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External focus of attention and autonomy support have additive benefits for motor performance in children

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ABSTRACT

Objectives: The purpose of this study was to examine the combined effects of external focus instructions and autonomy support on motor performance of children. In addition, we sought to provide evidence for an increased focus on the task goal under the external focus condition by using an inattentional blindness manipulation.
Design: Within-participant design.
Method: Thirty-six children (mean age = 8.5 ± 1.3 years) were asked to perform a bowling task with their dominant hand. Each participant performed 8 trials under external focus (path of the ball), internal focus (hand), or control conditions. In each attentional focus condition, they performed half of the trials under a choice (autonomy support) condition, in which they were able to choose among 4 bowling balls, and a no-choice condition (white ball).
Results: The external focus instruction resulted in greater bowling accuracy (i.e., more pins knocked down) than internal focus and no instructions (control). Furthermore, choice resulted in more effective performance than no choice. Thus, both factors had additive benefits for performance. There was some evidence for an increased task focus in the external condition.
Conclusions: The present results show that, within the same individuals, instructions to adopt an external focus and the provision of a small choice contributed independently to enhance motor performance in children.

1. Introduction

Understanding factors that influence motor skill performance and learning is not only of theoretical interest but also of importance for teaching and training in applied settings (e.g., sports, occupational or physical therapy, performing arts). Effective instructional methods can speed the learning process and lead to higher levels of performance sooner. Over the past two decades, two variables that have reliably been shown to have beneficial effects on motor learning are (a) instructions that promote an external focus of attention (for a review, see Wulf, 2007a; Wulf, 2013) and (b) practice conditions that provide learners with a sense of autonomy, for example, by giving them choices (for reviews, see Sanli, Patterson, Bray, & Lee, 2013; Wulf, 2007b). The present study is concerned with the effects of both variables, as well as their combined effects, on motor performance in children. We provide a brief review of the respective findings and a rationale for the present study next.

1.1. External focus of attention

Numerous studies have demonstrated that an external attentional focus – that is, a concentration on the intended movement effect (e.g., movement of an implement, hitting a target, force exerted against an object) – enhances motor performance and learning compared with an internal focus on body movements, or control conditions without focus instructions. In the first study to

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show this effect (Wulf, Höß, & Prinz, 1998; Experiment 1), the learning of a ski-simulator task was enhanced by instructing learners to focus on putting pressure on the wheels of a platform on which they were standing (external focus), as compared to exerting force with their feet (internal focus), or no focus instructions (control). Since then, benefits of an external focus have been found for various measures of movement *effectiveness*, such as accuracy in dart throwing (e.g., Lohse, Jones, Healy, & Sherwood, 2014; Lohse, Sherwood, & Healy, 2010; Marchant, Clough, & Crawshaw, 2007; Marchant, Clough, Crawshaw, & Levy, 2009), volleyball, soccer (Wulf, McConnel, Gärtner, & Schwarz, 2002), or golf (Wulf & Su, 2007), or temporal evenness in playing music (e.g., Duke, Cash, & Allen, 2011). Similarly, movement *efficiency* is greater with an external focus, as measured for example by reduced muscular activity (e.g., Marchant, Greig, & Scott, 2009; Wulf, Dufek, Lozano, & Pettigrew, 2010; Zachry, Wulf, Mercer, & Bezodis, 2005), heart rate (Neumann & Brown, 2013), or oxygen consumption (Schücker, Anheier, Hagemann, Strauss, & Völker, 2013; Schücker, Hagemann, Strauss, & Völker, 2009). External focus advantages have been shown for the performance and learning of a wide variety of skills, and the effect is independent of the task, performer's skill level, or (dis)ability (for reviews, see Lohse, Wulf, & Lewthwaite, 2012; Marchant, 2011; Wulf, 2013). Similar findings have been obtained with children performing motor tasks such as throwing beanbags (e.g., Chiviacowsky, Wulf, & Ávila, 2013), hitting tennis balls (Hadler, Chiviacowsky, Wulf, & Schild, 2014), or shooting basketballs (Perreault & French, 2015).

The advantages of an external relative to an internal focus of attention have been explained with the constrained action hypothesis (Wulf, McNevin, & Shea, 2001). According to this view, an external focus promotes a more automatic type of control and allows the motor system to take advantage of unconscious and fast control processes. In contrast, an internal focus results in a conscious type of control, causing performers to constrain their motor system by interfering with automatic processes. Support for this notion comes from various converging lines of evidence. For instance, increased automaticity with an external compared to an internal focus has been demonstrated by reduced attentional demands or enhanced secondary-task performance (e.g., Kal, van der Kamp, & Houdijk, 2013; Wulf et al., 2001). According to a recent account, the OPTIMAL theory of motor learning (Wulf & Lewthwaite, 2016), an external focus serves as an important contributor to *goal-action coupling*. By directing concentration away from the self and to the intended movement effect, or task goal, an external focus facilitates the establishment of effective neural connections that are critical for optimal performance. The result is an effective and efficient movement pattern, and enhanced performance and learning.

1.2. Autonomy

Practice conditions in which performers are granted at least some degree of autonomy – for example, conditions in which they are given choices – have frequently been shown to be beneficial for learning (for reviews, see Sanli et al., 2013; Wulf, 2007b). For instance, giving performers the opportunity to request feedback (e.g., Chen, Hendrick, & Lidor, 2002; Chiviacowsky & Wulf, 2002), letting them decide when to use an assistive device (e.g., Hartman, 2007), or choose the number of practice trials (Post, Fairbrother, Barros, & Kulpa, 2014) generally results in more effective learning than (yoked) control conditions. Perhaps even more interestingly, giving performers choices that are incidental to the task has been shown to have a positive effect on learning. In one study (Lewthwaite, Chiviacowsky, Drews, & Wulf, 2015; Experiment 1), allowing participants to choose the color of golf balls led to more effective learning of a putting task than not giving them this choice. Also, balance performance and learning have been shown to be enhanced when performers were given small choices (Wulf & Adams, 2014). Another recent study examined the effect of incidental choices on performance in athletes (Halperin, Chapman, Martin, Lewthwaite, & Wulf, 2016). In that study, kickboxers were, or were not, able to choose the order of different punches delivered to a punch integrator, a force measurement device. When they had a choice, punching velocities and impact forces were higher, compared with a control condition with a prescribed order of punches. Overall, there is consistent evidence demonstrating that giving performers choices – even small ones or ones that are not directly related to the task – has the capacity to facilitate motor skill learning as well as immediate performance. Relatively few studies have included children (e.g., Chiviacowsky, Wulf, Medeiros, Kaefer, & Tani, 2008). In their meta-analysis, Patall, Cooper, and Robinson (2008) found that the effects of having choices were stronger in children than in adults. Moreover, Patall et al. found that incidental choices, or those that are not directly task-relevant, seem to be particularly motivating.

Autonomy has been viewed as a fundamental psychological need (e.g., Deci & Ryan, 2000, 2008) or even biological need (Leotti, Iyengar, & Ochsner, 2010). Potential underlying reasons for the benefits of autonomy-supportive conditions include the facilitation of performance through enhanced processing of task errors and greater self-regulatory responsiveness (Legault & Inzlicht, 2013). Benefits of autonomy also include the opportunity to enhance expectations for future performance (Wulf & Lewthwaite, 2016). Relative to learners who are not given choices, those who have control over an aspect of the practice conditions have been found to have higher self-efficacy (e.g., Wulf, Chiviacowsky, & Cardozo, 2014), a predictor of performance (e.g., Feltz, Chow, & Hepler, 2008). Autonomy-supportive conditions likely instill a sense of agency (e.g., Barlas & Obhi, 2013; Chambon & Haggard, 2012) that increases learners' confidence in being able to do well on a given task. Sense of agency refers to the experience of perceiving control over one's actions. Expected positivity of being in control appears to serve as a predictor of positive outcomes, thus producing the inherent reward of choice (Leotti & Delgado, 2011).

1.3. Combining an external focus and performer autonomy

While each factor independently – an external focus and performer autonomy – has been demonstrated to enhance the performance and learning of motor skills, Wulf, Chiviacowsky, and Drews (2015) found that a combination of both factors had additive benefits for learning. These findings were in line with the notion that autonomy support and an external focus of attention (as well as enhanced performance expectancies) contribute in independent or complementary fashion to skill learning (Wulf & Lewthwaite, 2016; Wulf, Lewthwaite, Cardozo, & Chiviacowsky, 2017). Given the potential significance of those findings for theory and practical application, we deemed it important to try to replicate and extend this effect. Also, in light of the relatively small number of studies related to each variable that included children, we examined whether the performance of a novel motor skill in children would benefit from an external focus and autonomy. Thus, we combined attentional focus instructions (external focus, internal focus, control) and autonomy support (choice, no choice) in a factorial design, which allowed us to determine individual and potential additive effects.

1.4. External focus and goal-action coupling

Finally, we sought to provide support for the notion of goal-action coupling resulting from an external attentional focus (Wulf & Lewthwaite, 2016). By definition, an external focus is a concentration on the intended movement outcome or task goal (Wulf, 2013). Thus, one would expect a greater *task focus* with instructions promoting an external focus relative to internal focus and presumably no focus instructions (control condition). Having an external focus should therefore shift the performer into a higher likelihood of achieving a fluid goal-action coupling, that is, an efficient connection between the movement goal and the resultant action.

Few studies have used dual-task paradigms to examine the degree of task focus under different attentional focus instructions. In one study, Russell, Porter, and Campbell (2014) investigated the effects of attentional focus on dart-throwing accuracy. These authors found that only an external focus on the task goal (flight of the dart) benefitted performance, but not an external focus on a secondary task (touching a sheet with the non-dominant hand) or internal foci (throwing arm, non-throwing hand) – supporting the notion that a task focus, or a focus on the intended movement outcome, is critical. Further empirical support for the idea of enhanced goal-action coupling with an external focus comes from the study by Perreault and French (2015), in which children reported mostly goal-related thoughts in the external focus condition, and self-related thoughts in the internal focus condition.

In the present study, we used a different approach in an attempt to determine the extent of task focus (or goal-action coupling) under external focus, internal focus, and control conditions. We made use of a manipulation typically used to examine inattentional blindness. Inattentional blindness is related to individuals' failure to notice unexpected events or stimuli that are in plain sight, resulting from their (intense) engagement in task-related information processing (Mack & Rock, 1998). Studies have shown that the likelihood of failing to notice an unexpected object increases with task demands (e.g., perceptual load) (Cartwright-Finch & Lavie, 2007; de Fockert & Bremner, 2011), or when an individual intensely focuses on the task goal. A well-known demonstration of the inattentional blindness phenomenon is the failure to notice a "gorilla" walking into a basketball game, stopping and thumping its chest, and eventually leaving, while participants are focused on counting the number of passes between players. About half of the participants typically fail to notice the gorilla (Simons & Chabris, 1999). In the present study, we used the same manipulation to determine whether an external focus would result in participants' missing more unexpected events (i.e., gorillas), due to a greater task focus, relative to an internal or no instructed focus.

1.5. Present study

In summary, the purpose of the present study was to examine individual and combined effects of attentional focus instructions and performer autonomy (choice) on the performance of a bowling task in children. Attentional focus was directed to either the bowling ball (external) or hand (internal), or no instructions were given (control). The choice involved the opportunity to choose among 4 balls (i.e., 3 balls with children's stickers and 1 white ball), as opposed to having to use a white ball (no choice). A within-participant design was used to examine the effects of all possible combinations of attentional focus and choice/no choice. We predicted enhanced performance (number of bowling pins knocked down) with an external focus or choice, with the combination of the two expected to result in the most effective performance. While participants were performing the bowling task, a video showing players passing basketballs was projected behind the target (pins). On the last trial of each attentional focus condition, the video included a gorilla. We hypothesized that, in the external relative to the internal and control conditions, participants would notice the change in the video (or gorilla sightings) to a lesser extent.

2. Methods

2.1. Participants

Thirty-six children (21 females, 15 males) from an elementary school in Madrid, Spain, with a mean age of 8.5 $\pm$ 1.3 years and without any physical or mental disability, participated in the experiment. A priori power analysis showed that 36 participants would be sufficient to identify a significant effect of the two independent variables with a repeated measurements within-subject design with a power (1 - β) of 0.90, effect size of 0.25, and an α of 0.05 (Faul & Erdfelder, 1992). Participants did not have any experience with the task and were not aware of the purpose of the study. The study's protocol was submitted to and approved by the university's institutional review board. The children gave their assent, and informed consent was obtained from the children's parents or legal guardians prior to participation in the study.

2.2. Apparatus and task

Participants' task involved bowling with their dominant hand. Specifically, a toy bowling set was used, and participants were asked to roll a bowling ball (150 g) towards 10 pins. The colored plastic pins were 8 cm wide at their widest point and 25 cm tall. They were laid out in an equilateral triangle formation, with 20 cm between adjacent pins. The distance of the first pin from the start line was 6 m. Scores were based on the number of pins knocked down after each throw. Four white plastic balls (15 cm in diameter) were used. Three of 4 balls had children's stickers (trees, gift boxes, or animals) attached to them (see Fig. 1).

The inattentional blindness manipulation involved 2 3-s clips from the video used by Simons and Chabris (1999). Participants were not familiar with the video. In each video, 3 players wearing white T-shirts and 3 players wearing black T-shirts, pass basketballs to each other while moving around in a random fashion. Videos 1 and 2 were similar, with the exception that, in Video 2, a person wearing a black gorilla costume appeared. The gorilla turned to face the camera, thumped its chest, and then turned away from the camera. A video projector projected the videos onto a 2.5 $\times$ 2.5 m screen placed 30 cm behind the bowling pins. The image of the video was 2 m (horizontal) x 1 m (vertical).

Fig. 1. A participant choosing a bowling ball in the choice condition.

2.3. Procedure

At the beginning of the experiment, the experimenter demonstrated the proper execution of the bowling action to each participant. Participants were asked to stand behind a yellow 1-m line and bowl the ball with their dominant hand by first swinging the ball back, then forward and rolling it towards the pins. All participants performed 2 practice trials to familiarize themselves with the task. Subsequently, they performed 8 trials (plus 1 additional trial; see below) under each of 3 conditions: External focus (EF), internal focus (IF), and control (C). In the EF condition, participants were instructed to "focus on the path of the ball," whereas in the IF condition, they were asked to "focus on your hand." No attentional focus instructions were given in the C condition. In each of the 3 attentional focus conditions (IF, EF, C), participants performed half of the trials (4) under the choice condition and 4 under the no-choice condition. In the choice condition, they were able to choose among 4 bowling balls (3 with different stickers and 1 white ball), whereas in the no-choice condition they had to use the white ball. This procedure was explained to participants before the beginning of the experiment. Thus, they knew that they would perform the task under two conditions. The order of the attentional focus instructions and choice/no-choice conditions was counterbalanced (see Table 1). Attentional focus instructions or reminders were given to the participants during each 30-s interval between trials. On each trial, Video 1 was projected when participants initiated the bowling motion. The projection of the video was controlled manually by the experimenter. The video was 3 s in duration and ended at approximately the time of ball release. Participants were not given any information about the video.

After completing the 8 throws in each focus condition, a manipulation check was conducted. Each child was asked, "What did you concentrate on?". Next, they were asked to indicate, on a Likert scale from 1 (not at all) to 7 (very much), "how much you concentrated on it."

After completing 8 trials in each attentional focus condition, participants were asked to perform 1 additional trial (Trial 9) with the white ball in each condition. On Trial 9, Video 2 (including the gorilla) was projected when participants initiated their throw. After the trial, participants were asked whether they had noticed anything that was different on that last trial. If the answer was "yes," they were asked to describe what they saw. All answers were recorded. The reason for using a white ball on the inattentional blindness trial was to have identical conditions in all attentional focus conditions and to eliminate potential confounds with choice.

2.4. Data analysis

The number of pins knocked down (throwing accuracy) on each trial was considered the main dependent variable. To search for any possible extreme outliers within each condition, a criterion (cut-off scores) as determined by a distance of 2.2 times the interquartile range from the 1st and 3rd quartile was implemented (Hoaglin, Iglewicz, & Tukey, 1986). No outliers were identified. Throwing accuracy scores were averaged across 4 trials and analyzed in a 3 (attentional focus: EF, IF, C) x 2 (choice: yes, no) repeated measures analysis of variance (RM ANOVA) on both factors. To analyze the accuracy on the inattentional blindness trials, a one-way RM ANOVA was conducted.

Assumptions of sphericity were assessed by the Mauchly's test. Greenhouse-Geisser epsilon values were applied to adjust the degrees of freedom when necessary. Bonferroni adjustments were used for all pairwise post-hoc comparisons. The alpha level was set at 0.05 for all the tests. Estimates of effect size were quantified by using two measures. First, partial eta squared (ηp^2) was employed where $\eta p^2 = 0.01$, 0.06, and 0.14 were estimated for a small, moderate, or large effect, respectively (Larson-Hall, 2009). Next, Cohen's d was utilized as a measure of difference between group means using the repeated-measures version of Cohen's d that factors in the correlation between time points (Morris & DeShon, 2002). The evaluation of Cohen's d corresponded to low ($d = 0.2$), medium ($d = 0.5$), and large ($d = 0.8$) effects (Cohen, 1988).

Participants' responses to the manipulation check ("What did you focus on?") were categorized independently by 2 raters (93% agreement) into external foci (e.g., path of the ball, pins), internal foci (e.g., hands, fingers), and other foci (e.g., start line). To assess the "intensity" of their attentional focus, participants' ratings on a Likert scale (1–7) were analyzed using a one-way ANOVA with repeated measurements on attentional focus (IF, EF, and C).

After the 9th trial (inattentional blindness) in each attentional focus condition, participants were asked to report whether they noticed a difference on the video relative to the previous trials. The number of their "yes" and "no" responses were recorded. Cochran's Q test was conducted to test the significance of differences between responses under different conditions.

3. Results

3.1. Throwing accuracy

When participants adopted an external focus of attention ($M = 3.98 \pm 1.55$), throwing accuracy was higher relative to the internal focus ($M = 2.47 \pm 1.17$) or control conditions ($M = 3.08 \pm 1.22$). Also, accuracy was generally higher in the choice ($M = 3.58 \pm 1.49$) compared with the no-choice condition ($M = 2.78 \pm 1.31$) (see Fig. 2). The main effects of both attentional focus, $F(1.37, 48.20) = 19.73$, $p < 0.001$, $\eta p^2 = 0.36$, and choice, $F(1, 35) = 40.71$, $p < 0.001$, $\eta p^2 = 0.53$, were significant. Post-hoc tests

Table 1
Counterbalancing procedure for the attentional focus and choice conditions.

Participant number	Order of attentional focus conditions	Order of choice conditions
1	C – EF – IF	No choice – Choice
2	EF – IF – C	No choice – Choice
3	IF – C –EF	No choice – Choice
4	EF – C – IF	No choice – Choice
5	C – IF – EF	No choice – Choice
6	IF – EF – C	No choice – Choice
7	C – EF – IF	Choice – No choice
8	EF – IF – C	Choice – No choice
9	IF – C – EF	Choice – No choice
10	EF – C – IF	Choice – No choice
11	C – IF – EF	Choice – No choice
12	IF – EF – C	Choice – No choice
……...	……...	……...

indicated significant differences between the EF and IF ($p < 0.001$, $d = 1.27$), and between the EF and C conditions ($p < 0.001$, $d = 0.47$). Also, scores in the C condition were significantly higher compared with the IF condition ($p < 0.001$, $d = 0.36$). Moreover, children's performance was better in the choice compared with the no choice condition ($p < 0.001$, $d = 0.64$). The interaction of attentional focus and choice was also significant, $F(1.95, 68.48) = 4.00$, $p = 0.023$, $\eta p^2 = 0.10$. Follow-up analyses were conducted to determine the source of the interaction. Pairwise post-hoc tests revealed significant performance differences between the choice versus no-choice condition for the EF (choice: $M = 4.58 \pm 1.44$; no choice: $M = 3.38 \pm 1.42$, $p < 0.001$, $d = 0.93$), IF (choice: $M = 2.72 \pm 1.13$; no choice: $M = 2.22 \pm 1.17$, $p = 0.017$, $d = 0.41$), and C conditions (choice: $M = 3.43 \pm 1.28$; no choice: $M = 2.73 \pm 1.07$, $p < 0.001$, $d = 0.72$). Thus, even though all differences were significant, the magnitude of effect of the choice advantage was greatest in the EF, and smallest in the IF condition. Also, in the no-choice condition, EF was more effective than IF ($p < 0.001$, $d = 1.07$). There was no significant difference between C and EF ($p = 0.147$, $d = 0.39$), or C and IF ($p = 0.203$, $d = 0.33$). In the choice condition, EF was more effective than IF ($p < 0.010$, $d = 1.54$) and C ($p < 0.001$, $d = 0.84$), while IF and C were not different from each other ($p = 0.073$, $d = 0.44$).

3.2. Manipulation check

Participants' responses to the question about what they focused on revealed that they followed the EF and IF instructions to a large extent (see Table 2). Even though some participants reported the use of other foci, a large proportion of those foci was external or internal in the EF versus IF conditions, respectively. In the C condition, a relatively large percentage was external in nature, which may not be surprising given the (target-oriented) nature of the task.

Ratings of the "intensity" of participants' foci ("How much did you focus on it?") were comparatively high (see Table 2). There was no significant difference among attentional focus conditions in this respect, $F(2, 70) = 0.53$, $p = 0.588$, $\eta p^2 = 0.03$.

3.3. Inattentional blindness manipulation

On the additional (9th) trial in each attentional focus condition, the video projected behind the bowling pins (Video 2) included a gorilla. We were interested in the extent to which participants would notice a difference, and perhaps identify the gorilla, relative to the video shown on Trials 1–8 (Video 1). Overall, participants noticed fewer differences between videos in the EF compared with the IF and C conditions. Specifically, in response to the question, "Did you notice anything different on the last trial?," there were 6 "yes" versus 30 "no" responses in the EF; 25 "yes" versus 11 "no" responses in the IF; and 16 "yes" versus 20 "no" responses in the C condition. Cochran's Q test revealed significant differences among conditions ($Q(2) = 28.52$, $p < 0.001$, *Cramer's V* $= 0.62$). Follow-up tests with Bonferroni adjustments ($p = 0.0167$) showed that, in the IF condition, participants reported noticing more differences relative to the EF ($Q(1) = 19.00$, $p < 0.001$, $\phi = 0.72$) and C conditions ($Q(1) = 9.00$, $p = 0.004$, $\phi = 0.50$). Also, in the C condition, participants noticed more differences compared with the EF condition ($Q(1) = 10.00$, $p = 0.002$, $\phi = 0.52$). As to the description of the differences they noticed, only 2 participants in the IF condition reported seeing the gorilla. All other responses referred to children or people (playing ball).

Finally, as on the regular (first 8) trials, in the EF condition ($M = 4.66 \pm 2.12$), participants had higher bowling accuracy scores than in the IF ($M = 1.97 \pm 1.74$, $p < 0.001$, $d = 1.16$) and C ($M = 2.83 \pm 1.88$, $p < 0.001$, $d = 0.81$) conditions. The main effect of attentional focus was significant, $F(2, 70) = 27.17$, $p = 0.766$, $\eta p^2 = 0.43$. Post hoc tests revealed that accuracy scores were higher in the EF relative to both the IF ($p < 0.001$, $d = 1.16$) and C conditions ($p < 0.001$, $d = 0.81$), but there was no difference between the IF and C ($p = 0.057$, $d = 0.41$) conditions.

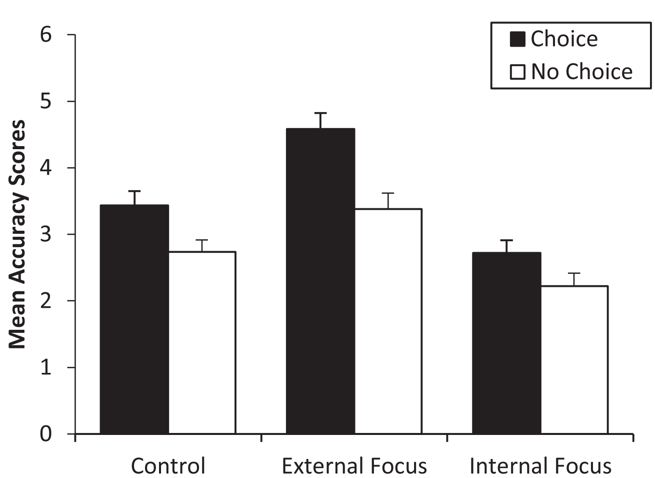

Fig. 2. Mean of bowling accuracy scores for the control, external focus, and internal focus conditions across choice conditions. Note: Error bars represent standard error and were calculated on the basis of within-participant error (Masson & Loftus, 2003).

4. Discussion

The findings of the present study were in line with our hypotheses. First, an external focus of attention led to superior bowling performance compared with both internal focus and control conditions. Second, letting participants choose which bowling ball to use benefitted performance compared with the no-choice condition. Consequently, performance was most effective in the condition that included both factors, the EF-choice condition. The interaction of attentional focus and choice highlighted the superiority of this condition relative to all other ones, in particular the IF-no choice condition. While both factors – an external focus (for a review, see Wulf, 2013), and autonomy-supportive conditions such as providing performers with choices (e.g., Halperin et al., 2016) – have previously been shown to independently enhance motor performance, the present study appears to be the first one to examine *combined effects* of both factors on *immediate performance* in *children*. A previous study, in which individual and combined effects of an external focus and choice were examined (Wulf et al., 2015), used adult participants and a learning paradigm. In that study, both factors had additive effects on the learning of a throwing task as measured by retention and transfer tests. The present results extend those previous findings by showing that, even within the same individuals, instructions to adopt an external focus and providing them a small choice can contribute independently to enhance motor performance. Next, we discuss how an external focus of attention and autonomy-supportive conditions facilitate motor performance, and why both factors contribute to optimal motor performance.

An external focus is assumed to play a dual role by directing attention to the task goal and reducing a focus on the self (including body movements) or other off-task activity (see McKay, Wulf, Lewthwaite, & Nordin, 2015; Wulf & Lewthwaite, 2010). Both aspects seem to be necessary for optimal performance and learning (Wulf & Lewthwaite, 2016). In contrast, internal focus instructions presumably result in an activation of the self (e.g., Northoff et al., 2006), with the consequence that movements are controlled

Table 2
Participants' responses to the questions, "What did you focus on?" in percent, and "How much did you focus on it?" (Likert scale from 1 to 7) in different attentional focus conditions.

	Control		External		Internal	
	"What did you focus on?" (%)	"How much … ?" (1–7)	"What did you focus on?" (%)	"How much … ?" (1–7)	"What did you focus on?" (%)	"How much … ?" (1–7)
Reported external foci						
Path of the ball	16.7	5.8	58.3	5.9	–	–
Pins	70.8	5.7	30.6	5.3	16.7	6
Ball	5.5	4.5	8.3	5	–	–
Total	93	–	97.2	–	16.7	–
Average	–	5.6	–	5.6	–	6
Reported internal foci						
Hand	4.2	6	–	–	81.9	5.4
Fingers	–	–	–	–	1.4	2
Total	4.2	–	–	–	83.3	–
Average	–	6	–	–	–	5.4
Other foci						
Start line	2.8	7	–	–	–	–
Nothing	–	–	2.8	7	–	–
Total	2.8	–	2.8	–	–	–
Average	–	7	–	7	–	–

more consciously, automaticity is disrupted, and muscular activation becomes inefficient (Wulf & Lewthwaite, 2010). By reducing a self-focus and ensuring a focus on the task goal, an external focus directly connects goals and actions, termed *goal-action coupling* by Wulf and Lewthwaite (2016). Findings by Perreault and French (2015) provided some support for the idea that internal focus instructions promote self-related processing. After practicing basketball free-throws, their 10-year old participants reported more self-evaluative thoughts during practice (36%) and on the retention test (57%) when they had been given internal-focus feedback (e.g., "Snap your wrist forward when releasing the ball") compared with participants who had received external-focus feedback (e.g., "Try to make the ball spin backward when you release it") (7% and 21%, respectively).

Even though a large number of participants in the present study also reported adopting an external focus in the C condition (see Table 2), performance was not as effective as it was in the EF condition. One reason for the less-than-perfect performance in the C condition could be related to the type of external focus chosen by participants. Most participants indicated that they focused on the pins, a more distal focus (i.e., at a greater distance from the body) than the instructed focus in the EF condition (path of the ball). While a more distal external focus has often been found to be more advantageous than a proximal external focus (e.g., Bell & Hardy, 2009; McNevin, Shea, & Wulf, 2003), novices performing relatively complex tasks presumably benefit more from a proximal focus (e.g., Wulf, McNevin, Fuchs, Ritter, & Toole, 2000; for a discussion of the distance effect, see; Wulf & Prinz, 2001; Wulf, 2013), such as the path of the ball in the present study.

The results of our inattentional blindness manipulation are in line with the notion that external focus instructions promote a focus on the task goal. In the EF condition, significantly more so than in the IF and C conditions, participants were unable to distinguish between Video 1 (no gorilla) and Video 2 (with gorilla). We interpret this finding as suggesting that the increased focus on the task goal in the EF condition prevented performers from noticing the unexpected stimulus and led to more successful movement outcomes. Conversely, the reduced task focus in the IF and C condition, as evidenced by the greater number of detected discrepancies between videos, resulted in less effective motor performance. [In fact, there was moderate, but significant, negative correlation between the number of pins knocked down on the inattentional-blindness trial and participants' noticing a difference in the video (1) versus not (0), $r = -0.27$, $p = 0.005$.] Interestingly, only a few (i.e., 2) gorillas were reported, even though many participants in the IF and C conditions noticed a difference in Video 2. Yet, they were not able to correctly describe the nature of the difference. This finding might suggest that the unexpected stimulus (gorilla) was detected implicitly, and without participants' being able to verbalize what they saw. It is also possible that participants' attention was more distracted and unstable or fluctuating in the IF and C conditions, resulting in their inability to describe the exact nature of the difference between videos. It may be fruitful to follow up on these findings in future studies, perhaps with different or longer-duration inattentional blindness manipulations, or several trials involving this manipulation. The present results suggest that it could be a useful measure of task focus in studies on motor performance and learning.

Beneficial effects on learning of autonomy-supportive practice conditions, including those in which performers are provided small or even incidental choices (e.g., Lewthwaite et al., 2015), have been demonstrated in many previous studies (for reviews, see Sanli et al., 2013; Wulf, 2007b). Advantages on immediate performance as a function of individuals' having choices have been seen in only a few recent studies (e.g., Halperin et al., 2016; Wulf & Adams, 2014). For example, similar to the current study, Halperin et al. had the same participants (boxers) perform under choice and no-choice conditions, and they also found that a small choice (order of punches) enhanced performance. Exercising control appears to be inherently rewarding (e.g., Karsh & Eitam, 2015) and to heighten expectations for positive outcomes (e.g., Chiviacowsky, 2014; Hooyman, Wulf, & Lewthwaite, 2014; Wulf et al., 2015). Thus, one role of autonomy support may be to facilitate performance (and learning) by enhancing performers' expectancies (Wulf & Lewthwaite, 2016). Autonomy, or lack thereof, may also have a more direct influence on performance. Lack of autonomy (i.e., controlling conditions) is associated with cortisol release which down-regulates dopamine and leads to non-optimal performance and learning (Hooyman et al., 2014; Reeve & Tseng, 2011).

Autonomy is also assumed to be an important contributor to goal-action coupling, even though we did not directly examine this role of autonomy in the present study. In the OPTIMAL theory (Wulf & Lewthwaite, 2016), an external focus and autonomy (in addition to enhanced performance expectancies) are seen as key factors in this process of creating effective neural connections in support of effective motor performance and learning. Performing under optimal motivational (e.g., autonomy-supportive conditions) and attentional focus conditions are assumed to facilitate functional connectivity, that is, task-specific neural connections across distinct brain regions that are seen in skilled performers (Bernardi et al., 2013; Milton, Solodkin, Hluštík, & Small, 2007). The switching to neural networks that are necessary for successful task performance – and away from the default mode network, which supports mind wandering and self-referential thinking (Buckner, 2012) – is facilitated by the so-called salience network (Menon, 2015). Lack of a clear task focus (e.g., internal focus) or non-optimal motivational conditions (e.g., no autonomy) would limit switching to task-related functional networks or goal-action coupling.

The present study demonstrated that an external focus of attention and autonomy support have immediate beneficial effects for children's motor performance. Moreover, both contributed to performance in an independent fashion. Instructors in applied settings can easily take advantage of these effects. Most likely, the resulting performance enhancements will also have positive consequences for children's motivation and motor skill learning. Future studies will be necessary to examine longer-term effects of combining these variables on motor learning as well as intrinsic motivation. A third key variable for motor learning, enhanced expectancies for future performance (Wulf & Lewthwaite, 2016), could provide further benefits for performance in children. Potential complementary effects of enhanced expectancies, an external focus and/or performer autonomy should be examined in future studies as well.

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Conflict of interest

None.

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