Instructions for Motor Learning: Differential Effects of Internal Versus External Focus of Attention

Gabriele Wulf
Max Planck Institute for Psychological Research, Munich

Markus Höß
University of Munich

Wolfgang Prinz
Max Planck Institute for Psychological Research, Munich, University of Munich

ABSTRACT. The effects of different types of instructions on complex motor skill learning were examined. The instructions were related either to the participant’s own body movements (internal focus) or to the effects of those movements on the apparatus (external focus). The hypothesis tested was that external-focus instructions would be more beneficial for learning than internal-focus instructions. In Experiment 1, the participants (N = 33) performed slalom-type movements on a ski-simulator. The instructions referred to the way in which force should be exerted on the platform that the participant was standing on. The instructions given 1 group of participants referred to the performers’ feet (internal focus), whereas the instructions given another group referred to the wheels of the platform, which were located directly under the feet (external focus). The control group was given no focus instructions. All participants practiced the task on 2 consecutive days and performed a retention test on Day 3. Compared with the effects of internal-focus instructions and no instructions, the external-focus instructions enhanced learning. Internal-focus instruction was not more effective than no instructions. In Experiment 2, an attempt was made to replicate the differential effects of external- versus internal-focus instructions with a different task (balancing on a stabilometer). Consistent with Experiment 1, instructing learners (N = 16) to focus on 2 markers on the platform of the stabilometer (external focus) led to more effective learning than instructing them to focus on their feet (internal focus), as measured by a retention test after 2 days of practice. Practical and theoretical implications of those results are discussed.

Key words: focus of attention, instructions, motor learning, ski-simulator

In an effort to identify variables that affect the learning of motor skills, researchers have been concerned with various aspects of the learning situation. Those include, for example, the organization of practice (for reviews, see Magill & Hall, 1990; Shapiro & Schmidt, 1982), the frequency or kind of feedback given to the learner (for reviews, see Salmoni, Schmidt, & Walter, 1984; Schmidt, 1991), the presentation of a model (for a review, see McCullagh, 1993; McCullagh, Weiss, & Ross, 1989), or the provision of physical guidance (e.g., Weinstein, Pohl, & Lewthwaite, 1994; Wulf, Shea, & Whitacre, in press). One factor that has been largely ignored in motor learning research is the instruction given to the learner who is in the process of acquiring a new motor skill. Instructions are given before or during practice and include information as to how to perform the skill. Instructions may be particularly relevant for the learning of complex skills—for example, in sports—in which, often, several movement sequences have to be coordinated or many degrees of freedom must be controlled. In such cases, it is often important to focus the learner’s attention on the relevant aspects of the task because those are not necessarily picked up from the observation of a model, for example. To achieve that focus, researchers often confront the learner with information regarding the correct placement of various body parts, the timing of different submovements, or the overall dynamics of the movement. Little is known about how much or what kind of information should be provided to the learner and at what point in the learning process, however, because those questions have hardly been addressed in the research literature. Yet, if a researcher’s goal is to optimize learning, providing the learner with the right information could be critical, and that poses a challenge for the practitioner. To provide practitioners with guidelines for their teaching but also to further our un-
standing of the learning process, one must investigate the effectiveness of different types of instructions experimentally.

Therefore, our purpose in the present study was to contribute to a better understanding of how instructions function in the learning process. That is, we wanted to examine how different kinds of instructions would affect learning. More specifically, we asked whether instructions referring to the performer’s body movements (internal focus)—which are commonly provided in applied settings—are always effective for learning or whether learning can be optimized by giving instructions that direct the performer’s attention away from his or her body movements and to the effects that those movements have on the environment (external focus).

Typically, a learner who is learning a new motor skill is provided with instructions about the correct movement pattern. That is, the instructions usually refer to the coordination of the performer’s body movements. In learning a tennis forehand, for example, the learner is told where to place his or her feet; how to perform the backswing, forward-swing, and follow-through; where (in relation to the body) to hit the ball; and how to time the whole action with the arrival of the ball. Body-related instructions such as those are very common in the teaching of motor skills.

Yet, there is some—although mostly anecdotal—evidence suggesting that paying attention to one’s movements can disrupt performance, especially when it comes to well-practiced skills (Bliss–Boder hypothesis; Bliss, 1892–1893; Boder, 1935; see also Gallwey, 1982; Kimble & Perlmuter, 1970; Klatsky, 1984; Masters, 1992; Schmidt, 1988). Gallwey (1982, p. 8), for example, suggested that you ask your tennis opponent, while switching courts, what he is doing that is making his forehand so good today, because that should make him think about his swing and disrupt his performance. Walter Schneider shared a personal experience that he had in downhill skiing: When he found himself thinking about which foot was carrying his weight in a turn, he noticed “substantial performance decrements (that is, many falls) for the remainder of the slope” (Schneider & Fisk, 1983, p. 133).

Even though there seems to be ample anecdotal evidence for the detrimental effects of self-attention on the performance of well-learned skills, there is only sparse experimental evidence for that phenomenon. Baumeister and colleagues (Baumeister, 1984; Baumeister & Steinhalber, 1984) provided some evidence that increased conscious attention to one’s own performance (produced by pressure to perform well) can disrupt the execution of overlearned skills. Wulf and Weigelt (1997) examined the effects of instructions on the performance of a complex motor skill, namely, the production of slalom-like movements on a ski-simulator. They found that giving participants instructions about the optimal “timing of forcing” (e.g., Vereijken, 1991; Vereijken, Whiting, & Beek, 1992), that is, when to exert force within the movement cycle—instructions that pre-
However, directing one’s attention to the tilt and pitch of the surfboard usually results in more effective power-jibes and fewer falls. Similar observations can probably be made in many other sports as well.

Interestingly, the differential effects of focusing on one’s own body movements versus focusing on the effects of those movements on the environment have also been postulated by James (1890) in his discourse on close effects and remote effects in the control of action. Whereas the term close effects refers to those consequences that are directly related to the action (e.g., kinesthetic feedback), remote effects refers to the more or less distant results of the action (e.g., a nail in the wall after hammering it in). In discussing which aspects of intended actions are functional in action control, James pointed out that remote effects are often more important than the action itself (or its close effects). For reaching movements, for example, James stated: “Keep your eye at the place aimed at, and your hand will fetch [the target]; think of your hand, and you will likely miss your aim” (James, 1980, p. 520).

Also, according to Henry and Rogers’ (1960) memory drum theory of motor control, attempts to consciously control movements, especially well-learned, complex movements, should interfere with performance. One result of that interference should be an increased reaction time under conditions of enforced motor set, that is, when the performer is asked to concentrate on the to-be-performed movement, as opposed to an enforced sensory set, namely, when the performer is to concentrate on the stimulus that evokes the response. Support for that prediction was provided in the studies by Henry (1960) and Christina (1973). Thus, even though the focus in those studies was on performance rather than learning, and on the stimulus rather than the result of the action, the results of those studies demonstrated that concentrating on something that is related to but external to the movement can be more effective than concentrating on the movement itself.

Therefore, in the present study, we wanted to test the hypothesis that an external focus of attention can be more effective for motor skill learning than an internal focus of attention. In Experiment 1, we used a ski-simulator (e.g., Durand, Geoffroi, Varray, & Prefaut, 1994; Vereijken, 1991; Wulf & Weigel, 1997) and instructed participants when to exert force on the platform. The instructions given the two groups of participants differed, however: They were told to focus their attention on the force exerted either on their feet or on the wheels of the platform (which were located directly under the feet). In addition, there was a control group given no instructions. Our purpose in Experiment 2 was to replicate the findings of the 1st experiment, but with a different task. Therefore, we used a stabiometer and instructed learners to focus either on their feet or on two markers on the platform. We questioned whether an external focus of attention (wheels or markers, respectively) would result in more effective learning than an internal focus of attention (feet).

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**EXPERIMENT 1**

The task used in this experiment required participants to perform ski-type slalom movements on the ski-simulator (see Figure 1). The ski-simulator consists of two bowed rails and a platform on wheels that is attached to it by elastic rubber belts; the rubber belts ensure that the platform returns to the center position. One can make the platform move sideways on the rails by exerting force on it. The goal of the participant standing on the platform was to make oscillatory movements that had as large an amplitude as possible (e.g., den Brinker & van Hekken, 1982; den Brinker, Stähler, Whiting, & van Wieringen, 1986; Durand et al., 1994; Vereijken, 1991; Vereijken, van Emmerik, Whiting, & Newell, 1992; Whiting, & Vereijken, 1993; Wulf et al., in press; Wulf & Weigel, 1997). In a previous study, Wulf, Shea, and Matschiner (1998) found that compared with the performance of beginners, one characteristic of expert performance on that task is that the peak force exerted on the platform by the outer foot (e.g., the right foot, when the platform is moving to the right) occurs relatively late in time, that is, close to the time when the platform reaches its peak amplitude. That is, experts not only produce larger movement amplitudes but also tend to shift their weight to the inner foot later than beginners. The weight shift to the inner foot reduces the force exerted by the outer foot against the rim of the platform. Because the outer foot is more effective in stretching the rubber belts that pull the platform to the center of the apparatus, an early weight shift is counterproductive for the production of large amplitudes (see Wulf et al., in press; Wulf et al., 1998). Therefore, the weight should be left on the outer foot as long as possible (that is, until the platform has reached its reversal point).

In the present experiment, the instructions given to the learners referred to that aspect of the task. One group of participants was given instructions referring to their own movements, whereas another group was provided instructions referring to the effects of their movements on the apparatus. Specifically, learners were instructed to try to exert force either on the outer foot (e.g., the right foot) or on the outer wheels (e.g., the right pair of wheels), as long as the platform moved in the respective direction (e.g., to the right). In addition, we formed a control group, which was given no instructions (other than to try to produce large-amplitude movements), so that the contribution of those instructions could be compared with the contribution evoked by giving no additional information. All participants practiced the task for 2 days under the respective conditions. Learning was assessed 1 day later in a retention test in which no instructions were given.

**Method**

**Participants**

Thirty-three persons (20 women and 13 men) between 19 and 35 years of age (mean age = 25 years) volunteered to participate in this experiment. Most of the participants were
students at the University of Munich, and some were professionals. They received DM 24 (about $14) for their participation. None of the participants had prior experience with the task, and they were not informed about why the experiment was being conducted.

Apparatus and Task

The ski-simulator, illustrated in Figure 1, is a commercially available apparatus (Trimm-Drive; Bremshey). The participant's task was to move the platform of the ski-simulator rhythmically to the right and to the left as far as possible by making slalom-type movements. The maximum deviation of the platform in either direction from the center was 55 cm.

Procedure

Participants were randomly assigned to one of three groups: the internal-focus group, the external-focus group, or the control group. All participants were told that the task was to move with as large an amplitude as possible. In addition, at the beginning of practice, the internal-focus group was instructed to try to exert force on the outer foot (e.g., the right foot) as long as the platform moved in the respective direction (e.g., to the right side). The instructions for the external-focus group were similar, except that that group was instructed to try to exert force on the outer wheels as long as the platform moved in the respective direction. The control group did not get any additional instructions. All participants performed a total of twenty-two 90-s trials, with 90-s breaks between trials, on 3 consecutive days. There were 8 trials on each of the 2 days of practice. The instructions for the internal-focus and external-focus groups were given at the beginning of practice and were repeated before every other trial, that is, Trials 3, 5, and 7 (Day 1), and Trials 9, 11, 13, and 15 (Day 2). Day 3 consisted of 6 retention trials without instructions.

Data Analysis and Dependent Variables

The movement of the platform was monitored by means of a potentiometer that was linked to the platform via a sprocket and chain assembly. The analog signal from the potentiometer (Novotechnik P4501, 5-kΩ resistance and .01% linearity) was sampled at 50 Hz with 12-bit resolution. One revolution of the potentiometer reflected 12.1 cm of movement of the platform. A reed switch mounted on the center of the platform and a magnet mounted on the center of the front rail provided an analog pulse each time the platform passed the center. The onset of the reed switch provided a reference for transforming the potentiometer data into platform position. From the platform position data, amplitude and frequency were derived.

The dependent variable of major interest here was movement amplitude. Yet, we also report movement frequency to provide a more complete picture of the groups’ performances. Amplitude and frequency were analyzed for the first trial and the last trial of each of the 2 days of practice (Trials 1, 8, 9, and 16), as well as for the first and last trials of the retention test on Day 3 (Trials 17 and 22). The practice data were analyzed in 3 (group) × 2 (day) × 2 (trial) analyses of variance (ANOVAs), with repeated measures on the last two factors. The retention data were analyzed in 3 (group) × 2 (trial) ANOVAs, with repeated measures on the last factor.

Results

Practice

Amplitude

All groups demonstrated increasing amplitudes from the beginning to the end of both practice days (Figure 2, left panel). Also, amplitudes were larger overall on Day 2 than on Day 1. The main effects of both day, $F(1, 29) = 44.8, p < .001$, and trial, $F(1, 29) = 261.4, p < .001$, were significant. In addition, the Day × Trial interaction was significant, $F(1, 29) = 29.5, p < .001$, reflecting the fact that performance gains were greater on Day 1 than on Day 2. Although all three groups demonstrated similar amplitudes at the beginning of practice (Trial 1), clear group differences emerged toward the end of Day 1 and remained present throughout Day 2. The external-focus group had the largest amplitudes, whereas the internal-focus group showed the smallest amplitudes, and the control group demonstrated intermediate performance. The main effect of group was significant, $F(2, 29) = 3.4, p < .05$. Post hoc tests (Newman–Keuls) indicated that the external-focus group was overall signifi-

FIGURE 1. Schematic of a participant on the ski-simulator.
cantly more effective than the internal-focus group, $p < .05$. In addition, the interactions of day and group, $F(2, 29) = 3.2, p = .05$; trial and group, $F(2, 29) = 5.3, p < .05$; and day, trial, and group, $F(2, 29) = 4.7, p < .05$, were significant. Post hoc tests indicated that the internal-focus group had significantly smaller amplitudes than both the external-focus group and the control group on the last trial of Day 1 (Trial 8), as well as on Day 2 (Trials 9 and 16), $p < .05$. In fact, by the end of Day 2, the internal-focus group had not reached the level of performance that the external-focus group had reached after 1 day of practice (see Figure 2).

**Frequency**

Movement frequencies are shown in Table 1. Frequencies were generally higher on the first trial than during the remainder of the practice period, with the control group showing the highest frequencies on Trial 1. That is, with the increase in amplitude from the beginning (Trial 1) to the end of Day 1 (Trial 8), movement frequencies became lower. The frequencies demonstrated at the end of Day 1 remained at about the same level on Day 2, however, despite the further increase in amplitude. Except for the very first trial, there were no clear differences between groups, even though the external-focus group—probably because of its larger amplitudes—tended to show somewhat lower frequencies than the other two groups. Primarily because of the higher frequencies on Trial 1, the main effects of day, $F(1, 29) = 25.2$, trial, $F(1, 29) = 42.1$, and the Day x Trial interaction, $F(1, 29) = 39.6$, $p < .001$, were significant. In addition, because of the group differences on the first trial, the Group x Day x Trial interaction, $F(2, 29) = 3.8, p < .05$,
was significant. The main effect of group, $F(1, 29) = 1.6, p > .05$, and the interactions of group and day, $F(2, 29) < 1$, and of group and block, $F(2, 29) = 1.7, p > .05$, were not significant.

**Retention**

On the 3rd day, we conducted a retention test consisting of six trials to determine the learning effects of the different treatment conditions. No instructions regarding the focus of attention were given on Day 3.

**Amplitude**

The external-focus group was clearly more effective in producing large movement amplitudes than both the internal-focus and the control groups, whereas there was not much difference between the latter two groups. The group main effect was significant, $F(2, 30) = 3.7, p < .05$. Post hoc tests indicated that the external-focus group differed significantly from both the internal-focus group and the control group, $p < .05$. Also, across the retention test, there was a further increase in amplitude for all groups (see right panel of Figure 2). The main effect of trial was significant, $F(1, 30) = 36.8, p < .001$. There was no interaction of group and trial, $F(2, 30) < 1$. Thus, the instructions to focus on the wheels were more beneficial for the learning of this task than the instructions to focus on the feet or no instructions.

**Frequency**

Whereas both the external-focus and the control groups tended to show an increase in movement frequency from the beginning to the end of the retention test, the internal-focus group remained stable across retention. Nevertheless, the main effect of trial was significant, $F(1, 30) = 7.7, p < .001$. The interaction of group and trial failed to reach significance, however, $F(2, 30) = 2.5, p = .10$. The main effect of group was not significant, $F(2, 30) < 1$.

**Discussion**

Our purpose in this experiment was to determine whether instructions that direct the performer’s attention not to his or her own movement pattern but to the effects of that movement on the environment, in this case, on the apparatus or sporting equipment, are more advantageous for learning. Participants learning to perform slalom-type movements on the ski-simulator were instructed to try to exert force either on the outer foot (internal focus) or on the outer wheels of the platform (external focus) as long as the platform moved in the respective direction. Even though the actual locus of attention differed only slightly between those conditions (the wheels were located directly under the feet), the two types of instructions had dramatically different effects on participants’ ability to produce large-amplitude movements.

The external-focus group showed a greater improvement across the 2 days of practice than the internal-focus group. Also, the internal-focus group was less effective than not only the external-focus group but also the control group, which had not received instructions. That is, the body-related instructions degraded performance, compared with no instructions, at least when they were present during practice. Those results are in line with those of Wulf and Weigelt (1997, Experiment 1), who found that compared with no instructions, instructions to delay the timing of forcing (e.g., Vereijken, 1991) reduced the performance improvement during practice.

No instructions were provided during the delayed retention test on Day 3, and the external-focus group produced significantly larger amplitudes than both the internal-focus group and the control group. The latter two groups showed similar performances. That is, the degrading effects of the internal-focus instructions seen during practice were not permanent in nature. Yet, those instructions were no more effective for learning than no instructions at all. Compared with no instructions (or internal-focus instructions), however, the external-focus instructions did have an advantage for learning. Thus, only the instructions that directed the learner’s attention away from her or his own performance were more beneficial for learning than no instructions.

Those results call into question the learning effectiveness of the body-related instructions that are typically used in applied settings. Also, theorists have argued that paying attention to and being aware of one’s body movements during movement execution enhances performance and learning (e.g., Cox, 1933; Meinel & Schnabel, 1976). Yet, it seems that compared with no such instructions, instructions calling for the performer to pay attention to his or her movements can, in fact, degrade performance or even learning (Singer et al. 1993; Wulf & Weigelt, 1997). More important, the present results suggest that in order to enhance the learning effectiveness of instructions, the learner’s attention should be directed toward the effects of his or her movements on the environment, or apparatus (external focus). Because of the potential practical and theoretical importance of those results, we decided to try to replicate them in a second experiment.

**EXPERIMENT 2**

To examine the robustness and generalizability of the findings of Experiment 1, we wanted to replicate the differential effects of the internal- and external-focus conditions with a different task. The task used in this experiment required participants to balance on a stabilometer. We used that task, because it allowed us to examine the learning effects of extremely subtle differences in the instructions given to the learners. We were mainly interested in the effectiveness of instructions that promoted an internal or external focus of attention, and therefore we used only two groups: one given internal- and the other given external-focus instructions. Both groups practiced the task on 2 consecutive days. Learning was assessed in a retention test on Day 3.
Participants
Sixteen students (10 men and 6 women) from Texas A&M University were recruited as participants for this experiment. They received extra class credit for their participation. None of them had prior experience with the task, and all of them were naive as to the reasons we were performing the experiment.

Apparatus and Task
We used a stabilometer task that requires dynamic balancing. The stabilometer consists of a 26-× 42-in. wooden platform; the maximum possible deviation of the platform to either side was 15°. Two round red markers with a diameter of 1.5 in. were placed on the platform, 6.5 in. from the front edge and 8 in. from the midline of the platform. Participants were instructed to place their feet on the platform so that the tip of each foot touched one of the markers. The task was to remain in balance, that is, to keep the platform in a horizontal position, for as long as possible during each 90-s trial. By means of a potentiometer (Novotechnik P4501, 5-kΩ resistance, and .01% linearity) that was linked to the platform, we monitored the movements of the platform. To analyze skill development, we recorded an analog signal (50 Hz, 12-bit resolution) from the potentiometer for the whole duration of a trial.

Procedure
Participants were randomly assigned to either the internal-focus or the external-focus group. (Unlike the procedure used in Experiment 1, there was no control group without instructions, because our main interest was in determining the relative effectiveness of the different types of instructions.) Participants in the internal-focus group were instructed to focus on their feet and to try to keep them at the same height, whereas the external-focus group participants were instructed to focus on the red markers and to try to keep the markers at the same height. There were seven 90-s trials on each of 3 consecutive days, with 90-s breaks between trials. Participants were reminded of the instructions before every other practice trial on the first 2 days, that is, before Trials 3, 5, and 7 (Day 1), and before Trials 8, 10, 12, and 14 (Day 2). The 7 trials on Day 3 were considered a retention test, and participants were given no reminders on that day.

Data Analysis and Dependent Variable
The potentiometer data were transformed into degrees out of balance. As the dependent variable, we used root-mean-square (RMS) error (degrees), with the 0° position (board in horizontal) as the criterion. RMS error during practice was analyzed in 2 (group) × 2 (day) × 7 (trial) ANOVAs, with repeated measures on the last two factors. The retention data were analyzed in a one-way ANOVA, in which we used trials as repetitions.

Results
RMS errors for the internal- and external-focus groups during the 2 days of practice can be seen in Figure 3 (left and middle panels). Both groups showed considerable reductions in RMS errors across both days, with larger improvements on Day 1 than on Day 2. The external-focus group tended to have larger errors than the internal-focus group on the 1st day, whereas both groups demonstrated very similar performances on the 2nd day. The main effects of both day, $F(1, 14) = 157.9, p < .001$, and trial, $F(6, 168) = 63.1$, as well as the Day × Trial interaction, $F(6, 168) = 13.8$, all $p s < .001$, were significant. The interaction of group and day just failed to reach significance, $F(1, 14) = 4.4, p = .054$. None of the other main or interaction effects were significant, all $F s < 1$.

Retention
As can be seen from Figure 3 (right panel), the external-focus group was clearly more effective than the internal-focus group on the retention test on Day 3, in which no instructions were given. The group effect was significant, $F(1, 110) = 8.5, p < .01$. Thus, again, the instructions that directed the participants’ attention to something external of their bodies (that is, the markers on the board) enhanced learning in comparison with the instructions that focused the learners’ attention on their own body movements (i.e., their feet).

Discussion
Our purpose in this experiment was to replicate and extend the findings of Experiment 1. Here, we used a different motor task and provided learners with a different set of instructions from those used in the 1st experiment. Yet, similar to the procedure followed in Experiment 1, the instructions directed the participants’ attention either to their body movements (internal focus) or to the effects of their movements on the apparatus (external focus). Even though in this experiment there were no advantages for the external-focus condition during practice—the internal-focus group demonstrated even slightly better performance on Day 1—the results of the retention test on Day 3 were again clear in showing that the external-focus condition was more effective for learning than the internal-focus condition. Those results provide additional evidence for the learning advantages of external-focus instructions. In addition, they show that those effects are generalizable to different tasks. The present results therefore increase our confidence in that effect.

GENERAL DISCUSSION
In this study, we examined the effectiveness of different types of instructions on the learning of complex motor skills such as performing slalom-type movements on a ski-simulator (Experiment 1) and balancing on a stabilometer (Experiment 2). The results of previous research have suggest-
ed that instructions that direct the performer's attention to her or his own movements (internal focus) might not be very effective for learning; in fact, compared with instructions to not attend to the movement while executing it (Singer et al., 1993) or with no additional instructions (Wulf & Weigelt, 1997), such attention-directing instructions can even disrupt performance and learning. Therefore, we wanted to examine whether learning could be optimized by directing the learner's attention to the effects of his or her movements on the environment (external focus). Both experiments were clear in showing that instructing learners to focus on the apparatus (i.e., the wheels of the ski-simulator in Experiment 1, the markers on the stabirometer in Experiment 2) was clearly more effective for the learning of those tasks than directing their attention to their body movements (i.e., their feet). Those results cause one to question the effectiveness of body-related instructions—which are commonly used in practical settings—for the teaching of motor skills. It seems to be more beneficial for learning to find instructions that have the same goal but direct the learners' attention away from their own movements, for example, to the effects that those movements have on the environment, or sporting equipment.

Although both experiments were consistent in demonstrating advantages of external-focus over internal-focus instructions in delayed retention, there were some differences with regard to acquisition performance of the external and internal-focus groups. Whereas during practice on the ski-simulator task (Experiment 1) the external-focus condition showed a performance benefit, compared with the internal-focus group, there were no group differences on the stabirometer task during practice (Experiment 2). A possible explanation for that difference in acquisition performance might be related to the differential demands of the two tasks. Performing slalom-type movements on the ski-simulator requires the beginner to figure out how to move the platform and therefore might be more sensitive to (different types of) instructions than trying to remain in balance on the stabirometer. The latter task seems to be more motor in nature and may not be affected by cognitive intervention strategies, such as those imposed by the instructions, until a certain skill level is reached.
The greater learning effectiveness of external-focus than internal-focus instructions could also have implications for feedback procedures—for example, knowledge of results (KR) or knowledge of performance (KP)—that are typically thought of as being instructive to learning. KR, which provides the learner with information about the results of her or his movement, in most cases seems to imply an external focus. KP, on the other hand, informs the learner about the movement pattern in relation to a goal pattern and seems to promote an internal focus. Because those feedback procedures have different informational contents, however, their relative effectiveness is difficult to determine. It depends on the focus of attention induced by KR and KP (e.g., Brisson & Alain, 1996; Kernodle & Carlton, 1992). It might therefore be interesting to examine to what extent the effectiveness of feedback depends on the attentional focus it induces.

The present results, of course, raise the question of why focusing on the effect of the movement is more effective than focusing on the movement itself. It is possible that attempts to consciously control movements actually interfere with automatic motor control processes. The ability of the motor system in the automatic control of action was impressively demonstrated in a study by Henry (1953). He showed that participants whose task was to hold the position of a lever constant responded to minimal changes in pressure applied to the lever by a mechanical device. In fact, the pressure required for conscious perception of a change in pressure was, on average, 20 times as large as the pressure that participants actually responded to. Perhaps it is not surprising, then, that attempts to exert conscious control over processes that would otherwise regulate the movement automatically can actually hamper performance (and learning). Several studies in the implicit learning literature—although those are mainly concerned with the acquisition of more cognitive tasks (for an exception, see Green & Flowers, 1991, who used a simulated ball-catching task)—have shown that directing participants' attention to a rule underlying the task to be learned can actually degrade the learning of that rule, compared with not informing them about the existence of the rule (e.g., Berry & Broadbent, 1988; Reber, 1976; Reber, Kassin, Lewis, & Cantor, 1980). Apparently, unconscious learning processes can be more effective than conscious learning processes. In fact, implicit (unconscious) learning may be particularly relevant in the acquisition of motor skills, because those skills are thought to have important automatic components (e.g., Anderson, 1995; Schmidt, 1988).

The Henry (1953) study showed another interesting parallel to the present results. In Henry's study, participants were required either to hold the position of the lever constant, that is, to direct their attention to the position of an object in the environment (external focus), or to maintain a constant pressure on the lever, that is, to direct their attention toward their kinesthetic feedback (internal focus). He found that the performances of participants who concentrated on the object were clearly more effective than the performances of participants who concentrated on their own movement. Even though Henry examined performance, not learning, his findings are nicely in line with the present results in demonstrating advantages of directing one's attention to the effects of one's movement, rather than to the movement itself (see also Christina, 1973; Henry, 1960; Henry & Rogers, 1960).

The differential effects of an internal versus an external focus of attention in the performance of motor skills are also reminiscent of James's (1890) distinction between close and remote effects, and their role in the control of action. According to James, focusing on the remote effects of actions, that is, their (perceived) results, should be more effective for their control than focusing on their close effects, that is, the movements themselves. Similar ideas can be found in Lotze's work (1852). In his view, movements are represented by codes of their perceived effects. The desired outcome has the power to guide the action so that the outcome is obtained; that is, the motor system simply does what the mind intends it to do.

More recently, Prinz et al. (Prinz, 1992, 1997; Prinz, Aschersleben, Hommel, & Vogt, 1995) and Hommel (1997) have taken up James's and Lotze's idea that actions are (best) planned and controlled by their intended effects (action effect hypothesis; Prinz, 1997). When speaking, for example, we usually are not aware of the articulators involved. That is, our plans and intentions do not refer to the spatiotemporal patterns of the movements. Rather, they refer to the audible effects that those movements have. The intended effects seem to be capable of somehow guiding the motor system so that it produces the effects (e.g., Kelso & Tuller, 1981; Kelso, Tuller, & Harris, 1983). Experimental evidence for the functional efficiency of intended effects has also been discussed by Prinz and colleagues (Prinz, 1992; Prinz et al. 1995) and Hommel (1993).

Prinz (1990) offered a common coding explanation for that phenomenon. Contrary to traditional views, which assume that there are different and incommensurate coding systems for afferent and efferent information (e.g., Massaro, 1990; Sanders, 1980; Welford, 1968), Prinz argued that there is a common representational medium for perception and action. According to that view, the reason we plan our actions in terms of distal events and perceived distal events is that efferent and afferent codes can be generated and maintained in a commensurate way only at that abstract level of representation. That is, only the format of distal events allows for commensurate coding, and thus for efficient planning of action (see Prinz, 1992). Thus, according to the common coding view, actions should be more effective if they are planned in terms of their intended outcome (or remote effects, in James's terms), rather than in terms of the specific movement patterns. Our results were in line with that prediction.

Overall, the present results suggest that the instructions one gives to learners while they are practicing a motor skill
can have a decisive influence on learning. They also show that giving beginners instructions that are based on expert performance can actually enhance learning and reduce the time needed to reach a certain performance criterion—provided those instructions are given in a form that is conducive to learning. That is, the effectiveness of instructions seems to critically depend on the way in which they are presented to the learner. Apparently, instructions related to the performer's body movements are not always optimal; in fact, compared with no instructions at all, they can degrade performance. More important, we showed that giving instructions that distract the performer from concentrating on their own movements and cause the performer to focus on the effects that those movements have on the environment can be much more effective for motor skill learning. Determining the underlying causes for that effect and possible limiting factors might be a fruitful direction for future research.

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NOTES

1. Because of technical problems, the data of 1 participant in the external-focus group on Trial 8 could not be analyzed.
2. Thanks to Tim Lee for pointing that out.

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