive choices contribute to provide immersive experiences which can lead to a higher motivation.

Second, strategic choices are choices that affect the manner in which games are played. It refers to the ability of players to change different game attributes, such as difficulty levels, amount of time to play and the number of players (Charsky, 2010). Charsky (2010) states that not only learning by success, but also learning by failing is very effective.

Third, tactical choices involve how the gamers play the game. Why does the gamer select 'x' instead of 'y' in a given situation or why chooses the gamer to get help or not (Charsky, 2010). If the choices are successful, the player will use that choice again until it results in an undesirable outcome. In mobile applications, the assistance of the game is often offered throughout a "help button" that leads the gamer to manuals, tutorials and glossaries which contain rules, scorings, and reviews of the game play.

Challenges

All mobile applications request challenges from their learners (Dickey, 2005). Challenges can occur in various ways, but mostly they are seen as tasks or activities in gaming (Charsky, 2010). Challenges are also often used as a practice for a gamer's learning and therefore, the challenges should be designed to fulfill learning. Especially in serious games, the challenges are fully integrated with the game which makes it difficult to distinguish learning from fun. According to Gee (2003), the gamer gains skills that ask for more complex challenges which lead to better skills and so on.

It is of great importance that the designed challenges have a good fit with the context (Harrison et al., 2013). According to Aldrich (2003), people can gain advantages by similarities when designing training in a familiar context. A way to create engaging

challenges is adding fantasy elements (Iuppa & Borst, 2006; Charsky, 2010). Therefore, narratives are often used to provide an authentic context (Charsky, 2010).

Fantasy

Almost every game uses fantasy elements. Two important elements of fantasy are "fidelity" and "context". Fidelity refers to the use of graphics, audio, video and so on. Context is defined as the setting, narrative, story, scenario, characters, and etcetera. These elements are used to improve motivation, time on task, and assist transferring in learning processes (Charsky, 2010).

Every game element can enhance motivation. This is why these elements are of great importance for our study. Hence, children with ADHD are easily distracted (Ota & DuPaul, 2002; Loe & Feldman, 2007; Sowerby & Tripp, 2009) and if motivation enhances, children with ADHD will perform better than when motivation is limited (Prins et al., 2011).

Furthermore, it is argued that children with ADHD need to have clear, structured goals and rules (Daley & Birchwood, 2009). By fixing certain rules, the children with ADHD are provided with a clear context when using the mobile applications.

Finally, by making mobile applications more fun to use throughout choice in avatars, different games, etcetera, the task will be less boring to perform. If tasks are less boring or even fun to do, the attention-span of children with ADHD will increase (Luman et al., 2005).

7. Game elements linked to usability of mobile applications

In the previous research, the importance of game elements as well as the importance of usability of mobile applications is emphasized. In this chapter the importance of both the concepts linked together will be stressed. Mobile applications that are used within the educational field more often use games (or game-like elements e.g. reward and punishment) to make the learning more attractive and fun (Dickey, 2006). As mentioned before, designers of games and mobile applications use specific game elements e.g. the game elements that Charsky (2010) developed (and many other similar frameworks where competition & goals, rules, choice, and challenges are key elements).

On their own, the five elements are of great importance for the game design. However, when applying these game elements to regular educational mobile applications, it is imperative to link these elements to the usability of mobile applications because these mobile applications should not only be engaging but also fully usable. Furthermore, using these game elements while designing mobile applications for educational purposes especially for children with ADHD, can positively affect the usability of such applications.

There are different industry-standard scales for measuring the usability of mobile applications. The usability scale that is used for this study is based on the System Usability Scale (SUS) which was developed by John Brooke (1996). The SUS measures three different aspects of usability, namely: effectiveness, efficiency, and satisfaction. Effectiveness examines whether or not users are able to complete tasks using the particular system. Efficiency refers to the amount of effort and resource that is expended in completing the tasks. Satisfaction is defined as the users' subjective reactions about the experience with using the system (Brooke, 1996). For every game element of Charsky's framework, all aspects of SUS can be integrated. The integrations that will be used for this study are represented in table 1.

	Effectiveness	*Efficiency*	*Satisfaction*
Competition & Goals	Are goals realistic to meet by using the system?	Does it not take too much effort to meet the goal?	Do I feel that I can meet the goals with this system?
Rules	Is it feasible to achieve certain tasks within the set rules?	Do the rules not lead to unnecessary effort that has to put in?	Do I think that I practice skills with those rules by using the system?
Choice	Is the level that was chosen realistic to play?	Does it not lead to putting in too much effort on completing this level?	Do I feel better if I choose for option x instead of y?
Challenges	Are the challenges realistically set for the target group?	Does it not take too much effort to face the challenges?	Do I feel that the challenges do not hinder the fun of playing too much?
Fantasy	Does the fantasy that is used not distract too much to complete certain tasks?	Does it not take too much effort to get rewarded (exogenous)	Do I feel that the fantasy that is used really supports the feeling of the game?

Table 1: System Usability Scale integrated in Game elements

8. Current study

It is well-known that children with ADHD need and ask much more attention from caretakers and teachers in comparison to children without ADHD, because their attention-span is very limited (Lefever et al., 2002; Nevertheless Prins et al., 2011). Recent research has shown that

mobile applications with educational purposes have the capacity to not only assist teachers or caretakers by easing out their job, but also help children in improving their attention-span while learning new things. For any mobile application, particularly designed for children, to work it is important that it is not only engaging in terms of contents and interaction, but that it is also usable. Although a lot of work has been done on investigating the relationship between usability of applications and task performance (which can be affected by the lack of attention and motivation), previous work did not explicitly explore how the usability of a mobile application designed for children with ADHD affects their attention-span.

This study will look at the already existing mobile applications which focus on children with ADHD and attention-span enhancement. The mobile applications will be evaluated and reviewed for usability by children with ADHD. At that same time, the attention-span of the children with ADHD will be measured. After that, the results will be analyzed to discuss how good (usable) or bad (unusable) design affects attention-span and task performance.

9. Methodology

In this chapter, the methodology of the study will be explained. Firstly, the type of research will be explained. After that, the variables will be operationalized. Finally, the sample will be defined, as well as the research design and the test method.

9.1 Type of research

This study had an inductive research design, which suggests that the specific observations can be argued into broader generalizations (Saunders & Lewis, 2012). Furthermore, this study had an exploratory nature and therefore it can be seen as qualitative research (Saunders & Lewis, 2012). According to Denzin and Lincoln (2000), qualitative research is focused on meanings rather than on quantifiable concepts. Also, the data collection is gathered among few respondents rather than among many respondents (Denzin & Lincoln, 2000). With qualitative research it is said that the researcher can go more into depth for his or her study than with quantitative research (Boeije, Hart, & Hox, 2009).

9.2 Variables

For this study, two variables were used to examine the relation. The dependent variable was attention-span and the independent variable was usability. In this study, the relationship between the usability of mobile applications and the attention-span of children with ADHD

was examined. Usability will be measured by a questionnaire, observations and interviews. Attention-span will be measured throughout video analysis.

9.3 Sample

Test Group.

Eight children (seven boys and one girl) diagnosed with ADHD of ADD participated in this study. The children were in age of 8- to 10- years (M = 9.5, SD = 0.9). Five children were from a primary school in Bergen op Zoom, The Netherlands. The other three children were educated at a school for special education in Cuijk. All of the children were familiar with activities concerning ADHD embedded in their daily school routine. All the selected children met criteria of ADHD (mostly ADHD-C) and suffered from major inattentiveness.

Control Group.

To enhance the validity of the measurements, a control group was included in the study. For the control group, five children (three boys and two girls) in the age of 8- to 10- years (M = 9.2, SD = 0.8) were asked to participate. Neither of those children were diagnosed with ADHD nor ADD. The children selected for the control group were also attending the primary school in Bergen op Zoom. Because of the special education at the school in Cuijk, there were no participants without ADHD or any other disorder suitable for the control group. There were no differences between the test group and the control group with respect to age and socioeconomic status.

9.4 Research design and test method

In both the test groups and the control group, the children were asked to evaluate a set of different mobile applications that were selected based on expert view of an internal supervisor at the primary school in Bergen op Zoom. The expert evaluated a total set of six mobile applications, which were focused on children in the age of 6- to 12- years old, ADHD, and enhancing attention and concentration. The mobile applications out of both App Store and Play Store were selected. App Store and Play Store are the two most dominant providers within the market of mobile applications.

During the interview, the opinion of the expert was asked about which mobile application would be suitable for the children and for conducting the study. Also, the experts were asked to think about what sort of mobile applications would be suitable in the educational field. The interviewed expert was active within the primary school and knew what is or is not suited for children with ADHD. Elaborated on this information, the final set of applications was carefully selected. Only the applications that met the criteria mentioned

above were selected which resulted in a final set of three applications. The mobile applications were as followed: “Fragenbär”, “Focus Pocus”, and “ADHD Trainer”.

The first mobile application that was evaluated is Fragenbär (Figure 1). The mobile application contained different games which are aiming to train concentration and attention. The mobile application did not have a specific target group, but it was typically developed for children. The mobile application was only available in English and Spanish. Nevertheless, there was a large amount of audiovisual support containing instructions of the games, which allowed the users to understand it without speaking the language. Also, in Fragenbär, there was an avatar which can be chosen by the users. The challenges in this mobile application were formed by games in which the user must play against the computer. When winning a game, the user earned coins with which the user can buy treasures. The difficulty level of the game can be adjusted by the user. After playing, the user can review his or her performances since different scores were presented in the overview.

Figure 1: Application Fragenbär

The second mobile application that was used for this research is Focus Pocus. In this mobile application, the focus was on attention, relaxation, impulse-control and working memory. Overall, the mobile application was typically designed to practice cognitive skills in a fun environment. The target group of the app contained children between the ages of 6- to 12- years old. In the mobile application games were offered in a setting with monsters, and poison drinks. Before starting a game, a wizard explained the instructions needed. In Focus Pocus, the instructions were presented in English and only spoken. For each game, the scores were shown in numbers and in stars. The difficulty level increased by leveling up, which means that the further you get in the game, the harder it gets to achieve success.

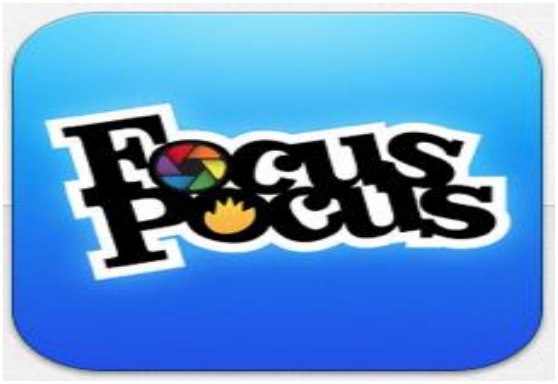

Figure 2: Application Focus Spocus

The final mobile application that was used for his study is ADHD Trainer, which was a cognitive training application developed for children with ADHD. The focus was on attention, perceptual reasoning, and inhibition. The target group contained children between the ages of 4- to 12- years old. In the mobile application, a distinction was made between daily training and free mode. The daily trainings were mandatory for each day. ADHD Trainer divided the training in different areas, which conclude attention, and impulsiveness. The instructions were written in English. For each area, the score was displayed so that children could see what they did or did not improve. The mobile application used descending time which can be seen as racing against the clock. The difficulty levelled up for some games, other games remained at a same level of difficulty.

Figure 3: Application ADHD trainer

To control for an order effect, each child started with a different app in a different order. Fragenbär is shown as application 1, Focus Spocus as 2, and ADHD Trainer is represented as application 3. In the following tables (table 2 & table 3), the design of the experiment is shown.

Test Group	*Round 1*	*Round 2*	*Round 3*
Child # 1	**1**	**2**	**3**
Child # 2	**2**	**3**	**1**
Child # 3	**3**	**1**	**2**
Child # 4	**1**	**2**	**3**
Child # 5	**2**	**3**	**1**
Child # 6	**3**	**1**	**2**
Child # 7	**1**	**2**	**3**
Child # 8	**2**	**3**	**1**

Table 2: Research test group

Control Group	*Round1*	*Round2*	*Round 3*
Child # 9	**1**	**2**	**3**
Child # 10	**2**	**3**	**1**
Child # 11	**3**	**1**	**2**
Child # 12	**1**	**2**	**3**
Child # 13	**2**	**3**	**1**

Table 3: Research design control group

All children were observed in a separate area within their own school. As already mentioned in the research design section, three observation rounds were scheduled at the same day. Each observation lasted for approximately 20-30 minutes per child.

The usability of the applications was measured by using three different ways. Firstly, a very short questionnaire was used which was read out by the researcher (Appendix 1). As noted earlier, the questionnaire was based on the SUS, which measures effectiveness, efficiency, and satisfaction. The children had to indicate according to a 5-points Likert scale whether or not they agreed with the statement that was proposed. For the observations and interviews, the data was categorized according to Charsky's framework (2010) that was discussed in chapter 6. Although Charsky's framework is about game elements in general, the elements have an overlap with the SUS. For example, if a child indicates that the sounds in the game were distracting, for the SUS it is categorized in efficiency and in Charsky's framework it will be classified in fidelity, which is part of fantasy. In this way, Charsky's

framework will be suitable for the evaluation of the results and it will be possible to use it for usability measurements as well.

The attention-span of the children was measured throughout observation and video recordings. In appendix 2, screenshots are presented of the video recordings that were made during the testing process. The observations were led to the concept of visual attention. According to existing literature, attention is characterized by preferential selection and the processing of sensory information (Bear, Connors, & Paradiso, 2007). Inattention on the other hand, is defined as frequent shifts in activity and behaviors that are not task related (Bear, Connors, & Paradiso, 2007). Elaborated on these definitions, this study operationalized attention as on-task behavior; there was visual attention to the required stimuli (Rapport, Kofler, Alderson, Timko, Dupaul, 2009). Inattention was defined as visual inattention to one's material for more than two consecutive seconds within each fifteen observed seconds within the same task (Rapport et al., 2009). For the research, the total amount of time observed for measuring the attention span was two minutes for every child, for every round. Those two minutes were, as mentioned above, divided in fifteen second blocks. Within those blocks, inattention was binary counted (1 for inattention, 0 for attention) and if inattention was found, the total amount of seconds were counted.

10. Results

In this chapter the results of the research are presented. The findings are based on the data gathered throughout the qualitative and quantitative research as mentions above. Firstly, the quantitative data will be discussed. Herein, the questionnaire and the attention-span measurements will be highlighted for both groups. The main focus for our study is on the special findings out of the observations and the interviews. In this section, important quotations will be highlighted.

10.1 Questionnaire and attention-span measurements

As mentioned earlier, the questionnaire that was used was based on SUS. The questionnaire used for this study contained 16 questions. Within these questions, there was a distribution between questions about the application as a whole, which mainly was about the navigation throughout the application, and about the game elements within the application. The results were analyzed in different ways. First, the usability score of the application was analyzed. Second, the usability score of the game was reviewed. Third, the overall score of the application was given. In this score, the total score of the application as a whole as well as the

total score of the games within the application is presented. Because of the small amount of respondents, nothing could be said about significance. For both the test group as well as the control group, the same test method was used. The results of the usability scores of both groups are shown in table 4.

Attention-span was measured in seconds using the video material as reference. For attention-span, for each application separately the score was measured. Again, the score represented the total amount of seconds as a mean in which the children showed attentive behavior. Also the scores for attention-span are shown in figure 4.

		Attention-Span	*Usability App*	*Usability Game*	*Usability Total*
Test Group	*Fragenbär*	114.14 (5.15)	4.00 (.76)	3.93 (.63)	3.96 (.65)
	Focus Spocus	117.86 (3.08)	4.05 (.82)	4.00 (.75)	4.03 (.78)
	ADHD Trainer	117.29 (.95)	3.95 (.58)	3.83 (.75)	3.89 (.63)
Control Group	*Fragenbär*	118.50 (1.92)	3.96 (.57)	3.92 (.54)	3.94 (.53)
	Focus Spocus	120.00 (.00)	4.00 (.58)	3.96 (.52)	3.98 (.53)
	ADHD Trainer	119.50 (1.00)	3.84 (.74)	3.88 (.72)	3.86 (.72)

Table 4: Results attention-span and questionnaire

For this research, the measurements of the attention-span and the measurements of the total usability score are of most importance. For the test group, the total usability score of Fragenbär was 3.96 (*SD = .65*). The attention-span for this application was the lowest, namely 114.14 (*SD = 5.*15*)*. This means that the mean of the total seconds attentive was 114.14 seconds where it could have been 120 seconds. For Focus Spocus, the total usability score was the highest: 4.03 (*SD* = .78). Also for attention-span, Focus Spocus scored the highest: 117.29 (*3.08*). Finally, the total usability score of ADHD Trainer was 3.89 (*.63*) with an attention-span score of 117.29 (*.95*).

For the control group, the total usability score of Fragenbär was 3.94 (*SD = .53*) with an attention-span score of 118.50 (*SD = 1.92*). Also for the control group, Focus Spocus scored the highest on total usability score: 3.98 (*SD = .53*). The attention-span was measured at its optimum level: 120.00 (*SD = 1.00*). For ADHD trainer, the total usability score was 3.86 (*SD = .72*) and for attention-span the score was 119.50 (*SD = 1.00*).

One can see that for both the test group as the control group, Focus Spocus scored the highest of all three applications on total usability score and attention-span score as well. Also,

it can be seen that for the highest total usability score, also the highest attention-span is measured.

10.2 Observations and interviews

To report the results of the observations and interviews, again, Charsky's framework will be used. All findings will be categorized according to the elements in Charsky's Framework: Competition & Goals, Rules, Choice, Challenges, and Fantasy.

Competition and Goals

In Fragenbär, the user can play against the computer. The computer was represented by another character and gave comments during play (figure 4).

Figure 4: Character in Fragenbär explaining instructions

The children indicated that they liked it much if they won against the computer but losing scenario was not appreciated. This dichotomy can be clearly displayed by reference to the following quotes. In the first quote, the child won the game and in the second quote, the child lost. In ADHD trainer, most games were based on racing against the clock (Figure 5).

> *I really like it that you can play against another bear. It is funny that you can steal his coins and that he tells me he is sad right now [Child #3].*

> *I do not like it when the bear is saying that he won from me. It is not nice that he takes my coins and that he is constantly talking [Child #11].*

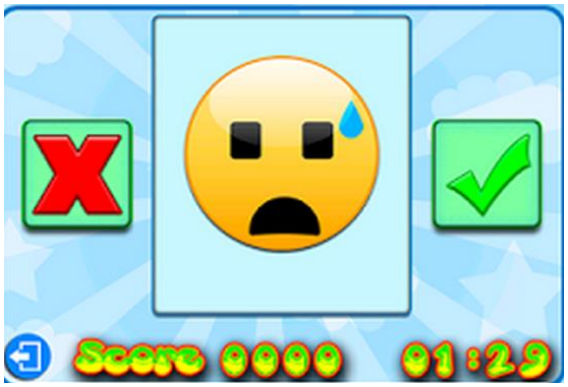

Figure 5: A game in ADHD Trainer with racing against the clock

Another result showed that four of the children with ADHD mentioned they liked racing against the clock. The other four children of the test group did not mention if they liked it or not. All of the children of the control group on the other hand, did not like to race against the clock.

Since all applications were in English, all children experienced difficulties in understanding which goals were set in the games. This resulted in limitations in playing the games. To control for this effect, we explained the rules to the children when they showed confusion.

Rules

For every application, rules were set, but they were not always clear in all games. Children with ADHD seemed to face a lot problem with unclear rules, which were hidden. For example, in ADHD trainer there was a game in which the user must solve a maze (Figure 6).

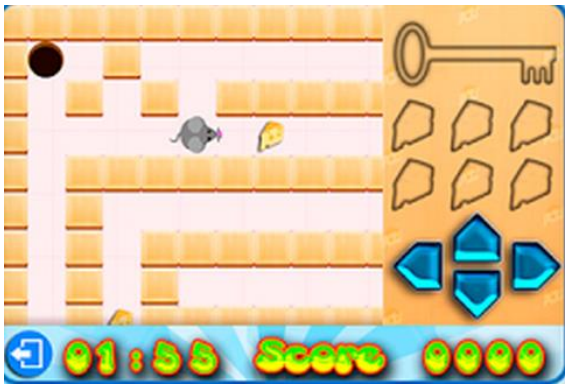

Figure 6: A game within ADHD Trainer with a mouse as avatar

The avatar within this maze was a mouse. This mouse should get the key and then go to the lock. However, in the maze there were cheeses. The more cheeses were picked, the higher the score. Although it was not a fixed rule to pick up the cheeses, all children did pick them up before going to the lock. However, six of the eight children with ADHD indicated that they liked it when the rules were clearly set up. Out of the control group, there was no specific preference for fixed rules. The following quote stresses out that for most children with ADHD, fixed rules are better:

> *But I don't know exactly what to do now… Do I have to get all the cheeses or not? Because I can go to the lock and then the game is finished. It would have been better if this was more explained, because now I'm getting confused [Child #8].*

It was notable that all ADHD children were very easily distracted when the rules were not clear or when they did not know what to do. The children of the control group however, did not seem to be affected by this. They were rather comfortable in this scenario.

Choice

In Fragenbär, there was a possibility to choose between different avatars (Figure 7). Although there was little choice, the children of both groups indicated that they really liked to choose. This type of choice refers to expressive choices.

> *I really like it that I can choose the bear I want. In this way, I feel more like him [Child #6].*

Figure 7: Avatars that were possible to choose

Another finding was the opinion about choosing the level by themselves or the leveling up method. In the test group, a number of children indicated that they like to choose the difficulty level themselves. They indicated that they like to control those things and that it is clear on forehand what the difficulty level is. In the control group however, children liked it better when the difficulty is increasing during the game. These children liked this better, because they found that they were constantly challenges. These types of choices refers to strategic choices.

> *… I like it better in this way, because in most games, it gets more difficult as the game continues. I like it much more that I can set the difficulty level on my own now [Child #5].*

In Focus Pocus, there was a very clear "help" button indicated with a question mark (Figure 8). The children out of both the test and the control group indicated that a help button is very useful and that they would definitely use it. The children in the test group used the help button more often that the children in the control group.

Figure 8: Focus Spocus provided with a help button

Furthermore, almost all of the children indicated that too much explanation is not necessary. They stated that instructions are clear once they heard it and that it is annoying when the game provides instructions again when you start a game in the application. Therefore they suggested that there must be an opportunity to pass the instructions if you want. Children with ADHD were particularly annoyed with 'unrequired' instructions and wanted to skip it asap without looking at it.

Challenges

It was notable that all of the children did almost directly recognized the challenges in the applications. For the most games, the challenge was to earn as much points as possible. Almost all of the children wanted to improve their high scores.

> *I really like to earn as many points as possible. That is what I'm competing for with my dad. We always try to break each other's records, but also the records of ourselves. That is really challenging! [Child #10].*

Referring to the game with the maze and the mouse (Figure 4), all of the children were challenged to pick up as many cheeses as possible within the given time. All of the children were very motivated by different challenges and were very proud if they achieved the tasks. When the children were challenged by the prospect of treasures, new avatars etcetera, they were extra motivated to achieve the challenge.

> *I think it is really nice if you are challenged to earn extra stuff. For example, in subway server, you can buy a snowboard with which you can go faster. But you do have to have enough money to buy it! You can also buy a new avatar, which is what I really like best [Child #7].*

For the challenge element, no significant different was found between the test and the control group. All children of both groups wanted to be challenged and felt motivated to achieve the task.

Fantasy

The most important elements of fantasy are fidelity and context. The results will be categorized along those elements.

A very notable finding was about the use of sounds and music. Out of the eight children within the test group, five children did not like the music. The children even indicated that they think it was distracting, annoying and stupid. Most children suggested that they want to put the sound off. This could also refer to as choice.

> *I really don't like the music. I think it is really distracting and not fun. At home, I always put my sound off. This way, I can concentrate much better! [Child #4].*

Out of the control group, however, four out of five children said they do liked the sound and music. When asked if they do not think it was distracting or annoying, all four answered no. The fifth did not have a very clear opinion about the music.

For Fragenbär and Focus Pocus a really clear setting and story element was included. Most children did not like the setting of Fragenbär, because they found it childish. Children in the control group wanted to have more representative sounds. The setting of Focus Pocus however, was really liked. They also liked the way instructions were explained by avatars. 6 of the in total 8 children of the test group liked it when a figure is used to explain the instruction. All children of the control group supported this opinion.

> *I really like those monsters and the wizard that explains the instructions. The monsters are even a bit creepy! But still nice though [Child #13].*

There was no clear preference about spoken or written instructions. The opinions about this were very mixed. There was a tendency among the test group to prefer written instruction because they wanted to have more control.

An important finding is that the opinion about how to represent the score was much divided. Some children indicated they liked the reviewing of the scores better in digits, other children stated that they liked it better when it was represented in stars. However, most of the children within the test group preferred digits to display the score over stars or other figures because they are much clearer.

In summary, the results of our study show that there are differences in the way children with ADHD and without ADHD perceive different game elements in mobile applications and react to good or bad design. Although the attention span of both groups were quite good while using mobile applications, there is a trend that children with ADHD had more problems with attention-span while using an unusable application or the application they did not like.

11. Conclusion and discussion

11.1 In summary

The aim of this study is to investigate the influence of usability of mobile applications on the attention-span of children with ADHD. In order to provide an answer to the research question

of this study, the results of previous chapters are used with reference to the literature described earlier in this review.

In chapter 7, the framework of Charsky (2010) is linked to the elements of usability. In the results, the observations and interviews were analyzed according to Charsky's framework. In this chapter, the elements of Charsky will be linked to the usability scale. This way it can be shown that the observations and interviews can be useful to estimate the usability of the mobile applications as well.

The children like to play against a computer. They experience it as fair which refers to the effectiveness aspect of SUS. Notable was that children with ADHD liked racing against the clock, but children without ADHD did not. According to the children of the control group, the goal is not realistic and it takes too much effort to race against the clock. This is a very interesting finding and show how two different groups react to two different design elements where unnecessary and unrealistic rush in not appreciated by one group but liked by other group. The work of Ota & DuPaul (2002) shows that applications and games should be customized for children ADHD because of different demands.

Another interesting result is the reaction of children especially with ADHD on game rules. Although rules were not fixed within the game, children tend to perform as best as they could do. This results refers to all three types of the SUS scale. Under SUS, children experienced the tasks as feasible, they did not think that the rules lead to unnecessary effort and they experienced practicing skills. Children without ADHD liked it to create their own rules and indicated that they prefer clear rules beforehand. Children with ADHD indicated that they liked rules and they would like to have a clear overview before the game starts. When the rules were not clear, the children in the test group were very easily distracted. They also didn't show any interest in creating their own rules.

When it comes to choices, children in both groups were happy to see different choices and were generally interested in more possibilities. All children were very pleased to choose their own avatar. Another interesting finding is about the difficulty level. All children with ADHD prefer to choose their own difficulty level. They were not pleased if the game got difficult or changed automatically without prior notice. On the other hand, children without ADHD however, indicated that they prefer leveling up method. They wanted to leave the control to the game and let it adjust the difficulty for different levels as the game progresses. This again shows how two groups look for different type of control over the game and have different usability and game design requirements.

All children showed an interest in improving their high score and feel really challenged by the possibility to earn treasures, new avatars, extra coins, and etcetera. These challenges can be classified as satisfaction under SUS. All the children indicated that they want to use their favorite applications/games at home and in the classroom as well. This refers to the efficiency aspect of SUS.

Another very notable finding was that the children within the test group did not like the music and sounds within the apps. They experienced it as very distracting. The children in the control group did not report any specific or outspoken opinions about the music and sounds. This again shows a clear difference between two groups. Furthermore, it shows how the effectiveness and efficiency of the application is evaluated differently by different groups and how this affects the overall game design. All children, out of both the test group and the control group, liked the avatar explaining the instructions. This fits well with the satisfaction aspect of SUS.

In summary, it can be concluded that, looking at the observations, interview, and the questionnaire, children with ADHD are more easily distracted that children without ADHD. The results also show that the test and control groups have different requirements and rate the usability and design of an application or game in a different way and therefore there is a need of more customized application design for children with ADHD. Finally, the results also show that the attention-span of children with ADHD is shorter than the attention-span of children without ADHD. Thereby, the application with the highest usability score, scored best on attention-span.

11.2 Conclusion

To provide an answer to the research question, it can be suggested that the usability of mobile applications does influence the attention-span of children with ADHD. The direction of the relationship will be seen as the lower the usability score, the lower the attention-span. Nevertheless, with the incorporation of a control group it can be argued that the results not only account for children with ADHD. Hence, also for children without ADHD it is found that the application with the highest usability score relates to the highest attention-span as well but the trend is a little stronger for children with ADHD. This means that it can be argued that the usability of mobile applications influences attention-span in general and not only the attention-span of children with ADHD.

For the designers of mobile applications, these results can give them insights in the importance of usability testing of mobile applications. This study also gives them an idea

about different design elements, which should be taken into consideration while designing educational apps for children. It is important that the usability is optimal so that children with ADHD can enhance their attention-span.

One limitation of this study is the limited number of participants. Due to the limited number of respondent for both the test as the control group, no significant findings can be presented nor concluded. Furthermore, the study was only conducted in the Netherlands and only within two different primary schools.

To obtain a more complete and better generalizable view, future studies should focus on expanding the research area and gain much more respondents. This way, social and cultural differences can be considered as well. Furthermore, incorporating more respondents leads to more solid results.

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Appendix 1

Naam:

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Applicatie:

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Leuk

Niet leuk

Vond je de applicatie leuk?

Helemaal niet leuk Heel leuk

Vond je de applicatie moeilijk te gebruiken?

Heel moeilijk Helemaal niet moeilijk

Had je hulp nodig bij het gebruiken van deze applicatie?

Heel veel hulp Helemaal geen hulp

Wist je snel hoe je de applicatie moest gebruiken?

Helemaal niet snel Heel snel

Vond je de applicatie druk?

Heel druk Helemaal niet druk

Vond je dat je de applicatie goed gebruikte?

Helemaal niet goed Heel goed

Spel

Vond je het spel moeilijk?

Heel moeilijk Helemaal niet moeilijk

Vond je het spel eerlijk?

Helemaal niet eerlijk Heel eerlijk

Had je hulp nodig bij het spelen van het spel?

Heel veel hulp Helemaal geen hulp

Wist je snel hoe je het spel moest spelen?

Helemaal niet snel Heel snel

Vond je het spel leerzaam?

Helemaal niet leerzaam Heel leerzaam

Vond je het verhaal van het spel leuk?

Helemaal niet leuk Heel leuk

Vond je het spel druk?

Heel druk Helemaal niet druk

Vond je dat je het spel goed speelde?

Helemaal niet goed Heel goed

Wil je deze applicatie vaker gebruiken?

Helemaal nooit Heel vaak

Vind je dat andere kinderen deze applicatie ook moeten gebruiken?

Helemaal niet Helemaal wel

Appendix 2