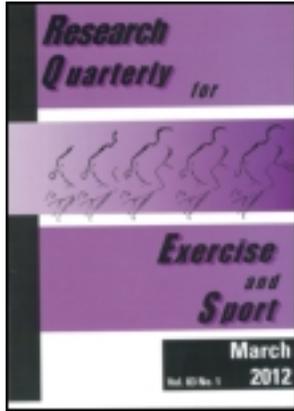


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### Attentional Focus Effects as a Function of Task Difficulty

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## Attentional Focus Effects as a Function of Task Difficulty

*Gabriele Wulf, Thomas Töllner, and Charles H. Shea*

*Key words:* balance, focus of attention, motor performance, task difficulty

An individual's focus of attention can have a considerable effect on motor performance and learning. While it has long been known that expert performance tends to suffer if the performer directs his or her attention to the details of the action (e.g., Baumeister, 1984; Baumeister & Steinhilber, 1984) more recent studies have shown that, even for novice performers, directing attention to one's movement control is not effective and can be detrimental (e.g., Hodges & Lee, 1999; Singer, Lidor, & Cauraugh, 1993; Wulf & Weigelt, 1997). It has been demonstrated that performing and learning of motor skills can be enhanced if the individual's attention is directed to the movement effect, for example, on an implement or apparatus (external focus) rather than to the body movements per se (internal focus; for a review, see Wulf, 2007).

Advantages for learning, when attention is directed to the movement effect as compared to the movement itself, have been shown for a variety of motor tasks, including a ski-simulator task (Wulf, Höß, & Prinz, 1998; Experiment 1), riding a Pedalo (Totsika & Wulf, 2003), basketball (Al-Abood, Bennett, Hernandez, Ashford, & Davids, 2002), golf (Wulf, Lauterbach, & Toole, 1999), as well as soccer and volleyball skills (Wulf, McConnel,

Gärtner, & Schwarz, 2002). Other studies used dynamic balance tasks, such as the stabilometer, which requires participants to balance on a left-right tilting platform while trying to minimize platform deviations from the horizontal (e.g., Wulf et al., 1998, Experiment 2; Wulf, McNevin, & Shea, 2001; Wulf, Shea, & Park, 2001). Results from these experiments consistently demonstrated that participants instructed to focus externally (i.e., on keeping platform markers horizontal) produced more effective performance and learning than those who focused internally (i.e., on keeping their feet horizontal). The type of attentional focus not only affects motor skill learning, but it can also have almost immediate effects on performance (e.g., Landers, Wulf, Wallmann, & Guadagnoli, 2005; McNevin & Wulf, 2002; Vance, Wulf, Töllner, McNevin, & Mercer, 2004; Wulf, Mercer, McNevin, & Guadagnoli, 2004). For example, Wulf and colleagues (2004) used a task that required participants to balance on an inflated rubber disk. Although there were only three trials lasting 15 s each, adopting an external focus resulted in less postural sway than an internal focus, showing that the effects of attentional focus on performance can be almost instantaneous.

A few studies have claimed to show benefits of an internal focus for novices (Perkins-Ceccato, Passmore, & Lee, 2003) or individuals who are motorically challenged (i.e., people with Parkinson's disease; Canning, 2005). However, in those studies the instructions were rather vague, so it is not clear what performers attended to. For example, in the golf study by Perkins-Ceccato et al. (2003), the "internal" focus instructions to "...adjust the force of their swing depending on the distance of the shot" (p. 596) could have induced an internal or external focus. For example, it is possible learners focused on the impact the club had on the ball (external focus) rather than the force produced with their arms (inter-

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nal focus). Overall, there does not seem to be any indication that focusing on one's movements (internal focus) is advantageous for novices; rather, instructions to focus on the movement effect (external focus) have consistently resulted in more effective performance and learning (see Wulf, 2007; Wulf & Prinz, 2001).

Interestingly, benefits of external focus conditions have been found relative to internal focus as well as to control conditions (Landers et al., 2005; McNevin & Wulf, 2002; Wulf et al., 1998, Experiment 1; Wulf & McNevin, 2003; Wulf, Weigelt, Poulter, & McNevin, 2003). In those studies, control conditions without focus instructions resulted in similar performances as internal focus conditions, and both were less effective than external focus conditions. This suggests that participants who did not receive specific focus instructions might spontaneously direct their attention to controlling their movements.

The constrained action hypothesis (e.g., Wulf, McNevin et al., 2001) has explained the effects of different attentional foci. According to this view, adopting an external focus of attention allows unconscious or automatic processes to control the movements. In contrast, when participants adopt an internal focus, they are more likely to consciously intervene in these control processes, thereby inadvertently disrupting automatic control processes. Several lines of evidence support this view. For example, in the study by Wulf, McNevin et al. (2001), participants balanced on a stabilometer, and probe reaction times (RTs) were taken as a measure of the attention demands required under external versus internal attentional focus conditions. External focus participants demonstrated shorter probe RTs than internal focus participants, indicating reduced attention demands associated with an external focus. In addition, Fast Fourier Transform analyses of the balance-platform movements indicated a higher frequency of movement adjustment under external relative to internal focus conditions. High frequency/low amplitude adjustments are viewed as the result of a more automatic, reflex-type control mode based on faster and more finely tuned integrated movement responses (e.g., Newell & Slifkin, 1996). Finally, two recent studies (Vance et al., 2004; Zachry, Wulf, Mercer, & Bezodis, 2005) found reduced electromyographic activity when participants adopted an external relative to internal focus. This suggests that adopting an external focus results in movements that are controlled more automatically as well as in more efficient movement patterns.

To date, research examining the effects of attentional focus has been directed almost exclusively at performing and learning relatively difficult skills. Presumably, it was felt the external focus benefits might be especially pronounced for complex skills that pose comparatively high demands on the performer's control capabilities.

Also, most studies used novice performers with little or no experience with the respective task (for an exception, see Wulf, McConnel, Gärtner, & Schwarz, 2002). Thus, most studies on the attentional focus effect have used tasks that are relatively challenging to the performer. An interesting question is, therefore, if and how the type of attentional focus would affect performing task variations that differ in the demands placed on the performer.

Thus, the general purpose of the present experiments was to systematically examine the task conditions under which attentional focus manipulations exert an influence. This is important for theoretical reasons, because determining task characteristics that are sensitive to attentional focus manipulations will help isolate the mechanism(s) giving rise to the effect. Identifying conditions amenable to attentional focus effects is also important for practical reasons so that teachers, coaches, and therapists can appropriately use the benefits of an external focus in teaching motor skills and during rehabilitation therapies. This is especially important in light of recent findings demonstrating that performance and learning principles developed using a particular difficulty level do not always generalize to other difficulty levels (see Wulf & Shea, 2002, for a review). In fact, there are some indications that external focus instructions might be beneficial only if the task is difficult enough. For example, in a study by Landers et al. (2005), using participants with Parkinson's disease, external focus instructions only enhanced balance on the most difficult of three balance tasks. Moreover, the external focus benefits were found only for those participants who had a history of falls—for whom the task was challenging—whereas no significant benefits were found for those without a fall history. Furthermore, some studies using easy tasks might have remained unpublished because they did not yield significant attentional focus effects (e.g., a study using a golf putting task by Tranter, 2001).

The purpose of the present study was to determine the effect of internal and external attentional foci while systematically varying the surface stability on which individuals stood. By varying the support surface, we expected to create situations that placed increasingly higher demands on performers to maintain a stable posture. Using this design strategy, we could determine if the effects of the attentional focus manipulation differentially impacted performance across a single postural stability task, where the surface they stood on imposed varying challenges to maintaining a stable posture. Control conditions were included to empirically determine if the attentional focus manipulations would change postural stability compared to a situation in which participants received no instruction.

We hypothesized that attentional focus effects would occur only if the task was relatively challenging for the performer. This prediction is based on the constrained

action hypothesis (e.g., Wulf, McNevin, et al., 2001). According to this view, the advantages of adopting an external focus are due to the fact that it facilitates using automatic control processes, relative to internal focus, and presumably control, conditions. Thus, when a motor task is difficult, directing performers' attention to the effects of their movements might encourage them to use motor programs they developed through practice with other, similar tasks. However, if the task is relatively easy and already affords an automatic mode of control, no additional benefit of inducing an external focus would be expected.

## Experiment 1

In the first experiment, young healthy adults performed two versions of a static balance task. Specifically, in a within-participant design, participants were required to stand either on a flat, stable metal surface (force plate) or on a foam mat placed on top of the force plate. All tasks were performed under three attentional focus conditions: external focus, internal focus, and control (no attentional focus instructions) conditions. While the foam surface was selected to create a slightly less stable surface than the flat/metal surface of the platform, both conditions were expected to impose relatively small challenges to maintaining a stable posture. We hypothesized that advantages of an external focus, relative to internal focus and control conditions, would be greater (or would only be observed) when the support surface was relatively unstable. Also, based on previous findings (e.g., Landers et al., 2005; McNevin & Wulf, 2003; Wulf et al., 1998, Experiment 1), we expected to see no differences between internal focus and control conditions.

## Method

### Participants

Eighteen university students participated in this experiment. All were naive as to the purpose of the experiment, and all gave their informed consent.

### Apparatus and Task

Two task versions were used in the present experiment. One version ("solid") required participants to stand directly on a force plate, whereas the other ("foam") required them to stand on a foam mat (47 x 40 x 6.5 cm; Airex Balance Pad™, Perform Better, Cranston, RI) placed on the force plate. In the foam condition, we measured the forces exerted on the foam, rather than on the feet per se; however, this well accepted procedure has been

used in numerous studies (see also Landers et al., 2005; Wulf et al., 2004). In both cases, participants stood with their feet slightly apart. The force plate (Model #9286AA; Kistler Instrument Corp., Amherst, NY) recorded center of pressure data at 500 Hz. Two sets of yellow rectangles (30.5 x 17 cm) cut out of contact paper were placed on the force plate and on the foam, respectively. The rectangles were 7 cm apart. Participants stood on the rectangles, which also served as focus points under external focus conditions.

### Procedure

Participants were told to stand as still as possible under both "solid" and "foam" surface conditions. They were also told they would be asked to focus on different things while standing on either surface. Specifically, under *external* focus conditions, participants were instructed to focus on the rectangles on which they stood, and to try to put an equal amount of pressure on each rectangle (solid) or to move the rectangles as little as possible (foam). Under *internal* focus conditions, they were asked to focus on their feet, and to try to put an equal amount of pressure on each foot (solid), or to move their feet as little as possible (foam). Finally, under *control* conditions, participants were simply instructed to "stand still." It should be pointed out that, under all conditions, participants were instructed to look straight ahead (i.e., not to look at the rectangles or their feet) and concentrate on the rectangles or their feet, respectively. All participants performed three consecutive 15-s trials under each of the three attentional focus conditions. The order of task versions and conditions was counterbalanced across participants. Specifically, one third of the participants performed the task in the order control-internal-external, internal-external-control, and external-control-internal, respectively, so that each focus condition was performed first, second, or third the same number of times. Also, half the participants in each subgroup started with either the solid or the foam surface.

### Dependent Variables and Data Analysis

The data were converted to ASCII format and processed using custom laboratory software. The center of pressure (COP) data were adjusted so that the central coordinates were (0, 0). Data were then converted from Cartesian to Polar coordinates, and the root mean square error (RMSE) of the COP vector magnitude was calculated and served as a measure of postural sway (see also Wulf et al., 2004). RMSE was analyzed in a 2 (task: solid, foam) x 3 (focus of attention: external, internal, control) x 3 (trial) repeated measures analysis of variance (ANOVA).

## Results

Standing on foam resulted in greater postural sway than standing on a solid surface (see Figure 1). The main effect of task was significant,  $F(1, 17) = 91.27$ ,  $p < .001$ ,  $\eta^2 = .84$ . The Task x Focus of Attention interaction was significant, with  $F(2, 34) = 5.04$ ,  $p = .012$ ,  $\eta^2 = .23$ . Simple main effects analysis of the Task x Focus of Attention interaction indicated significantly less postural sway in the external focus of attention condition than in the control condition when participants stood on foam,  $p < .05$ . This result, however, was qualified because the internal focus of attention condition was not significantly different from either the control or the external focus of attention condition. Simple main effects analysis failed to detect any differences between focus of attention conditions when participants stood on the solid surface. The main effect of focus of attention was not significant,  $F(2, 34) < 1$ . The main effect of trial,  $F(2, 34) < 1$ , and the other interaction effects were not significant.

To be sure the effects of task and attentional focus were not limited to a certain task order (or orders), we conducted a supplemental 3 (order: control-internal-external, internal-external-control, external-control-internal) x 2 (task: solid, foam) x 3 (focus of attention: external, internal, control) x 3 (trial) repeated measures ANOVAs. There was a significant interaction of task order, task, and focus of attention,  $F(4, 30) = 3.22$ ,  $p = .026$ . Post hoc tests, which compared focus conditions within each task order, were not able to identify the exact source of the interaction, however. Thus, there was no evidence that task order qualified the Task x Attentional Focus interaction found in the primary analysis.

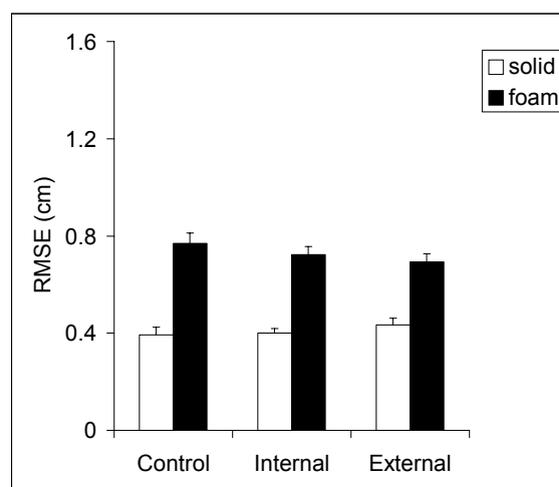
## Discussion

The balance tasks in the present experiment were relatively easy for young, healthy adults. Standing on a solid surface can be considered a well practiced skill, and even standing on a more compliant surface (foam) did not pose much challenge for this population. Presumably because of this, there were only small differential effects of attentional focus. The interaction between task and attentional focus indicated there were no attentional focus differences for the easier task (solid surface). Yet, the external condition produced greater postural stability than the control condition on the foam surface. Although the internal focus condition did not differ from either the external focus or control condition, the external benefit relative to the control at least partially supports the hypothesis that for the attentional focus manipulation to be effective, a certain degree of task difficulty is required. The difference between the external focus and control conditions is in line with the results of previous studies (e.g., Landers et al., 2005; Mc-

Nevin & Wulf, 2003; Wulf et al., 1998; Wulf et al., 2003). These authors argued that performers who do not have specific attentional focus instructions tend to focus on their body movements—making control conditions more similar to internal focus conditions. Thus, although the present results do not match a strict interpretation of the constrained action hypothesis (i.e., that external focus instructions should be more effective than internal focus instructions), they are at least partially consistent with this hypothesis. However, we wanted to have more convincing evidence that task difficulty is a qualifying factor for the attentional focus effect. Therefore, we conducted another experiment, in which we further manipulated the surface on which participants stood. We expected that, by using conditions that further decreased postural stability, more pronounced advantages from adopting an external focus would be found.

## Experiment 2

In this experiment, we chose two tasks that also required static balance but were more challenging than the tasks used in Experiment 1. Both tasks involved balancing on an inflated rubber disk. Because of the disk's shape and compliance, standing on it results in even less stability than standing on foam. This was also demonstrated by the greater amount of sway for this task compared to the foam task (Wulf et al., 2004). In the present experiment, we also varied stability by requiring participants to stand either on two legs or on one leg. Thus, by reducing the support surface (from two feet to one foot), the



**Figure 1.** Magnitude of sway (root mean square error; RMSE) as a function of surface type (solid, foam) and type of attentional focus (control, internal, or external) in Experiment 1. Error bars indicate standard errors.

task difficulty was further increased. For both tasks, we expected to find advantages of an external focus, relative to internal focus and control conditions, with no difference between the latter two conditions and possibly even greater advantages when participants were required to stand on one leg rather than two legs.

## Method

### Participants

Twenty-four university students participated in this experiment. None of them had participated in Experiment 1, and none of the participants was aware of the purpose of the study. All gave their informed consent prior to participating.

### Apparatus, Task, and Procedure

The task required participants to balance on an inflated rubber disk (Disc 'O' Sit™, Perform Better, Cranston, RI) with a 13-inch (33.02 cm) diameter. The disk was placed on a force plate that recorded the center of pressure data. The procedures were similar to those used in Experiment 1. Under external focus conditions, participants were instructed to focus on moving the disk as little as possible, whereas under internal focus conditions they were instructed to focus on moving their feet (their foot) as little as possible. Under control conditions, participants were asked to just "stand still." If the participant lost his or her balance and had to step off the disk, the trial was repeated. (This only happened on three occasions, once for three different participants.) Each participant performed three 15-s trials under each of the three attentional focus conditions (external, internal, control) on each task. The order of tasks and focus conditions was counterbalanced across participants.

## Results

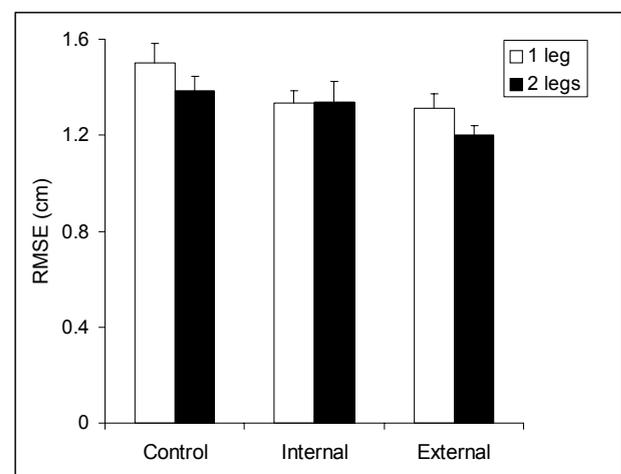
As expected, standing on one leg produced larger postural sway than standing on two legs (see Figure 2), as indicated by a main task effect,  $F(1, 23) = 5.40, p < .05, \eta^2 = .19$ . Also, the focus of attention main effect was significant, with  $F(2, 46) = 7.79, p < .001, \eta^2 = .25$ . Post hoc tests indicated the external focus condition differed significantly from both internal focus ( $p < .05$ ) and control conditions ( $p < .001$ ), whereas the difference between internal focus and control conditions just failed to reach significance ( $p = .059$ ). The main effect of trial and all interactions was not significant.

To determine whether task order had an influence on performance, we conducted a 3 (task order: control-internal-external, internal-external-control, external-con-

trol-internal)  $\times$  2 (task: 1 leg, 2 legs)  $\times$  3 (focus of attention: external, internal, control)  $\times$  3 (trial) repeated measures ANOVAs. There was a significant interaction of task order and focus of attention,  $F(4, 42) = 5.65, p = .001$ . This interaction appeared to be due to the fact that the effects of attentional focus were somewhat overshadowed by a practice, or warm-up, effect. That is, the focus conditions performed first (e.g., control in the order control-internal-external) tended to have larger errors than those performed second or third, except when the external condition was performed first. Specifically, in the order control-internal-external, RMSEs were 1.59 ( $SD = 0.11$ ), 1.33 ( $SD = 0.09$ ), and 1.20 ( $SD = 0.08$ ); in the order internal-external-control, errors were 1.53 ( $SD = 0.09$ ), 1.35 ( $SD = 0.08$ ), and 1.44 ( $SD = 0.11$ ); and in the order external-control-internal, errors were 1.21 ( $SD = 0.08$ ), 1.30 ( $SD = 0.11$ ), and 1.15 ( $SD = 0.09$ ), respectively. Follow-up analyses for each of the three task orders indicated the effect of attentional focus was significant for the order control-internal-external,  $F(2, 14) = 17.48, p < .001$ , with all three focus conditions differing significantly from each other,  $p < .05$ . For task orders internal-external-control,  $F(2, 14) = 2.76, p = .098$ , and external-control-internal,  $F(2, 14) = 3.12, p = .076$ , the main effects of focus failed to reach significance.

## Discussion

Postural sway was generally greater in Experiment 2 than it was in Experiment 1. This suggests that both the one- and two-leg tasks decreased stability at least relative to the tasks in the first experiment. Also, standing on one leg resulted in more sway than standing on



**Figure 2.** Magnitude of sway (root mean square error; RMSE) as a function of task (1-legged stance, 2-legged stance) and type of attentional focus (control, internal, or external) in Experiment 2. Error bars indicate standard errors.

two legs. Importantly, for both tasks there were effects of attentional focus. The instructions to focus on the disk (external focus) significantly enhanced postural stability, compared to instructions to focus on the feet (internal focus), or no attentional focus instructions (control). This is somewhat qualified by the fact that the effect was only significant when the external focus condition was performed last. Nevertheless, the overall advantage of an external focus replicates the findings of previous studies comparing the effectiveness of external and internal focus instructions to control conditions and that consistently found external focus benefits relative to internal or no instructions (control), and no difference between the latter two (Landers et al., 2005; Wulf & McNevin, 2003; Wulf et al., 1998, Experiment 1; Wulf et al., 2003, Experiment 2). Thus, when balancing was more demanding, the typical benefits of an external focus seen in numerous previous studies (see Wulf & Prinz, 2001, for a review) emerged. The type of attentional focus had similar effects on both tasks. That is, there was no interaction between task and focus of attention. Apparently, both tasks were sufficiently challenging to yield performance differences as a function of type of attentional focus.

## General Discussion

The purpose of the present study was to examine whether the advantages of adopting an external focus would be seen primarily for relatively challenging (postural stability) tasks but not less demanding tasks. To examine this, we used balance tasks that imposed increased challenges to maintaining stability. The present results support the view that attentional focus effects emerge only when the support surface sufficiently compromises maintaining a stable posture. In Experiment 1, there was an interaction between task and attentional focus. Specifically, while there were no attentional focus differences for the solid surface task, an external focus resulted in greater stability compared to the control condition for the foam surface task. In Experiment 2, where more challenging balance tasks were used and postural sway was perceptibly increased, external focus benefits emerged relative to both internal focus and control conditions. Thus, it seems the more apparent need to control stability, coupled with the greater coordination demands of Experiment 2, resulted in the external focus benefits seen in previous studies. This confirmed the hypothesis that a certain degree of instability may be a precondition for the attentional focus effects to occur.

Additional support for this view comes from a recent study by Landers and colleagues (2005), in which the postural stability of individuals with Parkinson's disease

was measured under various conditions. Specifically, participants were required to stand quietly (a) with their eyes open, (b) with their eyes closed, and (c) with their eyes open but on a sway-referenced support surface (where the support surface tilts forward or backward, as the individual's center of mass shifts forward or backward, respectively). Postural stability systematically decreased from (a) to (c), that is, with increasing task difficulty. More importantly, no differences were found between external focus (rectangles under feet), internal focus (feet), and control conditions (no focus instructions) on the relatively "easy" tasks with a stable support surface—(a) and (b). On the more challenging task with a sway-referenced support surface, an external focus produced less sway than both internal focus and control conditions. It is also interesting to note that significant external focus benefits were only found for persons with a history of falls, whereas this effect did not reach significance for those without a fall history. The results of the present study extend those findings by showing that performance benefits of an external focus depend on the challenges imposed by the task on young, healthy adults as well. These findings provide converging evidence that the relative level of task difficulty, that is, the difficulty as a function of the performer's capabilities, might be the critical factor for the occurrence of attentional focus effects.

Why do more challenging tasks appear to be a precondition for attentional focus effects? We suggest that the type of attentional focus affects the degree to which voluntary and reflexive control mechanisms are balanced to maintain stability. When the surface was not compliant (solid surface) or only minimally compliant (foam surface), postural sway was maintained with little or no perceived need to intercede with additional voluntary corrections. Thus, instructions to maintain an internal or external focus produced only minimal effects on postural sway. However, when the surface was relatively unstable, participants presumably experienced conscious feelings of instability. In their attempts to compensate for the increased sway, they may have elicited voluntary motor commands that interfered with the more natural and effective integration of ongoing reflexive processes. This interference was less when participants adopted an external attentional focus in comparison to internal focus and control conditions.

The constrained action hypothesis (e.g., McNevin, Shea, & Wulf, 2003; Wulf, McNevin, et al., 2001) predicted that an external focus would mainly benefit relatively challenging tasks. According to this hypothesis, the advantages of focusing on the movement effect (external focus) are due to the greater degree of automaticity in movement control, relative to the slower and more conscious control processes apparently used when the individual directs attention to his or her body move-

ments. As a consequence of the more automatic control processes, corrective movement adjustments occur more frequently and at a faster rate, thus minimizing errors and generally improving performance. When a motor task is challenging, directing the performers' attention to the movement effect might encourage them to use motor programs they have developed through practice with other, similar tasks. In contrast, when performers are left to their own devices (control condition), or if their attention is specifically directed to controlling their movements (internal focus), the situation might promote more conscious intervention in the control processes. Thus, adopting an external focus would be expected to provide performance (and learning) benefits under those circumstances. In contrast, if the task is not challenging and the performer is satisfied with the ongoing motor control processes, he or she would not be as tempted to intervene. Thus, instructions to adopt an external focus would not be expected to provide additional advantages. The present findings suggest that external attentional focus instructions are only beneficial for skills in which errors, or postural instability, tend to be large and performers are more prone to intervene into automatic control processes. External focus instructions seem to inhibit this tendency, whereas internal focus instructions do not.

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## Authors' Note

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