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RESEARCH ARTICLE

Focus of Attention in Children's Motor Learning: Examining the Role of Age and Working Memory

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ABSTRACT. The authors investigated the relative effectiveness of different attentional focus instructions on motor learning in primary school children. In addition, we explored whether the effect of attentional focus on motor learning was influenced by children's age and verbal working memory capacity. Novice 8–9-year old children ($n = 30$) and 11–12-year-old children ($n = 30$) practiced a golf putting task. For each age group, half the participants received instructions to focus (internally) on the swing of their arm, while the other half was instructed to focus (externally) on the swing of the club. Children's verbal working memory capacity was assessed with the Automated Working Memory Assessment. Consistent with many reports on adult's motor learning, children in the external groups demonstrated greater improvements in putting accuracy than children who practiced with an internal focus. This effect was similar across age groups. Verbal working memory capacity was not found to be predictive of motor learning, neither for children in the internal focus groups nor for children in the external focus groups. In conclusion, primary school children's motor learning is enhanced by external focus instructions compared to internal focus instructions. The purported modulatory roles of children's working memory, attentional capacity, or focus preferences require further investigation.

Keywords: constrained action hypothesis, children, external focus of attention, motor learning, working memory

Instruction and feedback are crucial means for promoting motor skills. Subtle differences in the wording of a teacher's or trainer's instructions and feedback can significantly influence to what aspects of the to-be-learned motor skill the learner directs attention, and consequently on the degree of learning. In this respect, Wulf and Prinz (Wulf, Höß, & Prinz, 1998; Wulf & Prinz, 2001) have proposed that encouraging an external focus of attention is more beneficial for learning than promoting an internal focus of attention. They defined external focus as directed at the effects that the learner's movements have on the environment. An internal focus, on the other hand, is defined as directed at the learner's body movements. For instance, in golf putting, an external focus instruction would direct attention to the motion of the golf club, whereas an internal focus instruction would result in attention being paid to the movements of the arms (e.g., Wulf, Lauterbach, & Toole, 1999).

In adults, there is ample evidence that learning under external focus instructions is more effective than learning under internal focus instructions (Wulf, 2007). According to the constrained action hypothesis (Wulf, McNevin, & Shea, 2001; Wulf & Prinz, 2001), an external focus of attention induces more automatic control of movement and thereby enhances movement effectiveness and efficiency relative to an internal focus. Accordingly, external focus instructions have been shown to result in more fluent movement execution (e.g., Kal, van der Kamp, & Houdijk, 2013). In fact, an internal focus of attention is thought to trigger a conscious mode of control that involves working memory. In support of this hypothesis, Poolton, Maxwell, Masters, and Raab (2006) showed that only golf putting performance of participants who practiced under the internal focus instructions deteriorated when they concurrently executed a tone-counting task: putting performance of the external focus group, however, remained unaffected by the secondary task. Further support that attending to the effects of movements yields superior dual-task performance has been reported for balancing and stepping tasks (Kal et al., 2013; Wulf et al., 2001). These findings indicate that movements performed and learnt under an internal focus of attention more strongly capitalize on working memory resources.

Notwithstanding its relevance for physical education and adapted physical activity, research examining the effects of foci of attention on motor learning is largely limited to adults and only recently has begun to explore motor learning in children. It is pertinent, however, to scrutinize whether the benefits of an external focus of attention relative to an internal focus observed in adults are also evident in children's motor learning, and if so, whether they are dependent on a child's age. In this respect, it is crucial that children's working memory capacity develops at least until early adolescence (Gathercole, Pickering, Ambridge, & Wearing, 2004). Hence, with age an internal focus of attention may become increasingly effective for motor learning. Conversely, the changes with age may be much weaker for an external focus of attention, because it relies less strongly on working memory capacity than an internal focus of

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Color versions of one or more of the figures in the article can be found online at www.tandfonline.com/vjmb attention. Hence, using external focus instructions may be especially advantageous for motor learning in children, especially at a younger age.

Currently, there is only a handful of studies that have examined the effects of attentional focus on children's motor learning (Chow, Koh, Davids, Button, & Rein, 2013; Emanuel, Jarus, & Bart, 2008; Hadler, Chiviacowsky, Wulf, & Schild, 2014; Thorn, 2006). These studies, however, do not provide unambiguous support for enhanced learning with an external focus of attention, unlike the reports on adults' motor learning. That is, neither Emanuel et al. (2008) nor Chow et al. (2006) observed performance differences following practice with internal and external focus instructions in 9- and 10-year-olds' dart throwing and jumping, respectively.[1] Yet, for somewhat older children between 10 and 12 years of age, Hadler et al. (2014) reported that in learning a tennis forehand external focus of attention instructions resulted in greater accuracy in hitting a target than internal focus of attention instructions or no instructions (see also Abdollahipour, Wulf, Psotta, & Nieto, 2015 for similar immediate performance benefits among 12-year-old gymnasts). A highly speculative explanation for this set of findings would be that the benefits of an external focus of attention only emerge after 10 years of age. However, there is only one study that investigated the modulatory effects of attentional focus between children of different age. Thorn (2006) had 9–12-year-old children practice a dynamic balance task under both an external and internal focus of attention. The learning benefits of an external focus of attention relative to an internal focus appeared larger among the younger group; they showed a larger improvement in mediolateral stability. Yet, the younger children were also generally more stable than their older peers. Hence, it might have been that the differential effect of external and internal focus for the two age groups arose from younger children being inherently more proficient at the balancing task, rather than to differences in age per se.

In sum, we tentatively conclude that, as in healthy adults, an external focus of attention is more advantageous for younger children's motor learning than an internal focus, a benefit that may or may not increase with age. However, additional research is needed to be able draw more definite conclusions. In addition, previous work did not address the underlying factors that may constrain the differential benefits of focus of attention, or any age-related changes therein. Therefore, we compared the relative benefits of external and internal focus instructions on learning a golf-putting task in 8–9-year-old and 11–12-year-old children. Additionally, we explored the relationship between learning and working memory capacity. We hypothesized that learning under external focus instructions would be more effective than learning under internal focus instructions. We additionally hypothesized that working memory capacity would be more predictive of learning with an internal focus of attention than of learning with an external focus of attention instruction, and consequently (considering the working memory capacity increases with age) that learning under internal focus instructions would show larger increments with age than learning under external focus instructions.

Methods

Participants

Sixty children (26 male, 34 female) were recruited through primary schools and local sports clubs. Thirty 8- and 9-year-olds (M = 8.94 years, SD = 0.45) and thirty 11- and 12-year-olds (M = 11.66 years, SD = 0.43) were randomly assigned to either an internal focus of attention group or an external focus of attention group. These sample sizes (i.e., 60 in total and 15 per group) were based on previous work on this topic, which showed that samples of 10–15 participants per group are large enough to detect differences in learning with external and internal focus instructions (e.g., Poolton et al., 2006; Wulf et al., 1999; Wulf & Su, 2007). The children were novices to the golf-putting task and unaware of the purpose of the study. The local ethics committee had approved the protocol of the study, and parents provided written informed consent before the start of the study.

Apparatus and Task

An artificial green of 5.0 m long and 1.0 m wide was used (see Figure 1). The hole (10 cm diameter and 2 cm deep) was located at a distance of 2.5 m from where the participant strikes the balls, leaving a 2.0 m distance beyond the hole. The younger children used a 70 cm Spalding Junior Putter Green and the older children a 77.5 cm Spalding Junior Putter Blue (Spalding, Bowling Green,

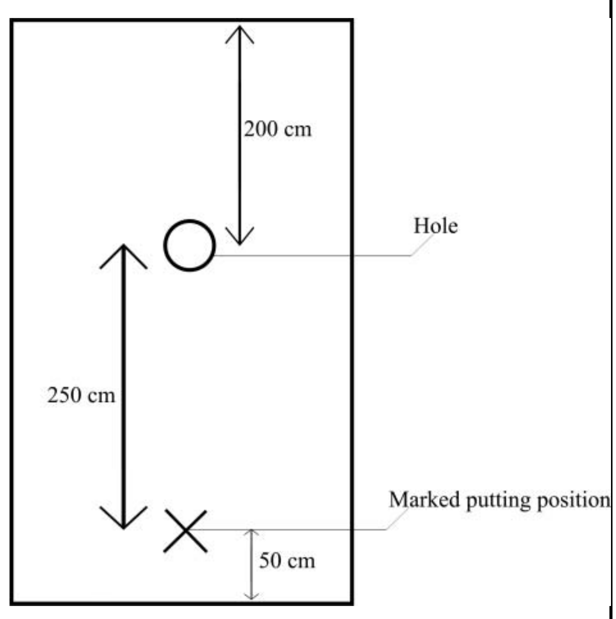

FIGURE 1. Schematic outline of experimental set-up.

KY). Ten regular golf balls were used, allowing each block of trials to be performed without interruption. A tapeline was used to measure the distance the ball landed from the hole.

The Dutch version of the Automated Working Memory Assessment (AWMA; Alloway, 2007) was administered to assess the children's working memory capacity. The AWMA is an automated, computerized assessment battery validated for children from age 4 years old and older. For the current study, the listening span subtest was administered to assess verbal working memory. In this test, short sentences are presented to the child. These sentences have a simple subject-verb-object order and only contain early developing vocabulary. The child has to judge whether the content of the sentence is correct by saying correct or false. In addition, when all sentences have been presented, the child also has to recall the first word of every sentence in the correct order. An example of an item is, "Tomatoes play football." The child has to answer "false" and repeat the word *tomatoes*. A block contains a maximum of six trials. In the first block, each trial consists of one sentence and therefore one word has to be recalled. When the child gives three correct answers in a row or four correct answers within the block, the test will continue with the next block, again with six trials. In the second block, each trial consists of two sentences and the child has to recall two words, and so on. The test is stopped when three mistakes are made within one block. According to the manual, test–retest reliability for the listening span test is .88.

Procedure and Design

A pretest, practice, retention test design was used. On the first day, the pretest and the practice blocks were conducted, while on the second day, the retention test and the AWMA were administered. During the pretest, children performed 30 golf putts, during which they attempted to land the ball in the hole. Beforehand, all children of all groups received the same general instructions regarding grip, standing posture and task goal. However, no further instructions and feedback were provided during the pretest. Following the pretest, the children performed 80 practice trials. Beforehand, the children in the external focus groups received external focus of attention instructions, while children in the internal focus groups received internal focus of attention instructions. To this end, the experimenter demonstrated the children the workings of a pendulum (i.e., by showing a cord with a small object attached to it) and instructed the children to move like a pendulum. Specifically, the children in the external focus of attention groups were instructed "to move the *golf club* like a pendulum," whereas the children in the internal focus of attention groups were instructed "to move the *arms* like a pendulum.." In other words, the internal and external instructions only differed by interchanging the words *golf club* and *arms*; all else was identical. The experimenter repeated the instructions at the beginning of each block of 10 trials. There were short breaks between the eight blocks. On the second day, the children performed a 30-trial retention test. They were not given any of the general or attention specific instructions other than to put as accurately as possible.[2]

After the retention test, the AWMA was administered on a laptop in a quiet room. After the experimenter's explanation, practice trials were administered to ascertain that the children understood the task. Following this, the test started at the easiest level to increase in difficulty each time the child gave the correct answers. Testing was stopped when more than three mistakes were made within a trial. The child's responses were fed into the computer by the experimenter. The outcome scores were calculated by the AWMA program. For the purpose of this study (i.e., we were interested in the relation of learning with a individual child's actual working memory capacity, rather than with a child's working memory capacity relative to that of their peers), only raw working memory scores were used.

Data Analysis

For each trial, the putting performance score was defined as the distance between the ball's end location and the midpoint of the hole (in cm). In the case the ball landed in the hole, a performance score of zero was assigned. When the ball landed beyond the green, a (maximum) score of 200 was given. The average distance for the pretest and the retention test were calculated, with the difference in scores between pretest and retention test serving as the primary dependent variable to indicate learning.

Data analyses were performed with SPSS 22. First differences between groups during the pretest were assessed. To this end, the performance score for the pretest was submitted to a 2 Age (young, old) $\times$ 2 Instruction (external, internal) analysis of variance (ANOVA). Subsequently, learning was assessed a 2 Age (young, old) $\times$ 2 Instruction (external, internal) analysis of covariance (ANCOVA) using the pretest performance score as covariate, and the difference in performance scores between the pretest and retention test as the dependent variable.

Next, we explored whether learning was differently predicted by verbal working memory capacity in the external attention focus instruction and internal attention focus instruction groups. To this end, we first submitted the raw verbal working memory score to a 2 Age (young, old) $\times$ 2 Instruction (external, internal) ANOVA to verify differences in working memory capacity as function of age. Subsequently, a hierarchical three-stepped linear regression analysis was performed. First, a basic model was defined with focus instruction (external vs. internal), age (in months), and pretest scores as predictors, and learning scores (i.e., the difference in performance scores between the pretest and retention test) as dependent variable. Next, to investigate whether verbal working memory influenced learning, raw verbal AWMA scores were added to this basic model as a predictor. Finally, to determine whether verbal working memory differentially influenced learning under external and internal instructions, the verbal working memory by focus interaction was added to the model. Verbal working memory and the verbal working memory by focus interaction were considered to have influenced motor learning when adding these variables resulted in significant improvements in model fit, as evidenced by a significant increase in R^2. For the regression analysis, the assumptions of (lack of) multicollinearity (variance inflation factors < 1.7, tolerances > 0.6; Bowerman, & O'Connell, 1990; Myers, 1990), homoscedasticity (inspection of plot of the standardized residuals and predicted values), independence of errors (Durbin-Watson = 1.821 > 1.559, the critical value for analyses with four predictors and 60 participants; Durbin & Watson, 1951), and normal distribution of errors were verified (i.e., Kolmogorov-Smirnov test on residuals = .080, $p > .200$). However, one case in the 11–12-year-old internal focus group was found to exert disproportionate influence on the regression parameters, as evidenced by a Cook's distance greater than the cutoff value (4/(n-k-1) = 0.071; Chatterjee & Hadi, 1986). Data of this child were therefore excluded from the regression analysis. For ANOVAs, effect sizes were expressed in partial eta squared (η^2), with values of .01, .06, and .14 representing small, medium, and large effects, respectively (Cohen, 1988). For all analyses, the significance level was set at $p = .05$.

Results

Effects of Attentional Focus Instructions on Motor Learning

Figure 2 shows the average scores for each experimental block. Table 1 lists the means and standard deviations of the putting performance scores for pretest, practice phase and retention test as function of age and focus instruction, including the difference in performance score between pretest and retention test. The pretest scores seem to suggest that the older groups outperformed the younger groups, and that the internal focus groups performed better than the external focus groups. However, an ANOVA on the pretest performance scores showed no significant effect of age, $F(1, 56) = 1.47$, $p = .23$, $\eta^2 = .03$, nor of instruction, $F(1, 56) = 2.84$, $p = .10$, $\eta^2 = .05$), and also no significant instruction by age interaction, $F(1, 56) = 0.15$, $p = .70$, $\eta^2 = .003$, reached significance. Nonetheless, to correct for the weak trend for better pretest performance in the internal focus instruction groups, it was decided to add the pretest scores as a covariate to the subsequent analysis of motor learning.

With respect to learning, Table 1 suggests larger improvements for the external focus instruction groups than for the internal focus instruction groups (i.e., higher difference scores indicate more learning), while no pronounced differences are apparent between younger and older children. The statistical significance of these observations was tested with an ANCOVA. As expected, the pretest score was a significant covariate, $F(1, 55) = 30.96$, $p < .001$, $\eta^2 = .36$. More importantly, however, a main effect of instruction was found, $F(1, 55) = 7.29$, $p = .009$, $\eta^2 = .12$, indicating that the external groups showed larger improvements in putting performance than the internal focus instruction groups. Contrary to what was hypothesized, there was no significant main effect of age, $F(1, 55) = 1.06$, $p = .31$, partial $\eta^2 = .02$, and no significant interaction between age and instruction, $F(1, 55) = 0.33$, $p = .57$, partial $\eta^2 = .006$.[3] Finally, one-sample t tests showed that the improvement of the external focus instruction group was significantly different from zero for both the

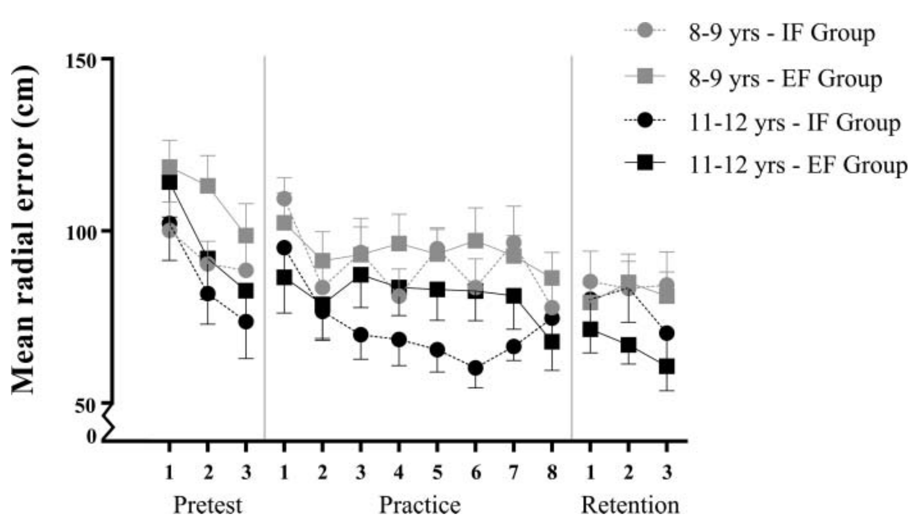

FIGURE 2.

TABLE 1. Putting Performance and Learning Scores as a Function of Age and Instruction

		Pretest		Practice phase		Retention test		Difference	
Age (years)	Instruction	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
8–9	Internal	93.0	27.8	90.2	22.6	84.3	27.9	8.8	17.6
	External	110.1	27.9	94.3	24.5	81.8	21.6	28.3	30.4
11–12	Internal	86.2	33.6	72.1	18.7	78.3	33.6	8.0	22.6
	External	96.9	37.5	81.3	28.8	66.3	19.7	30.6	28.2

Note. Putting performance is expressed in distance from target in centimeters. Thus, for the pretest, practice, and retention tests, lower values represent better performance. Difference scores were obtained by subtracting the pretest scores from the retention test scores, with more positive values representing larger improvements in putting accuracy.

younger group, $t(14) = 3.61$, $p < .01$, $d = 0.93$, and the older group, $t(14) = 4.20$, $p < .001$, $d = 1.09$. By contrast, for the internal focus groups, no significant improvement in putting accuracy was found, $t(14) = 1.93$, $p = .08$, $d = 0.50$; $t(14) = 1.36$, $p = .19$, $d = 0.35$, for the younger and older groups, respectively. In conclusion, the external focus instructions resulted in superior motor learning compared to the internal focus instructions, irrespective of children's age.

Working Memory

Raw verbal working memory scores (Table 2) were analysed with ANOVA. Results showed a large main effect of age, $F(1, 56) = 10.6$, $p < .01$, partial $\eta^2 = .16$, but not of instruction, $F(1, 56) = 0.84$, $p = .36$, partial $\eta^2 = .02$. Also, no interaction between age and instruction was found, $F(1, 56) = 0.05$, $p = .83$, partial $\eta^2 = .001$. Thus, as expected, older children had greater verbal working memory capacity than younger children, whereas no significant differences existed between the groups that received different focus instructions.

Next, hierarchical linear regression analysis was used to assess whether children's working memory capacity predicted their learning improvement, and whether this was different for the external and internal focus instruction groups. First, a basic model was fitted with instruction, age, and pretest scores as predictors, after which verbal working memory scores and their interaction with instruction were subsequently added to this model in a stepwise fashion. Table 3 summarizes the results. The first basic model significantly predicted children's learning, $F(3, 55) = 18.04$, $p < .001$ ($R^2 = .496$). Both the predictors instruction ($B = -12.02$, $p = .024$) and pretest were significant ($B = 0.51$, $p < .001$). When verbal working memory was added to this model it neither significantly predicted learning ($B = 0.52$, $p = .48$), nor significantly improved model fit ($\Delta R^2 = .005$, $p = .51$). Finally, the interaction between verbal working memory and instruction was added to the model. This interaction term also neither significantly predicted learning ($B = 1.35$, $p = .35$), nor did its inclusion improve model fit ($\Delta R^2 = .008$, $p = .89$). Thus, verbal working memory capacity did not predict learning, neither for children in the internal focus group nor for children in the external focus group.

TABLE 2. Verbal Working Memory Scores as a Function of Age and Instruction

		Verbal working memory	
Age (years)	Instruction	*M*	*SD*
8–9	Internal	15.1	2.8
	External	15.7	4.7
11–12	Internal	17.9	3.5
	External	19.0	3.3

Note. Absolute scores are reported, with higher scores indicating better working memory capacity.

Discussion

The current study assessed the effects of different attentional focus instructions on learning a golf task by 8–9- and 11–12-year-old children. In addition, it was examined whether the effect of attentional focus on motor learning was influenced by children's age and verbal working memory capacity. Consistent with many reports on adults' motor learning, children who received instructions to focus externally on the golf club demonstrated greater improvements in putting accuracy than children who focused internally on their arm movements. In fact, only the children in the external focus groups demonstrated significant improvement at retention. These results are in line with those of earlier studies that showed that an external focus enhances children's learning of a tennis forehand stroke (Hadler, Chiviacowsky, Wulf, & Schild, 2014) and balancing (Thorn, 2006), and also result in short-term benefits in gymnastic performance (Abdollahipour et al., 2015). Thus, it seems that the benefits of learning with an external focus are not restricted to the

TABLE 3. Hierarchical Linear Regression Model of Learning Score

	B	[95% CI]	*SE B*	*β*	*p*	R^2	ΔR^2
Step 1						.496 (***p* = .000**)	
Constant	–41.43	[–85.70, 2.84]	22.09		.066		
Focus (EF vs. IF)	–12.02	[–22.42, –1.63]	5.19	–.23	**.024**		
Age (in months)	0.15	[−0.15, 0.45]	0.15	0.10	.323		
Pretest	0.51	[0.34, 0.67]	0.08	.62	**.000**		
Step 2						.501 (***p* = .000**)	.005 (*p* = .513)
Constant	–35.97	[–83.01, 11.06]	23.46		.131		
Focus (EF vs. IF)	–11.57	[–22.10, –1.04]	5.25	–.22	**.032**		
Age (in months)	0.10	[–0.22, 0.43]	0.16	.07	.524		
Pretest	0.51	[0.34, 0.67]	0.08	.62	**.000**		
WM (raw AWMA)	0.52	[–0.93, 1.96]	0.72	.08	.477		
Step 3						.509 (***p* = .000**)	.008 (*p* = .888)
Constant	–31.79	[–79.73, 16.15]	23.90		.189		
Focus (EF vs. IF)	–11.46	[–22.00, –0.91)	5.26	–.22	**.034**		
Age (in months)	0.09	[–0.24, 0.41]	0.16	.06	.602		
Pretest	0.49	[0.32, 0.66]	0.08	.60	**.000**		
WM (raw AWMA)	0.07	[–1.66, 1.80]	0.86	.01	.936		
WM by Focus	1.35	[–1.52, 4.22]	1.43	.12	.350		

Note. For the WM by Focus interaction term the external group served as reference. Significant ($p < .05$) and near-significant ($p < .10$) *p* values are emphasized and in italics, respectively. AWMA = Automated Working Memory Assessment; EF = External focus; IF = Internal focus; WM = working memory.

adult population (e.g., Wulf, 2013), but are already evident in young children.

Generally, the superiority of using instructions that elicit an external rather than internal focus is considered to be due to differences in the amount of cognitive control required to perform these two foci of attention. That is, an external focus is thought to be less working memory-demanding than an internal focus, hence allowing for more automatic and efficient motor control (Kal et al., 2013; Lohse, Sherwood, & Healy, 2010; Wulf, 2013). Accordingly, recent evidence suggests that an external focus may also enhance motor learning of children with intellectual disabilities (Chiviacowsky, Wulf, & Ávila, 2013). At first glance, it might seem that this rationale can also account for the results of the present study: as children's working memory capacity is not yet fully matured (Gathercole et al., 2004) this may compromise their ability to make use of the more working memory-demanding internal focus instructions, especially for the younger children. Nonetheless, our observations with regard to the role of children's age and working memory did not bear out these conjectures. First, if learning with an external focus indeed was less reliant on working memory control, working memory capacity should have more strongly predicted learning in the internal focus groups. However, verbal working memory capacity was not more predictive of learning of the internal focus groups than of the external focus groups. Second, we also did not find any age-related differences regarding the relative effect of external and internal focus instructions. That is, despite the fact that younger children had significantly smaller working memory capacity than the older ones, external focus instructions were equally beneficial to motor skill learning in both age groups. Combined, the present results therefore do not support the idea that reduced working memory loading underlay the superiority of external focus learning in children. This seems to be at odds with the consistent reports of reduced working memory involvement with an external focus in healthy adults (Kal et al., 2013; Poolton et al., 2006), as well as with reports that children with greater verbal working memory capacity are more likely to consciously control their movements, and demonstrate better motor performance when triggered to do so (Buszard, Farrow, Reid, & Masters, 2014; Buszard, Farrow, Zhu, & Masters, 2013; Van Abswoude, Santos-Vieira, van der Kamp, & Steenbergen, 2015).

One possible explanation for the lack of modulatory effect of working memory may be the relatively high verbal working memory capacity of the children in our study. Children's working memory scores were on average more than 1 *SD* above the age-referenced norm (i.e., age-standardized scores for the younger children: 118 ± 15; for older children: 122 ± 14; norm = 100 ± 15). Thus, even if focusing internally was indeed more working memory demanding than directing attention externally, it might have been that for most children their verbal working memory capacity was sufficiently large to accommodate these demands. As a result, working memory capacity might not have been the most important constraint on learning for the internal focus groups. Additionally, both attentional instructions were conveyed as an analogy, and the use of analogies has been shown to diminish the appeal on working-memory in comparison to more explicit instructions that stipulate the movement in detail (Liao & Masters, 2001). This may have further reduced the purported contribution of working memory in the current study. This would imply that the observed differences in motor skill learning are genuinely attentional, instead of reflecting disparate demands on working memory (cf. Poolton et al., 2006).

This triggers the question as to how attention explains the individual differences in learning within and across the external and internal focus groups? One option might be that differences in attentional functioning may (also) underlie the attentional focus effects. For instance, it has been suggested that visual attentional functioning may modulate the effects of internal and external focus: in a recent study (Kasper, Elliott, & Giesbrecht, 2012) healthy adults' putting performance correlated more positively to participants' visual attentional capacity in external than in internal conditions. As a possible explanation for these findings, the authors proposed that an external focus promotes the use of relevant visual information in the environment, whereas an internal focus prevents the pick-up of task-relevant cues. Thus, for our study, this hypothesis would imply that adopting an external focus facilitated motor learning as it allowed the children to pick up more task-relevant information (see also Van der Kamp, Oudejans, & Savelsbergh, 2003). Yet, visual attentional functioning is unlikely to fully account for the results noted in our study: Recent studies actually suggest that attentional focus effects are also evident in situations in which no visual information is available to the learner (Schlesinger, Porter, & Russell, 2012; Sherwood, Lohse, & Healy, 2014). In any event, we encourage future studies to more directly assess how different measures of children's attentional functioning influence the effectiveness of different attentional foci for motor learning.

A final note concerns children's preferred, or default, mode of learning. According to the so-called sensorimotor hypothesis, children predominantly rely on implicit motor learning strategies, and are less likely to engage in explicit motor learning (Hernandez & Li, 2007; Hernandez, Mattarella-Micke, Redding, Woods, & Beilock, 2011, see also Masters, van der Kamp, & Capio, 2013). If so, it might be that children were more likely to benefit from learning with an external focus, as it more closely resembles their preferred implicit mode of learning compared to learning with an internal focus. Indeed, it has been shown that attentional focus instructions benefit motor performance most when they are congruent with the performer's focus preferences (Kal et al., 2015; Maurer & Munzert, 2013). As we did not investigate children's focus preferences, this hypothesis awaits further investigation.

In conclusion, compared to internal focus instructions, external focus instructions resulted in superior learning on a golf-putting task in 8–9- and 11–12-year-old children. This beneficial effect of external focus instructions was neither influenced by children's age nor by their verbal working memory capacity. Future research should look further into the mechanisms underlying these attentional focus effects, and more closely examine the role of children's focus preferences, attentional capacity, and working memory capacity.

NOTES

1. Note that with only six participants for each instruction condition, the study of Chow et al. (2014) might have had limited power for discerning differences.

2. Yet, several children spontaneously asked the experimenter whether they should perform the task in the same way as they had done the day before (during practice). In these cases the experimenter just repeated that they should try to do the same they did the day before. However, care was taken that no explicit reference was made to the pendulum analogy or to directing attention to either the arms or club.

3. Of note, to determine whether including the pretest scores as a covariate influenced our findings, we also ran an ANOVA without these scores. Results were essentially the same: the effect of instruction remained significant, $F(1, 56) = 10.52$, $p = .002$, $\eta^2 = .16$), while the effect of age, $F(1, 56) = 0.01$, $p = .91$, partial $\eta^2 < .01$, and instruction by age interaction remained nonsignificant, $F(1, 56) = 0.06$, $p = .82$, partial $\eta^2 < .01$.

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