The Virtual Schoolyard

Attention Training in Virtual Reality for Children with Attentional Disorders

Katharina Krösl[1]
TU Wien
kkroesl@cg.tuwien.ac.at

Anna Felnhofer
Medical University of Vienna
anna.felnhofer@meduniwien.ac.at

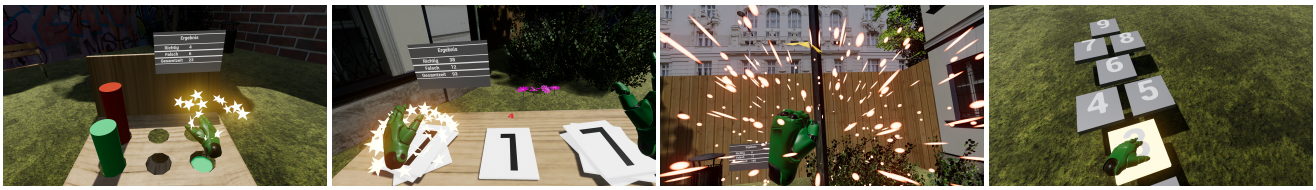
Johanna X. Kafka
Medical University of Vienna
johanna.a.kafka@meduniwien.ac.at

Laura Schuster
University of Vienna

Alexandra Rinnerthaler
University of Vienna

Michael Wimmer
TU Wien

Oswald D. Kothgassner
Medical University of Vienna
oswald.kothgassner@univie.ac.at



(a) whack a mole **(b) card sorting** **(c) catching butterflies** **(d) hopscotch**

Figure 1: Training modules for response inhibition (a), focused attention (b), vigilance (c) and working memory (d).

ABSTRACT

This work presents a virtual reality simulation for training different attentional abilities in children and adolescents. In an interdisciplinary project between psychology and computer science, we developed four mini-games that are used during therapy sessions to battle different aspects of attentional disorders. First experiments show that the immersive game-like application is well received by children. Our tool is also currently part of a treatment program in an ongoing clinical study.

CCS CONCEPTS

• **Applied computing** → **Psychology**; • **Human-centered computing** → **Virtual reality**; **User studies**;

KEYWORDS

Virtual reality, attentional disorders, user study

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[1]Also with VRVis Research Center.

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1 INTRODUCTION

Developing novel effective means of treatment for children with attentional disorders is one of the main goals and challenges in child psychology. Virtual reality (VR) technologies provide possibilities to assess and train cognitive abilities, as well as cognitive and behavioral impairments or disorders, in a controlled virtual environment (VE). Especially for children, attentional disorders, like attention deficit hyperactivity disorder (ADHD) can be very problematic because they hinder them from properly studying in school, giving them a disadvantage for their later careers. Rizzo et al. [Rizzo et al. 2000] developed *the virtual classroom*, a VR tool to assess ADHD in children by measuring attention performance when presenting users with visual and auditory stimulus challenges.

In our work we combine neuropsychological concepts with a VR application (developed in Unreal Engine 4) to create a tool that can be used during therapy sessions to train the attention of children, in contrast to the work of Rizzo et al. which is focused on the assessment rather than the training of cognitive abilities. Our goal is to develop an application that is able to motivate children who are easily distracted, have difficulties focusing on tasks or with impulse control and sustained attention, and train them to keep their attention on the target at hand, even if auditory or visual distractions appear. Children with attentional disorders are in general hard to motivate, but it is crucial for the effectiveness of the training to keep them engaged. Therefore, we especially focus on keeping users excited by gamifying the treatment (e.g. with incentives, storyline, highscore) , rather than mimicking real-world situations like Rizzo et al. In contrast to traditional treatments with medication and counseling, our VR simulation offers a controlled environment, with absolute control and consistency over stimulus delivery and the possibility to instantly measure and record performance in

terms of attentional abilities. Our tool consists of four modules in the form of mini-games that train *response inhibition*, *focused attention*, *vigilance*, and *working memory*. The developed attention training tool is currently used in a clinical study at the Medical University of Vienna/Vienna General Hospital to treat children and adolescents who suffer from ADHD.

2 APPROACH

We selected four attention domains to train in four different modules during therapy sessions. Each module is playable as a VR mini-game, set in a virtual school yard. The achieved score, which is displayed in-game, serves as measurement to monitor progress and also as positive reinforcement to keep the users motivated and ambitious to improve their skills.

Module 1: Response Inhibition. Our first module is concerned with response inhibition, which is the ability to control one's impulses and resist a certain temptation or urge. The module features an adaptation of the well known *whack-a-mole* game to train inhibitory control or response inhibition. Moles are represented as wooden logs in the colors green and red (see Figure 1a) that ascend from holes in the wooden table in front of the player. Green logs are the targets that have to be hit, while touching red logs should be avoided, thus inhibiting the impulse to hit these logs.

Module 2: Focused Attention. The second module, *card sorting* (see Figure 1b), serves the purpose of training the users to focus their attention and reduce their distractability. The game shows a card with the numbers 7 or 1 written on it, and the user quickly has to touch the correct card staple it belongs to. While the game progresses, cards appear faster and auditory or visual distractions (e.g. a butterfly, a burning paper plane) appear. Users have to learn to ignore such distractions and focus their attention on the cards in order to avoid mistakes.

Module 3: Vigilance. The goal of the third module is to train vigilance, the ability to sustain attention over a longer period of time, while waiting for a rare target stimulus to appear. In the implemented *catching butterflies* game, the user watches a swarm of orange butterflies (see Figure 1c). The target stimulus is represented by a red butterfly that only appears after certain periods ot time and has to be caught by the user without touching any of the orange butterflies. The time between the appearances of red butterflies is extended the further the game progresses, requiring the user to maintain concentration for longer periods of time later in the game.

Module 4: Working Memory. Our last module is an adapted *hopscotch* game (see Figure 1d), which is focused on training the working memory of users. This module requires the user to memorize and repeat a certain sequence of fields, which either glow or are recited by audio. The user then has to touch the correct fields in the given sequence. Sequences become longer and are played faster during the progression of the game.

3 PRELIMINARY RESULTS

We evaluated the feasibility of our training tool with six adolescents (50% females, age 15 – 18). All subjects consented to their participation in the current study (according to the Declaration of Helsinki [World Medical Association 2015]). The children played all four games in a randomized order. Apart from a demographic survey, the Brief Symptom Inventory (BSI) [Derogatis and Melisaratos 1983] provided information on mental health symptoms of the participants before the training; physical presence and technology characteristics, in turn, were assessed immediately after the virtual experience. Symptom severity, assessed with the BSI, was moderate across participants, with the highest average values in *somatization*[1], *obsessive-compulsive*[2] and *depressive* symptoms. We used the *Technology Usage Inventory* [Kothgassner and Felnhofer 2013] to evaluate the following four aspects of the VE on a Visual Analogue Scale (VAS) (ranging from: 0 – does not apply, to 100 – fully applies): (1) *Perceived Usability*, (2) *Accessibility*, (3) *Usage* and (4) *Intention to Use*. The iGroup Presence Questionnaire [Schubert et al. 2001] was used to evaluate the level of immersion in the VE on a 7-point *Likert scale*[3] (not at all – very much).

Except for one participant, all subjects reported to have had a strong sense of immersion in the VE ($\tilde{x}$ = 6, range: 3 - 7). Similarly, all except for one participant rated the application as very usable on the VAS (Usability: $\tilde{x}$ = 75.50, range: 35 - 90) and indicated that they would mostly like to use the technology. Finally, five out of six participants wished to have access to the application. These preliminary results show that our tool is immersive, motivating and engaging and therefore feasible for studies with children and adolescents with attentional disorders.

An ongoing study at the Medical University of Vienna/Vienna General Hospital led by clinical psychologists from the Medical University of Vienna uses our four developed training modules in a series of therapy sessions with children and adolescents suffering from ADHD. Measurements before, during and after the treatment will show whether the therapy program with our tool has a positive and – if so – lasting effect on specific attentional abilities in affected children and adolescents.

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[1] experiencing psychological distress as somatic symptoms
[2] uncontrollable repetitive behavior or thoughts (e.g., counting objects, hand washing)
[3] psychometric scale to rate people's attitudes to a topic
[4] https://www.black-cell.com/