

The Impact of Inhibition Training on Symptoms of Attention Deficit/Hyperactivity Disorder and Social Skills

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Abstract

The aim of the present study was to develop a response inhibition training program and investigate its effectiveness on reducing attention deficit/hyperactivity disorder (ADHD) symptoms and improving social skills in children with ADHD. The research design was quasi-experimental, with comparisons across pre-test, post-test, and control groups. Sixteen students with ADHD who ranged in age from 7 to 11 years old (Mage=8.67 years) were recruited and randomly assigned to an experimental or a control group. The experimental group received different types of response inhibition training over 12 sessions, while the control group received no training. When the data were analyzed with Multivariate Analysis of Covariance, receipt of the inhibition training problem, relative to control, was associated with a reduction in ADHD symptoms and an improvement in social skills. In this instance, response inhibition training was demonstrated as effective for children with ADHD.

Keywords: Attention deficit hyperactivity disorder; Response inhibition; Social skills

Introduction

Response inhibition, an important executive function, is the ability to suppress context-inappropriate behaviors and manage thoughts and feelings whose enactment would interfere with desirable outcomes. Meta-analyses have shown that response inhibition tends to be one of the core deficits in attention deficit/hyperactivity disorder (ADHD) [1-5], and it is one of four core executive functioning deficits seen in the disorder, which include response inhibition, attention, planning, and working memory [5]. The consequences of impaired response inhibition associated with ADHD to emotional competence include increased emotional reactivity, decreased frustration tolerance, and diminished ability to self-regulate emotions. Impaired response inhibition also undermines the ability to separate affect from the informational content of a message, which interferes with the process of objective appraisal [6].

In children with ADHD, impaired response inhibition has been correlated with cognitive and developmental deficits, comorbid disorders such as anxiety and depression, and an increased probability of behavioral disorders, poor social skills, and low educational performance [6,7]. Further, recent studies suggest ADHD symptoms mediate the effect of executive function deficits on social impairment [8-10]. Specifically, the relationship between inhibition and social impairment is mediated by the hyperactivity/impulsivity symptoms of ADHD [11]. These findings emphasize the need for further investigation regarding executive function deficits in children with ADHD, namely in regards to alternative treatment approaches. Inhibition and social behaviors conceptualized at the level of neuropsychological precursors to functional impairment, relative to the more heterogeneous symptom-based presentation, could potentially provide a more direct pathway for treatment.

According to Barkley [6], in regards to ADHD, inhibition can be thought of as comprising “three interrelated processes: (a) inhibition of the initial prepotent response to an event (inhibitory control); (b) stopping of an ongoing response, which thereby permits a delay in the decision to respond; and (c) the protection of this period of delay and the self-directed responses that occur within it from disruption by competing events and responses (interference control)” (p. 67). Impaired response inhibition, referred to as response disinhibition, and may contribute to ADHD symptoms through any or all of the interrelated processes [11-13]. As response inhibition is critical to behavioral regulation [14], impairment results in a wide spectrum of hyperactive and impulsive behaviors that may explain such behavior in children with ADHD. When response inhibition is impaired, children with ADHD cannot suppress or manage behaviors, thoughts, and feelings that emerge in context-inappropriate times or places [15]. Accordingly, children with ADHD may respond to questions in sudden or untimely ways, or they may interrupt others. Such behaviors can make them appear rude or hasty and lead to social sanctions such as rejection and punishment [16].

Children with response disinhibition also tend to be deficient in expected social mannerisms such as taking turns, responding to nonverbal signals, being considerate of others' feelings, and engaging in social interactions with normative behaviors and cooperation [11]. They may be too aggressive during social interactions or have difficulties in making and keeping friends [7,17]. Further, these children have difficulties in thinking before they respond, planning their actions and managing their time to accomplish goals, and predicting the probable outcomes of inappropriate or dangerous behavior. These deficits in regulation stem, in part, from disinhibition and have been found to increase risk for engagement in behaviors like driving aggressively, abusing drugs, or engaging in risky sexual activity [8,18] and these risks may occur in adolescence if these children are not adequately treated in a psychological way.

Several studies have examined the idea that impulse control can be improved through training. For example, Thorell, et al. [19] investigated executive function training in normal preschool children (i.e., children without ADHD who were 4 to 5 years old). Participants were divided into four groups: a working memory training group (n=17), an inhibition training group (n=10), a passive control group (n=16), and an active control group (n=14). Over a five-week period, children in the two experimental groups and the active control group played computer games for 15 minutes daily. Children in the two experimental groups played games designed for improving either their visuospatial working memory (Robomemo, designed by Cogmed) or their impulse control (five activities based on three paradigms: go/no-go, stop-signal, and the flanker task). By comparison, children in the active control group played a commercial computer program designed to have minimal effects on visuospatial working memory and inhibitory control. Pertinent to the present inquiry, the study demonstrated significant improvement in impulse control in the go/no-go and flanker task activities but not in the stop-signal task.

This discrepancy in improvements could be due to the different neuropsychological skills underlying each task, specifically inhibition of a preponent motor response in the go/no-go task versus stopping of an ongoing response in the stop-signal task [19]. While improvement on the specific tasks was observed, improvement on non-trained inhibition tasks was not observed. The authors suggested this was a result of inadequate training time on the specific skills involved in inhibition, as the inhibition skills were only utilized a fraction of the task, whereas working memory skills were utilized the full duration of the task. The authors also noted that the inhibition tasks had a less reliable difficulty-adapting algorithm than the working memory counterpart [19]. The findings and limitations suggest a refined and consistent training paradigm could potentially lead to improvements on non-trained inhibition tasks.

Kimberlee [20] attempted to improve self-control in children through exercises that included thinking aloud, imitation, and Role-play (impulsive children who were 4 to 5 years old). At the end of the training, the children demonstrated a reduction in impulsive behavior and an enhancement of self-control. In a third study, Poushaneh, et al. [21] studied the effect of impulse control training on the attention span of children with ADHD in the first grade of elementary school (N=40). In this program, impulse control training included deep breathing, attending to the breath, drawing lines slowly, and competitive seating and standing (Appendix). These tasks focused on slowing motor movements and controlling responses. The results demonstrated a significant increase in the attention span of the experimental group relative to the control group.

While some training programs focus on inhibiting motor movements, others emphasize controlled motor movement training and relaxation techniques. It remains unclear which paradigm is the most effective as well as the overall efficacy of inhibition training. Although the evidence-based practices of behavioral management and organizational training interventions are considered well-established practices for children with ADHD, not enough randomized controlled trials of cognitive training have been conducted to determine their efficacy [22]. Accordingly, the present study aimed to compare the effectiveness of various techniques and evaluate whether the training could reduce impulsive behavior and improve social skills in children with ADHD.

Methods

Participants

Participants were 16 children diagnosed with ADHD, selected from among elementary school students referred to the Rofeideh Rehabilitation Hospital in Tehran. Selection criteria were based on the following specifications and requirements: participants needed to be at least 7 and not more than 11 years old and to have been diagnosed with ADHD by an accredited child/adolescent psychiatrist. They also needed to possess an IQ above 90 and to have been prescribed Ritalin for a period of at least one month, information that was collected from the Counseling and Guidance Center of the Department of Education of Tehran. The Ritalin inclusion criterion was to ensure inhibition treatment is indicated, as according to Barkley [6] the inhibitory deficit could underlie both inattentive and impulsive/hyperactive symptoms. Finally, they could not have been diagnosed with comorbid disorders (e.g., anxiety, depression, learning difficulties) by prior accredited physicians.

Procedure

The experiment used a mixed factorial design with a pre-test, post-test, and a control group. The participants (Mage=8.67 years) were randomly assigned to either the experimental or the control group, with seven boys and one girl placed in the experimental group, six boys and two girls in the control group. The experimental group received various forms of response inhibition training during 12 sessions, each 30 minutes in duration for 6 weeks, while the control group received no training during the same period. All participants completed all sessions of the training.

Participant ADHD symptoms and social skills were assessed using a pre-test/post-test format. ADHD symptoms were evaluated with Conner's Parent Rating Scale [23,24]. This scale was developed for children ageing 3 to 17 years old from schools throughout the USA, and Canada, and reported its test-retest reliability 0.7 to 0.9. In Iran, Khoushabi and Pouretemad [25] reported reliability of Conner's Parent Rating Scale based on Cronbach alpha 0.93, as well as Shahaian, et al. [26] reported test-retest reliability of this scale 0.58 and Cronbach alpha coefficient for this scale 0.73. Social skills were evaluated with the Social Skills Improvement System Rating Scale (SSIS-RS; teacher's form; Gresham and Elliot [27]. It is designed to assist in the screening and classification of students who are suspected of having significant social skills deficits, and to offer support in the development of interventions for those found to display significant social skills impairments. Internal consistency for the SSIS-RS was reported as 0.75, and Cronbach alpha was reported as 0.92 [28]. In Iran, Beh-Pajooh, et al. [29] computed its reliability by Cronbach alpha to be 0.87.

Inhibition training

The content and structure of the response inhibition training program were designed to remediate ADHD symptoms attributed to response disinhibition (e.g., lack of self-control or ignoring distractions), impulsiveness (e.g., inability to delay gratification), and a lack of time management. The intervention was developed based on a thorough review of the previous literature and the components were based on techniques to address each symptom of interest (All techniques were approved by the Iranian Psychological Association). The training was carried out by the first author, a research assistant

attended to the children at all times while the training was being conducted. To support program implementation, ancillary instruments and test devices were gathered (or in some cases, created), including the devices needed for the researcher to administer training protocols and gather data (e.g., a clock, stopwatch, and voice recorder); a traffic light with two different colors; a flag; a set of cards containing letters of the Persian alphabet, words, or images; puppets; and children's toys (e.g., Legos, puzzles, and storybooks). A testing area was also prepared to ensure comfort and minimize distractions. A summary of the response inhibition training protocols used over the 12 sessions of training is contained in the Appendix.

Statistical analysis

The data was analyzed using a MANCOVA comparison for each task. The difference in results between pre-test and post-test was the within-subjects variable and the type of group (training vs. control) was the between-subjects variable. We used a significance level of $p=0.05$.

Results

A MANCOVA analysis was pursued to investigate the differences between groups. As displayed in Table 1, the mean score of the experimental group on the attention-deficit subscale of Conner's Parent Rating Scale was 8.62 (SD=3.20) before training and 5.50 (SD=3.50) after training. In comparison, the mean score of the control group on the same subscale was 11.25 (SD=5.39) before the training, with a small decrease noted on the post-test. On the hyperactivity subscale, the mean score of the experimental group was 13.12 (SD=3.52) on the pre-test and 6.12 (SD=3.60) on the post-test, while that of the control group was 8.25 (SD=5.09) with no change from pre- to post-test. Finally, the experimental group's mean summed scaled score was 51.25 on the pre-test (SD=16.32), and decreased to 27.12 (SD=14.80) on the post-test; on the same measure, the control group's mean score was 41.75 (SD=20.58) with a small increase between the pre- and post-tests.

Variable	Group	Pre-test		Post-test	
		X	SD	X	SD
Attention-Deficit	Experimental	8.62	3.20	5.50	3.50
	Control	11.25	5.39	14.50	7.83
Hyperactivity	Experimental	13.12	3.52	6.12	3.60
	Control	8.25	5.09	9.37	6.13
Total score	Experimental	51.25	16.32	27.12	14.80
	Control	41.75	20.58	45.87	21.18

Table 1: ADHD subscales of Conner's parent rating scale.

Variable	Sum of Squares	df	Mean Square	F	p	Partial η^2
Attention-Deficit	114.48	1	114.48	26.08	0.002*	0.66
Hyperactivity	155.97	1	155.97	11.75	0.004*	0.47
Group	2373.671	1	2373.671	31.90	0.0001**	0.71
Error	967.274	13	967.274			
Total	27398.000	16				

* $p<0.05$; ** $p<0.001$

Table 2: Covariance analysis in subscales of Conner's parent rating scale.

As shown in Table 2, there were significant decreases in attention deficit, $F(1,13)=26.08$, $p<0.05$, $\eta^2=0.66$, hyperactivity, $F(1,13)=101.80$, $p<0.05$, $\eta^2=0.47$, as well as the total score of the Conner's Parent Rating Scale, $F(11,13)=31.0$, $p<0.01$, $\eta^2=0.70$, for children in the experimental condition relative to those in the control group. This supported the research hypothesis that training would improve the ability of children with ADHD to manage their symptoms.

Regarding social skills (Table 3), the mean score of the experimental group on the SSIS-RS was 36.50 (SD=8.07) on the pre-test and 52.06 (SD=11.09) on the post-test. By comparison, the control group scored a mean of 48.80 (SD=9.70) on the pre-test and 48.40 (SD=11.60) on the post-test.

Group	Pre-test		Post-test	
	X	SD	X	SD
Experimental	36.5	8.7	52.6	11.9
Control	48.8	9.7	48.4	11.6

Table 3: Social Skills Improvement System-Rating Scale (SSIS-RS).

As shown in Table 4, by taking pre-test scores as the covariance variable, response inhibition training was demonstrated as creating significant differences between the experimental and control groups,

$F(1,13)=16.07, p<0.001, \eta^2=0.57$, with response inhibition training accounting for well over half (57%) of the post-test variance and increasing the social skills of participants in the experimental group.

Sources	Sum of Squares	df	Mean Square	F	p	Partial η^2
Pre-test	1548.547	1	1548.547	69.848	0.0001**	0.85
Group	356.308	1	356.308	16.071	0.0001**	0.57
Error	266.043	13	22.170			
Total	35068.000	16				

* $p<0.05$; ** $p<0.001$

Table 4: Covariance analysis in Social Skills Improvement System-Rating Scale (SSIS-RS).

Discussion

The present study was designed to develop a response inhibition training program and investigate its effectiveness in decreasing ADHD symptoms and improving social skills in children diagnosed with ADHD. A treatment plan targeting behavioral inhibition through response disinhibition tasks, self-control tasks, and time management tasks was created in attempt to target one of the core deficits of ADHD. The findings confirmed the hypothesis that response inhibition training would be effective in decreasing ADHD symptoms stemming from disinhibition and increasing social skills in the sample.

The present study showed that response inhibition training, relative to control, was associated with a reduction in ADHD symptoms as measured on Conner's Parent Rating Scale subscales of attention deficit and hyperactivity. This suggests that response inhibition training improves an individual's ability to ignore distractions and maintain an attentional focus on goals. The increase in attentional focus was thought to be related to the improvement in the ability to filter out intervening stimuli. In this regard, Barkley [30] argues that in individuals with ADHD, attention deficit is related to deficiencies in response inhibition. More recently, Bunford et al. [8] illustrated the link between working memory deficits and ADHD inattention symptoms on social impairment. In other words, attention deficit might be a secondary deficiency related to poor response inhibition in self-regulation or executive control of behavior. Thus, increased response inhibition might enable an individual to process received data, ignore distractions, and attend to pertinent stimuli. Further, it may be that when children learn strategies to increase their response inhibition, they exhibit less ADHD symptoms through an increase in their ability to regulate and objectify their behaviors, think before they respond, wait for others to finish speaking, and ignore distracting stimuli. Acquiring these skills could lead to decreased impulsive behaviors and hyperactivity. Through response inhibition training,

children might become better able to increase attention and control impulsivity, which could potentially improve behavioral symptoms associated with ADHD.

Another important aspect of behavioral functioning in children with ADHD is the presence of social skills. As was previously noted, reckless and hasty behavior in children with ADHD, associated with response disinhibition, frequently leads to social sanctions and undesirable or dangerous outcomes, thus likely increasing the probability of disorders such as anxiety, depression, and aggression [16]. Similarly, children with ADHD are often deficient in social skills, such as waiting for their turn, responding to nonverbal signs, perceiving others' feelings, and participating in social situations that require inhibition and cooperation. They may also be aggressive toward others, behavior that tends to make it difficult for them to make and keep friends [17]. Since these ADHD symptoms and social skills were improved with response inhibition training in the sample of the current study, many of the behavioral, educational, and social problems associated with ADHD might be improved through similar training in children.

The present study was focused on school-age children, and many of the training techniques were age-specific; thus, the results may not be generalizable to other age groups. Due to a lack of resources, previous diagnoses (possibly from different diagnostic criteria), small sample sizes, and only parent ratings were used (as opposed to both parent and teacher ratings). The differing diagnostic criteria could be a concern as the children were diagnosed from external, accredited psychologists and was not under the direct control of the researchers. Additionally, researchers, parents, and children were not blinded to the experimental training, and therefore results are subject to expectancy effects. Parents, who knew whether or not their children were receiving inhibition training, could have unconsciously affected the results because of the underlying belief that symptoms would improve with

treatment. It is unclear how much of the effects seen in the treatment group are due to expectancy effects.

In the future, longitudinal studies could shed further light on the persistence of improvements from inhibition training. Determining how long the effects last is an important component of developing treatment plans and determining their efficacy. Further, components of the treatment plan can be evaluated in different combinations in order to optimize the inhibition training and ensure each component is useful. The results also suggest that future research into response inhibition training could be appropriate for children with other disorders that involve response inhibition impairment. On the other hand, such studies suggest with larger samples.

Through the response inhibition training program, children had improved parent-rated social skills which seemed to correlate with improved patience and consideration during social interactions, paying more attention to the possible outcomes of responses, and more precise verbal communications. These skills and behaviors helped the children to seem more polite, patient, and calmer in social interactions, allowing for the possibility that social others would form more positive opinions of them. In addition, both deficits in attention and behavioral inhibition, key components of ADHD, were improved after training. As the training techniques were easily administered, counselors, child psychologists, and child psychiatrists might find the addition of these techniques to their toolkit beneficial.

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