

ADOPTING AN EXTERNAL FOCUS OF ATTENTION FACILITATES MOTOR LEARNING IN CHILDREN WITH ATTENTION DEFICIT HYPERACTIVITY DISORDER

Esmaeel Saemi¹, Jared Porter², Gabriele Wulf³,
Ahmad Ghotbi-Varzaneh⁴ and Sabah Bakhtiari⁴

¹*Department of Sport Sciences, Shahid Beheshti University, Tehran, Iran*

²*Department of Kinesiology, Southern Illinois University Carbondale, USA*

³*Department of Kinesiology and Nutrition Sciences, University of Nevada, Las Vegas, USA*

⁴*Department of Sport Sciences, Shahid Chamran University of Ahvaz, Iran*

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Abstract:

The purpose of the present study was to investigate if children with attention deficit hyperactivity disorder (ADHD) would show enhanced motor skill learning with instructions to adopt an external focus of attention (i.e. on the movement effect) rather than an internal focus (i.e. on the movements themselves). The task involved throwing tennis balls with the dominant arm at a circular target that was placed on the floor at a distance of three meters. Twenty children with ADHD, ranging in age from 8 to 11 years, were randomly assigned to either an external or internal focus group. Participants performed 180 practice trials with focus instructions and reminders before each block of 30 trials. Learning was assessed 48 hours after practice. The external focus group demonstrated more effective learning than the internal focus group. This finding has implications for applied settings that involve sports or physical activity with children who have ADHD.

Key words: *attentional focus, motor skills, throwing, ADHD*

Introduction

According to the American Psychiatric Association (2009), attention-deficit/hyperactivity disorder (ADHD) is one of the most common mental disorders in school-aged children. Additionally, it is estimated that 3–7% of school-aged children have symptoms consistent with ADHD (American Psychiatric Association, 2009). The exact cause of ADHD is not fully known, but some researchers have suggested that its cause may be linked to genetics or various biological indicators. Furthermore, symptoms may be triggered by defects in neural transmitters (e.g. dopamine, norepinephrine) in the central nervous system (Barkley, 1998).

Children with ADHD often suffer from difficulties in the cognitive, social and emotional domains of their behavior (Barkley, 2005). Additionally, it is well documented that children with symptoms associated with ADHD often have difficulty learning and performing motor skills (Barnes, Howard, Howard, Kenealy, & Vaidya, 2010; Eliasson, Rosblad, & Forsberg, 2004; Harvey & Reid, 2003; Kopecky, Klorman, Chang, Thatcher, & Borgstedt,

2005; Pitcher, Piek, & Hay, 2003). For example, Eliasson and colleagues (2004) compared motor skill learning of goal-directed arm movements in 25 children with ADHD with those of 25 age-matched typical developing children. Their results indicated that children with ADHD showed less effective performance and reduced accuracy relative to the age-matched controls. This result is consistent with findings reported by Gillberg and colleagues, which indicated that about half of all children with ADHD suffer from developmental coordination disorders (Kadesjö & Gillberg, 1998; Landgren, Pettersson, Kjellman, & Gillberg, 1996; Rasmussen & Gillberg, 2000).

With such consistent findings indicating that children with ADHD have difficulty learning and performing motor skills, questions arise about how to create more effective motor learning environments for these children. Understanding how to best design motor skill practice is critical for parents and practitioners (e.g. behavioral therapist, physical educators, youth sport coaches, etc.) working with this population of children. A topic that has been a

major focus of motor behavior research for the last several years has been the investigation of how to best direct a person's attention, through instructions or feedback, during motor skill execution (for reviews, see Wulf, 2007, 2013). In this area of study, researchers have compared the effects of directing attention internally or externally. An internal focus of attention is directed at the performer's body movements, whereas an external focus is directed at the effect the performer's movements have on the environment (Wulf, Höß, & Prinz, 1998). For example, in the task involving kicking a ball towards a target, children could focus their attention on how to move their foot and leg towards the ball (i.e. internal focus), or they could focus on the resulting desired path they would like the ball to take as it is kicked towards the target (i.e. external focus).

Numerous studies have been conducted to investigate the effectiveness of adopting an external rather than an internal focus of attention (e.g. Al-Abood, Bennett, Hernandez, Ashford, & Davids, 2002; Freudenheim, Wulf, Madureira, Pasetto, & Corrêa, 2010; Porter, Nolan, Ostrowski, & Wulf, 2010; Porter, Ostrowski, Nolan, & Wu, 2010; Wulf, McConnel, Gärtner, & Schwarz, 2002; Zarghami, Saemi, & Fathi, 2012). The majority of the research investigating the focus of attention effect has been conducted with persons without disabilities, and only a few experiments have been conducted with persons with disabilities. In a recent study by Chiviacowsky, Wulf, and Ávila (2012), the authors examined the effect of adopting either an external or internal focus of attention on motor learning in children with mild intellectual disabilities. Participants assigned to the internal condition were instructed to concentrate on the motion of their hand while tossing beanbags towards a target. These participants were compared to participants who directed their attention externally towards the flight of the beanbag during practice. All participants returned after one day of practice and had their throwing performance assessed with retention and transfer tests. The results of that study revealed motor learning benefits in favor of the participants who directed their attention externally during practice. In another study, Wulf, Landers, Lewthwaite, and Töllner (2009) examined the effectiveness of external versus internal foci on balance performance in older adults with Parkinson's disease. Balance performance was improved when participants were instructed to direct their attention externally to keep an inflated disk still, on which they were standing, rather than internally on keeping their feet still. Similar results were reported by Porter and Anton (2011) in which adult cancer survivors suffering from symptoms associated with "chemo-brain" practiced a visuomotor tracking task.

Wulf, McNevin, and Shea (2001) proposed the constrained action hypothesis to explain the benefits of adopting an external focus of attention. According to this hypothesis, an external focus promotes a more automatic mode of control by utilizing unconscious, fast, and reflexive control processes. In contrast, an internal focus induces a conscious type of control, causing individuals to constrain their motor system, thereby interfering with automatic control processes. Several studies provide support for the predictions of the constrained action hypothesis (Lohse, 2012; Lohse, Sherwood, & Healy, 2011; Makaruk, Porter, Czaplicki, Sadowski, & Sacewicz, 2012; Marchant, Greig, & Scott, 2009; Wulf, Dufek, Lozano, & Pettigrew, 2010; Wulf, et al., 2001).

Although numerous studies have demonstrated the benefits of adopting an external relative to an internal focus of attention, only one study has been conducted with non-typical children (Chiviacowsky, et al., 2012). To date, there have been no reported studies examining the effects of different foci of attention in children with ADHD. As noted previously, it is well documented that children with ADHD often display deficits in motor skill performance compared with age-matched typical children. If motor learning could be enhanced in children who have ADHD, simply by changing their attentional focus through instructions, this could have important practical implications. Therefore, the purpose of the present study was to examine whether the learning benefits of an external focus would generalize to children with ADHD. We used a throwing task and gave two different groups of participants either external or internal focus instructions. Learning was assessed by a retention test without instructions or reminders two days later (see Schmidt & Lee, 2011).

Methods

Participants

Participants were 20 children ranging in age from 8 to 11 years (12 boys and 8 girls, $M_{age}=10.1$, $SD=0.85$ years.) diagnosed with combined ADHD (ADHD-C). Participating children were recruited from a special school for children with ADHD. None of the participants were taking medication at the time of the study. Participants were considered low-skilled throwers, and were not aware of the purpose of the study. Informed consent was obtained from the elementary school as well as parents of participating students, and the children provided their assent. The study was approved by the university's institutional review board.

Instruments and experimental procedure

The task was similar to one used by Saemi, Porter, Ghotbi-Varzaneh, Zarghami, and Shafinia

(2012). Participants were asked to throw a tennis ball with their dominant hand towards a target lying flat on the floor. The target was located directly in front of the participant at a distance of three meters. The target included a series of ten concentric rings. The center of the target had a radius of ten centimeters. Concentric circles with radii of 20, 30 ... 90, and 100 centimeters were drawn around the center circle. These circles served as zones to assess the accuracy of the throws. If the tennis ball landed on the center target, ten points were awarded. If the ball landed in one of the other rings, or outside the marked target, 9, 8, 7 ... 1, or 0 points, respectively, were recorded. If the ball landed on a line separating two rings, the participant was awarded the higher (i.e. better) score. All practice and retention test trials took place in a controlled research laboratory.

After all necessary paperwork was completed, all participants received general verbal instructions indicating that the goal of the task was to throw the tennis ball with their dominant hand and strike the center of the target located in front of them. Following these instructions participants were randomly assigned to either the external or internal focus of attention group, with the restriction that there were an equal number of boys and girls in each condition. Participants assigned to the external group were given the instruction: "Take the tennis ball with your dominant hand, and as accurately as possible throw it toward the target while concentrating on the ball, particularly the landing location of the ball." In contrast, participants assigned to the internal group were given the instruction: "Take the tennis ball with your dominant hand, and as accurately as possible throw it towards the target while concentrating on the motion of your hand and wrist that is throwing the ball." All participants were instructed to keep their eyes focused on the target while performing the throwing task. The practice phase consisted of 180 trials. Participants were reminded of the instructed focus before each block of 30 trials. All participants returned 48 hours later and completed the retention test which included ten throws from the same three-meter distance. However, participants were not provided any attentional focus instructions prior to or during the retention test. They were simply asked to throw ball as accurately as possible.

Data analysis

Accuracy scores during the practice phase were averaged across blocks of 30 trials and analyzed in a 2 (group) x 6 (blocks of 30 trials) analysis of variance (ANOVA) with repeated measures on the second factor. A one-way ANOVA was used to compare accuracy scores on the first trial to ensure the two groups were not different at the initiation of practice. A one-way ANOVA was also used to compare retention test performances.

Results

Practice

Both groups had trial similar accuracy scores on the first practice trial (see Figure 1), $F(1, 18) < 1$. Throughout the practice phase, the external focus group had higher scores than the internal focus group. The main effect of group was significant, $F(1, 18) = 5.80$, $p < .05$, $\eta^2 = .24$. Also, both groups consistently improved across practice blocks. The main effect of block was significant, $F(5, 90) = 4.59$, $p < .001$, $\eta^2 = .20$. The interaction of group and block was not significant, $F(5, 90) < 1$.

Retention

On the retention test without focus instructions or reminders, which was conducted two days after the practice phase, the external focus group ($M = 7.14$) again demonstrated more effective performance than the internal focus group ($M = 5.6$) (see Figure 1, right). The group effect was significant, $F(1, 18) = 4.47$, $p < .05$, $\eta^2 = .20$.

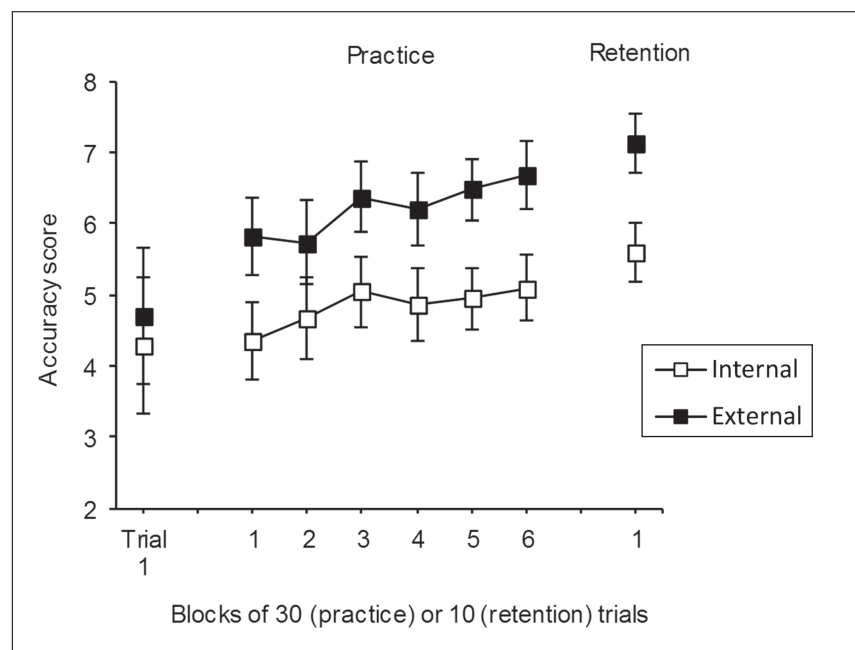


Figure 1. Accuracy scores of the external and internal focus groups during the practice phase and retention test. (Error bars represent standard errors.)

Discussion and conclusions

In the present study, we investigated whether the often found advantages of an external relative to an internal focus of attention would generalize to motor learning in children diagnosed with ADHD. The results showed that a small difference in the wording of instructions had a significant impact on motor performance and learning. During practice, children whose attention was directed to the effects of their movements on the environment (i.e. the ball movement) showed greater throwing accuracy than did children whose attention was directed to their own movements (i.e. their hand). More importantly, this benefit was not only temporary – that is, present only when focus instructions and reminders to maintain the instructed attentional focus were given – but was still seen after a two-day delay and without instructions. Thus, the induced focus of attention during the practice phase had a relatively permanent effect on learning. The findings of the present study add to the growing body of attentional focus literature by showing that an external focus of attention can facilitate motor skill learning in children with ADHD. These findings are consistent with previous studies using young adult, non-impaired participants (e.g. Freudenheim, et al., 2010; Lohse, Sherwood, & Healy, 2010; Marchant, Clough, & Crawshaw, 2007; Porter, Nolan, et al., 2010; Porter, Ostrowski, et al., 2010; Stoate & Wulf, 2011; Zarghami, et al., 2012). Our findings are also in line with studies examining the focus of attention effect in patient populations (Porter & Anton, 2011; Wulf, et al., 2009), and children with intellectual disabilities (Chiviacowsky, et al., 2012; for a recent review, see Wulf, 2013).

The benefits of adopting an external focus (e.g. for movement accuracy, balance, force production) have been attributed to the greater automaticity in motor control, compared with a more conscious control effort that is characteristic for an internal focus and that tends to constrain the motor system (Wulf, et al., 2001). Numerous studies have provided evidence for this view by demonstrating reduced attentional demands, an increased use of reflexive control mechanisms, and more efficient muscular activity with an external focus (e.g. Lohse, et al., 2010, 2011; Marchant, et al., 2009; McNevin, Shea, & Wulf, 2003). Thus, an external focus seems to speed the learning process, such that a higher skill level is achieved sooner, relative to an internal focus. These findings are particularly important in light of the pervasiveness of internal focus instructions used in practical settings (e.g. Durham, van Vliet, Badger, & Sackley, 2009; Porter, Wu, & Partridge, 2010).

Studies have shown that children with ADHD have deficits in motor skill learning and performance compared with age-matched typical children (Barnes, et al., 2010; Eliasson, et al., 2004; Harvey

& Reid, 2003; Pitcher, et al., 2003; Verret, Gardiner, & Béliveau, 2010). Motor coordination problems have also been shown to be related to impaired daily living skills (Kopp, Beckung, & Gillberg, 2010). Such motor deficits presumably lead to low self-efficacy (Cairney, Hay, Wade, Corna, & Flouris, 2005) which, in turn, may exacerbate those deficits. Several recent studies provide converging evidence that the perception of competence or increased self-efficacy facilitate motor performance and learning (e.g. Ávila, Chiviacowsky, Wulf, & Lewthwaite, 2012; McKay, Lewthwaite, & Wulf, 2012; Saemi, Porter, Ghotbi-Varzaneh, Zarghami, & Maleki, 2012; Wulf, Chiviacowsky, & Lewthwaite, 2012). Conversely, low self-efficacy leads to less-than-optimal performance and learning, potentially resulting in a vicious circle for children with ADHD or other motor impairments. The present findings show that, with a simple change in the wording of instructions, motor learning can be facilitated in children with ADHD. An improved skill level and presumably a resulting boost to perceived competence have the potential to stop, or even reverse, this downward trend. Children with ADHD have deficits in their attention and cognitive processing abilities when they attempt to learn new skills. Perhaps through the adoption of an external focus of attention, children with ADHD have reduced attentional and cognitive demands placed on them compared to when their attention is directed internally. As a result, when children with ADHD are instructed to focus externally, they may learn a new skill more effectively because the cognitive and motor systems are operating with fewer constraints.

The successful acquisition of fundamental motor skills in school-age children plays an important role in forming basic, and later advanced, physical and sports-related motor abilities (Haywood & Getchell, 2005). Overhand throwing is a fundamental motor skill and important for performing sports and recreational activities, not only in childhood but also in adulthood. The possession of basic motor skills might increase the likelihood of continued physical activity which, aside from its well-known health benefits, has also been shown to be associated with improved executive function in children with ADHD (Gapin & Etnier, 2010).

In future studies, it would be fruitful to examine longer-term effects of practice with an external attentional focus in children with ADHD or other developmental disorders – not only on motor skill learning but also on motivational or affective processes. In addition, it would be interesting to compare the performances of ADHD participants with age-matched typical participants. Doing so would draw valuable insight into the extent of the benefits of encouraging learners to use an external focus of attention. An aged-match comparison could

indicate if skill differences are inherently present, or if ADHD learners perform similarly to typical children when using an external focus of attention.

The findings of this study add to a growing body of literature that supports the conclusion that it is beneficial for learners to direct their attention externally, that is, to the intended movement effect or outcome, when performing a motor skill. Our

results demonstrate that children with ADHD experience similar benefits from an external focus of attention as other populations. The methods used in the study can easily be adopted by parents and practitioners working with young learners with ADHD. Doing so has the potential to narrow or even close the motor learning gap between children with ADHD and their typical peers.

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PRIMJENA VANJSKOG FOKUSA PAŽNJE OLAKŠAVA MOTORIČKO UČENJE U DJECE S POREMEĆAJEM HIPERAKTIVNOSTI I DEFICITOM PAŽNJE (ADHD)

Cilj je ovog istraživanja bio ustanoviti da li će djeca s poremećajem hiperaktivnosti i deficitom pažnje (ADHD) pokazati veću učinkovitost prilikom motoričkog učenja primjenom instrukcija vanjskog fokusa pažnje (tj. fokusa na učinak kretnje) u odnosu na učenje primjenom instrukcija unutarnjeg fokusa pažnje (tj. fokusa na sam pokret). Zadatak je uključivao bacanje teniskih loptica dominantnom rukom na kružnu metu koja je na podu bila udaljena 3 metra od ispitanika. Dvadesetoro djece s ADHD-om, u rasponu dobi od 8 do 11 godina, bilo je nasumično raspoređeno u grupu koja je tijekom učenja i vježbanja primjenjivala vanjski, odnosno grupu

koja je primjenjivala unutarnji fokus pažnje. Ispitanici su izveli 180 bacanja loptice u cilj s instrukcijama o fokusu i podsjetnicima prije svakog bloka od po 30 bacanja. Učinci učenja mjereni su 48 sati nakon vježbanja. Grupa s vanjskim fokusom pažnje pokazala je učinkovitije učenje u odnosu na grupu s unutarnjim fokusom pažnje. Rezultati imaju primjenu u praktičnim uvjetima koji uključuju sportove i tjelesnu aktivnost djece s ADHD-om.

Ključne riječi: fokus pažnje, motoričke vještine, bacanje loptice, ADHD

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Correspondence to:

Esmaeel Saemi, PhD Student, Motor Behavior

Department of Sport Sciences

Shahid Beheshti University, Tehran, Iran

Phone: +98(919)-1741715

E-mail: esmaeelsaemi@yahoo.com