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The Learning Advantages of an External Focus of Attention in Golf

Gabriele Wulf, Barbara Lauterbach, and Tonya Toole

This study examined whether the learning advantages of an external focus of attention relative to an internal focus, as demonstrated by Wulf, Höß, and Prinz (1998), would also be found for a sport skill under field-like conditions. Participants (9 women, 13 men; age range: 21–29 years) without experience in golf were required to practice pitch shots. The practice phase consisted of 80 practice trials. One group was instructed to focus on the arm swing (internal focus), whereas another group was instructed to focus on the club swing (external focus). One day after practice, a retention test of 30 trials without instructions was performed. The external-focus condition was more effective for performance during both practice and retention.

Key words: motor learning, computer skills, instructions, attentional focus

Instructions are a central part in teaching motor skills. When learning a new motor skill, the learner is usually given instructions regarding the correct technique. For example, in teaching a turn in downhill skiing, instructors typically demonstrate and describe to the learner the correct posture and coordination of the leg, trunk, and arm movements during the various phases of the turn, how to use the poles, when to shift the weight from one leg to the other, and so forth. Instructions such as those that refer to coordinating the performer's *body movements* are very common in the teaching of motor skills.

Recently, the effectiveness of such instructions has been questioned, however. Wulf and Weigelt (1997) showed that giving learners instructions about how to best produce slalom-type movements on a ski simulator, such as instructing learners when to exert force on the platform on which they were standing (e.g., Vereijken, 1991; Vereijken, Whiting, & Beek, 1992), degraded performance and transfer to a "stress" situation, compared to no instructions. This study provided preliminary evidence that directing the performer's attention to her or his own movements can not only disrupt the execution of automated skills, as was suggested previously (e.g., Bliss, 1892–93; Boder, 1935; Masters, 1992; Schmidt, 1988; Schneider & Fisk, 1983), but it can also have degrading effects on the acquisition of new skills. Interestingly, providing learners with instructions was even more detrimental than no instructions at all.

More importantly, Wulf, Höß, and Prinz (1998) argued that instructions might be more beneficial for learning if they direct the learner's attention to the *effects* that her or his movements have on the environment (e.g., the experimental apparatus or sporting equipment). In two experiments, they demonstrated the greater effectiveness of an "external" focus of attention (i.e., where the performer's attention is directed to the effect of the action, as compared to an "internal" focus of attention, where attention is directed to the action itself). Using a ski-simulator task (Experiment 1), they found that instructing participants to focus on the force they exerted on the *wheels* of the platform was more effective than focusing their attention on the *feet* that exerted the force (even though the wheels were located directly under the feet) in both acquisition and retention. Their Experiment 2 demonstrated the generaliza-

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Gabriele Wulf is with the Max Planck Institute for Psychological Research. Barbara Lauterbach is with the University of Munich. Tonya Toole is with the Department of Nutrition, Food, and Movement Sciences at Florida State University.

bility of this effect by showing that the learning of a stabilometer task was also enhanced by an external focus of attention (*markers* attached to the board), relative to an internal attentional focus (*feet*). Thus, both experiments were consistent in showing that minor differences in the attentional focus induced by the instructions given to learners can have a decisive effect not only on performance during acquisition, when the instructions are given, but also on learning, as measured by delayed retention tests without instructions.

The "common coding" view of perception and action (Prinz, 1990) provides a possible explanation for the advantages of focusing on the effects of one's movements rather than on the movements themselves. Similar to the ideas already proposed by James (1890) that actions are controlled by their "remote" effects, Prinz (1990, 1997) argued that we perceive and plan our actions in terms of "distal events" (i.e., their intended outcome), as this is the only format that allows for commensurate coding of perception and action. Therefore, actions should be more effective if they are planned in terms of the anticipated outcome, rather than in terms of the specific movement patterns.

The learning advantages of an external attentional focus in the Wulf and Weigelt (1997) and Wulf et al. (1998) studies could have important implications for the teaching of motor skills in practical settings. In sports, instructions are typically used that focus the performers' attention on their body movements (internal focus). Demonstrating that instructions inducing an external focus of attention can be more beneficial in these situations as well could potentially have major consequences for the effectiveness of training procedures. Therefore, the goal of this study was to determine the robustness of this effect and its generalizability to learning sport skills under field-like conditions. The need for this type of applied research with the goal to "develop theory-based knowledge appropriate for understanding the learning of practical motor skills in practical settings..." (Level 2 research) has been emphasized by Christina (1987, pp. 29–30). In contrast to the more prevalent Level 1 research (basic), which often lacks direct practical relevance, Level 2 research seems to have more potential to provide a rational basis for decision making in real-life training situations (Christina, 1987, 1989).

In the present study, participants with no experience in golf were required to perform pitch shots. While the basic instructions regarding grip, stance, and posture were the same for all participants, the instructions differed in that the attention of one group of participants was directed to the arm swing (internal focus), whereas participants of another group were instructed to focus on the club swing (external focus). The learning effects of these conditions were assessed 1 day after the practice session in a retention test without instructions. To ensure that the effects of the independent variables, if any, were not only temporary but relatively permanent in nature (i.e., affected the *learning* of this task; Magill, 1998; Schmidt & Lee, 1999), all participants performed a retention test without instructions 1 day after the practice session. Although different measures can be used to assess learning (cf. Christina, 1997), performance in retention is commonly used to infer whether the independent variables had differential effects on learning.

Method

Participants

Twenty-two right-handed students of the Technical University of Munich (9 women and 13 men) between the ages of 21 and 29 years volunteered to participate in this experiment. All provided informed consent before participating in the study. None of the participants had prior experience with playing golf or hitting golf balls.

Apparatus and Task

The experiment was conducted outdoors on a lawn surface. The participants' task was to hit golf balls into a circular target with a radius of 45 cm. Ten balls were provided so that a block of 10 trials could be performed without interruption. The target was located at a distance of 15 m from where the participant was standing. The club used was a 9 iron, because it is often used for the pitch shot when actually playing the game. Four concentric circles with radii of 1.45, 2.45, 3.45, and 4.45 m, respectively, were placed around the target to determine the distance off target. That is, the experimenter recorded where the ball landed.[1]

Procedure

Participants were randomly assigned to one of two groups with the restriction that there be an equal number per group: the internal-focus group and the external-focus group. Before the beginning of the practice phase, the experimenter spent about 10 min with each participant to explain and demonstrate the basic technique of the pitch shot. All participants were given the same instructions regarding the grip, stance, and posture. The overlapping grip was taught. The stance was open with the body leaning toward the left so that approximately 60–70% of the weight was centered on the left leg. A "C" posture was assumed that included flexion at the knees and hips.

The instructions for the two groups differed with regard to the swing, however. The instructions for the *internal-focus* participants were directed at the swinging motion of the arms. The participant was asked to put her or his hands together in the correct "grip," but without the club, and to swing the arms back and forth. The participant's attention was directed at the left arm being straight and the right arm being somewhat bent during the backswing, both arms being straight during the forward swing, and the right arm being straight and the left arm being bent during the follow-through. The participant then performed the swinging motion holding the club by both hands in the correct grip about 20 times (without hitting a ball), with the instruction to focus on the correct arm movements. The experimenter gave feedback about the grip, stance, posture, or swinging motion if necessary. The attentional focus of the *external-focus* participants was directed toward the club movement. Specifically, the participant was asked to let the club perform a pendulum-like motion. To illustrate this point, the participant was to hold the club by the grip between the thumb and index finger of the right hand, push the club to start a pendulum motion, and concentrate on the weight of the clubhead. Finally, the external-focus participants also performed 20 swinging motions with the club. Participants were instructed to let the club swing freely and focus on the weight of the clubhead, the straight-line direction of the clubhead path, and the acceleration of the clubhead moving toward the bottom of the arc. Again, participants were given feedback about their performance as necessary.

Thus, overall the instructions were similar for the two groups. The only difference in the instructions was that the attention of the internal-focus participants was directed toward their body movements (arms), whereas the external-focus participants were to focus on the club movement. After the introductory instructions and practice without the balls, all participants performed 80 practice trials, with the goal being to hit the target. Each participant hit 10 balls in a row, with the experimenter recording the scores. The balls were then collected, and the participant performed the next 10 shots, etc.. Before each set of 10 trials, the experimenter reminded the participant of the cue (arms or club) that he or she was to focus on. One day later, all participants performed a retention test consisting of 30 trials. No instructions or reminders were given on the second day.

Dependent Measures

Participants' performances were scored in the following way: Balls hitting the target received 5 points, balls landing in the first zone were given 4 points, balls landing in the second zone 3 points, and so forth. All shots were counted, independent of whether or not they had the proper 9-iron pitch trajectory. If the participant missed the ball or it did not land in one of the zones, zero points were recorded. The total score in each 10-trial block was then calculated for each participant. The practice data were analyzed in 2 (Groups) x 8 (Blocks) analyses of variance (ANOVAs) with repeated measures on the last factor, and the retention data were analyzed in 2 (Groups) x 3 (Blocks) repeated measures ANOVAs.

Results

Practice

Both groups became increasingly accurate in their shots across the practice phase, with the external-focus group achieving considerably higher scores than the internal-focus group throughout the whole practice phase (see left panel of Figure 1). The main effects of both group, $F(1, 20) = 37.5$, $p < .001$, $\omega^2 = .77$, and block, $F(7, 140) = 8.2$, $p < .001$, were significant. There was no Group x Block interaction, $F(7, 140) < 1$.

Table 1 shows the average percentages of scores achieved by the external- and internal-focus participants during the first and second half of the practice phase. While both groups hit more balls closer to the target in the second half of practice compared to the first half, the external-focus group was generally more effective (i.e., these participants achieved higher scores more frequently and lower scores, in particular, zero scores, less frequently than the internal-focus group participants.

Retention

Performance on the retention test without instructions on Day 2 can be seen to the right of Figure 1. The external-focus group was again generally more effective than the internal-focus group. The main effect of group was significant, with $F(1, 20) = 6.6$, $p = .018$, $\omega^2 = .34$. The main effect of block and the interaction of group and block were not significant, $F(2, 40) < 1$.

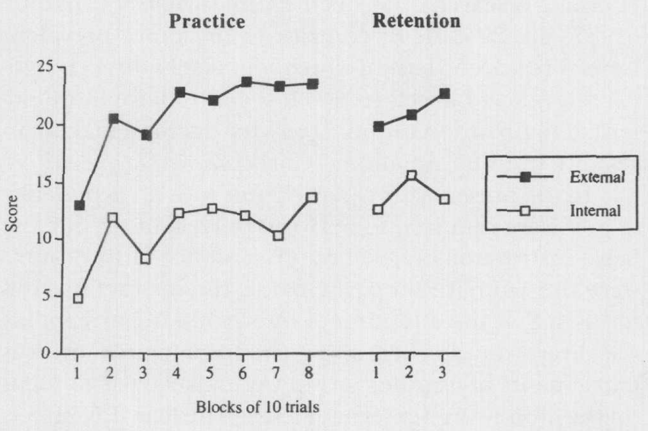

Figure 1. Average scores of the internal- and external-focus groups in practice and retention.

A comparison of the average percentages of shots that scored 5, 4, 3, 2, 1, or 0 points on the 30 retention trials also impressively demonstrates the superior performance of the external-focus group (see Table 1). While the number of times the target was hit (5 points) was relatively low for both groups, the external-focus group again hit the zones that were closer to the target more often than the internal-focus group, and vice versa. Also, the external-focus group had fewer scores of 0 than the internal-focus group.

Discussion

Our goal in this study was to determine the generalizability of the advantages of an external attentional focus found by Wulf et al. (1998) to learning a sport skill under field-like conditions. The results were clear in showing that the golf task used was learned more effectively if the learner's attention was focused on the implement, that is, golf club (external focus) as compared to when it was directed at the arm movements (internal focus). The external-focus group already demonstrated performance benefits early in practice (first block of ten trials), and this advantage was maintained throughout the whole practice session. In fact, the average scores of the external-focus group (21.0) were almost twice as high as those of the internal-focus group (10.8) during practice. The effect size (ω^2 = .77) also indicated that this group difference can be considered as large (Cohen, 1988). These benefits of the external-focus instructions were not only temporary, but were also seen in the delayed retention test (without instructions). Here again, the external-focus group demonstrated a significantly greater accuracy than the internal-focus group. The effect size (ω^2 = .34) was only small to moderate (Cohen, 1988) in retention, however, presumably participants were not given reminders regarding the attentional focus. This suggests that the effects of attentional focus instructions may be particularly powerful when they are present and directly affect the performer's focus of attention. Nevertheless, the instructions had a relatively permanent effect (i.e., they influenced the learning of this task). Overall, these results show that the advantages of directing the learners' attention away from their own movements and to the effects of these movements, as demonstrated by Wulf et al. (1998), are generalizable to learning sport skills.

Table 1. Average percentages of scores achieved by the internal- and external-focus groups during the first (Practice 1) and second half (Practice 2) of practice and in retention

Scores	Practice 1		Practice 2		Retention	
	External	Internal	External	Internal	External	Internal
5	3.4	0.5	5.0	1.4	2.7	3.0
4	18.0	6.8	22.3	6.4	24.0	10.0
3	17.5	8.6	23.0	12.7	21.0	13.0
2	16.6	10.7	18.0	16.6	14.7	14.0
1	13.9	16.3	12.5	19.1	10.0	16.3
0	30.7	57.0	19.3	44.1	28.0	43.3

The fact that the external-focus condition demonstrated performance benefits early in practice might seem surprising. In the Wulf et al. (1998) study, these advantages showed up at the end of the first day of practice on the ski-simulator task (Experiment 1), whereas they did not appear until the third day (retention) on the stabilometer task. Thus, there might be task-related differences affecting the differential effectiveness of external- versus internal-focus instructions. Also, it should be pointed out that the differences in the actual locus of attention between the two conditions were extremely small in the Wulf et al. experiments, that is, participants were to focus either on their feet or a pair of wheels directly under their feet (ski simulator), or on markers located directly in front of their feet (stabilometer), respectively. Considering the spatial proximity of these cues, it is surprising that group differences occurred at all. In the present experiment, the "distance" between the cues (arms vs. club) was considerably greater—not only spatially, but perhaps also in their distinctiveness for the participants. This might be one reason why group differences seemed to be even more clear in this case. In addition, one has to take into account that before the beginning of the actual practice phase participants performed 20 swings without hitting a ball, with their attention being directed at the respective cues (arms vs. club). This might also explain why the external-focus benefits were already seen on the first 10-trial block.

As early as 1920, Ernest Jones advocated his ideas about attentional focus on the clubhead in golf (cf. Jones & Eisenberg, 1952). Although Jones did not use the term "external focus," his ideas were certainly related to attentional focus on the clubhead, plane, direction of the clubhead, effects of the weight of the clubhead, etc.. One research study (Toole, 1969) supported his ideas, at least with those who were skilled in batting. In Toole's study, "for those who could adequately perform the body movement essential to skill in batting, attention to movement of the golf club pertaining to plane, range, and acceleration was sufficient to elicit the requisite body movements which were habituated in the related skill of batting" (p. 65). The results of the present study extend those of Toole's (1969) by showing that directing the learners' attention to the club might *generally* be more effective than directing their attention to their arm movements, as it is usually done in practical settings. In fact, the correct arm movements just seem to emerge as a natural consequence of the club movement.

Differential effects of focusing on one's own body movements versus focusing on the effects of these movements on the environment have also been postulated by James (1890). He distinguished between "close effects" that are direct consequences of the action (e.g., the kinesthetic feedback associated with hammering in a nail), and "remote effects" that refer to the more or less distant results of the action (e.g., the nail in the wall). In discussing which aspects of intended actions are functional for action control, James points out that remote effects are often more important than the action itself (or its close effects). That is, focusing on the remote effects of actions, i.e., their (perceived) results, should be more effective for their control than focusing on their close effects, e.g., 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 somehow has the power to guide the action such that this outcome is obtained.

More recently, Prinz and colleagues (Prinz, 1992, 1997; Prinz, Aschersleben, Hommel, & Vogt, 1995) and Hommel (1997) have taken up the idea that actions are (best) planned and controlled by their intended effects ("action effect hypothesis;" Prinz, 1997). Prinz (1990) offered a "common coding" explanation for this phenomenon. Contrary to traditional views, which assume there are different and incommensurate coding systems for afferent and efferent information (e.g., Welford, 1968; Sanders, 1980; Massaro, 1990), Prinz argued for a common representational medium for perception and action. According to this view, we plan actions in terms of distal events and perceive distal events, because efferent and afferent codes can only be generated and maintained commensurately at this abstract level of representation. That is, only the format of "distal events" allows for commensurate coding and efficient action planning (see Prinz, 1992). Thus, according to the common coding view, actions should be more effective if planned in terms of their intended outcome (or "remote effects," in James' terms) rather than the specific movement patterns. Our results are in line with this prediction.

One advantage expert performers have, compared to novices, might actually be that they focus on the intended effect rather than on the movement itself. That is, they allow the motor system "to do what it has to do" to produce the intended effect. The so-called five-step approach proposed by Singer (e.g., Kim, Singer, & Radlo, 1996; Singer, Lidor, & Cauraugh, 1993) can be seen as simulating the strategies used by experts in teaching motor skills to novices. A critical feature of this approach is that the learner is instructed *not* to think about the movement while executing it. Singer and colleagues (e.g., Kim, Singer, & Radlo, 1996; Singer, Flora, & Abourezk, 1989; Singer et al., 1993) have shown that this approach can be more effective for learning new skills rather than instructing learners to be aware of their body movements during execution. Similarly, Wulf and Weigelt (1997) found that asking performers on the ski simulator to pay attention to their "timing of forcing" disrupted not only the performance of experts (Experiment 2) but also the performance (and learning) of novices, relative to no instructions, that is, to a discovery learning condition (Experiment 1). The present results, together with those of Wulf and colleagues (1997, 1998), suggested that an effective strategy for teaching is not only to direct the learners' attention away from their movements (or hope they will discover the correct movement pattern themselves) but also to focus their attention on the external effects of their movements.

Interestingly, based on his extensive experience as a tennis coach, Gallwey (1982) came to a similar conclusion. A strategy he recommended to players too concerned with *how* they hit the ball—which is probably not uncommon, considering the emphasis placed on the correct technique during training—was what he called "programming for results." Gallwey suggested they "shift their attention from means to ends" (Gallwey, 1982, p. 56). He gave the example of a player who tried to work on various aspects of her forehand. Instead of giving her instructions on each of these elements, Gallwey asked her to focus on how she wanted the ball to go over the net and where she wanted it to land (i.e., to have "a clear visual image of the *results* she desired;" p. 57, emphasis by Gallwey). Gallwey noticed almost immediate changes not only of the ball's path, but also with elements of the player's movement pattern that she had unsuccessfully tried to correct earlier (apparently without the player being aware of these changes).

The advantages of an external focus of attention are perhaps most easily seen in tasks requiring the use of an implement (e.g., ball, bat, skis, surfboard, hang glider). One question that needs to be addressed in future research is whether similar observations would also be made in movement skills that do not have obvious effects on the environment (e.g., gymnastics, diving). In these cases, one might have to resort more to body-related (internal-focus) instructions. Also, independent of the type of skill, focusing on one's body movements might be necessary in situations, for example, in which an error is resistant to correction by simply focusing on the movement outcome. Furthermore, the generalizability of the benefits of external-focus instructions to different types of skills, skill levels, or age groups needs to be examined in future studies.

The present results could also have implications for other aspects of teaching. The use of metaphors, for example, might be beneficial for performance and learning, as they seem to detract the performer's attention from his or her body movement while providing a mental image of the movement goal. Also, the effectiveness of modelling could perhaps be optimized by encouraging the learner to just imitate the movements of the model without worrying about whether the movements are performed correctly. In fact, anecdotal evidence suggests that, for example, playing tennis after watching a world-class tennis match can result in much better performance than usual—at least until the performer thinks about what she or he is doing differently to make her or his game more effective. Also, one reason children seem to learn new motor skills faster than adults might be that they do not think or worry about the correct technique but simply imitate their idols. Finally, the effectiveness of feedback procedures might depend on whether they direct the performers' attention to their own movement patterns or the results of their movements (Shea & Wulf, 1998). Questions such as these also need to be addressed by future research.

Overall, the present results, together with those of Wulf et al. (1998), provide converging evidence demonstrating that instructions focusing the learners' attention on the intended effect of their movements (external focus) rather than the movements themselves (internal focus) seem to be more advantageous for performance and learning. These results seem to have important implications for optimizing instructions for motor learning.

References

Bliss, C. B. (1892–93). Investigations in reaction time and attention. *Studies from the Yale Psychological Laboratory, 1,* 1–55.

Boder, D. P. (1935). The influence of concomitant activity and fatigue upon certain forms of reciprocal hand movements and its fundamental components. *Comparative Psychology Monographs, 11* (No. 4).

Christina, R. W. (1987). Motor learning: Future lines of research. In M. J. Safrit & H. M. Eckert (Eds.), *The cutting edge in physical education and exercise science research* (American Academy of Physical Education Papers No. 20, pp. 26–41). Champaign, IL: Human Kinetics.

Christina, R. W. (1989). What happened to applied research in motor learning? In J. S. Skinner, C. B. Corbin, D. M. Landers, P. E. Martin, & C. L. Wells (Eds.), *Future directions in exercise and sport science research* (pp. 411–422). Champain, IL: Human Kinetics.

Christina, R. W. (1997). Concerns and issues in studying and assessing motor learning. *Measurement in Physical Education and Exercise Science, 1,* 19–38.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences (3rd ed.).* New York: Academic Press.

Gallwey, W. T. (1982). *The inner game of tennis.* New York: Bantam Books.

Henry, F. M. (1953). Dynamic kinesthetic perception and adjustment. *Research Quarterly, 24,* 176–187.

Hommel, B. (1993). Inverting the Simon effect by intention. *Psychological Research, 55,* 270–279.

Hommel, B. (1997). Toward an action-concept model of stimulus-response compatibility. In B. Hommel & W. Prinz (Eds.), *Theoretical issues in stimulus-response compatibility* (pp. 281–320). Amsterdam: Elsevier.

James, W. (1890). *The principles of psychology* (Vol. 2). New York: Dover Publications.

Jones, E., & Eisenberg, D. (1952). *Swing the clubhead.* New York: Dodd, Mead, and Co.

Kim, J., Singer, R. N., & Radlo, S. J. (1996). Degree of cognitive demands in psychomotor tasks and the effects of the five-step strategy on achievement. *Human Performance, 9,* 155–169.

Lotze, R. H. (1852). *Medicinische Psychologie oder Physiologie der Seele* [Medical psychology or physiology of the soul]. Leipzig, Germany: Weidmann'sche Buchhandlung.

Magill, R. A. (1998). *Motor learning: Concepts and applications* (5th ed.). Madison, WI: WCB/McGraw-Hill.

Massaro, D. W. (1990). An information-processing analysis of perception and action. In O. Neumann & W. Prinz (Eds.), *Relationships between perception and action: Current approaches* (pp. 133–166). Berlin, Germany: Springer.

Masters, R. S. W. (1992). Knowledge, knerves, and know-how: The role of explicit versus implicit knowledge in the breakdown of a complex motor skill under pressure. *British Journal of Psychology, 83,* 343–358.

Prinz, W. (1990). A common coding approach to perception and action. In O. Neumann. & W. Prinz (Eds.), *Relationships between perception and action: Current approaches* (pp. 167–201). Berlin, Germany: Springer.

Prinz, W. (1992). Why don't we perceive our brain states? *European Journal of Cognitive Psychology, 4,* 1–20.

Prinz, W. (1997). Perception and action planning. *The European Journal of Cognitive Psychology, 9,* 129–154.

Prinz, W., Aschersleben, G., Hommel, B., & Vogt, S. (1995). Handlungen als ereignisse [Actions as events]. In D. Dörner & E. van der Meer (Eds.), *Das Gedächtnis: Probleme—Trends—Perspektiven* (pp. 129–168). Göttingen: Hogrefe.

Sanders, A. F. (1980). Stage analysis of reaction processes. In G. E. Stelmach & J. Requin (Eds.), *Tutorials in motor behavior* (pp. 331–354). Amsterdam: North-Holland.

Schmidt, R. A. (1988). *Motor control and learning: A behavioral emphasis* (2nd ed.). Champaign, IL: Human Kinetics.

Schmidt, R. A., & Lee, T. D. (1999). *Motor control and learning: A behavioral emphasis* (3rd ed.). Champaign, IL: Human Kinetics.

Schneider, W., & Fisk, A. D. (1983). Attention theory and mechanisms for skilled performance. In R. A. Magill (Ed.), *Memory and control of action* (pp. 119–143). Amsterdam: North-Holland.

Shea, C. H., & Wulf, G. (1998). *Enhancing motor learning through external-focus instructions and feedback.* Paper presented at the Third Annual Meeting of the European College of Sport Science, Manchester (UK), July 15–18.

Singer, R. N., Flora, L. A., & Abourezk, T. (1989). The effect of a five-step cognitive learning strategy on the acquisition of a complex motor task. *Journal of Applied Sport Psychology, 98*(1), 98–108.

Singer, R. N., Lidor, R., & Cauraugh, J. H. (1993). To be aware or not aware? What to think about while learning and performing a motor skill. *The Sport Psychologist, 7,* 19–30.

Toole, T. (1969). *The effect of three teaching methods in golf on achievement of learners with differential skill in a related task.* Unpublished Master's thesis, University of Wisconsin, Madison.

Vereijken, B. (1991). *The dynamics of skill acquisition.* Meppel, Holland: Krips Repro.

Vereijken, B., Whiting, H. T. A., & Beek, W. J. (1992). A dynamical systems approach to skill acquisition. *Quarterly Journal of Experimental Psychology, 45A,* 323–344.

Welford, A. T. (1968). *Fundamentals of skill.* London: Methuen.

Wulf, G., Höß, M., & Prinz, W. (1998). Instructions for motor learning: Differential effects of internal versus external focus of attention. *Journal of Motor Behavior, 30,* 169–179.

Wulf, G., & Weigelt, C. (1997). Instructions about physical principles in learning a complex motor skill: To tell or not to tell... *Research Quarterly for Exercise and Sport, 68,* 362–367.

Note

1. To avoid variability due to differences in the lawn surface, we used the landing point of the ball, rather than the point where the ball came to a stop, to determine the deviation from the target.

Authors' Notes

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E-mail: wulf@mpipf-muenchen.mpg.de