Performance test for prototype game for children with ADHD

R Bahana¹,², F L Gaol³, T Wiguna⁴, S W H L Hendric⁴, B Soewito⁴, E Nugroho⁵, B P Dirgantoro⁶ and E Abdurachman¹

¹Computer Science Department, BINUS Graduate Program - Doctor of Computer Science, Bina Nusantara University, Jakarta, Indonesia 11480
²Computer Science Department, Faculty of Computing and Media, Bina Nusantara University, Jakarta, Indonesia 11480
³Faculty of Medicine, University of Indonesia, Jakarta, Indonesia
⁴Computer Science Department, BINUS Graduate Program - Master of Computer Science, Bina Nusantara University, Jakarta, Indonesia 11480
⁵Kummara Game Design Studio, Bandung, Indonesia
⁶Graphic Design and New Media Program, Visual Communication Design Department, BINUS Northumbria School of Design, Bina Nusantara University, Jakarta, Indonesia 11480

E-mail: rbahana@binus.edu

Abstract. The gaming industry has become one of the fastest growing industries in the world. In recent years there have been several studies that have used games, especially computer-based ones to improve the executive function of children with Attention Deficit Hyperactivity Disorder (ADHD) especially in working memory improvements. There are still several obstacles in using computer-based games that have been circulating today in Indonesia. The aim of this research is to develop and create a prototype game that can be used to improve working memory of children with ADHD using Bahasa Indonesia. The prototype game application is a race game with matching colors and memory work tasks; developed using Construct2. Players will play as a driver, delivering certain fruits to specific homes with different colors. The game also included visuospatial tasks such as remembering the objects. For performance test, CPU utilization, average FPS and image memory usage has been tested in several browsers. In conclusion, the performance tests results show that the first type of the prototype game is good enough to be played in desktop or laptop.

1. Introduction

The game industry has turned out to be one of the fastest growing industries in the world. According to Newzoo, the provider of market intelligence that covers e-sports, the global games, and mobile markets [1], shows their Global Games Market Report for 2017. It states that around 2 billion gamers over the globe are created almost $109 billion in diversion incomes in year 2017. That is $7.8 billion or 7.8% more than 2016. Portable is the most lucrative fragment, with cell phone and tablet gaming growing 19% year on year to $46.1 billion, asserting 42% of the market. [2]. Newzoo predicts that the worldwide market will grow around 6.2% toward 2020 to reach $128.5 billion [2]. In addition, with the
development of open source applications for game development, such as Unity, Game Maker and Construct2, everyone could have the opportunity to create their own games more easily [3].

The rapid development of games does not all have a positive impact. Many popular media issue warnings against the dangers of addiction to this game, as well as games can lead to violence and aggression, especially in children and adolescents. Most of the psychological research on gaming effects is more focused on negative impacts such as potential dangers associated with aggression, addiction, and depression [4,5,6]. But in the field of research, many researchers are seeing the diverse potential benefits of cognitive-related, motivational, social, and emotional development of children's games. In the field of medicine began to elevate this positive effect [7], this can be seen with the publication of Games for Health Journal. Researchers and practitioners in medicine are beginning to realize the power of video games to encourage and, ultimately, to improve the patients’ health [8].

In recent years there have been several studies that have used games, especially computer-based ones to improve the executive function (EF) of children with Attention Deficit Hyperactivity Disorder (ADHD) especially in working memory improvements, but have not been able to deliver consistent results. Research conducted by Nouchi [9] in healthy young adult individuals using computer games applications such as 'Tetris' and 'Brain age' for 5 times a week; within 4 weeks of training it improves the executive function of working memory. Meanwhile, in a meta-analysis study on the effectiveness of training with computer-based games in children with ADHD with a duration of 4-14 weeks or 3-36 sessions with an average duration of 30 minutes [10]; the results concluded that the training had effect on working memory of children with ADHD but did not affect the ADHD clinical symptoms so it was suggested that training using computer-based games should also be accompanied by drug administration. Computer-based game training to improve executive function including working memory for children is the right choice because childhood is an explorative and playing period is one of the activities favoured by every child especially with computer-based games. By giving stimulation in the form of the computer-based game repeatedly then there are two things can be achieved at once that is to give them a fun time as well as stimulate their executive function. For that, it is necessary to create a game application to give impact to brain development of children with ADHD.

There are still obstacles in using computer-based games that have been circulating today in Indonesia, including: incompatibility with the culture and background of Indonesia, the use of English or other foreign languages as the language of instruction, and the use of the application is also required a fee that is not cheap. The aim of this research is to test the performance of a prototype game that has been developed and created using Bahasa Indonesia. Then it can be used to help to improve working memory of children with ADHD. In this research paper, the prototype game that has been tested only contains one type (with visual direction) and the performance tests have been done to several browsers in desktop/personal computer (PC) and laptop.

2. Theoretical Framework

2.1. Attention Deficit Hyperactivity Disorder (ADHD)
ADHD is one of the most common health disorders found among children. Around the world ranges from 3-15% [11,12]. In Indonesia until now there is still no definite data. As an illustration, the proportion of primary school children with ADHD of 26%, and the proportion of children with ADHD who visited the Child and Adolescent Psychiatric at Cipto Mangunkusumo Hospital in 2015 also around that number [13]. This disorder has a major impact on children and adolescents, especially the impact on their daily functions. Children experience learning difficulties, interactions with disturbed social environment and often fail to continue education to a higher level. Therefore, effective handling of these conditions is absolutely necessary for the quality of life of children with ADHD to be maintained as much as possible. A study using the Behavior Rating Inventory for Executive Function tool indicates that the executive function impairment in children with ADHD is largely a work-related memory disorder (56.8%) [13]. Current research suggests that intelligence and memory capacity in working
memory is an important factor in determining children's learning abilities. Working memory is defined as the ability to process and remember information for a short time. Every person including a child has an unequal working memory capacity and this capacity is not influenced by social or economic status [14]. For a child with ADHD, working memory greatly determines the ability to process all the information obtained from the surrounding environment so that the existence of interference in working memory is certainly complicate the learning ability of children.

2.2. Performance Test

Some companies already have started to utilize software engineering techniques in the game development process. Most of the companies separated their game application developer to several teams that manage different parts of the application, so every single process could be tested to make sure every step meet the expectation. Many kind of testing techniques can be used right now [15]. One of non functional testing techniques which have a significant impact on the final product quality is performance test. Performance tests will detect how fast the system of the product or some parts of it can work under the specific workload. Stress testing, configuration testing, load testing, and spike testing are some of example of performance testing [16]. In this research paper, Central Processing Unit (CPU) utilization, average (in one minute) frame per seconds (FPS) and image memory usage will be tested in several browsers.

2.3. Construct2

Construct2 is an HTML5 game engine made by Scirra. Construct2 has a distinguished feature compared to other HTML game engines: developers do not have to code to create games. Some coding logics still exists, but in a form of click-and-drag. Sprites and entities can be drag-and-dropped to the stage, called layout, while the game logic is put on event sheet. The basic component of display is called a sprite object, and behaviours can be added to supported objects, sprite included [17]. Construct2 also supports AJAX request, collision detection, multiple animations, path finding and AI (from behaviour), and some WebGL effects. Using the behaviour-concept for objects, Construct2 enables a wide open extensibility support for custom objects and behaviour [18].

3. Related Work

3.1. Re-Mission video game

Perhaps a well-known success story of games that have a big impact on health-related condition is the Re-Mission video game [19], a video game designed for pediatric cancer patients [20]. Players are asked to control the nanobot by shooting cancer cells, overcoming bacterial infections, and knowing signs of nausea and constipation (common in cancer patients). A study conducted globally in 34 health centers, comparing children playing Re-Mission with children playing other computer games [19]. The result is that children who play Re-Mission more obediently follow their cancer treatment. This game has been distributed to more than two hundred thousand patients and continues to be referred to as a successful treatment approach using game assistance.

3.2. Braingame Brian

The Braingame Brian is a computer-based training with three EFs: visuospatial, inhibition, and cognitive flexibility. One may choose to train one, two, or all three EFs. Braingame Brian consists of 25 training sessions of about 40–50 minutes. Every session contain two sets of three training tasks in a fixed order. The first training task is always a training task; the second and third task, an inhibition training task and a cognitive flexibility task, are presented in changing order. In the current double-blind, placebo-controlled study by Prins et al using this game, they researched, 5-week at home, multiple executive function training intervention in children with ADHD [21]. The result of their study is promising although Braingame Brian is better not to be considered as a stand-alone treatment module. It should be
combined with existing, empirically supported treatments for ADHD such as parent and teacher training programs, and/or medication, to have full impact [21].

3.3. Performance test by Scirra
Scirra has been done three performance tests in the past for Construct2 game application, once in 2012, 2014 and 2016 [22]. The test is using an automated version of Space Blaster that included in Construct2 demo program. The performance test that they did is by taking an average frame rate over a period of about one minute. The reason is because usually browsers spend the first few seconds optimising Javascript. The higher FPS (average frame rate) is better. Below 20 FPS means it is questionable if the game will be playable; 30 FPS is perfectly playable; 60 FPS is the target. Based on their tests, all of the devices that they test with Space Blaster game performed well (38 FPS – 61 FPS).

4. Development of the Prototype
The prototype game application is a race game with matching colors and memory work tasks. Players will play as a driver, delivering certain fruits to specific homes with different colors. In level one or first location, the player should deliver two types of fruits (total is three kind of fruits) to specific homes (total is three kind of houses) as many as possible in two minutes. The direction is in visual images. This prototype game was developed in several months, started from collected user requirements from Doctors at Cipto Mangunkusumo hospital and based on several papers that discussed about this kind of game for therapy. Some inputs from the doctors are very interesting such as, it is better the game does not show the score because maybe it will create an anxiety for the children with ADHD. The score itself with others data (deliver correctly, deliver wrongly, total correct etc) will be recorded in several variables (and arrays) and all data will be transfer to a database.

The game also included visuospatial tasks such as remembering the objects. Visuospatial is a loss of the sense of where about in the relation of environment [23]. The player is given an object that must be remembered, then associate the object in accordance with the given task. This game is trying to stimulate players on the side of accuracy and speed in completing the mission. Only one type has been tested for this prototype, three more types will be added after beta testing. This game is intended for children aged between 7 to 12 years. Therefore, the design of this game follows the rating used under the Indonesian Game Rating System (IGRS) for 7 years and above. According to the Regulation of the Minister of Communication and Information Technology of the Republic of Indonesia Number 11 of 2016 on the classification of electronic interactive games, the rating for 7 years and above must follow Article 6 of the rule [24].

5. Testing and Analysis
For performance test, CPU utilization, average (in one minute) FPS and image memory usage has been tested in several browsers. In this testing, the devices for testing are desktop (Windows XP SP3, Dual-Core E5400 @ 2.70 GHz; 2GB RAM) and laptop (Windows 8.1 64-bit Edition, Core i3-2357M @ 1.30 GHz; 2GB RAM). Browsers tested include Google Chrome (ver. 60.0.3112.90), Firefox (ver. 54.0.1) and Opera (ver. 46.0.2597.32). The testing is only for those two devices because for actual testing to the children, it will only use desktop and/or laptop. Total size of the file is around 450 KB for browser or around 1.4 MB for execution file. In this test, the CPU utilisation measurement only indicates time spent in the main Javascript thread because Javascript does not provide direct access to the CPU usage. As an alternative, Construct2 estimates it using timers. ImageMemoryUsage is an estimate of the total memory used by the currently loaded WebGL textures in the game. Usually textures exist in GPU memory, which will not appear in Task Manager's measurements. Games may also need a lot of other memory for everything else other than images. Basically, ImageMemoryUsage is an indication of GPU texture memory usage, which is just one aspect of the overall memory usage.
Figure 1 shows the game page of the game application. For the purpose of the performance tests, several statements were added to show the result (Figure 2). In actual game application, the results of performance tests are not appeared. First line in Figure 2 indicates FPS at that time, second line indicates CPU Utilisation, test score in third line indicates the average of FPS and the fourth line indicates image memory usage of the game. The last line is the status that FPS already reaches one minute. Table 1 shows the result of three kinds of the performance tests with two different devices and several browsers. Based on the result, all of the devices and the browsers performed well for average FPS; near 60 FPS. CPU utilisation is low and also the ImageMemoryUsage is low for both devices.

| Browser | FPS 1 minute avg | CPU Utilisation (%) | ImageMemoryUsage (MB) |
|---------|------------------|---------------------|-----------------------|
| PC      | Laptop           | PC                  | Laptop                |
| Chrome  | 57               | 58                  | 3.9                   | 2.5                   |
| Firefox | 58               | 58                  | 2.1                   | 1.9                   |
| Opera   | 57               | 59                  | 1.7                   | 1.8                   |

6. Conclusion

The prototype game for children with ADHD has been tested. In conclusion, the performance tests results show the first type of the prototype game is good enough to be played in desktop or laptop. In the next three types, audio, voice over and obstacles will be added, so the performance tests results should be different from the first type.

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