Internal focus of attention decreases adolescents' motor learning

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Abstract

Introduction: Motor skill acquisition is influenced by motivational and attentional factors. Among these, the focus of attention—internal or external—plays a critical role in performance and learning. This study examined the effects of different attentional foci on motor skill learning in adolescents.
Methods: Seventy-seven adolescents (M = 16.5 years, SD = 1.4) of both sexes performed a Response Time task. After one pretest trial, participants completed 16 practice trials and were assigned to one of four groups: internal focus (attention on arm movement), proximal external focus (attention on lights), distal external focus (attention on a green cone), or control (no focus instruction). Twenty-four hours later, participants completed retention and transfer tests (three trials each), with the transfer test involving a change in the light stimulus color.
Results: The internal focus group showed significantly worse performance than the proximal and distal external focus groups, as well as the control group, across the practice, retention, and transfer phases.
Discussion: An internal focus of attention may disrupt motor learning by overloading cognitive processes or interfering with automatic control mechanisms. In contrast, external foci appear to support more efficient motor learning.
Conclusion: The findings suggest that encouraging an external focus of attention—either proximal or distal—enhances motor skill learning in adolescents, while an internal focus may be detrimental. These insights can inform instructional strategies in educational and sports settings.

Keywords

External focus; Instruction; Motor behavior; OPTIMAL theory.

Resumen

Introducción: La adquisición de habilidades motoras está influenciada por factores motivacionales y atencionales. Entre ellos, el foco de atención—interno o externo—desempeña un papel clave en el rendimiento y el aprendizaje. Este estudio examinó los efectos de diferentes focos atencionales en el aprendizaje de una habilidad motora en adolescentes.
Métodos: Setenta y siete adolescentes (M = 16.5 años, DE = 1.4), de ambos sexos, realizaron una tarea de Tiempo de Respuesta. Después de una prueba previa, los participantes completaron 16 ensayos de práctica y fueron asignados a uno de cuatro grupos: foco interno (atención al movimiento de los brazos), foco externo proximal (atención a las luces), foco externo distal (atención al cono verde), o grupo control (sin instrucciones de atención). Veinticuatro horas después, se realizaron pruebas de retención y transferencia (tres ensayos cada una), esta última con un cambio en el color del estímulo luminoso.
Resultados: El grupo de foco interno presentó un rendimiento significativamente inferior al de los grupos con foco externo proximal, distal y al grupo control durante la práctica, la retención y la transferencia.
Discusión: El foco interno puede perjudicar el aprendizaje motor al interferir con los procesos automáticos. En cambio, un foco externo favorece un aprendizaje más eficiente.
Conclusión: Fomentar un foco externo de atención mejora el aprendizaje de habilidades motoras en adolescentes, mientras que el foco interno puede resultar perjudicial. Estos hallazgos son relevantes para contextos educativos y deportivos.

Palabras clave

Enfoque externo; Instrucción; Comportamiento motor; Teoría OPTIMAL.

Introduction

Sports coaches, physical educators (PE) teachers, and therapists employ various strategies daily to improve learning, with verbal instructions and feedback being the most common (Omarov et al, 2025). These strategies can convey essential information about the movement, motivate the learner, and focus their attention on specific goals during the task, providing enhanced motor skill acquisition through time and practice. However, how these skills are taught and practiced has changed considerably in recent decades (Chiviacowsky, 2020, 2022; Wulf et al., 2010). In the last years, a growing number of investigations have shown that the acquisition of motor skills varies according to motivational and attentional factors (Wulf et al., 2010; Wulf & Lewthwaite, 2016), with the learner's attentional focus being the subject of much research (Lohse et al., 2014; Neumann, 2019; Saemi et al., 2022; Wulf, 2012).

Directing the learner's attention can enhance the conscious processing of a specific cue (Saemi et al., 2022). Therefore, the information using instruction or during feedback can direct the learner's attention to a specific goal on the body movement (movement-oriented focus), known as an internal focus (IF), or on the effects of these movements on the environment (external focus - EF) (Wulf, 2012; Wulf et al., 1998). In general, the literature has shown that the EF provides enhanced motor skill acquisition over the IF, regardless of age, sport, task, or condition (Becker & Smith, 2015; Chiviacowsky et al., 2010; Chua et al., 2019, 2021; Flôres, Schild, et al., 2015; Silva et al., 2017; Wulf et al., 2015). The advantages of the EF have also been demonstrated by comparing different distances of the EF, either near or far from the learner (proximal external focus – PEF; distal external focus - DEF), enabling higher levels of motor learning and performance when compared to IF (Bell & Hardy, 2009; Flôres, Menezes, et al., 2015; Malek et al., 2012; McKay & Wulf, 2012; McNevin et al., 2003; Singh et al., 2022). For instance, imagine a learner practicing a golf swing. With a PEF, they might focus on the movement of the club head during the swing, which is relatively close to them. In contrast, a DEF would involve focusing on the desired path or target of the ball at a given distance. Investigations suggest that focusing on a distal target often enhances performance and learning more effectively than focusing on a nearby aspect of the movement, and both are generally more effective than IF, which might involve concentrating on one's arm or shoulder movements during the swing (Chua et al., 2021; Flôres et al., 2024).

According to the Constrained Action Hypothesis (McNevin et al., 2003; Wulf, McNevin, et al., 2001; Wulf, Shea, et al., 2001), the EF facilitates a more automatic movement control, while an IF evokes conscious movement control, disrupting the motor system, consequently impairing performance and learning. The IF also usually provides lower learning levels than control conditions (no-focus group) (Flôres, Schild, et al., 2015; Stoate & Wulf, 2011). Hence, how learners use information from the environment to guide their actions may contribute to or limit their process of motor skills acquisition (Wulf, 2007).

The advantages of adopting an EF, mostly in adults, have been vastly shown in the literature (Makaruk et al., 2020; Wulf et al., 2015; Wulf & Lewthwaite, 2010). In their original investigation, Wulf et al. (1998) performed two experiments to analyze the effects of directing attention in adults. In experiment 1, their results showed that participants focusing on the pressure applied on the wheels of a ski simulator exhibited higher levels of motor learning compared to the group instructed to focus on the force exerted by the feet. During experiment 2, Wulf and colleagues replied to the first experiment but used a different task. Using a stabilometer, the authors found that participants who focused on the balance platform (EF) markers showed better learning than those instructed to focus on the feet (IF).

Since then, many studies have indicated that EF can improve this population's motor learning and performance levels (Chiviacowsky et al., 2010; Shimi et al., 2021; Wulf et al., 2015). Despite that, few investigations have still studied this topic in adolescents (e.g., McNamara et al., 2017; Saemi et al., 2022; Tse & van Ginneken, 2017). For instance, Saemi et al. (2022) discovered that EF enhances the performance of experienced adolescent swimmers, but no significant effects were observed for beginners. Similarly, another experiment (McNamara et al., 2017) found that adolescents with moderate visual impairment induced by an EF exhibited improved dynamic balance performance. Still, no differences were observed between the groups when the visual impairment was profound. Schwab et al. (2019) found benefits of adopting an EF instead of an IF during a free kick task in football.

Marchant et al. (2018) observed that increased distances on children's focus of attention can provide better levels of motor performance during a standing long jump task. Hence, research has shown that children aged 6 to 10 can improve their dynamic balance more effectively using DEF than IF or PEF

(Flôres, Schild, et al., 2015). Furthermore, recent systematic reviews showed that the direction of instructions/feedback can influence the performance and learning of motor skills, but only studies using children were assessed so far (Flôres et al., 2024; Van der Veer et al., 2022). Research has also provided insights into the influence of different attentional focus strategies on response time tasks; however, none of these studies have been conducted with an adolescent sample (Allen & Smith, 2012; Fogarty et al., 2018; Kovacs et al., 2018; Remaud et al., 2013; Zheng et al., 2022). In addition, the literature has also pointed out that attention capacity decreases over time, especially at the end of the school period (Rueda & Castro, 2010).

PE teachers, sports coaches, and therapists apply these principles daily, highlighting their relevance beyond research (Simpson et al., 2024). Based on the OPTIMAL theory, the authors analyzed high school PE teachers during 10 PE classes. Their results showed they used more IF instructions than internal ones; however, the authors did not differentiate between PEF and DEF. Thus, despite the growing interest in this topic in recent years (Van der Veer et al., 2022), further research is needed to explore the effects of different types of attentional focus in school-aged adolescents. Therefore, to the best of our knowledge, there is still little evidence on the effects of focus of attention on adolescent motor learning. As far as we know, no previous investigation has examined the effects of different attention focuses on adolescents' motor learning in a response time task. Hence, this research aimed to investigate the effects of different attention focuses on learning a novel motor skill in adolescents. Based on previous findings with similar tasks (Kovacs et al., 2018; Zheng et al., 2022) and similar age-range samples (Kovacs et al., 2018; Remaud et al., 2013). Adolescents practicing under an IF are expected to show worse performance and learning than the other groups. In addition, DEF adolescents are expected to outperform adolescents practicing under PEF in both experimental phases.

Method

Participants

Participants were randomly recruited from a Portuguese public school, with eligibility criteria including being an adolescent with no prior experience with the task, no injuries or developmental disorders, and a willingness to participate. Participants were excluded from the final sample if they did not attend the second day of testing or had injuries or developmental disorders (provided by a parental self-report). Therefore, 77 adolescents participated in this investigation (three participants were excluded after missing the second-day testing), of both sexes, with no previous experience with the task, and who consented to participate (Table 1). Regarding sports participation, 71.8% of the sample practice, and 28.2% do not. The participants' sample size was based on previous literature concerning the focus of attention (Hadler et al., 2014; Palmer et al., 2017).

This investigation was approved by the University Ethics Committee (P02-S09-27.04.22). Parental consent and participants' oral assent were obtained before beginning the experiment. All procedures followed the ethical standards of the Declaration of Helsinki for the Study of Humans (2014).

Table 1. Descriptive values of the sample.

Variables	All participants		Male participants		Female participants	
	N	M±SD	N	M±SD	N	M±SD
Age (years)	77	16.49 ± 1.44	39	16.86 ± 1.51	38	16.11 ± 1.28
BMI (kg/m^2)	77	21.77 ± 2.93	39	21.94 ± 2.73	38	21.59 ± 3.14
Sports (hours/week)	77	6.16 ± 3.73	39	7.51 ± 4.27	38	4.76 ± 2.44

Procedure

Participants were conveniently selected, matched for sex and age, and randomly assigned to one of the following groups: IF (10 male, 16.78 ± 1.24; 10 female, 16.15 ± 1.36), PEF (10 male, 16.21 ± 1.41; 9 female, 16.26 ± 1.48), DEF (9 male, 17.67 ± 0.87; 10 female, 15.62 ± 1.18), and Control (10 male, 16.87 ± 2.07; 9 female, 16.46 ± 1.15). All tests were performed in a restricted room, without any interference or sound that could disrupt the concentration of the participants. None of the participants had any information about the goals of the experiment.

Before the start of the testing, all participants were instructed to press the pods as quickly as possible when the pods lit up. Based on previous literature (Abdollahipour et al., 2017; McNamara et al., 2017; Silva et al., 2017), participants performed a pretest trial immediately followed by 16 trials during the practice phase. The IF, PEF, and DEF groups received specific reminders (Table 2) directing attention during the practice phase. Reminders were provided every three trials (1st trial, 4th trial, 7th trial, 10th trial, 13th trial, and 16th trial).

After 24 hours, participants performed three trials in the retention phase to assess how well they retained the skill without changing task conditions. Immediately following the retention phase, participants proceeded to the transfer phase, completing three more trials. The main difference in the transfer phase was a change in the color of the pods, introducing a slight variation in the task (De Giorgio et al., 2018). This color change tested participants' ability to apply the learned skill to a slightly modified context, assessing the adaptability of their learning.

Table 2. Attention focus instructions

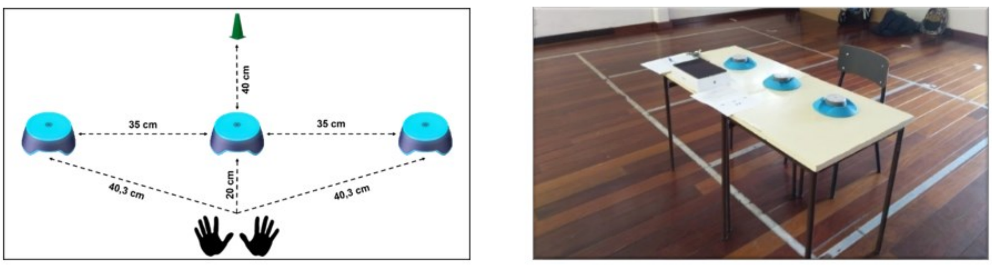
Group	Instruction
Control	No instruction focus, or feedback.
Internal Focus	"You should pay attention to the movement of your arms."
Distal External Focus	"You should pay attention to the green marker in front of you."
Proximal External Focus	"You should pay attention to the lights that turn on."

Response Time task

The test goal was to measure the time interval between the presentation of a visual stimulus and the participant's response (measured in milliseconds). The test requires three pods arranged in a row on a table (see Figure 1). The pods' position was always the same, regardless of participants' arm length. To perform the task, the participant should sit in front of the pod in the center, with their hands positioned over the table. The task started with a beep sound, and the lights went on and off alternately randomly (random time intervals between 0.5 and 1.5 milliseconds between them). The lights turn off only when the participant presses the pod with the light on.

This task's maximum time was 15 seconds, with 10 seconds of recovery between trials. The number of lights that appeared depended on how quickly the participant reacted. If their RT was faster, more lights appeared. This means the task became more challenging for participants who responded quickly while keeping everyone's total time the same. Thus, this design ensures that the task dynamically adapts to the participant's performance level, providing a more challenging experience for quicker participants while keeping the task duration constant for everyone. Therefore, the frequency of light activation was dependent on the participant's RT, with a greater number of lights appearing for lower RTs.

Figure 1. Response Time task



a) Details of the trial setup b) Setup

Data analysis

Descriptive analysis was employed to characterize the sample using mean and standard deviation. Using Levene's test, the Kolmogorov-Smirnov test was used to verify data normality and the homogeneity of variances. RT was used as a dependent variable, and data were analyzed separately according to the phases: pretest, practice (4 blocks of 4 trials), retention (1 block of 3 trials), and transfer (1 block of 3 trials). The RT in the pretest was analyzed using the one-way ANOVA with LSD post-hoc. The practice phase was analyzed using two-way mixed ANOVA with repeated measures in the last factor, 4 (groups) x 4 (blocks of trials). The Greenhouse-Geisser adjustment was used to report F-values in repeated measures factors. The retention and transfer phases, similarly to the previous ones, were also analyzed by one-way ANOVA (TR x 4 groups: DEF, PEF, IF, C) with LSD post hoc, separately in each phase. Partial eta^2 (η^2) was interpreted as small ($\eta^2 \geq 0.01$), medium ($\eta^2 \geq 0.06$), or large ($\eta^2 \geq 0.14$) (Cohen, 2013). The Statistical Package for Social Sciences (SPSS, IBM Corporation) software version 29.0 was used, with an alpha level of significance of 0.05.

Results

Pretest

The results for the pretest indicate no differences [F (3, 73) = 0.12, p = 0.95, η^2 = 0.005] between the groups (Figure 2).

Practice

There was no difference between trial blocks [F (3, 219) =1.08, p = 0.36, η^2 = 0.01] and interaction between blocks and groups [F (9, 219) =.66, p = 0.74, η^2 = 0.03]. However, there was a significant difference between groups [F (3, 73) = 5.61, p < 0.001, η^2 = 0.19]; all groups outperformed the IF - DEF (p < 0.001), PEF (p < 0.001), and control (p = 0.04) groups (Figure 2).

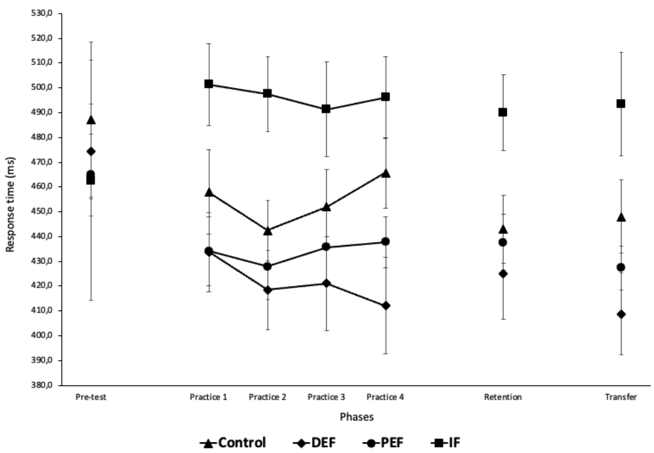
Retention

The retention phase showed significant differences between the groups [F (3, 73) = 3.78, p = 0.01, η^2 = 0.13], indicating lower performance of the IF compared to the DEF (p = 0.01), the PEF (p < 0.00), and the control (p = 0.03) groups. No other significant differences between the groups were found (Figure 2).

Transfer

The group main effect showed a significant difference [F (3, 73) = 5.26, p< 0.00, η^2 = 0.18]. The IF group showed inferior performance compared to the DEF (p < 0.00), the PEF (p < 0.00), and the control (p = 0.05) group. No other differences between the groups were found (Figure 2).

Figure 2. Response Time of the internal focus (IF), proximal external focus (PEF), distal external focus (DEF), and Control groups during the pretest, Practice phase (A1-A4), and Retention and Transfer tests.



Discussion

In the present research, our primary goal was to analyze the effects of different foci of attention on learning a motor skill in adolescents. As expected, the IF participants presented higher RT than the other groups, resulting in lower performance. These results occur through the practice, retention, and transfer phases, showing that IF can impair RT even during the learning phase. In general, our results agree with previous literature in adults (Roshandel et al., 2017), typically developed children (Hadler et al., 2014), and the elderly (Chiviacowsky et al., 2010), showing that the EF outperformed the IF.

Our findings also demonstrated that an enhanced distance focus from the body (DEF) provided benefits similar to PEF for the learner in an RT task. One of the reasons for the lack of difference could be the distance to the marker (about 40 cm, see Figure 1), which may have interfered with the participants' visual search. Comparably, these effects partially corroborate results from previous studies observed in children (Flôres, Schild, et al., 2015), where PEF and DEF did not differ, but the DEF group was the only one that outperformed the control group during the learning test. Although no difference was observed between the EF groups, the benefits of adopting a DEF concerning a PEF have been previously observed in balance skills (McNevin et al., 2003), golf swing accuracy (Bell & Hardy, 2009), javelin throwing (McKay & Wulf, 2012) and jumping distance (Porter et al., 2012) in adults. It has been suggested that the DEF is more effective, bringing more clarity to the performer and avoiding possible noise and distractions (for meta-analysis, see Chua et al., 2021). Furthermore, our findings revealed no differences between the EF conditions and the control group. The possible explanation for the null effect presented is that participants in the control group may also have adopted an EF. The lack of a manipulation check prevents us from confirming such an explanation.

The Constrained Action Hypothesis has supported the benefits of EF of attention (McNevin et al., 2003; Wulf, McNevin, et al., 2001; Wulf, Shea, et al., 2001), which suggests that an EF allows the motor system to function more automatically and efficiently. This is because an EF reduces the need for conscious Control of movement and working memory, allowing the motor system to operate more efficiently. By decreasing the time to process information in the brain, an EF can help learners react more quickly to their environment and make better decisions, leading to enhanced performance. In addition, the OPTIMAL Theory (Wulf & Lewthwaite, 2016) suggests that practice conditions with adopting an EF may facilitate the coupling of goals and actions, aiding the directing of attention to the task goal and preventing disruptive attentional drift from the task goal. The success resulting from the EF of attention increases expectations of success for future performance, stimulating the dopaminergic response, which contributes to the consolidation of information in memory (Camacho Lazarraga, P. (2019).

Perhaps one of the main limitations of the present investigation was not using a questionnaire to control participants' attentional focus. This procedure could have provided insights into where the control group directed their attention, potentially explaining why their performance did not differ significantly from the DEF and PEF groups. We speculate that the control group may have naturally adopted an EF during practice. In addition, children's developmental disabilities were self-reported by their parents/guardians, which could introduce additional variability due to the potential subjectivity of their perceptions. Third, the study only investigated the effects of attentional focus on adolescents learning an RT task. Finally, the RT task only provides the hand-eye RT and was not compared to other RT types. Therefore, future studies could investigate the effects of attentional focus on the adolescent learning of other RT tasks and motor skills, especially those used during sports participation.

Practical applications

Our results suggest some practical applications for professionals working in the field of motor learning and performance. PE teachers can apply the findings by encouraging a DEF rather than an IF when teaching motor skills to adolescents. Instructions that direct students' attention to the effects of their movements in the environment (e.g., focusing on a target rather than their limb movement) may enhance skill acquisition and RT performance. Furthermore, therapists can improve movement efficiency and reduce the cognitive load on patients using EF. This approach aligns with the Constrained Action Hypothesis, which suggests that EF promotes more automatic Control over movements, likely benefiting patients by improving their responsiveness and reducing the potential for conscious disruptions in movement execution. Tailoring cues to the environment (e.g., "reach for the handle" rather than "move your arm") may be advantageous for skill retention and adaptability. Lastly, this study highlights the potential for further exploration into the age-specific impacts of attentional focus. The results also open pathways for exploring the effects of EF at varying distances (PEF vs. DEF) in dynamic and high-stakes environments, such as competitive sports settings, to assess if and how EF improves decision-making and RT.

Conclusions

The current findings expand the existing body of research on attentional focus and motor learning in adolescents. This is the first study to examine the effects of different attentional foci (internal, proximal external, and distal external) on motor skill learning in a response time task among this population. Results consistently showed that an IF of attention impaired performance, while both EF conditions led to significantly better outcomes during practice, retention, and transfer phases. Finally, we believe these findings offer valuable guidance for professionals working in educational and therapeutic settings, who should prioritize IF instructions, particularly distal ones, when teaching motor skills. Thus, the implementation of these strategies might improve performance and RT. Sports coaches can implement similar strategies to improve performance and reaction time, helping them develop more automatic and efficient motor responses.

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