

COGNITIVE TRAINING AS TREATMENT FOR ADHD: EFFECTIVENESS IN SCHOOL-AGED CHILDREN

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ABSTRACT

The purpose of this investigation was to ascertain the effectiveness of Captain's Log, a computerized cognitive-training program designed to improve attention and reduce impulsivity. Participants consisting of 48 children in third through sixth grades were nominated by teachers for classroom behavior that interfered with their learning. Students were randomly assigned to either an experimental group or the control condition. All of the students have first completed the Integrated Visual and Auditory Continuous Performance Test (IVA CPT), which served as a pre-test measure of attention and impulsivity. Those assigned to the experimental group then received seven weekly sessions of Captain's Log, each lasting approximately 30 minutes. Those in the control group were excused from class for an equal amount of time, but played a basic computer game (Solitaire) instead. A multivariate analysis of variance (MANOVA) of the post-test measures found that the visual-focused attention scale showed a statistically significant improvement in the experimental group.

Key words: ADHD, cognitive training, school-age, children, Captain's Log

INTRODUCTION

Attention-deficit/hyperactivity disorder (ADHD) is a prevalent childhood disorder that impacts not only those who have the disorder, but all others in their social network. It can be especially troublesome in a school setting, interfering with the individual's ability to concentrate and perform necessary school tasks. Additionally, the behavior of those with ADHD is often disruptive and disturbing to their classmates and especially frustrating for teachers. With an estimated 2-18% of school-age children afflicted with ADHD (Rowland, Lesesne, & Abramowitz, 2002), it is a disorder that has serious implications for school systems. In order to successfully resolve the problematic behaviors associated with ADHD, three key domains must be improved: inattention, hyperactivity, and impulsivity, which constitute the core symptoms of ADHD (APA, 2000; Frick & Lahey, 1991; Shapiro & Herod, 1994).

While there are multiple treatment methods for ADHD, the most commonly employed treatment seems to be stimulant medication (Rowland, et al, 2002; Whalen & Henker, 1991). Stimulant medication has proven highly effective in treating many symptoms of ADHD, with as many as 85% of those with the disorder benefiting from

such treatment (Rowland, et al, 2002). However, these psychopharmacology treatments are by no means a miracle cure for ADHD. First of all, they are not effective for everyone who experience ADHD. Further, they have been noted to generate many aversive side effects and may produce even greater rebound effects when discontinued (Barnett & Labellarte, 2001). Another drawback is that these drugs do not teach individuals how to control or modify their own behavior. There are other treatment approaches, such as behavior modification and cognitive-behavioral therapy that do directly educate individuals on ways to improve their thinking and behavior. A similar mode of treatment is computerized cognitive training program, which require children to progress through a series of tasks designed to improve cognitive facilities such as attention skills, inhibition, processing speed, and working memory. One such program is Captain's Log, which not only is reported to produce marked improvement in functioning, but is also reported as enjoyable and captivating by those exposed to it (Slate, Meyer, Burns, & Montgomery, 1998).

The literature pertaining to ADHD is extensive and will only be briefly summarized in this paper. Common symptoms, prevalence rates, treatment approaches, and effect on

academic performance will also be discussed. In addition, methods of assessing ADHD, particularly parent and teacher rating scales and continuous performance tests, will be included. Of particular interest is the Integrated Visual and Auditory Continuous Performance Test (IVA CPT), which will be evaluated in detail. Next, a synopsis of the Captain's Log program will be presented. The review will conclude with overall research findings and implications, rationale, and hypotheses of the current study.

As with multiple other etiological theories, the existing explanations for ADHD can be condensed into two broad fields: genetic predispositions and environmental factors (DuPaul & Stoner, 2003). There is a plethora of research that emphasizes brain abnormalities or neurological deficiencies as a basis for ADHD (Faraone, 2000; Tannock, 1998). There are also many who speculate that exposure to toxic chemicals as a fetus, or other birth complications may result in a higher propensity to later manifest symptoms of ADHD (Mick, Biederman, Faraone, Sayer, & Kleinman, 2002; Milberger, Biederman, Faraone, Chen, & Jones, 1996; Mick, Biederman, Prince, Fischer, & Faraone, 2002). A word of caution should be issued regarding the interpretation of the various etiological speculations regarding ADHD: most of the research is based on correlational data and causal explanations are only speculated.

The three core characteristics of ADHD are inattention, hyperactivity, and impulsivity (APA, 2000; Frick & Lahey, 1991; Shapiro & Herod, 1994). The DSM-IV-TR (APA, 2000) is commonly used by practitioners to diagnosis ADHD and contains a list of inattention criteria as well as a list of hyperactivity-impulsivity criteria. Based on this, individuals can be classified as either predominantly inattentive, predominantly hyperactive-impulsive, or be characterized by both. Those considered inattentive must display at least six of the following conditions: inattention to details or numerous mistakes in activities, difficulty maintaining attention, failing to respond when addressed, failing to follow instructions or finish projects, lacking organizational skills, avoiding undertakings that require prolonged attention and effort, frequently

misplacing objects, easily distracted, forgetful. The hyperactivity-impulsivity measures (at least six of which must be met) include: being restless or fidgety, having difficulty remaining seated and being still, running and/or climbing when it is inappropriate to do so, frequently unable to play quietly, incessantly active, engaging in excessive rambling, impulsively blurting out answers and having great difficulty refraining from such outbursts, lacking patience in waiting for their turn, habitually interrupting others. The first six of these criteria describe hyperactive behavior, while the last three pertain to impulsivity. The symptoms displayed must cause impairment in daily functioning, be present before the age of seven, and be apparent in at least two settings, such as home or school.

The three key symptoms associated with ADHD are likely to interfere with academic performance in school. According to Alyward, Bell, and Gordon (1995), "The ability to sustain attention and inhibit responding is central to general academic achievement" (p. 2). Specifically, the inability to focus and maintain attention over extended periods of time disrupts the acquisition of knowledge in the classroom (Barry, Klingler, Lyman, Bush, & Hawkins, 2001; Das & Papadopoulos, 2003; Gordon, Mettelman, & Irwin, 1994). Sustained attention deficits may interfere with the ability to focus on lessons as the teacher explains them. If students do not initially acquire the pertinent information, they lack the knowledge to perform well on future assessment of material. Gordon, et al. (1994) found that individuals who have repeated a grade in school scored significantly lower on measures of sustained attention than did those who never retained. They suggest that the inability to focus on relevant information and to sustain attention is a key factor in academic failure.

It has also been determined that ADHD children suffer from poor working memories. In a classroom setting, working memory contributes to aspects such as note taking, completing assignments, and doing well on examinations; thus, those who have a deficient working memory will do poorly on all such tasks. Another common academic hindrance associated with ADHD is lack of

motivation (Barkley, 1998). However, this lack of motivation may not be a direct result of the disorder; it may be the result of difficulties associated with the disorder such as poor sustained attention and inability to grasp concepts. Continued failure due to these attention problems likely discourages ADHD individuals, which then results in poor motivation. "Furthermore, many such children develop secondary emotional problems as a consequence of the frustrations and failures they experience" (Silver, 1981, p. 396).

The poor academic performance of those with ADHD and the aversive consequences it causes them and the entire school system is well documented in the literature. When compared to normal controls, hyperactive individuals have been found to complete lower levels of education, which is likely the result of repeated years of academic struggle (Weiss, Hechtman, Milroy, & Perlman, 1985). Many have found that those with attention disorders are commonly academic underachievers, are likely to be placed in special education classes, and are more likely than those without attention deficits to be retained in school (Barkley, 1998; Cantwell, 1996; Frick, et al., 1991; Frick & Lahey, 1991; Gordon, et al, 1994; Reid, Maag, Vasa & Wright, 1994). In a three year longitudinal study of academic achievement in a group of boys who were referred for clinical treatment, Frick, et al. (1991) discovered that underachievement was associated with the presence of ADHD. It has further been noted that approximately 30% of ADHD children may repeat a grade in school, and 30-40% require special education courses (Barkley, 1998). Children with ADHD are often disruptive in class and interfere with the learning process of other students (DuPaul & Stoner, 2003). They may distract others by fidgeting in their seat, repeatedly leaving their seat, continually tapping their hands and feet, making frequent outbursts, and inappropriately talking to their classmates. Thus, ADHD is not only disruptive to those children who have the malady, but it is also taxing for the schools in terms of extensive time and resources that are spent educating and disciplining them.

A promising new treatment for ADHD is computerized

training. Xu, Reid, and Steckelberg (2002) stress the new and unique options that technology offers in the treatment of children with ADHD, stating such notable contributions as the ability to "simulate real world situations with images and sounds . . . provide step-by-step instruction, wait for responses, and offer immediate feedback and reinforcement" (p. 224-225). DuPaul and Stoner (2003) testified that computer-assisted instruction is very advantageous in teaching new skills to those with attention disorders because computer programs can "readily present specific instructional objectives, provide highlighting of essential material, use multiple sensory modalities, divide content material into smaller bits of information, and provide immediate feedback about response accuracy" (p. 181). While there is currently very limited research examining the use of technology in treating ADHD individuals, the findings that are present have been extremely positive.

Computerized Cognitive Training Program

Captain's Log is a structured computerized cognitive training program that has been successfully used in the past to improve attention and reduce behavioral impulsivity (Kotwal, Burns, & Montgomery, 1996; Slate, et al, 1998). The program consists more than eight hours of training, with a total of 33 exercises compiled into five modules. The exercises are constructed in a game format so that the participants can enjoy the learning process. Participants begin with easier tasks and progress through increasingly more challenging tasks. The training exercises are designed to improve such facets as general attention, focused attention, sustained attention, visual and auditory processing speed, working memory, self-control, motivation and self-esteem.

Kotwal, et al. (1996) had a child with ADHD participate in the Captain's Log training program for a total of 35 sessions. In order to progress from one level to another more difficult level, the subject had to make no mistakes (a perfect score of 100%) on two consecutive task trials. Parents and teachers completed surveys and reported on the child's behavior, and both noted an improvement in behavior during and after completion of the training. The most notable improvement occurred in classroom

behavior, as reported by his teacher. Further, the child reported enjoying the computerized training program. Thus, this program was not only successful in improving attention skills, with the improved attention and inhibition generalizing to the classroom, but was also considered enjoyable by the participant. The researchers contended that this program had potential as a new form of treatment for attention disorders or, at the very least, as a supplement to other forms of treatment.

A few years later some of the same researchers conducted a similar study using a sample of four children with severe emotional disturbances who were currently living in a youth treatment facility (Slate, et al. 1998). In addition to ADHD, the children suffered disorders such as posttraumatic stress disorder, conduct disorder, bipolar disorder, and psychotic disorder. While in the facility, these children were receiving both medication and behavior modification treatments, the researchers wanted to determine if the addition of Captain's Log cognitive training could improve their functioning. Each participant completed 30-minute sessions of the program, four times a week for a total of 16 weeks. A comparison of pre and post IVA CPT tests confirmed that all of the participants improved their attentional performance after completing the Captain's Log program, and all showed greater impulse control and less hyperactivity in their daily functioning as well. The researchers noted that the program was an excellent supplement to the more traditional forms of treatment. Once again, the participants reported that the program was very engaging and rewarding and even requested to continue the training after the study concluded. Thus, studies utilizing Captain's Log have found very encouraging results and received positive feedback from all participants, suggesting that it is a viable alternative for those who do not respond or wish to undertake the more traditional treatments for attention disorders.

Most research on ADHD children has involved those who are referred for clinical treatment with very little research conducted on those in school settings (Reid, et al. 1994; Rowland, et al. 2002). These samples of children may not

accurately represent the general population of children with attention disorders. Children referred for clinical treatment may exhibit more acute symptoms, may more outwardly express their symptoms and display more hyperactivity, may be especially disruptive to others, and may also manifest other co-occurring disorders. It is likely that most children who struggle with attention problems are not as outwardly disruptive and thus go unnoticed or at least avoid referral to clinicians. This study attempts to examine how attention disorders are expressed in a school population and thus clarify differences from those in a clinical sample.

Hypothesis

Those who participate in the Captain's Log training program will show marked improvements in attention and impulsivity, as measured by the IVA CPT.

Methodology

Participants

Participants for this study were recruited from a rural school in southeast Texas that encompassed third through sixth grades. Students were nominated by teachers who had identified them as having attention and/or impulsivity problems that either interfered with their ability to learn or disrupted the learning process of their fellow classmates. A total of 80 students were recommended for inclusion in the study and were provided with parental consent forms to take home to get consent from their parents. Parental consent was granted for 50 students, who were then randomly assigned to either an experimental condition or a control condition. Two participants (one from the experimental group and one from the control group) were subsequently eliminated from the study due to suspension from school and noncompliance.

The final 48 participants included 30 males (63%) and 18 females (37%). The participants ranged in age from 8 to 12, with a mean age of 9.92. The sample included 15 (31%) third grade students, 10 fourth grade students (21%), 12 fifth grade students (25%), and 11 sixth grade students (23%). The sample was ethnically diverse, being comprised of 28 Caucasian students (58%), 12 African American students (25%), and 8 Hispanic students (17%).

Materials

Students first took the Integrated Visual and Auditory Continuous Performance Test (IVA CPT). This computerized test, lasting approximately 20 minutes altogether, examines issues of inattention and impulsivity. A series of numbers, either "1" or "2", are visually displayed on the computer screen or orally spoken by a female voice, and participants are instructed to click the mouse button when they see or hear a "1" but refrain from clicking the mouse button when they see or hear a "2". At times, the number "1" is a very common, frequently presented stimulus, which produces a situation in which errors of commission are likely to occur. Other times, the number "1" is rarely presented, a circumstance that promotes errors of omission. Thus, the IVA CPT assessed participant's ability to focus and sustain their attention and not respond impulsively to distracter stimuli.

The IVA CPT produces a global rating of attention and a global rating of response inhibition, as well as six subscales: prudence, consistency, stamina, vigilance, focus, and speed. Furthermore, each of the subscales includes an auditory and visual component, corresponding to the auditory and visual stimuli presented in the test. The measures of prudence, consistency, and stamina are considered subscales of response inhibition, while vigilance, focus, and speed are classified as attention variables. Prudence measures participants' ability to think before they respond and avoid impulse errors (inappropriately responding to the number "2"). Consistency determines the regularity of response times throughout the task, while stamina concerns maintenance of response times and whether participants were able to stay focused for the duration of the 15-minute test. Vigilance measures the ability to identify correct targets (the number "1"). The focus scale establishes the extent to which participants are able to remain attentive during the entirety of the test, and speed calculates the amount of time taken to respond to correct stimuli. Of note is that assessment of ADHD using the IVA-CPT has been shown to be more resistant to malingering than the more common rating instruments (Quinn, 2003).

An additional computer program that was employed was the Captain's Log cognitive training program, which was completed by students in the experimental group. Captain's Log is designed to improve cognitive skills such as focused attention, sustained attention, alternating attention, processing speed, and working memory. It also aims to train participants to control their initial impulses and think before responding. The exercises in the Captain's Log program are organized in such a way that they become increasingly more difficult. Thus, as participants pass each level, they progress to gradually more difficult levels and restrictive instructions with added stimuli to which they must attend. At some of the higher levels, participants are given no explicit instructions, but instead are required to determine for themselves, through trial and error, what the specific rule is.

In order to pass a task and move on to another, participants must correctly identify and respond to the stimuli as they are instructed. They are limited on the number of errors allotted, and they must respond in a timely fashion, as response time is an additional factor. Thus, it is possible to correctly identify all of the correct stimuli, yet fail to pass the stage due to inadequate response time. If a participant fails to pass the first stage, they must continue until they do successfully complete the requirements of that level. If they fail in any successive stages, they are immediately downgraded to the preceding stage.

Procedure

Students with attention disorders, as determined by their teachers, were selected as possible participants in a computerized cognitive training program designed to improve their attention and response inhibition. Once the students and their parents agreed to participate in the study by signing an informed consent form, the students were randomly assigned to either an experimental condition or to a control group. Participants in both conditions first completed the IVA CPT, which served as a pre-test to which future performance was compared. Those in the experimental condition then completed a weekly session of the Captain's Log program for a total of

seven weeks. Sessions were divided into 25-minute blocks, with two students from the experimental group and two from the control group present for each session. The control group was extracted from class just as the experimental group was and played Solitaire on the computer instead of engaging in Captain's Log. At the conclusion of the seven-week treatment program, all participants again completed the IVA CPT, which served as a post-test to compare to the original pre-test.

Results

Data were analyzed using Multivariate Analyses of Variance (MANOVA) in which the two groups, experimental and control were compared on several measures of the IVA CPT post-test administered after the seven-week treatment program. As mentioned previously, IVA CPT measures of interest included global response inhibition, global attention, and the six subscales of prudence, consistency, stamina, vigilance, focus, and speed. The response inhibition subscales (prudence, consistency, and stamina) were analyzed separately from the attention categories (vigilance, focus, and speed). Although there were a number of analyses conducted, alpha was set at .05 due to the exploratory nature of the study.

The experimental and control groups exhibited extremely variable scores on both global measures (response control and attention), as is evidenced by their large standard deviations. Descriptive statistics for both groups are presented in Table 1.

The two groups were then analyzed for differences in global response inhibition and attention scores using a MANOVA. Unfortunately, these results did not reach statistical significance. The two groups did not statistically differ in their post-test IVA CPT measures of global response inhibition or attention.

Source	Group	Mean	Std. Deviation
Response Control	Experiment	86.29	19.128
	Control	76.54	21.317
Attention	Experiment	81.37	26.909
	Control	76.29	25.175

Table 1. Descriptive Statistics for Global Response Control and Attention

Next, the groups were analyzed for differences on each of the subscales of response inhibition. These categories include prudence, consistency, and stamina, and each is further classified as auditory and visual. There were no significant differences between the experimental and control groups on any of the response inhibition measures.

Another MANOVA examined the group's post-test scores on the IVA CPT attention subscales of vigilance, focus, and speed. Similar to the response control measures, these also include both an auditory and visual component. One of the attention categories, visual focus, did show a significant difference on the post-test score ($F(1, 47) = 4.56, p < .05$). The focus scale measures the participant's ability to sustain attention and maintain consistent and reliable response patterns. None of the other attention scales demonstrated statistically significant differences. The results of the MANOVA are shown in Table 2.

Of all the variables analyzed, only one factor was found to be statistically different on the IVA CPT post-test, and that was visual focus, one subcategory of the attention appraisal. None of the other attention subscales, or any of the response inhibition subscales showed any significant difference on the post-test. Further, the global measures of attention and response inhibition also failed to show evidence of significant change on the post-test. It seems that in this examination of the utility of Captain's Log cognitive training program, only visual focused attention was improved in a seven session training period. Student's ability to sustain their visual attention over the duration of the test and to consistently respond to the target stimuli did improve as a result of cognitive training. However, as visual focused attention was the only aspect that showed improvement, only a small portion of

Source	SS	DF	MS	F	Sig. of F
Vigilance (Aud)	346.687	1	346.687	.464	.499
Vigilance (Vis)	.000	1	.000	.000	1.000
Focus (Aud)	540.021	1	540.021	.177	.676
Focus (Vis)	1397.521	1	1397.521	4.559	.038
Speed (Aud)	588.000	1	588.000	1.720	.196
Speed (Vis)	825.021	1	825.021	2.307	.136

Table 2. Summary of MANOVA for Attention Subscales

Hypothesis 1, which stated that those who participate in the Captain's Log training program will show marked improvement in attention and impulsivity, was supported.

Discussion

Attention disorders are prevalent in school-aged children and frequently interfere with their academic pursuits. A lack of attention in school, as well as impulsive behavior, often inhibits the learning process. Further, such children often monopolize a teacher's time, disrupt their classmates learning, and command a great deal of resources from the school district. The impact of attention disorders not only impacts those with the disorder but also pervades many of the networks with which they are involved, particularly the school system where they spend most of their time.

For these reasons, it is imperative to identify possible school-based interventions for attention disorders. This study examined one possible intervention that could be implemented in schools, Captain's Log computerized cognitive training program. This program was chosen because of its many unique features and because previous studies have revealed very promising results. However, only two such studies have been published and they contained several shortcomings. The current research project attempted to expand previous investigations while addressing some of their limitations. However, despite high expectations for success, this study found only limited benefit to the participants. The measure that showed improvement after sessions of Captain's Log was the visual focused attention subscale. Of course, visual focused attention is an important factor for success in school and other venues. The other subscales of the global factors (attention and response inhibition) showed no significant difference after treatment.

There are several possibilities as to why this experiment did not produce more changes on the post-test. The short duration of the treatment period is one of the reasons; the experimental group received seven 30-minute sessions of Captain's Log for a total of three and half hours of program time, may have been inadequate for

measurable effect. In two other studies of Captain's Log, participants completed 35 and 64, 30-minute training periods of the program (Kotwal, et al, 1996; Slate, et al, 1998). This is much more than the seven performed in the current study. While it would have been desirable to conduct greater number of sessions, the school schedule and research timeline prevented doing so. However, the current results showing at least one significant effect holds promise that more exposure might present greater effect. Additionally, in the current study four students were present at each session. It is possible that the presence of the other students interfered with concentration on the Captain's Log program. However, students were seated such to see their computer monitor in an attempt to promote full attention to the task at hand. At times, there were unavoidable distractions during the pre-testing, training sessions, and the post-testing. Teachers or other students sometimes entered the room, announcements were occasionally made over the intercom, and noisy groups sometimes loitered outside the door. These distracting events, particularly during the post-testing, could have altered a student's scores. It is also possible that the attention paid to the control group and the experience of playing Solitaire may have had positive effects on them.

Conclusion

In conclusion, while the current study found only limited significant changes in attention and response control after a treatment regime of Captain's Log, more exposure may render the program a useful treatment. Previous studies that performed many more sessions of the program found extremely positive, lasting results. There is good reason to believe that future studies which implement a higher number of training sessions will also improve the level of attention and impulse.

The most notable limitation of this study was the limited time allotted for Captain's Log training. Seven 30-minute sessions were not enough training time to produce improvements in attention and inhibition. Another limitation is the small sample size. While this study did include a much larger sample than previous Captain's

Log studies, it was still a relatively small sample of students. Furthermore, having multiple students at a time in the testing room was likely distracting and detracted from the program's effectiveness.

Future studies should concentrate on implementing Captain's Log in a school-based sample of children. Children spend much of their time at school and their lack of attention and impulsivity adversely impacts their learning abilities and also detracts from their classmate's education. Teaching those with attention disorders is also very taxing for schools. Treating attention disorders in the school would benefit all involved.

Further studies should also implement the training program for a longer period of time. A program that ran for an entire year or even one academic semester could provide an abundant amount of information regarding the program's effectiveness. Additionally, considering a student's course grades could be useful in determining generalizability to the classroom.

Testing the program on different populations could also be useful. One recommendation is to utilize the program with student's involved in special education classes. Additionally, children of different ages should be examined. This study employed children in third through sixth grades. It would be useful to observe how both younger and older children respond to the program.

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