A Brain-To-Computer Interface (BCI) Paired with a Videogame to Improve Core Symptoms of ADHD in Children: A Real World Pilot Study

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Objectives/Hypotheses

Attention-deficit hyperactivity disorder (ADHD) is the most common neurodevelopmental disorder in children with a prevalence estimated to be 5% worldwide.[1] First-line treatment for ADHD includes pharmacotherapy which may not be suitable for some patients due to caregiver preferences or concerns about abuse, misuse, and diversion of stimulants.[2]

Digital therapeutics for ADHD may address these limitations with improved access, minimal side-effects, and low potential for abuse. The BCI training technology method presented here, Skylar's Run™, has demonstrated efficacy in 8 clinical studies, with 337 children, ages 7-13 with ADHD and/or attentional difficulties. [3,4,5,6,7] More research is needed on the feasibility of this tool within the home setting to improve both core symptoms and functions of ADHD. This is a real-world pilot conducted on children ages 8-12. We hypothesized that this proof-of-concept study would replicate previous findings and that this intervention could be successfully administered virtually in the home setting.



Figure 1



Figure 2

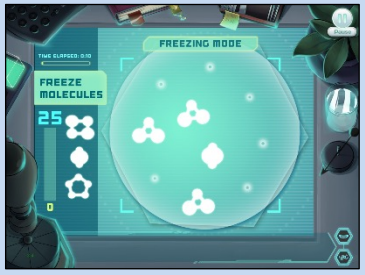


Figure 3

Methods

Participants. 22 children diagnosed with ADHD by a clinician using DSM-5 criteria were recruited to participate in the Skylar's Run training. Recruitment came from an outpatient clinic of a large children's specialized hospital. 12 children who completed the pretest, posttest, and treatment within 4 months (4 female, 8 male, Age *Range* = 8-12) were included in analyses.

Skylar's Run. The training captures factors of neural circuits of attention via EEG which are used to establish personalized communication to a video game through a BCI (Fig. 1). The training utilizes attention levels to control the runner in the game–the more a child pays attention, the faster the runner goes. During mission 1, a calibration is completed to determine the personalized neural correlates of each player's attention levels. This allows for a real-time physiological measure of attention enabling the child to use their attention to drive the character forward (Fig. 2). The game is also designed to train 13 cognitive skills (i.e., attention, inhibition, and self-regulation, Fig. 4). The training is comprised of 15 missions whereby each mission challenges the player with various game mechanics to retain each of the 13 cognitive skills using dynamic cognitive modeling (Fig. 4). This 'focus-forward' approach provides the player with instant recognition of actual attention performance, which motivates them to learn each cognitive skill.

There are two elements to each session, a runner module (i.e., learn one or more cognitive skill; Fig. 2) and a fog analysis module (i.e., apply a newly learned cognitive skill in a different virtual environment; Fig. 3). Performance reports were created based on the participants' level of inattention and impulsivity.

Procedure. Each session lasted approximately 30 minutes. Before and after completing the training, caregivers completed the Parent-Rated NICHQ Vanderbilt Assessment to assess core symptoms of ADHD.

13 Cognitive Skills Trained Across 15 Missions		Game Mission No. 1-3	4-6	7-9	10-12	13-15
Focused Attention	Arousing one's attention and focusing it on a stimulus	■	■	■	■	■
Sustained Attention	Maintaining attention on a stimulus for a prolonged period	■	■	■	■	■
Selective Attention	Directing attention toward a specific stimulus			■		■
Alternating Attention	Rapidly shifting one's focus of attention				■	■
Divided Attention	Maintaining two or more focuses of attention simultaneously				■	■
Cognitive Inhibition	Suppressing distraction from irrelevant thoughts	■	■	■	■	■
Behavioral Inhibition	Suppressing pre-potent or impulsive responses		■	■	■	■
Motivational Inhibition	Modifying behavior in response to punishments or rewards		■	■	■	■
Interference Control	Suppressing distraction from irrelevant stimuli			■		■
Novelty Inhibition	Suppressing distraction from new stimuli					■
Inner Voice	Use of an inner monologue to motivate and guide actions	■	■	■	■	■
Delay Gratification	Suppressing immediate desire for a greater long-term reward		■	■	■	■
Self-Regulation	Modifying behavior in response to future goals and past outcomes		■	■	■	■

Figure 4

Results

Participants exhibited a mean 37.81% reduction on the Vanderbilt from pre to post, with 8 participants exhibiting a greater than 25% reduction (MCID). Results pointed to a **significant decrease** in core symptoms of ADHD after completing Skylar's Run (M = 23.50, SD = 8.34), vs. baseline (M = 37.50, SD = 6.50), t(11) = 7.58, p < .0001, Cohen's d = 1.87, 95% CI [0.86, 2.89]; see Fig. 5.

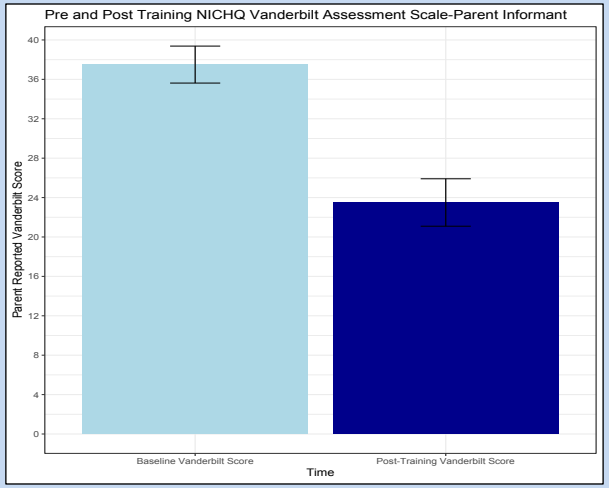


Figure 5

Discussion

This small real world pilot study replicated findings from previous controlled clinical trials. Results highlighted the potential of home-based BCI training to improve the core symptoms of ADHD within a short time frame.

This study has some limitations, the first being lack of a control group. A second limitation is the small sample size. Lastly, we did not assess the durability of the effect of this intervention. While previous clinical studies demonstrated maintenance of effect, large real world maintenance studies should be performed.

These findings present evidence for Skylar's Run to be used as monotherapy or adjunctive therapy in a comprehensive treatment plan for ADHD in children.

References
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