

*Original article (short paper)*

## **Children's learning of tennis skills is facilitated by external focus instructions**

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**Abstract**—The present study examined the effects of instructions promoting external versus internal foci of attention on the learning of a tennis forehand stroke in 11-year old children. Three groups of participants practiced hitting tennis balls at a target. External focus group participants were instructed to direct their attention to the movement of the racquet, while participants in the internal focus group were asked to direct their attention to the movements of their arm. Participants in a control group did not receive attentional focus instructions. Two days after the practice phase (60 trials), learning was assessed in retention and transfer tests. The results showed that the external focus group demonstrated greater accuracy in hitting a target relative to the two other groups in retention, and relative to the internal focus group in transfer. We conclude that instructions inducing an external focus of attention can enhance children's sport skill learning.

Keywords: motor learning, attention, childhood, sports

**Resumo**—“Aprendizagem de habilidades do tênis em crianças é facilitada por instruções de foco externo.” O presente estudo examinou os efeitos de instruções promovendo foco de atenção externo versus interno na aprendizagem da rebatida de *forehand* do tênis em crianças de 11 anos de idade. Três grupos de participantes praticaram a tarefa. Os participantes do grupo de foco externo foram instruídos a direcionar a atenção para os movimentos da raquete, enquanto os participantes no grupo de foco interno a direcionar a atenção aos movimentos do braço. Participantes do grupo controle não receberam instruções de foco de atenção. Dois dias após a prática (60 tentativas) a aprendizagem foi avaliada através de testes de retenção e transferência. Os resultados demonstraram que o grupo de foco externo apresentou maior precisão em relação aos dois outros grupos na retenção e em relação ao grupo de foco interno na transferência. Conclui-se que instruções induzindo foco externo de atenção pode melhorar a aprendizagem de habilidades esportivas em crianças.

Palavras-chave: aprendizagem motora, atenção, infância, esportes

**Resumen**—“Aprendizaje de habilidades del tenis en los niños es facilitada por instrucciones con foco externo.” El presente estudio examinó los efectos de las instrucciones con foco de atención interno frente a externo en el aprendizaje de “forehand” del tenis en niños. Tres grupos de participantes practicaron la tarea. Los participantes en el grupo de foco externo fueron instruidos para dirigir la atención a los movimientos de la raqueta, mientras que los participantes en el grupo de foco interno a poner la atención a los movimientos del brazo. El grupo control no recibió instrucciones de foco de atención. Dos días después el aprendizaje se evaluó mediante pruebas de retención y transferencia. Los resultados mostraron que el grupo de foco externo presentó mayor precisión en relación con los otros grupos en la retención y al grupo de foco interno en la transferencia. Llegamos a la conclusión de que las instrucciones que inducen foco externo de la atención pueden mejorar el aprendizaje de habilidades deportivas en los niños.

Palabras clave: aprendizaje motora, atención, infancia, deportes

## Introduction

Not all instructions are created equal. Instructions for motor learning differ in their effectiveness depending on how they direct the performer's attention. Specifically, instructions promoting an external focus on the intended movement effect (e.g., movement of an implement or support surface, intended trajectory of an object, target) have been found to result in enhanced learning relative to instructions referring to body movement (internal focus) (Wulf, 2007). Benefits of instructions or augmented feedback promoting an external focus have been demonstrated for different skills, levels of expertise, and healthy individuals as well as those with motor or cognitive impairments (for a review, see Wulf, 2013).

An external focus facilitates automaticity as evidenced by reduced attentional demands (Kal, van der Kamp, & Houdijk, 2013; Wulf, McNevin, & Shea, 2001), high-frequency movement corrections indicating greater involvement of reflexes (e.g., McNevin, Shea, & Wulf, 2003), increased functional variability (Lohse, Jones, Healy, & Sherwood, 2013), and greater movement fluidity (Kal *et al.*, 2013). As a result, an external focus speeds the learning process relative to an internal focus which tends to interfere with automatic processes (Wulf *et al.*, 2001). Control conditions without specific focus instructions typically have similar effects as internal focus conditions and are less effective than external focus conditions (e.g., Freudenheim, Wulf, Madureira, & Corrêa, 2010; Wulf, Höß, & Prinz, 1998, Experiment 1; Wulf, Landers, Lewthwaite, & Töllner, 2009).

Only a few studies have examined attentional focus effects on motor learning in children. In one study, Wulf, Chiviacowsky, Schiller, and Ávila (2010) compared the effectiveness of feedback inducing an external versus internal focus for the learning of a soccer throw-in task in 10-year-old children and found enhanced learning of movement form in the former group. Benefits of external focus instructions were also seen for the learning of a throwing task in 12-year old children with intellectual disabilities (Chiviacowsky, Wulf, & Ávila, 2013). Another study (Emanuel, Jarus, & Bart, 2008) yielded inconclusive findings regarding internal versus external focus instructions for the learning of a dart-throwing task in 8 to 9 year-old children, perhaps as a result of confounding influences of the number of instructions provided to the different groups.

Given the relative dearth of studies examining attentional focus effects in children, and the fact that instructions given in practical settings are typically body-related and therefore induce an internal focus (Porter, Wu, & Partridge, 2010), it seemed important to further examine the influence of different types of instructions on sport skill learning in children. Studies have demonstrated differences in motor learning between children and adults. For instance, children tend to show a slower development of automaticity (Ruitenbergh, Abrahamse, & Verwey, 2013) and of movement representations (Gabbard, Caçola, & Bobbio, 2011). In addition, children appear to be more vulnerable to interference from distracters relative to adults (Bjorklund & Harnishfeger, 1990; Davidson, Amso, Anderson, & Diamond, 2006; Ordaz, Davis, & Luna, 2010). Also, children differ from adults in their capacity for top-down control of attention (Karatekin, 2004;

Wendelken, Baym, Gazzaley, & Bunge, 2011). Thus, further studies with children seemed desirable. In addition, control groups without attentional focus instructions were lacking in previous studies with children (Chiviacowsky *et al.*, 2013; Emanuel *et al.*, 2008; Wulf *et al.*, 2010). Therefore, in the present study, we examined the influences of external versus internal focus instructions, as well as a control condition, on the learning of the forehand tennis stroke in children. Learning was assessed by retention and transfer tests two days after the practice phase. We hypothesized that external focus instructions would benefit learning compared with internal focus or no focus instructions.

## Method

### Participants

Forty-five children (21 girls and 24 boys), ranging in age from 10 to 12 years (mean age 10.98;  $SD = 0.72$ ), with no previous experience with tennis specific motor skills, participated in the study. Oral assent was obtained from the participants, and informed consent from their parents/guardians and the schools. The participants were unaware of the purpose of the experiment, and the task was novel to all of them. The study was approved by the university's ethics committee.

### Apparatus and task

Participants were asked to perform forehand tennis strokes with the dominant arm. The goal was to hit a target placed on the opposite side of a mini tennis court (6 x 11 m; see Figure 1). The target was placed in the center of the opposite half of court, at a distance of 9 m from the participant. It consisted of a 2.45 x 2.45 m piece of colored cloth. The center of the target area measured 35 x 35 cm. The participant's task was to hit the ball with a tennis racquet over a net (1.07 m in height, measured in the center) and hit the center square. If a ball first bounced in the center of the target, a score of 4 points was recorded. Fewer points (3, 2, 1) were given if the ball hit one of the surrounding zones (35 cm in width) or missed the target area completely (0 points). A children's racquet (25 in.) and low-compression balls (50%) designed to bounce lower and move more slowly than official tennis balls were used in this study.

### Procedure

Participants performed the task individually. They were randomly assigned to the external focus, internal focus, or control groups, with the same numbers of boys (8) and girls (7) in each group. The experimenter explained and demonstrated the forehand stroke twice to each participant before the beginning of the practice phase. Specifically, participants were instructed to use the dominant hand to hold the racquet, using the "continental" grip. It is also known as "hammer grip" because it is naturally obtained when holding the racquet as if it were a hammer. The

base knuckle of the index finger is placed on bevel number 2 of the tennis racquet grip, and the heel pad of the hand is placed between bevels number 1 and 2 (e.g., Tagliafico, Ameri, Michaud, Derchi, Sormani, & Martinoli, 2009). Participants were also asked to stand behind the middle of their baseline, with the racquet in their dominant hand and the ball in the other hand. Participants were instructed to release the ball themselves and strike it after one bounce, and attempt to hit the target. After these general instructions, participants in the internal focus group were asked to focus their attention in the movement of their arm, whereas participants in the external focus group were asked to focus on the movement of the racquet. Participants in the control group did not receive any attentional focus instructions. External or internal focus reminders were provided after every 10<sup>th</sup> trial during the practice phase, instructing participants to keep focusing on the arm movement (internal focus group) or on the racquet movement (external focus group) during the trials. All participants performed 60 practice trials. Retention and transfer (from the right side of the court; see Figure 1) tests were conducted two days after the practice session and consisted of 10 trials each. No instructions or reminders were given during the tests.

*Data analysis*

Accuracy scores were averaged across blocks of 10 trials for the practice phase and were analyzed in a 3 (groups) x 6 (blocks) analysis of variance (ANOVA) with repeated measures on the last factor. For the retention and transfer tests, scores were averaged across all 10 trials and analyzed in univariate ANOVAs. An alpha level of .05 was used as the threshold for significance, and Tukey’s *post-hoc* test was used for follow-up analyses.

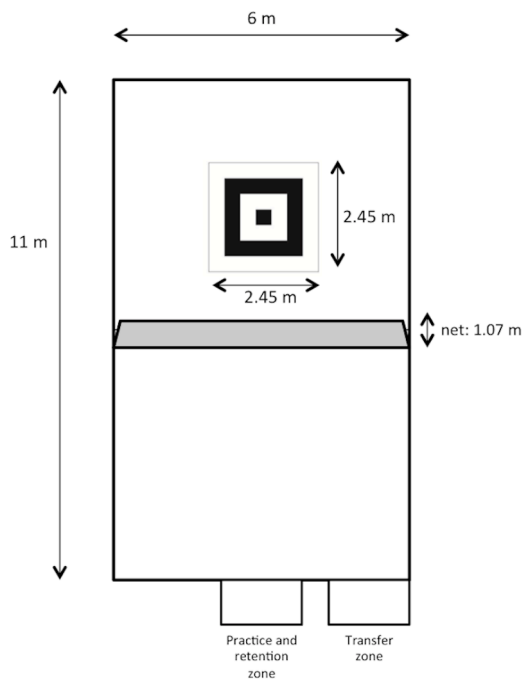


Figure 1. Schematic of the tennis court and target.

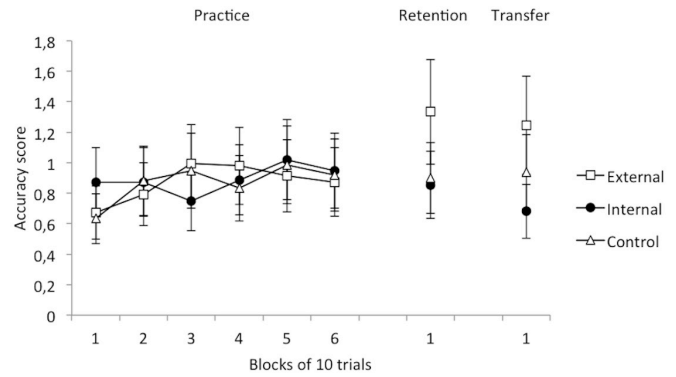


Figure 2. Accuracy scores of the external focus, internal focus, and control groups during practice, retention, and transfer. Note: Error bars represent standard errors.

**Results**

*Practice*

All groups increased their accuracy scores across the practice phase (see Figure 2, left). The main effect of block,  $F(5, 210) = 2.59, p < .05, \eta_p^2 = .06$ , was significant. The main effect of group,  $F(2, 42) < 1$ , and the interaction of block and group,  $F(10, 210) = 1.11, p > .05$ , were not significant.

*Retention*

The external focus group outperformed both the internal focus and control groups on the retention test (Figure 2, middle). The main effect of group was significant,  $F(2, 42) = 5.43, p < .01, \eta_p^2 = .20$ . *Post-hoc* tests confirmed that the external focus group differed from both the internal focus and control groups ( $p < .05$ ), whereas the internal focus and control groups’ performances did not differ.

*Transfer*

The external focus group also demonstrated the highest accuracy scores on the transfer test with a greater target distance. The main effect of group was significant,  $F(2, 42) = 5.62, p < .001, \eta_p^2 = .21$ . *Post-hoc* tests indicated that the external focus group differed from the internal focus group ( $p < .001$ ), but it did not differ significantly from the control group ( $p > .05$ ). Also, the internal focus and control groups did not differ from each other.

**Discussion**

Children learning a tennis forehand stroke benefited more from external focus instructions that directed their attention to the movement of the racquet as compared with internal focus instructions that directed attention to their arm motion, or no specific focus instructions (control group). The learning advantages seen with external relative to internal focus instructions

are consistent with previous studies with typical children (Wulf *et al.*, 2010), or children with intellectual disabilities (Chiviawsky *et al.*, 2013), as well as studies with adult learners (see Wulf, 2013). While control groups have been lacking in studies with children, in studies with adults control conditions almost always resulted in similar performance or learning as internal focus conditions—both of which were inferior to external focus conditions (e.g., Freudenheim *et al.*, 2010; Wulf *et al.*, 1998, Experiment 1; Wulf *et al.*, 2009). This was the case for the retention test of the present study as well. However, on the transfer test the control group did not differ significantly from the external focus group. We suspect that the novel situation on the transfer test (i.e., novel angle and target distance) turned the target into a more prominent external focus cue. That is, because control group participants had not been given explicit focus instructions, the need to “recalibrate” their movements due to the greater target distance might have promoted more of an external focus on the target. Apparently, this was not the case to the same extent in the internal focus group, which had been given explicit focus instructions during the practice phase. Participants may have remembered those instructions, but it is more likely that the instructions had a more permanent detrimental effect on learning (Wulf, Weigelt, Poulter, & McNevin, 2003).

As in previous studies, instructions that differed only in one or two words (e.g., “the racquet” versus “your arm”) produced significant differences in learning. It has been suggested that the mere mention of body parts may promote a focus on the self that leads to self-regulatory processes, which cause “micro-choking” episodes and degrade performance (Wulf & Lewthwaite, 2010). A reference to body parts (e.g., arm) in internal focus instructions seems to be sufficient to induce a self-focus, with the consequence that movement coordination is less than optimal. As studies have demonstrated, a focus on body movements leads to inefficient co-contractions and superfluous recruitment of motor units (e.g., Lohse & Sherwood, 2012). The result is a decrease in accuracy. Even in control conditions, participants might spontaneously focus on their own movements (e.g., Pascua, Wulf, & Lewthwaite, 2014), resulting in similarly detrimental effects on learning as specific internal focus instructions. The present findings suggest that children, similar to adults, seem to have a tendency to become self-focused. (In future studies with children, it might be useful to ask participants in control conditions what they focused on.) By directing performers’ attention away from the coordination of their body movements *and* to the intended goal or outcome of their actions, instructions to focus externally can perhaps be seen as serving a dual purpose.

In conclusion, the present results demonstrate how the wording of instructions can impact on sport skill learning in children. Directing attention externally through instructions or feedback enhances learning not only in adults, but also in children. In future studies it may be fruitful to examine variables that may mediate learning with different attentional foci, such as learners’ self-efficacy or positive affect. This might provide more insight into the mechanisms underlying the benefits of an external attentional focus.

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