

# Ameliorating Negative Perceptions of Attention Deficit Hyperactivity Disorder (ADHD) Students

Steven Walczak<sup>1\*</sup> and Robin Dawson Estrada<sup>2</sup>

<sup>1</sup>University of South Florida, School of Information & Florida Center for Cybersecurity, 4202 E. Fowler Ave., CIS 1040, Tampa, FL, 33620, USA

<sup>2</sup>University of South Carolina, College of Nursing, 1601 Greene Street, Room 623, Columbia, SC 29208, USA

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## Corresponding author(S)

Steven Walczak, University of South Florida, School of Information & Florida Center for Cybersecurity, 4202 E. Fowler Ave., CIS 1040, Tampa, FL, 33620 USA, Email: swalczak@usf.edu

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## Abstract

Attention deficit/hyperactivity disorder (ADHD) is a common mental health disease for children around the world. ADHD can cause negative perceptions of individuals and perceived need for additional interaction requirements among educators. These negative perceptions may result in poorer performance academically which will impact these ADHD children for the rest of their lives. We propose that simple behavioral training can lessen the negative perception of ADHD students and also lessen the stress experienced by educators. The recommended behavioral training is to modify ADHD behaviors so that these students will maintain eye contact longer and return to direct eye contact quicker, thus improving perceptions of interest and potential likeability.

## Introduction

Attention deficit hyperactivity disorder (ADHD) is a common and chronic mental health disorder found around the world. The worldwide rate for diagnosis of ADHD is just over 5% of the population and appears to be consistent for most of the world [1]. Within the United States, ADHD is the most commonly occurring childhood mental health disorder and incidence rates as high as 11% have been reported [2]. These numbers may well be inaccurate as ADHD can be misdiagnosed, depending on the diagnostic methodology utilized [3,4]. Prior research has indicated that the prevalence of ADHD is rising significantly in the United States, by almost 22% over a four year period [5]. ADHD occurs across all socioeconomic, cultural, and racial backgrounds [6] and is therefore a concern for all pediatric patients.

While parents may notice ADHD symptoms in their preschool child, American Academy of Pediatrics practice guidelines suggest clinical evaluation for ADHD should begin at age 4 years for children with academic and/or behavioral issues and hyperactivity, inattention, or impulsivity symptoms [7]. It is commonly diagnosed in primary school aged children [8], though late teen and adult diagnosis is possible [9]. This neuro developmental disorder has three presentations: predominantly hyperactive-impulsive, predominantly inattentive, and combined [10]. These symptoms are significant for a variety of reasons. They lead to adjustment and behavioral problems, as well as significant learning difficulties [11]. Students with ADHD have also been shown to have greater difficulty with time perception and impaired executive function [12,13], where executive function is the cognitive maintenance of facts and associated items for planning and goal achievement [14]. Executive function impairments have been shown to result in decreased academic achievement and a much greater risk for grade retention [13] as well as increased risk for suspension from school [15].

ADHD behaviors not only interfere with a child's ability to learn, but can affect the child's social relationships [16]. Children with ADHD symptoms may be viewed negatively by their normally developing peers [17], which can contribute to internalized stigma and feelings of despair and depression [18]. Often, ADHD school children, because of their behavioral symptoms including poor social skills, are not only viewed poorly by their peers, but are often rejected outright by their peers [19-21], further increasing feelings of isolation and stigmatization and potential victimization by classmates [22].

ADHD is a chronic disorder with long-term implications for educational outcome, safety, and the ability to maintain employment as an adult [23]. Adults with ADHD have problems with completing assignments and also with performing poorer quality work [9]. Research has shown that adults with ADHD (from childhood or adult onset) have substantial problems with executive function skills, (i.e., inhibitory control, working memory, and cognitive flexibility) resulting in social and employment problems [24], including higher risk of job loss [23]. Thus, a childhood diagnosis of ADHD has the potential for lifelong consequences.

## Treatment of ADHD

Various treatments exist for children diagnosed with ADHD. Psychosocial interventions such as behavioral therapy, for both the child and the parent, are suggested first-line for young children; for school-aged children and adolescents, medications in conjunction with behavioral therapy are recommended [25]. FDA-approved medications for ADHD include stimulants (e.g., methylphenidate and amphetamine) and non-stimulants (e.g., guanfacine and clonidine) [26]. Side effects and possible embarrassment from discovery of ADHD treatment [27] make treatment decisions a complex multi-criteria decision problem. Parents and teachers typically prefer psychosocial intervention methods over pharmacologic treatments [27-29]. However, parents of children with ADHD often do not follow through with behavioral treatment referrals due to concerns about stigma [30]. Additionally, it can be difficult for these parents to access behavioral services due to insurance constraints and out of pocket costs, distance to specialty sites, limited appointment availability, and long wait times.

## Teachers and ADHD Students

Primary school teachers are often the first to identify potential ADHD symptoms in a child [31] and are also frequently expected to do so by the community at large. As mentioned above, determining and following through on treatment for ADHD diagnosed students can be problematic. Cultural bias may also have an effect on teacher identification of possible ADHD, which is reinforced by research showing that western culture educators are more likely to rate boys as possibly having ADHD over girls exhibiting similar classroom behaviors [32,33].

Previous research has demonstrated that few teachers receive education on the etiology and neurobiology of ADHD in their training programs [2]. Teachers often rely on anecdotal information from colleagues or personal experience to guide their understanding of ADHD and to direct the educational strategies and interventions they employ in their classrooms. As a result, teachers may erroneously conclude features and behaviors associated with ADHD are intentional and controllable. Sub-optimal educational and behavioral outcomes may result when teaching strategies are not evidence-based. As a result, teachers may develop negative perceptions of students with ADHD. Teachers rate students identified as ADHD (with or without medication treatment) less favorably than non-labeled students on appropriate behaviors, as well as on intelligence and overall personality [34]. Other recent research evaluating education major student perceptions of ADHD found that when compared to slow cognition disorders and social anxiety disorders, the majority of the student pre-teachers rated the ADHD described primary students as being more problematic [35]. They also had more unfavorable attitudes towards working with ADHD students as compared to the other disorders, perhaps in part due to competing demands of time and other student needs.

Dealing with ADHD students requires significant increases in interaction time [36], including discussing hyperactive behavioral issues directly with the student or the need to administer behavioral corrective actions [36]. They may also have more frequent and more negative interactions with the students, as well as their parents. Students with ADHD have a greater risk of receiving negative behavioral adjustments [24], which may elevate their stress levels.

Similarly, teachers may be at risk for increased stress and emotional distress [2,37]. Teachers often feel that the requirements of dealing with the disruptive behaviors associated with ADHD cause them to not be able to also effectively teach their general population class [38], lowering their self-efficacy perceptions.

Numerous studies have indicated that increased training for teachers is critical to successfully enable teachers to understand the variable presentations of ADHD, both identify candidates for ADHD classification as well as how to work with this potentially disruptive student population [2,6,30,39,40]. Increased availability of training and consequent teacher participation in ADHD training will improve ADHD knowledge and acceptance and use of new classroom behavior management strategies [31], increase their knowledge and willingness to use appropriate behavioral intervention strategies [39], and may help increase teacher confidence in their ability to manage classrooms with ADHD students present among the general student population [38]. Finally, increased training and the knowledge gained will help improve teacher self-efficacy in working with ADHD students [39]. Training should be provided to all teachers because, due to the prevalence of ADHD, most teachers will have multiple ADHD students in their classrooms over their careers.

## Proposed Method

Creative, novel, and accessible interventions are needed to address socially problematic ADHD behaviors. Teachers perceive ADHD students as being significantly less socially perceptive than other students [41]. Positive teacher attitude is the key to a positive and productive learning environment and is achievable by enhancing students' socialization skills [6]. One behavioral social skill is the appearance of paying attention to another, which is primarily evaluated by individuals through eye contact or estimating another's gaze direction, and the ability to maintain appropriate eye contact in social interactions [42-44]. Maintaining eye contact is also a behavioral cue of interest in what another person is saying. ADHD individuals tend to show a lack of the ability to orient towards a social stimulus, including inadequate use of eye contact [23]. Increasing gaze hold time and reducing gaze return time may improve the perception of attention by social interactors such as teachers, parents, and classmates [43].

People automatically and rapidly analyze gaze direction and the human eye is built to assist with this analysis due to the shape and large area of the sclera surrounding the pupil [45]. Additionally, research has shown that most people are capable of recognizing gaze direction changes of as little as 2.8 degrees [44].

This raises the research question: can eye gaze be trained? Research with athletes has demonstrated that gaze can be trained and that gaze training improves not only attention, but also performance in the respective sports [46-48]. Gaze training has also shown performance improvements in other domains as well, such as surgical training [49]. A follow up research question is: can gaze training improve the perception of attention in ADHD patients? If ADHD students can have their gaze behavior trained to maintain eye contact for longer periods of time, we believe that this will not only help reduce teacher stress, but will also improve social interactions with classmates leading to greater inclusion and reduction in stigmatization.

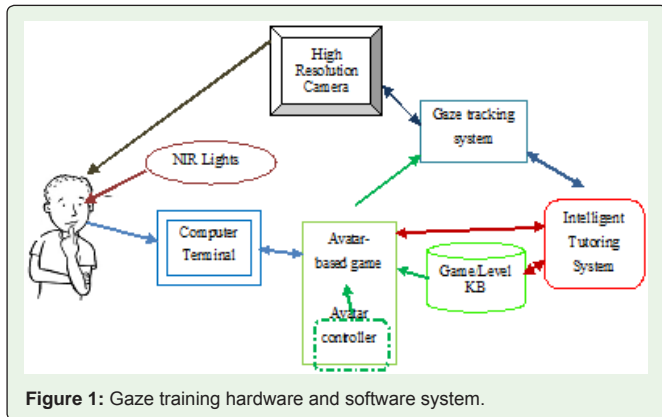


Figure 1: Gaze training hardware and software system.

Assistive technologies to assist with mental processing using visual systems have increased and improved remarkably over the past decade [50]. The proposed ADHD gaze training system is composed of several components shown in Figure 1. Gaze is tracked using near infrared (NIR) light emitting diodes (LED) and a high resolution camera. The NIR lights are generally considered safe to use on individual's eyes [51,52]. The high resolution camera is used to pick up the led reflections on the eye to determine gaze. A sample of an NIR LED system is shown in Figure 2. Multiple commercial glasses or headsets that track eye movement [53-56] could easily be substituted into the system shown in Figure 2, but this would require that the ADHD child not already be wearing glasses. The proposed system would actually mount the NIR lights around the screen to help prevent accidental displacement by the behavioral ADHD trainee, as shown in Figure 3.

The gaze tracking hardware and software is connected to an avatar-based game, which is what the ADHD student will use to train their gaze retention behaviors. In order to improve a child's ability to maintain eye contact, the child's eye movements that are relative to the avatar must be established and recorded by the gaze tracking system. The NIR lights reflect off eyes; and the positions of the NIR reflections together with eye images are recorded using the camera. The recorded signal is then passed to specialized software to determine the gaze or focus point of the subject's eyes on the screen. Changes in the relative position between NIR reflections and the pupil center will be used to detect when eye focus shifts and when it returns to the position of the avatar's eyes on the screen. The gaze-tracking software will be used to take several quantitative measurements to evaluate perceptual

attention behavior. These measurements will include total and average gaze focus time on the avatar's eyes, average and maximum gaze return time, and average and maximum gaze travel distance and distribution of gaze travel directions. Time to return a gaze and gaze travel distance are important, because the duration of gaze in most people is usually a couple of seconds, while conversations may last several minutes or longer, but returning to a direct gaze soon after gaze aversion maintains a behavioral display of interest [57].

Since NIR is not visible to the human eye, it should not pose a distraction to the ADHD user while interacting with the avatar-based game training system. Previous research has also shown that people interact well with and feel comfortable around human avatars, especially with avatars capable of maintaining eye contact with users [58]. Since the training is meant to improve social interaction perceptions of the ADHD student interacting with teachers and other students, the avatar should be as photorealistic human as possible and not use a more cartoon-like avatar figure as is popular in many video games.

The avatar in the avatar based game is meant to represent the teacher, or classmates. The NIR LEDs and the high resolution camera will track gaze direction and gaze movement, including time to return gaze, determining the ADHD student's focus on the teacher avatar. Signals from the gaze-tracking system are sent to the Intelligent Tutoring/Training System (ITS) part of the overall gaze behavioral training system. The ITS will utilize signals from the gaze-tracking system to record the eye focus and movement values. These values will be used to remind the child to "pay attention" or to "look at me (the avatar)" during the training session in order for the story or instructions to continue. Several different admonitions should be programmed into the training software so the subjects do not become overly familiarized with the training cues. The ITS will also enable some adaptability within the game software to keep the training challenging so subjects do not disengage due to boredom. The ITS will also be able to determine if improvement is occurring over time through increases in average and maximum eye contact time, as well as decreasing the time required to return focus to the avatar.

By assessing gaze maintenance and time to return gaze, improvements in these values are measured and used to offer rewards in the game. A reward system is important to encourage the

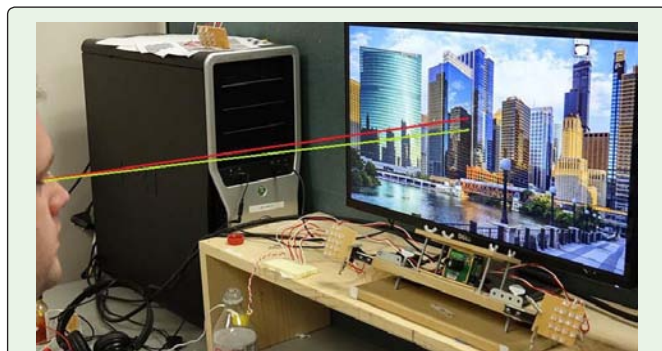


Figure 2: Example of NIR lights and high resolution camera added to a video display for tracking eye gaze direction and movements.

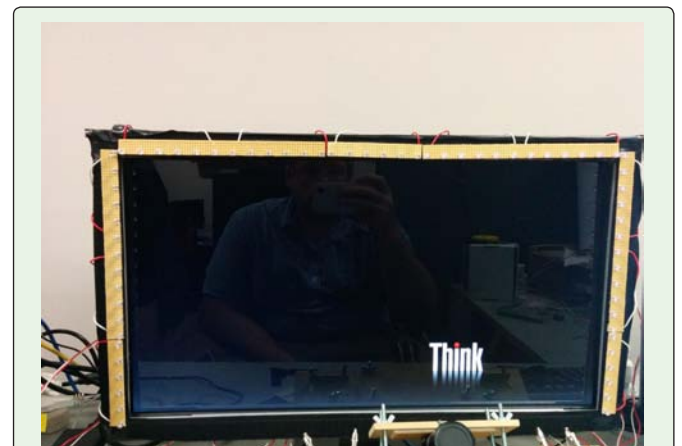


Figure 3: Frame showing NIR lights mounted around a video display unit.



participation of the ADHD students as most children enjoy extrinsic rewards from games, such as feeling powerful or famous within the game setting [59]. Reward systems can also help inspire and improve the intrinsic motivation to play the game and to perform well within the game for the ADHD children [60].

The probable age of students diagnosed with ADHD is from 4 to 12 years of age. The game that is played by the student must be age appropriate and for this reason, multiple games are stored in the game Knowledge Base (KB). As an example, younger students would engage with the avatar telling them a story (multiple stories of different difficulty levels would be stored in the game KB to enabling leveling) and asking them questions about the story. Overall rewards earned would result from a combination of gaze maintenance and shortened return times as well as correctly answering the avatar posed questions about the story. Older students would engage in an age appropriate adventure game, such as exploring a maze to find hidden objects. In these game scenarios the avatar, when present, would be giving directions and hints for finding different game objects. The leveling with the older ADHD student games would involve more complex mazes and tasks to be performed. Leveling enables multiple trajectories through a game, which is in general a good game design principle [61] and improves the students intrinsic motivation and interest in the game [62] and is controlled by the ITS.

Ideally, ADHD students would be exposed to the eye gaze training repetitively over a long period of time (at least several months). Prior research on developing muscle memory (in this case, focusing the eyes on a target location) has indicated the repetitive training is required to adequately train new muscle behaviors [63]. Training session should occur weekly over a period of several months. The specific number of training session required to enable embedded novel behavior in ADHD children is a subject for future research. Additional research has shown that an individual's motivation to learn may also impact the training outcomes [64], and thus the importance for using an avatar-based game to increase student motivation to engage in the training.

## Discussion

A growing debate exists concerning the role that social perception in the etiology of learning disabilities and other childhood disorders like ADHD [41]. The majority of research on negative peer interactions with ADHD students focuses primarily on either negative behavior or deficits in social skills [20]. The aim of the presented proposal is to develop a gaze tracking, avatar-based game focused on improving eye contact in children with ADHD. The proposed system is based on theoretical foundations and evidentiary results from psychology, psychiatry, education, and various computer disciplines. Future research is recommend to further evaluate the effectiveness of this proposed gaze behavior training system and the capability of achieving prolonged eye contact and shorter gaze return times in students with ADHD.

Technology-based, interactive behavioral interventions that are accessible, affordable, and student-driven (minimizing additional time demands for the teacher) have the potential to improve social and educational outcomes in children with ADHD. When a person moves their eyes to engage in eye contact, they are perceived as more likable and attractive [65]. Teaching appropriate eye contact in social

encounters may improve others' perceptions of children with ADHD, and may minimize internalized stigma experienced by these children.

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