IJACT 23-9-39

# Development of Digital Contents for ADHD Treatment Specialized for VR-based Children

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## Abstract

*This study aimed to develop a VR-based digital therapeutic intervention for the diagnosis and treatment of ADHD. The research combined medical data with virtual reality technology to develop an algorithm for ADHD diagnostic scales and implemented a VR-based digital therapeutic platform using a head-mounted display (HMD). This platform can be used for the diagnosis and treatment of ADHD in children and adolescents. Additionally, we four VR games were developed, including archery timing, Antarctic exploration, grocery shopping, and rhythm-based drumming(RBD), incorporating various psychiatric treatment techniques based on cognitive-behavioral therapy(CBT). To evaluate the usability of this digital therapeutic intervention, a group of experts specialized in counseling psychology participated in the study. The evaluations received highly positive feedback regarding the ability to access the system menu while wearing the HMD, the consistency of terminology used in menus and icons, the usage of actual size for 3D graphic elements, and the support for shortcut key functionality. The assessments also indicated that the games could improve attention, working memory, and impulse control, suggesting potential therapeutic effects for ADHD. This intervention could provide a daily treatment method for families experiencing financial constraints that limit hospital-based therapies, thereby reducing the burden.*

*Keywords: ADHD, Digital Therapeutic Intervention, VR-Games, HMD, Usability Assessment*

## 1. INTRODUCTION

Although the number of patients with mental disorders has been increasing in modern society, recently we have started to see limitations in treatment. Effective diagnosis and treatment of mental disorders heavily rely on changes in the client's behavior [1]. Among them, Cognitive Behavioral Therapy (CBT) is known as an effective treatment method [2]. However, the current use of CBT mainly requires direct involvement of clinical physicians, and there is a significant decrease in effectiveness when patient engagement is low [3]. To overcome these limitations, Digital Therapeutics (DTx) have been introduced. DTx refers to evidence-based therapeutic interventions driven by high-quality software programs for the prevention, management, or treatment of modifiable chronic conditions [4]. DTx products are mainly provided in the form of mobile applications, and they can also incorporate cutting-edge technologies such as Virtual Reality (VR) and Artificial Intelligence (AI). DTx offers several advantages compared to traditional treatment methods. Firstly, DTx digitizes the treatment approach. Through DTx, patients can receive treatment without the limitations of

restricted face-to-face contact in mental health therapy, providing benefits, especially for conditions like childhood ADHD [5]. Furthermore, DTx is software-based, allowing clinical physicians to remotely collect data, accurately assess treatment progress, and standardize it [6]. This helps physicians quickly understand the patient's situation and efficiently proceed with treatment even in cases where hospital visits are necessary [7]. Lastly, DTx enables personalized treatment. Even for the same mental disorder, the key symptoms can vary among patients. DTx allows detailed monitoring of specific symptoms, making it possible to provide patient-centered rather than disease-centered treatment [8-10]. Therefore, in this study, we have developed digital content using VR specifically for the specialized treatment of childhood ADHD. The developed VR games are designed based on cognitive-behavioral therapy and utilize different psychiatric treatment techniques to achieve therapeutic effects. This paper provides a detailed introduction to the developed four VR games and offers features for storing game scores in a database and allowing administrators to access them. The first game, "Archery Timing Challenge," is designed for training impulse control and managing impulsivity. The player performs the action of pulling the bowstring at the right timing to hit the targets flying on the screen. This game helps improve impulse control, selective attention, and divided attention. The second game, "Antarctic Exploration," allows the user to become a penguin and overcome obstacles that are coming their way by either smashing or avoiding them while reaching the destination within a time limit. This game enhances inhibition ability. The third game, "Grocery Shopping as Listed," is a game where the user needs to remember the shopping list displayed in the VR environment and put the items in the shopping cart accordingly. This game helps enhance working memory. The fourth game, "Drumming to the Rhythm," is a game where the user plays the drums when the descending notes align with the hit zone, following the rhythm of the selected music. This game improves attention and visual perception abilities. By providing such digital content, we aim to contribute to the research and improvement of ADHD treatment utilizing DTx.

## 2. ADHD DIAGNOSIS AND ASSESSMENT SCALE ALGORITHM DEVELOPMENT FOR SURVEY MODULE

The process of conducting ADHD diagnosis in VR through controller manipulation is illustrated is shown in Figure 1. The user is presented with a screen to select whether the respondent is the child themselves or a caregiver. Once the user selects the respondent, the content of the four ADHD assessment scales is retrieved from the database and stored. The user answers the survey questions using the controller. They can navigate back to previous questions or proceed to the next question. It is mandatory for the user to respond to all questions before proceeding to the next survey. Once all the assessment scales are completed, the user's response data is stored in the database, and they are taken back to the main screen. This VR-based ADHD diagnosis process involves the user selecting the respondent, answering the survey questions to store the data, and returning to the main screen after completing all the assessment scales.
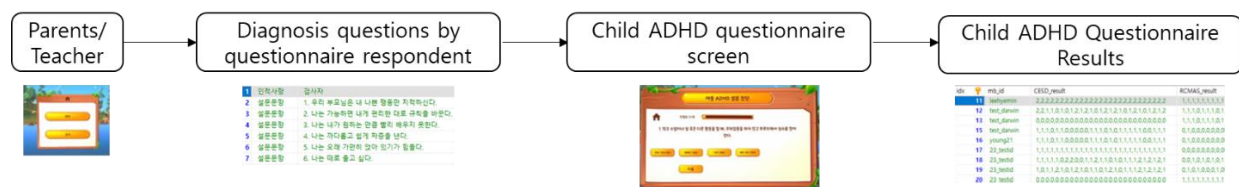


**Figure 1. ADHD Diagnostic Rating Scale Algorithm Application Process**

# 3. DEVELOPMENT OF DIGITAL THERAPEUTIC VR GAME SPECIALIZED FOR CHILDREN WITH ADHD

This chapter deals with the detailed introduction of 4 VR games such as "Archive at the right timing", "Antarctic Expedition", "Shopping by List", and "Drumming to the Rhythm". Find out what functions' administrators can view. Through these digital contents, specialized treatment for children's ADHD is provided, and the scores of each game are stored in a DB so that administrators can view them. For ADHD-specific treatment using VR 4 kinds of VR games were developed, and based on cognitive behavioral therapy, different psychiatric treatment techniques were used to achieve therapeutic effects. The scores of the 4 games are stored in the DB and can be viewed by the administrator.

## 3.1 Archery at the right time

It is a game for hyperactivity and impulsive control training. It is a game in which you pull the bow string to hit the flying enemies according to the timing. Impulsivity control, selection attention, and division attention are improved by having the left and right hands do different actions and perform the task on the screen through visual timing. The user can hold the bow with the desired hand and hold the arrow with the opposite hand. As shown in Figure 2, the arrow can be fired by moving the arrow to the bow string and putting it on the bow, then pulling and releasing the bow string with the hand holding the arrow. Scores are given according to the number of enemies hit within the time limit, and those scores are used as ADHD treatment data.
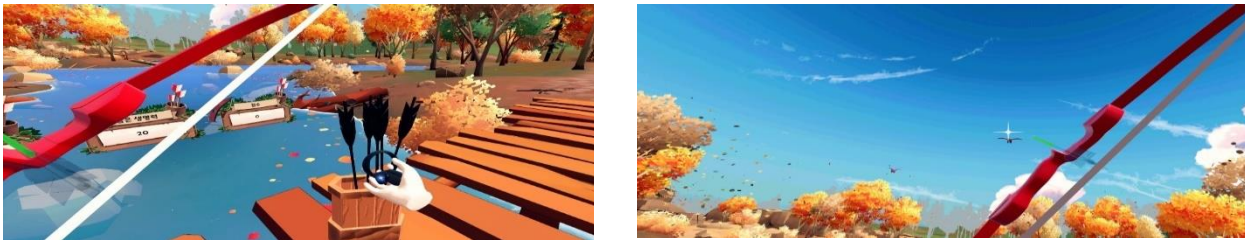


**Figure 2. Bow and arrow control Interface**

## 3.2 Antarctic Expedition

Figure 3 is a game in which the user becomes a penguin and has to reach the destination within the time limit while breaking or avoiding flying obstacles by swinging a hammer. By performing movement and evasion functions with a time limit, deterrence can be strengthened. At the beginning of the game, pressing the controller button on both hands creates a hammer, and releasing the button while holding the hammer also releases the hammer. The hammer is subject to the laws of physics, so you can destroy obstacles by swinging the hammer while holding it or by throwing the hammer. There are also obstacles that lose health and points when destroyed, which triggers the user's concentration and is scored according to the time spent surviving and the obstacles destroyed.

**Figure 3. A scene where you hold a hammer in both hands and destroy flying obstacles**

### 3.3 Shopping by List

Figure 4 is a game that proceeds with shopping after memorizing the list of purchases displayed on the VR screen for a certain period of time at the start of the game, which can improve working memory ability. After the game starts, a list of purchases is displayed, and when the user takes an action such as moving or picking up a shopping cart, the list disappears and a time limit pass. Users can pick up shopping carts or items from the mart when manipulating the controller button, and can move and switch screens using the stick of the controller. The user can pick up the product, put it in the shopping cart, and check the goal achievement score. A score is calculated through the matching rate with the list, and working memory ability is measured based on the score.



**Figure 4. Purchase list for shopping, manipulation of shopping cart and items, score calculation**

### 3.4 Drumming to the Rhythm

Figure 5 is a drumming game as soon as the notes descending to the rhythm of the music selected by the user enter the hit zone on the VR screen at the start of the game. As you play the game, you can improve your attention and visual recognition skills by hitting the drums according to the timing of the descending notes with a time limit. The user can select the desired song by manipulating the VR UI, and when pressing and holding the button on the controller, the user can hold the drum stick in their hand and play the drum with the stick. Based on the speed at which the drumstick touches the drum, the user's operation is recognized. When a song is completed or failed, a score is calculated based on the number of notes matched, and attention and visual recognition ability are evaluated based on the score.

**Figure 5. Drumming game based on the laws of physics**

### 3.5    Interface for patients and hospital administrators

Figure 6 is a web page where patients can record and check their own condition. Patients can record their condition every day by writing down the score and the corresponding content, and the information is stored in the DB. Patients can check their entire treatment situation. This is the process of creating a hospital operation site for direct management, data confirmation, and consultation of patients visiting the hospital. The doctor proceeds with a prescription to the patient by using the corresponding web page to check the patient's condition.
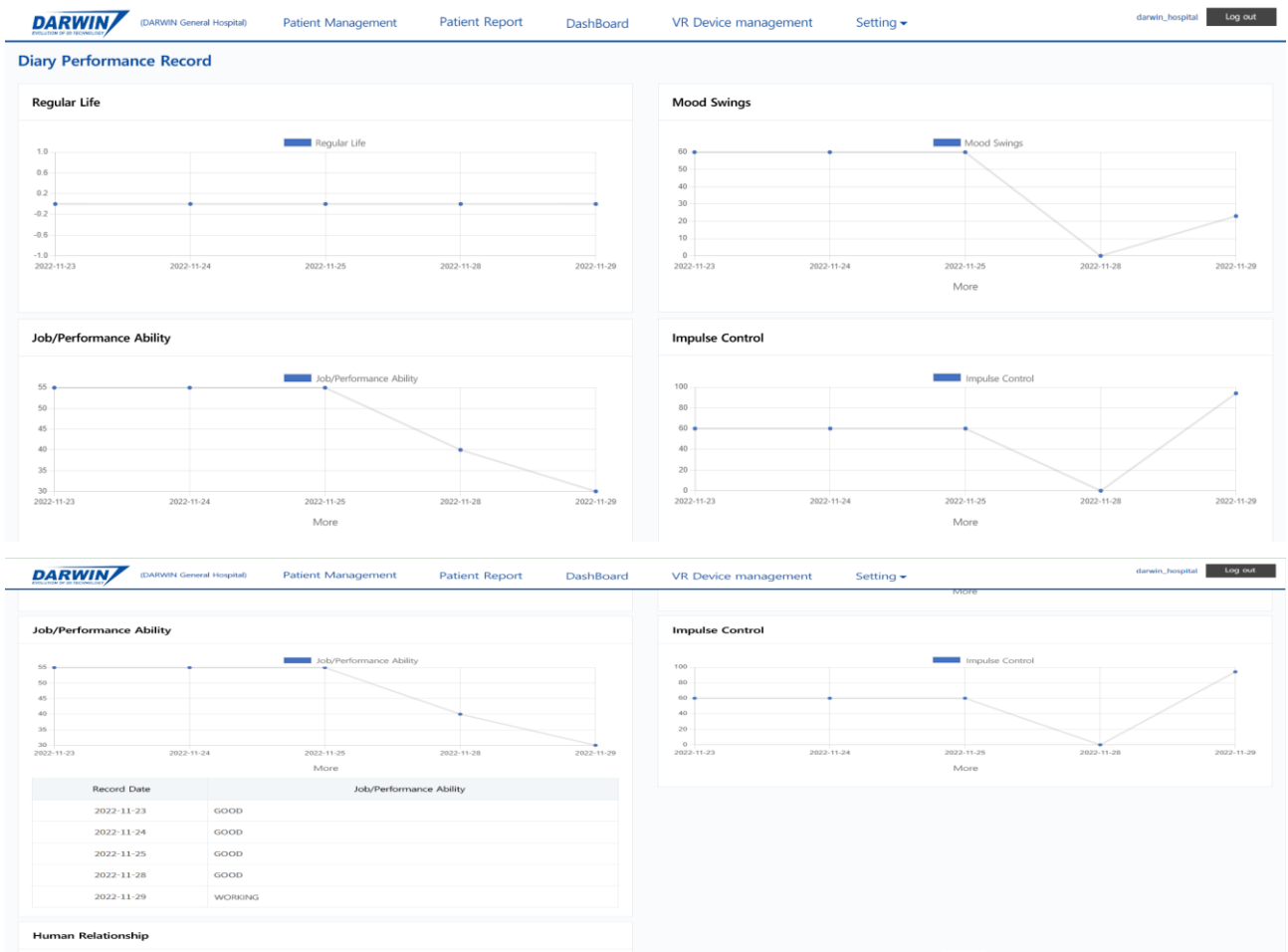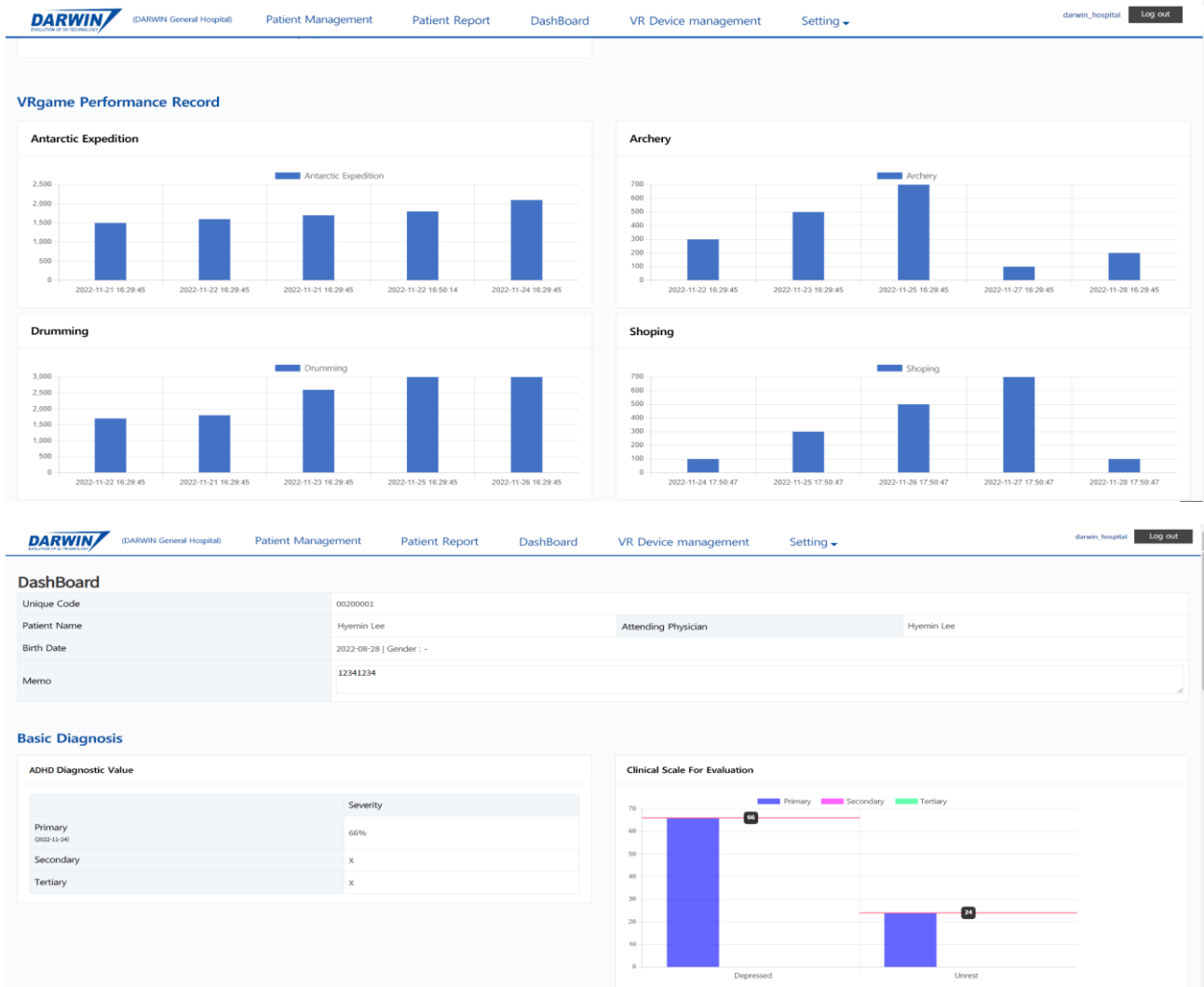
**Figure 6. Managed patient's recorded interface**

## 4. DEMONSTRATION THROGH USABILITYH USABILITY EVALUATION CENTERED ON COUNSELING PSYCHOLOGY EXPERTS

To evaluate the usability of the developed digital treatment, an expert group consisting of 2 males and 12 females majoring in counseling psychology at the Asian Dementia Center experienced children's ADHD VR-based digital treatment once a day for about 3 weeks and evaluated the usability. was performed. In the self-written usability evaluation centered on counseling psychologists, "whether system menus can be accessed while wearing an HMD", "whether terms used in menus or icons are consistent", "whether or not 3D graphic elements are used based on actual size" , received a very positive evaluation on the question of "shortcut key function support", and it is possible to develop attention concentration ability, working memory improvement ability, and impulsive control ability in 4 games, and ADHD therapeutic effect can be expected, which is ADHD The results confirmed the significance of judging that continuing hospital treatment after the onset of symptoms would be able to reduce the burden of being able to receive daily treatment in addition to hospital treatment for families who may feel an economic burden.

**Figure 7.   Expert verification for VR digital therapeutics usability evaluation**

## 5. CONCLUSION

In this study, we conducted research on the development of "VR-based digital content for ADHD treatment specialized for children". The developed digital therapy combines virtual reality technology with the ADHD diagnostic rating scale algorithm, creating a platform that can be applied to the diagnosis and treatment of ADHD in children and adolescents. This digital therapy includes four games that can enhance attention, working memory, and impulse control, thus offering potential therapeutic effects for ADHD. Moreover, it suggests the possibility of providing daily therapy in addition to hospital treatment, alleviating the economic burden on families that may arise from continuous hospital therapy after the manifestation of ADHD symptoms.

However, in order to commercialize the digital therapy, scientific clinical trial results and registration procedures with regulatory agencies are necessary. Furthermore, further research is needed to advance virtual reality technology and therapeutic techniques to apply digital therapy to a broader range of healthcare fields.

Finally, a usability evaluation of the developed digital therapy was performed with a group of experts consisting of counseling psychology professionals. The evaluation received highly positive ratings regarding the accessibility of the system menu while wearing the head-mounted display, consistency of terminology used in menus and icons, usage of 3D graphics based on real-life proportions, and support for shortcut functions.

In conclusion, based on these research findings, the title "Development of Digital Contents for ADHD Treatment Specialized for VR-based Children" accurately represents the content of the paper.

Please be noted that illustrations are black and white in printed volumes. However, colored pictures will be shown in the electronic version. If you send colored figures that are to be printed in black and white, please make sure that they really are legible in black and white. Some colors show up very poorly when printed in black and white.

### ACKNOWLEDGEMENT

### REFERENCES

[1]  National Institute of Mental Health (NIH), Mental Illness, https://www.nimh.nih.gov/health/statistics/ mental-illness, 2019.

[2]  K. Manasi and P. Kumar, "Impact of pandemic on mental health in lower-and middle-income countries

(LMICs)," Global Mental Health 7, 2020.

[3] C. H. Cho and H. J. Lee, "Could Digital Therapeutics be a Game Changer in Psychiatry?," Psychiatry Investig, Vol. 16, No. 2, pp. 97-98, Feb DOI: 10.30773/pi.2019.01.20. Epub 2019 Feb 21. PMID: 30808114; PMCID: PMC6393746.

[4] Digital Therapeutics Alliance. https://dtxalliance.org/

[5] V. Dam, J. H. Kristin and T.-W. Tricia, "Digital therapeutics: an integral component of digital innovation in drug development," Clinical Pharmacology & Therapeutics, Vol. 104, No. 1, pp. 72-80, 2018.

[6] N. A. Patel, A. J. Butte, "Characteristics and challenges of the clinical pipeline of digital therapeutics," npj Digital Medicine. Vol. 3, pp. 159, 2020. DOI: https://doi.org/10.1038/s41746-020-00370-8.

[7] F. F. Velez, S. Colman, L. Kauffman, K. Anastassopoulos, S. Murphy and Y. Maricich, "Real-world changes in US health system hospital-based services following treatment with a prescription digital therapeutic for opioid use disorder," Hospital practice, Vol. 49, No. 5, pp. 341–347, 1995. DOI: https://doi.org/10.1080/21548331.2021.1956256.

[8] F. P. Thorndike, R. B. Berry, R. Gerwien, S. Braun, and Y. A. Maricich, "Protocol for Digital Real-world Evidence trial for Adults with insomnia treated via Mobile (DREAM): an open-label trial of a prescription digital therapeutic for treating patients with chronic insomnia," Journal of Comparative Effectiveness Research, Vol. 10, No. 7, 2021. DOI: https://doi.org/10.2217/cer-2021-0004.

[9] Cognoa, "Canvas Dx.", CanvasDx, canvasdx.com. Accessed 17 Jan. 2022.

[10] S. H, Kollins, D. J. DeLoss, E. Cañadas, J. Lutz, R. L. Findling, R.S.E. Keefe, J. N. Epstein, A. J. Cutler and S. V. Faraone, "A novel digital intervention for actively reducing severity of paediatric ADHD (STARS-ADHD): a randomised controlled trial," The lancet. Digital health, Vol. 2, No. 4, e168 - e178, 2020. DOI: https://doi.org/10.1016/S2589-7500(20)30017-0.