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Influence of attentional focus distance on motor learning of skilled children

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Abstract: In adults, longitudinal external focus benefits the motor performance of high-skilled performers. While low-skilled performers benefit from a proximal external focus. Children seem to respond differently to adults regarding the effects of attentional focus on motor learning, and the cause of this difference remains unclear. The present study investigated the effects of the attentional focus distance on motor performance and learning of high-skilled children. Forty-five 8-years-old high-skilled children were divided into three groups with different attentional focus distances (internal, proximal external and distal external). All participants practiced an inside-of-the-foot kick soccer task in 5 blocks of 10 trials. Motor performance was assessed through absolute and variable errors before the practice (pre-test), immediately after the practice (post-test), and after 24-hours (retention test). As inferential analyses, we run an ANOVA two-way (3 groups x 3 times) for absolute and variable errors. For absolute error, there was an effect in time ($p < .0001$), with improvement across practice and retention; also, the distal external group demonstrated lower absolute error than other groups ($p < .0001$). In contrast, proximal external focus provides a lower variability inter-trials (but with a lower score) ($p < .001$). Our findings suggested that distal external attentional focus benefits motor performance and learning of skilled children. Practice and experience are the predominant factors in this interaction, as it happens in adults. Childhood characteristics seem not to influence this process.

Keywords: Motor learning; attentional focus; distance effect; children; soccer; childhood.

1. Introduction

Motor learning is a set of processes associated with practice or experience leading to relatively permanent changes in the capability for skilled movement (Schmidt et al., 2019). Several studies have identified that directing the attention consciously to the intended movement effect (external focus) enhances motor performance and learning if compared to directing the attention to body movements (internal focus) (Wulf, 2013; Wulf & Lewthwaite, 2020).

The superiority of external focus over internal focus on motor learning has been based on the Constrained Action Hypothesis (Wulf, McNevin, et al., 2001; Wulf, Shea, et al., 2001). In this view, the external focus promotes an automatic mode of movement control, enhancing movement efficiency. In contrast, the internal focus constrains the

"normally" regulated coordination parameters, impairing performance.

Additional researches have identified that increasing the distance of the external focus from the body enhances its effectiveness on motor performance and learning in adults. Given that, a more distal external focus facilitates the distinguishable between the movement effect and the body movements, increasing the automaticity of the movement (McNevin et al., 2003).

The superiority of motor performance and learning of more distal external focus was confirmed in adults submitted to the practice of a balance task (stabilometer platform) (McNevin et al., 2003), a golf task (Bell & Hardy, 2009; Kearney, 2015), a dart-throwing task (McKay & Wulf, 2012) and a jump task (Porter et al., 2012).

Additionally, the optimal distance of the external focus may depend on the level of the participant's expertise. Singh & Wulf (2020) identified that low-skilled practitioners benefited from a proximal external focus in a pass volleyball task. In contrast, high-skilled performers demonstrate a benefit for a distal external focus.

Until now, no study has investigated the distance effect of the attentional focus in children. In fact, the attentional focus effect (internal versus external focus) on motor performance and learning of children remains unclear. Some findings demonstrated benefits on motor performance and learning in the adoption of an external focus (Abdollahipour et al., 2020; Ashraf et al., 2017; Brocken et al., 2016; Olivier et al., 2008; Palmer et al., 2017; Teixeira et al., 2017; Wulf et al., 2010), while other did not found it (Emanuel et al., 2008; Krajenbrink et al., 2018; van Abswoude et al., 2018), which indicates that children had characteristics that influence the attentional focus effect (internal versus external focus).

With actual state of the art, it is difficult to determine whether children are influenced differently than adults regarding distances of attentional focus on motor learning. Thus, we investigated the effects of the attentional focus distance on motor performance and learning of skilled children.

2. Materials and Methods

Subjects - We used G*Power 3.1 software to sample size calculation. Considering an effect size of 2.19 (based on the score in the shooting task in De Giorgio et al. (2018)), α = 0,05 and power of 0.80, 6 participants per group were suggested.

Forty-five children (all males, *M*age = 8.84; SDage = 1.18) with experience at least 1 year of soccer training participated in this study. All children were enrolled in a soccer training center. The following inclusion criteria were employed: chronological age between 7 and 9 years, right-lower limb dominance, and experience of at least 1 year of soccer training confirmed by the soccer training center register, without continuous-1 month practice lack during this period. The Ethics Committee of the University approved the study (protocol n. 29074920.6.0000.5209). Legal guardians and participants signed the assent and consent terms, respectively.

Instrumental - For the task, we adopted the shooting test used by De Giorgio et al. (2018). The goal of the task was to kick as accurate and powerful as possible a soccer ball (Topper, model Slick II -, with a circumference of 62 - 64 cm and a weight of 400 - 440 grams) in a 1meter-goal placed 10 meters from the ball. For that, the participants should use a push kick or also called inside-of-the-foot kick. The goal was composed of two cones with a distance of 1 meter. At 3 meters from the center, two more cones were placed, one on each side, and at 5 meters from the center, there were more 2 cones, one on each side. The cones had a height of 24 centimeters.

If the participant kicked the ball into the centered cones was attributed 10 points. In the case of the ball passing between the centered cones and the cones placed at 5 meters from the center was attributed 7 points. If the ball passed between the 5 meters cones and the outermost cones, it was awarded 3 points. Finally, no score was assigned if the participant did not hit the kick between any positioned distances. When the participant hit the cone was attributed the higher punctuation relative to it. The scores were used to compute absolute and variable

errors, as described below. We tested these scores and distances among cones in a pilot study to set an optimal difficulty level.

Experimental design - We developed a parallel-3-groups controlled experimental design study. Participants were randomly assigned to three groups: Distal External Focus (DISTAL), Proximal External Focus (PROXIMAL), and Internal Focus (INTERNAL). All participants performed the same processes during the experiment, except concerning the attentional focus.

Firstly the participants received verbal instruction about the goal of the task. They also observed a video with a skilled person performing the task. After the demonstration, the following proceedings were provided for each group: DISTAL – The participants received the following statement "direct your attention to the goal between the centered cones". PROXIMAL – Based on De Giorgio et al. (2018), we attached a red tape to the inside-of-the-shoes of the participants. Then, the participants were oriented to "kick the ball with the red tape area". INTERNAL: The participants were oriented to "kick the ball with the inside-of-the-foot". The INTERNAL and PROXIMAL attentional focus instructions were based on De Giorgio et al. (2018). The DISTAL attentional focus instruction was based on the goal of the task, which is advised by the literature (Wulf, 2013).

After receiving the instruction about attentional focus, the participants completed a pre-test composed of 10 trials, followed by practicing 5 blocks of 10 trials after a post-test with the same pre-test conditions was run. We provided attentional focus instruction among all blocks of practice. Following 24 hours, they performed a retention test with the same pre-test characteristics. In a pilot study, we tested the amount of practice and the number of trials per block in the acquisition phase and retention. The participants did not receive instruction concerning the movement parameter, goal or attentional focus in the retention test. The experimental design can be verified in Figure 1.

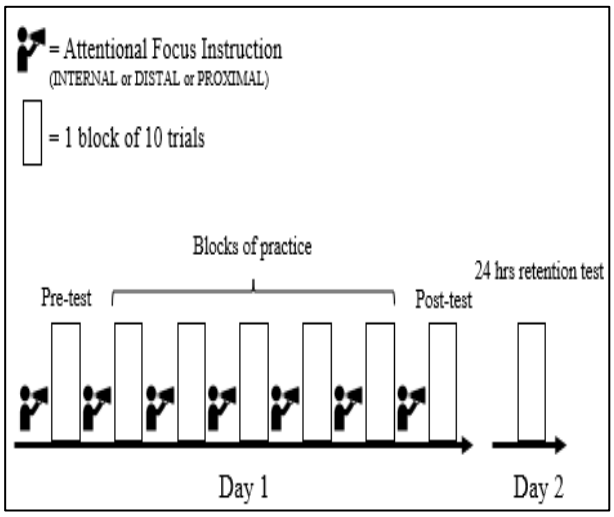

Figure 1. Experimental design.

Statistical Analyses - We used STATISTICA 11.0 (StatSoft Inc., Tulsa, OK, USA) and Microsoft Excel 365 for statistical analyses adopting a 5% significance level. We evaluated the normality and homogeneity of the data with the Shapiro Wilks and Levene tests, respectively.

To assess the magnitude of error in the motor performance, we used the absolute error as recommended by Schmidt et al. (2019), with the following equation:

Absolute Error = $\sum |x_i - T| / n$,

Where x_i = score on trial i, T = score maximum of the target, n = number of trials.

To verify the variability of motor performance, we computed the variable error with the equation (Schmidt et al., 2019):

Variable error = $\sqrt{\sum (x_i - M)^2 / n}$,

Where x_i = score on trial i, M = performer's average score, n = number of trials.

Finally, we analyzed absolute and variable error through a 3 (groups) x 3 (blocks - pre-test, post-test and retention test) ANOVA with repeated measures in the last factor. Tukey test was used for post hoc analyses, and Cohen's d was used to determine effect size. Magnitudes were classified as small (0.2–0.3), medium (0.5–0.8), or large (0.8 and greater).

3. Results

Absolute error - There was no interaction effect. The main effect of blocks was significant, [F (2,84) = 33.73, p < .0001, d = .97]. Tukey post hoc test revealed significance

between pre-test and post-test [$p < .0001$], and pre-test and retention test [$p < .0001$]. The main effect of group also was significant [F (2,42) = 65.49, $p < .0001$, $d = 2.77$], in which DISTAL was significantly different to PROXIMAL [$p < .0001$], and INTERNAL [$p < .0001$]; there was no significant difference between PROXIMAL and INTERNAL [$p = .99$] (see Figure 2).

Variable error - There was no interaction effect. There was a significance in main effect of blocks, [F (2,84) = 6.47, $p < .01$, $d = 1.009$]. Tukey post hoc test revealed significance between pre-test and post-test [$p < .01$], and pre-test and retention test [$p = .01$]. The main effect of group also was significant [F (2,42) = 5.15, $p < .001$, $d = 0.82$], in which DISTAL was significantly different to PROXIMAL [$p < .01$] (see Figure 3).

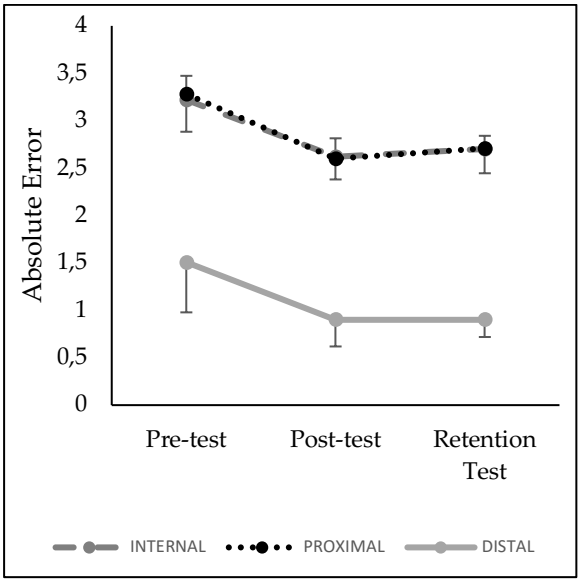

Figure 2. Absolute error for INTERNAL, PROXIMAL, and DISTAL groups across the experiment. Data represent mean and 95% confidence interval.

4. Discussion

We aimed to investigate the attentional focus distance on motor learning of skilled children. Our results indicated that all groups demonstrated performance improvement and maintained it in the retention test. Nevertheless, the participants demonstrated better motor performance and learning under distal external attentional focus, especially for absolute error. We identified that internal attentional focus induced a lower variability than external attentional focus. However, distal external focus induced a more variable performance in higher scores, which indicates a better general performance.

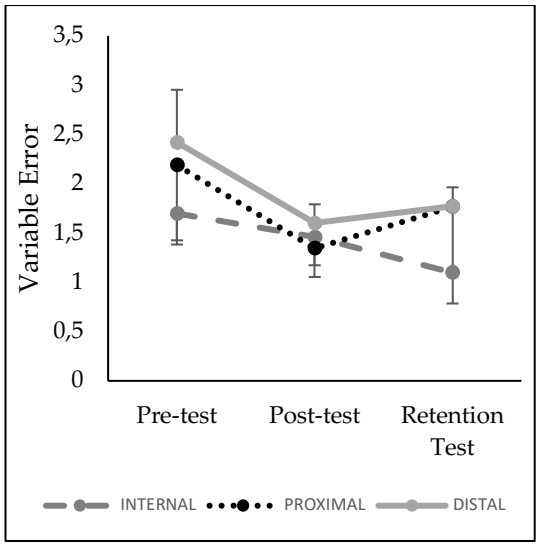

Figure 3. Variable error for INTERNAL, PROXIMAL, and DISTAL groups across the experiment. Data represent mean and 95% confidence interval.

These results indicate that children demonstrate equal responsivity to adults for attentional focus, especially regarding the distance effect. The critical aspect for adults and children is only the expertise level. In this way, childhood characteristics seem not to be a moderator regarding the effects of attentional focus on motor learning.

On the contrary, in our study with highly skilled Brazilian children (with high participation and skill level in soccer training), the proximal external focus did not enhance the performance compared to the internal focus. In this case, we suppose that the expertise level modulates the different findings between our study and De Giorgio et al. (2018). Maybe the difference between our results and De Giorgio et al. (2018) is based on the characteristics of the participants. In our study, the participants were very skilled children, while in De Giorgio et al. (2018), the participants were beginners in soccer practice.

The comparison of our results and De Giorgio et al. (2018) reinforce the hypothesis that children respond equally to adults regarding the attentional focus distance effects. In both cases, the level of expertise seems to modulate what external focus (distal or proximal) provides better motor performance and learning.

In the literature, the studies that did not find superiority for external focus in children justified the results on the idea that children are similar to novice players (Emanuel et al., 2008). Thus, children would lack experience, unfamiliarity with tasks, limited motor repertoire, difficulties focusing their attention during motor performance, and restricted working memory (Emanuel et al., 2008; Krajenbrink et al., 2018; van Abswoude et al., 2018).

This supposition needs to be revisited. For example, the working memory did not predict the extent to which motor learning occurs, neither after internal focus, nor after external focus (Krajenbrink et al., 2018). As well, working memory and attentional resources are highly susceptible to practice, with task-specific enhancement in these outcomes for skilled individuals (Magill & Anderson, 2017). Thus, practice and experience are imperative concerning attentional focus and motor learning. Even if children would demonstrate some characteristics that could influence this process, the practice had a superior effect on it.

Our study had some limitations. We recruited participants from a unique soccer training center; therefore, we had a convenience sample. However, it was necessary to facilitate the control of practice that the participants already had in soccer.

Also, as expertise level was a variable of interest in this study, naïve participants groups (under different attentional focus) could provide more information about the interaction between distance effect (proximal and distal external focus) and expertise level on motor learning in children (with an experimental design similar to Singh & Wulf's (2020)). Nevertheless, for this case, we suggest the investigation with another motor task. Kicking a soccer ball is a task that children, in general, have had some contact with, which does not make them naïve properly.

Further investigation could concentrate on a longitudinal approach in investigating the attentional focus during learning sports in a naturalistic condition. For that, eye tracking during training and measures of working memory and executive functions could reveal the role of attentional focus and its interaction with cognitive functions during (and "online") children's acquisition of sports skills. For us, it is an interesting field for future investigations in sports pedagogy and motor learning.

5. Practical Applications.

The distal external attentional enhances motor performance and learning of skilled children. The effects of proximal external attentional focus are not different from the internal attentional focus on motor learning of skilled children.

6. Conclusions

We conclude that distal external attentional focus is the ideal distance for motor performance and learning of children with an advanced skill level.

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