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# Increasing the distance of an external focus of attention enhances learning

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**Abstract** Previous studies (e.g., Wulf, Höß, & Prinz, 1998) have shown that motor learning can be enhanced by directing performers' attention to the effects of their movements ("external focus"), rather than to the body movements producing the effect ("internal focus"). The purpose of the present study was to test the hypothesis that increasing the distance between the body and the action effects might further enhance the learning advantages associated with an external focus of attention. The distance of the external effect was manipulated by instructing three groups of participants learning to balance on a stabilometer to focus on markers attached to the platform located at different distances from their feet. Specifically, two groups were to focus on distant markers on the outside ("far-outside") or inside ("far-inside") of the platform, respectively, whereas another group was instructed to focus on markers close to their feet ("near"). In a retention test administered after two days of practice, all three external-focus groups showed generally more effective balance learning than an internal-focus control group. In addition, the far-outside and far-inside groups demonstrated similar performances, and both were more effective than the near group. Furthermore, the far-outside and far-inside groups showed higher-frequency movement adjustments than the near group. These results suggest that focusing on more distant effects results in enhanced learning by promoting the utilization of more natural control mechanisms. The findings are in line with a "constrained action" hypothesis that accounts for the relatively poorer learning associated with an attentional focus directed towards effects in close proximity to the body, or towards the body itself.

**Keywords** Attentional focus · Stabilometer

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## Increasing the distance of an external focus of attention enhances learning

To assist learners in the process of acquiring a new motor skill, they are often given instructions that refer to the coordination of their body movements. That is, performers are provided information related to the correct positioning of their limbs during the various phases of the movement, as well as the overall movement dynamics. Recently, however, the efficacy of such instructions has been questioned. Wulf and colleagues (e.g., Wulf, Höß, & Prinz, 1998, Experiment 1; Wulf & Weigelt, 1997) demonstrated that directing learners to focus on their body movements, i.e., inducing an "internal" focus of attention, resulted in no learning benefits or even in learning decrements, relative to not giving learners instructions at all. However, instructions that were phrased in such a way as to direct the performer's attention to the *effects* of her or his movements, i.e., by inducing an "external" focus of attention, enhanced the learning process (e.g., Shea & Wulf, 1999; Wulf et al., 1998; Wulf, Lauterbach, & Toole, 1999; Wulf, McConnel, Gärtner, & Schwarz, 2002, Wulf, McNevin, & Shea, 2001; Wulf, Shea, & Park, 2001; for a review, see Wulf & Prinz, 2001).

In one such study, during which participants were required to learn to balance on a stabilometer platform, Wulf et al. (1998, Experiment 2) instructed one group of participants to focus on keeping their feet horizontal (internal focus). A second group of participants was instructed to focus on keeping two markers horizontal that were attached to the stabilometer platform directly in front of their feet (external focus). Thus, the actual locus of attention differed only minimally between groups; yet, in the former case, attention was directed towards the performer's body movements, whereas in the latter case it was directed towards the effects of the performer's actions on the platform. Despite the subtle difference in instructions, the attentional focus induced by them affected the learning of this task. Even though no group differences were apparent during the two days of practice, a retention test performed on the third day revealed that the external focus condition yielded superior balance learning relative to the internal focus condition.

In their Experiment 1, Wulf et al. (1998) manipulated the attentional focus of participants attempting to maximize the amplitude of slalom-type movements performed on a ski-simulator by instructing one group of performers to focus on the force exerted by their feet (internal focus) and another group to focus on the force exerted on the wheels of the platform on which they were standing (external focus). These instructional differences affected both performance and learning of this task in that the external focus condition promoted larger movement amplitudes than the internal focus condition during both practice and retention testing.

Wulf, Lauterbach, and Toole (1999) found similar performance and learning advantages for participants learning golf "pitch shots" when directed to attend to the motion of the club head, rather than to the motion of their arms. Learners instructed to focus on the movement of the club head demonstrated greater accuracy in pitching to a target compared to participants instructed to focus on their arm movements. Here, the benefits of an external attentional focus were apparent during the early stages of practice and remained significantly higher throughout the course of practice and during retention testing. Clear advantages of an external focus have also been found for the learning of volleyball and soccer skills (Wulf, McConnel, Gärtner, & Schwarz, 2002).

The consistently found benefits of an external versus internal focus of attention that have been shown for a variety of laboratory and sport skills suggest that this is a robust phenomenon. Wulf and colleagues (e.g., Wulf, McNevin, & Shea, 2001; Wulf & Prinz, 2001) suggested that the advantage of focusing attention on the movement effect might be that it allows unconscious or automatic processes to control the movements required to achieve this effect. When participants are asked to focus on their body movements, on the other hand, they might be more likely to consciously intervene in these control processes and may inadvertently disrupt the coordination of a number of relatively automatic (reflexive and self-organizing) processes that normally control the movement. In fact, it has long been known that when individuals attempt to consciously control their movements, the result is often a more awkward movement pattern than when one does not attempt to intervene (e.g., Bliss, 1892–1893; Boder, 1935; Gallwey, 1982; Schneider & Fisk, 1983).

Support for the notion that the adoption of an external focus promotes the utilization of more automatic control processes than does an internal focus comes from a study (Wulf, McNevin, & Shea, 2001) showing reduced attentional demands, that is, faster probe reaction times (RTs), for participants balancing on the stabilometer with an external focus compared to those with an internal focus. Furthermore, the frequency characteristics (Fast Fourier Transformation; FFT) of the platform movements demonstrated higher frequency adjustments for external versus internal focus participants. Higher frequency components seem to represent deterministic processes characterizing the incorporation and coordination of additional available degrees of freedom (see Thompson & Stewart, 1986) – a characteristic often associated with skilled performance. That is, higher frequency components in rhythmic activities represent the potential of the system to respond to perturbations and are seen as a characteristic of a biological system with more active degrees of freedom (Newell & Slifkin, 1996). Expressed at another level, the superior performance under external focus instructions may reflect a system in which the coupling between agonist and antagonist muscles is assumed to be more effective due to coherence between sensory input (originating from the rhythmic activity itself) and effector output (via the cerebellar system) (e.g., McAuley & Marsden, 2000). In fact, Marsden, Ashby, Limousin-Dowsey, Rothwell, and Brown (2000) identified a linear relationship between the oscillatory activities recorded in the cerebellar system, areas of the sensorimotor cortex, and muscles. It was further suggested that an action yielding too little oscillatory activity (i.e., frequency of responding) disrupted the coherence between the systems and this in turn disrupted movement coordination. A similar type of disruption is seen in a system that has been compromised by disease or aging (e.g., Gantert, Honerkamp, & Timmer, 1992; Newell, Gao, & Sprague, 1995), which has been shown to exhibit lower frequency components relative to compromised and/or constrained systems. For example, FFT analysis of finger or hand tremor of compromised motor systems (e.g., Gantert, Honerkamp, & Timmer, 1992; Newell, Gao, & Sprague, 1995), or of balance when inputs (e.g., vision) into the vestibular-occular system have been perturbed (e.g., Gurfinkel, Ivanenko, Levik, & Babkova, 1995), yield tremor and balance records characterized by large amplitudes and slow frequencies relative to that produced by uncompromised/unperturbed systems. We speculate that the poor performance (and learning) of internal focus participants, as reflected by balance records (RMSE), is due to a constrained motor system. Furthermore, the constraints imposed on the motor system are presumably due to poor sensorimotor integration – as reflected by slow frequency/high amplitude postural adjustments – as a result of the subtle interference into automated control processes.

While previous studies have almost exclusively examined the effectiveness of internal versus external attentional foci, in the present study we asked whether different external foci might also differ in their effectiveness. Of particular importance in this context was the observation that the magnitude of the external focus benefit seemed to vary across the different tasks used in the studies reviewed above. Despite the inherent limitations associated with comparing data across experiments and the obvious differences between the movements involved in performing each task, it is interesting to note that the beneficial effect of an external focus of attention seemed to vary as a function of the *distance* between an action and its remote effect. For example, in the Wulf, Lauterbach and Toole (1999) study, the advantage of the external focus was found almost immediately during acquisition for the golf task, where the distance between the arms and the club head was large. On the ski-simulator task (Wulf et al., 1998, Experiment 1), where the external cues (wheels) were located under the feet, the external-focus benefits were only seen at the end of the first day of practice and remained present throughout the second day of practice, as well as during the retention test on Day 3. Finally, for the balance task (Wulf et al., 1998, Experiment 2), where the distance between the feet and markers on the platform was very small (the feet touched the markers), the advantage of the external focus only became apparent during the retention test after two days of practice. Thus, it is possible that by increasing the distance of the movement effects from the body, the advantages of an external relative to an internal focus of attention may be more pronounced. Based on this observation, we speculated that a greater distance between the body and the remote effect produced by its movements might further enhance the learning advantage associated with an external focus of attention and thus identify it as a possible reason for the differential performance and learning benefits seen in previous attentional focus studies.

Why would something as innocuous as the spatial distance between an action and its effect have such profound effects on how well we learn a task? We suspected that effects that occur in close spatial proximity to the body are less easily distinguishable from the body than are more remote effects (see also Shea & Wulf, 1999). To test this hypothesis, we used the balance task and manipulated the distance of the external movement effects (i.e., markers) that the performer's attention was directed to. Importantly, participants did not visually monitor the position of the markers during a trial, but rather imagined the position of the markers while visually fixating on a wall directly in front of them. Thus, any error information conveyed by the relative positions of the markers would be inferred and not directly perceived. Performers in one condition were asked to focus attention on markers positioned directly in front of their feet (similar to Wulf et al., 1998, Experiment 2), while in two other conditions, performers were instructed to focus attention on markers that were placed equal distances to the outside or inside of the platform relative to the position of the feet. This latter distance manipulation also served to ensure that any learning benefits associated with the distance manipulation could not be attributed to differences in the amount of imagined error information conveyed by the relative position of the markers from the platform axis of rotation. Even though the degrees traversed by any region of the platform are identical, the angular displacement of each pair of markers (due to their position on the platform) is different. That is, the far-outside markers displace more than markers placed in front of the feet, and more so than markers placed close to the axis of rotation. If the distance manipulation conveyed differences in the magnitude of imagined error information, performance mediated by the far-outside markers would be better than performance mediated by the far-inside markers – with the near markers yielding intermediate performance between the two far conditions. However, if distance of the remote effect from its action is the critical variable underlying the attentional focus manipulation, we would expect both far-outside and far-inside conditions to yield comparable performance, with both conditions resulting in superior performances relative to the near condition. In addition, we added an internal-focus control group whose performance was expected to be less effective than that of all external-focus groups.

In addition to comparing the degree to which participants in the various experimental conditions maintained balance (root-mean-square error; RMSE), we also wanted to determine the frequency characteristics of the balance records. Wulf, McNevin, & Shea (2001) argued that when performers utilize an internal focus of attention they tend to interfere with automatic control processes that would normally regulate the movement, whereas an external focus of attention allows the motor system to more naturally self-organize. In line with this "constrained action" hypothesis, they found higher-amplitude and lower-frequency movement adjustments for internal- relative to external-focus participants – suggesting that an internal focus indeed causes performers to consciously intervene in the control processes, whereas an external focus promotes a more automatic, reflexive type of control. The present study followed up on this issue. We argued that, if participants are asked to focus on an effect that is in close proximity to their body, they might be more compelled to intervene in the control processes associated with maintaining balance than they would if they focused on a more distant effect. Assuming that an attentional focus directed towards a proximal effect ("near" group) compels participants to exert relatively more conscious control over the regulatory processes involved in balance, we would expect to observe compromised performance – characterized as high amplitude and slow frequency of responding – relative to participants focusing on more remote effects ("far" groups). For participants instructed to focus attention on effects that are more easily distinguishable from their actions ("far-outside" and "far-inside" groups), there should be no compelling reason to intervene in the automatic control processes intrinsic to the action, and therefore they should show lower amplitude and higher frequency responding. In addition, there should be no differences between the far-outside and far-inside groups, as the markers that these groups focused on were approximately the same distance from the feet for both groups. Furthermore, the internal-focus control group was expected to demonstrate lower-frequency in responding than the external-focus groups.

In summary, if the distance of the attentional focus from the body (feet) is critical for the effectiveness of an external focus, focusing on the far markers should result in learning benefits compared to focusing on the markers close to the feet (RMSE). With respect to the underlying control characteristics, if participants who focus on close markers do indeed more actively intervene in the control of their movements, we would expect the FFT analysis to reveal compromised postural adjustments compared to participants who focus on more distant markers.

## Method

### Participants

Forty university students (28 females; 12 males) served as participants in this experiment. None of the participants had prior experience with the task or was informed about the purpose of the study. All participants signed informed consent forms before the experiment.

### Apparatus and task

The task required participants to balance on a stabilometer. The stabilometer consists of a 65×105-cm wooden platform, with the maximum possible deviation of the platform to either side being 30 degrees. The task was to remain in balance, i.e., to keep the platform in a horizontal position, for as long as possible during each 90-s trial. Two markers (2×2-cm) were placed on the platform, 9 cm from the front edge and 23 cm from the midline of the platform. Participants were instructed to place their feet behind these markers. In addition to these markers, two other pairs of markers (2×2-cm) were attached to the platform. One set of markers was placed 26 cm to the outside of the markers in front of the feet, whereas the other set was placed inside of these markers and next to the midline of the platform (see Figure 1).

The movements of the platform were monitored by a potentiometer (Novotechnik P4501, 5 kΩ resistance, and 0.1% linearity) that was linked to the platform. To analyze performance, an analog signal from the potentiometer was recorded (50 Hz, 12 bit resolution) for the whole duration of each trial.

### Procedure

All participants were informed that the task was to keep the platform in the horizontal position for as long as possible during each 90-s trial. In addition, all participants were asked to put their feet on the platform such that each foot was placed behind one of the markers located between the outside and inside markers, with the tips of the feet touching the markers. Each trial started with the left side of the platform on the ground. Approximately 15 s before the start of a trial, the experimenter asked the participant to step on the platform and to keep the left side down until the experimenter gave the start signal. At the start signal, the participant attempted to move the platform, and data collection began as soon as the platform crossed the horizontal.

Participants were randomly assigned to one of four experimental conditions: Three external focus practice conditions, which differed with respect to the distance between the body (feet) and the markers on the stabilometer each group was instructed to focus on, or the internal-focus control group. Specifically, for one external-focus group (near), the markers were close to the feet, whereas for two other groups (far-outside, far-inside), the markers were further away from the feet. All groups were instructed to focus on the respective markers and to try to keep them horizontal. However, as we wanted to examine the effects of the distance of the (external) attentional focus from the body, and not the effects of visual feedback provided by looking at the markers, all participants were asked to look straight ahead at the wall in front of them (at a distance of about 2.5 m) while performing the task. Yet, before the experiment and during the breaks between trials, participants could obviously see the markers. As in previous studies (e.g., Wulf et al. 1998; Wulf, McNevin, & Shea, 2001), the internal-focus group participants were instructed to focus on their feet (while looking straight ahead) and to try to keep them horizontal.

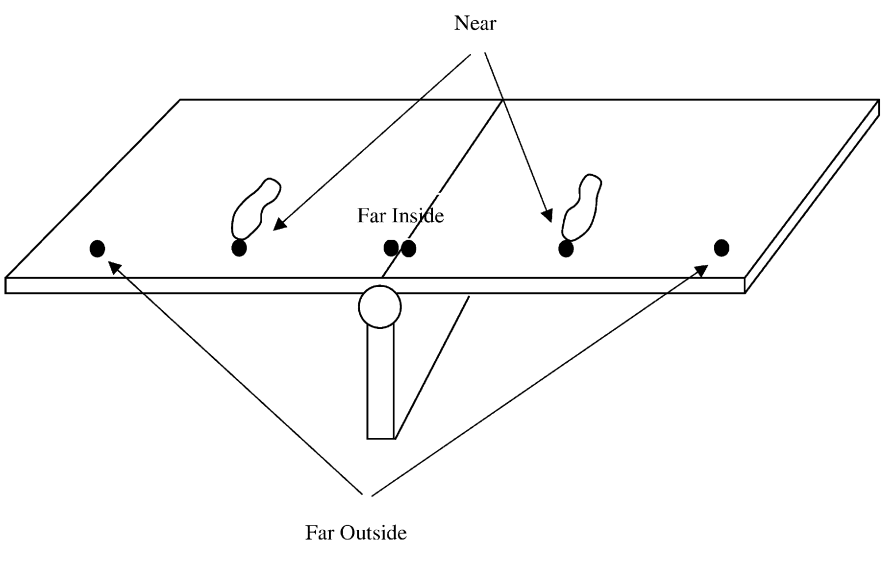


**Fig. 1** Diagram of the stabilometer, showing marker positions and foot placement of participants

All participants performed seven practice trials on each of two days of practice under the respective treatment conditions. Before every other practice trial, participants were given short reminders to focus on the respective markers. To assess the learning effects of the different attentional focus instructions, there was a retention test on Day 3 consisting of seven trials without instructions or reminders.

### Dependent variables and data analysis

The potentiometer data were transformed into degrees out of balance. Consistent with previous studies utilizing the stabilometer, participants' proficiency in performing the task was measured by RMSE in degrees, with the 0-degree position (platform in horizontal) as the criterion. In addition, a spectral frequency analysis was conducted on the waveform created by the movement of the platform on retention trials. From this analysis, mean power frequency (MPF) was computed. This analysis is capable of detecting subtle frequency differences in performance between groups that may provide important information related to the maintenance of better balance under the different experimental conditions.

RMSE during practice was analyzed in 4 (Focus) ×2 (Days) ×7 (Trials) ANOVAs, with repeated measures on the last two factors. The retention RMSE and MPF data were analyzed in 4 (Focus) ×7 (Trials) ANOVA, with repeated measures on the last factor.

## Results

### Practice

All groups demonstrated an increased proficiency in performance greater on Day 1 than on Day 2 (see Figure 2, left and middle panel). Although the far-inside group tended to have smaller errors than the internal, far-outside, and near groups throughout the whole practice phase, the main effect of focus was not significant, $F(3, 34) = 1.03$, $p > 0.05$. The main effects of day, $F(1, 34) = 150.73$, and trial, $F(6, 204) = 100.57$, as well as the Day × Trial interaction, $F(6, 204) = 33.19$ *p*s < 0.001, were significant. Also, the interactions of Focus × Day, $F(3, 34) = 1.41$, Focus × Trial, $F(18, 204) < 1$, and Focus × Day × Trial, $F(18, 204) < 1$, *p*s > 0.05, were not significant.

### Retention

The learning effects of the different attentional focus instructions were assessed in a retention test on the third day, with no instructions or reminders given to participants. All groups continued to show performance improvements across retention (see Figure 2, right panel). However, the two groups that focused on the distant markers (far-outside, far-inside) were clearly more effective in maintaining their balance on the platform than the group that focused on the markers close to the feet (near) or on their feet (internal). Also, the far-outside and far-inside groups showed very similar performances throughout retention. The main effects of trial, $F(6, 216) = 4.27$, $p < 0.001$, and focus, $F(3, 36) = 5.34$, $p < 0.01$, were significant. A Dunnett's test, specifically designed to test differences between a control group

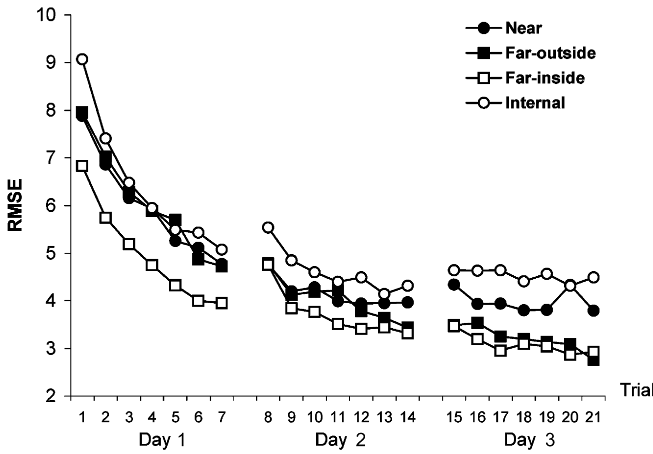


**Fig. 2** Root-mean-square errors (RMSE) of the internal, far-inside, near and far-outside groups during practice (Days 1 and 2) and retention (Day 3)

(internal) and multiple experimental groups (far-outside, far-inside, and near), was used as a preliminary test to confirm the findings from our previous experiments that internal focus of attention results in significantly larger RMSE than external focus of attention conditions. The test confirmed this assumption. In addition, subsequent *post-hoc* tests (Least Significant Difference) indicated differences between the external focus of attention conditions. Specifically, both the far-outside (3.20) and far-inside groups (3.08) had significantly smaller RMSE than the near group (4.00).[1] There was no Focus × Trial interaction, $F(12, 27) = 1.17$, $p > 0.05$. Thus, focusing on the more remote effects of the action was more beneficial than focusing on effects closer to the body.

Figures 3 and 4 show the results of the FFT analysis. Examination of Figure 3, which presents the platform deviation and FFT for a near participant, MP08 (top two panels), and a far-inside participant IP09 (bottom two panels) reveals clear differences in both maintaining a horizontal position of the platform and frequency of responding during retention testing. This pattern of results was supported by analysis of MPF data (see Figure 4). The two groups that focused on the distant markers (far-outside, far-inside) clearly made more and smaller corrections in maintaining their balance on the platform than the group that focused on the markers close to the feet (near). The main effect of focus, $F(3, 36) = 8.06$, $p < 0.001$, was significant. As with RMSE, a Dunnett's test was conducted to confirm our earlier findings that an internal focus of attention results in lower MPF than external focus of attention conditions. The analysis detected significant differences in MPF

[1] As the far-inside group tended to show performance advantages, compared to the other groups even early in practice, we analyzed the retention data in an analysis of covariance (ANCOVA) with the first practice trial as a covariate. The 4 (focus) ×7 (trials) ANCOVA revealed a significant main effect of focus, $F(3,34) = 4.228$, $p < 0.05$, confirming that the group differences in retention were not due to initial differences between groups.

between the internal condition (0.25) and the far-outside and far-inside conditions. The difference in MPF between the internal and near conditions, however, was marginal ($p = .06$). Subsequent *post-hoc* tests on the experimental groups indicated that both the far-outside (0.47) and far-inside group (0.46), which were not different from each other, had significantly higher MPF than the near group (0.33). The main effect of trial, $F(6,215) = 1.25$, $p > 0.05$, and Focus × Trial interaction, $F(18, 215) = 1.63$, $p > 0.05$, was not significant. Thus, focusing on the more remote effects of the action resulted in higher frequencies of responding than focusing on effects closer to the body or adopting an internal focus.

## Discussion

The purpose of this study was to determine the effectiveness of different external foci of attention. In particular, we asked whether the distance of the attentional focus from the body would differentially affect performance and learning. A comparison across previous experiments (Shea & Wulf, 1999; Wulf et al., 1998; Wulf, Lauterbach, & Toole, 1999) seemed to indicate that the advantages of an external focus were enhanced (and found to occur earlier in the learning process) as the distance of the external focus from the body increased. We therefore speculated that the distance between the body and the external effect produced by the body movements might be a critical factor underlying the external focus advantage. Even though increasing the distance of the effect from the action producing it did not produce immediate performance improvements (a trend for immediate performance benefits was only seen for the far inside condition), the present results were clear in showing that increasing the distance of the effect from the action producing it, through the attentional focus manipulation, enhanced *learning*. Furthermore, FFT analysis on retention data revealed that focusing on effects that were in close spatial proximity to the body (near), or focusing on the body itself (feet), compromised (or constrained) the regulatory processes involved in the control of balance. The question that

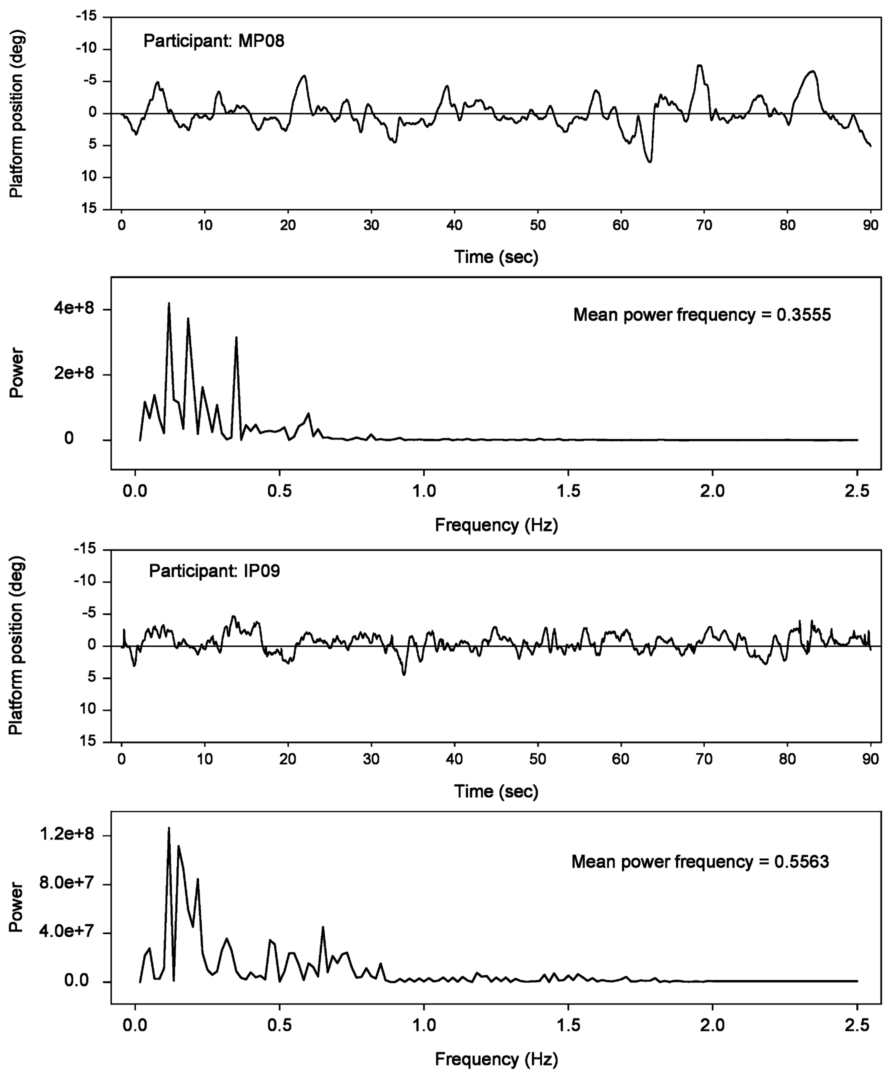


**Fig. 3** Examples of stabilometer performance in retention for Participant MP08 in the near condition (top two panels) and Participant IP09 in the Far-outside condition. These participants/trials were chosen because their RMSE were similar to the average for their respective conditions. For each participant, the top panel represents platform displacement and the bottom panel represents the results of the power spectral analysis

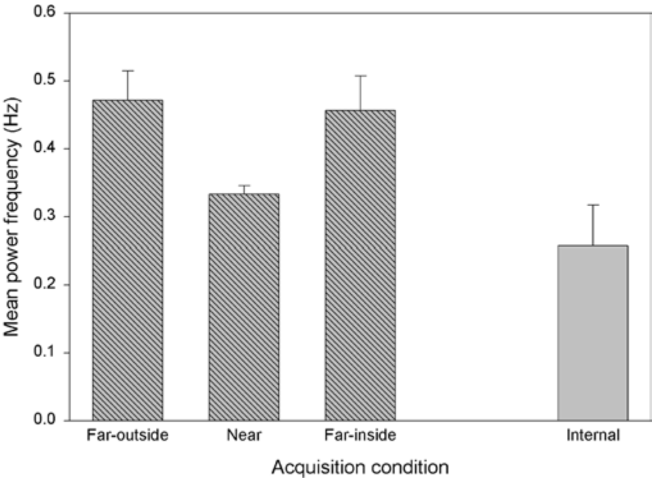


**Fig. 4** Mean power frequency for the internal, far-outside, near, and far-inside conditions during retention (Day 3)

follows is why focusing on proximal effects (or the movements themselves) should compromise the perceptual-motor system.

We interpret our findings as further support for the "constrained action hypothesis" (Wulf, McNevin, & Shea, 2001; Wulf, Shea, & Park, 2001; see also, Wulf & Prinz, 2001). This is based on the notion that internal-focus participants – and, to a certain degree, near-focus participants – tend to actively intervene in the maintenance of a stable posture more than performers who focus on more remote effects do. Given that balance on an unstable surface involves the delicate interplay between a number of central processes and peripheral reflexes, it might be reasonable to speculate that active intervention in these relatively automated processes may degrade, rather than enhance, a coordinated effector output. While degraded performance in the internal and near, relative to the far conditions, is clearly seen in RMSE scores in this experiment, the subtle increase in MPF for the far groups provide an important clue as to the cause of the effect.

Increases in small amplitude, high frequency postural adjustments superimposed on large amplitude, slow frequency adjustments might, at first, seem to merely reflect an increase in random noise in the motor system. However, a number of researchers (see Newell & Slifkin, 1996, for a discussion of this issue) have characterized increases in response frequency as an increase in the number of active degrees of freedom. Data from hand and finger tremor experiments, for example, indicate that when the motor system is compromised in some way (e.g., aging, Parkinson's disease, tardive dyskinesia) the frequency of hand and finger tremor decreases while the amplitudes increase. The decreases in frequency and related increases in amplitude make the tremor more perceptible. When the system is not compromised, hand and finger tremor is almost imperceptible because the driving frequency is relatively high.

Gurfinkel, Ivanenko, Levin, and Barbakova (1995), for example, had participants attempt to maintain a stable body position while the platform on which they were standing was very slowly tilted (frequency .007 Hz, amplitude 1.5 degrees) through a sinusoidal pattern. When they degraded the inputs into the vestibular-occular system by removing an external reference and then further by occluding vision, they found systematic decreases in the normally high frequency (low amplitude) characteristics of ankle angle, body sway, and force platform forces (sagittal plane) around the much slower frequency sinusoidal body movement that mirrored the platform movement. They argued that the higher frequency components of the stabilizing movements represented the functioning of a limited set of reflex mechanisms that was degraded when vision, for example, was occluded. The important point is that human posture is inherently unstable and must be maintained via small, very rapid (reflexive) patterns of muscle activation. Perturbations or loss of normal inputs to this relatively automatic system will result in degraded balance. We are proposing that in the internal and near conditions, participants attempted to exert more active postural control resulting in the degradation of the more natural movement dynamics. The result was poorer learning as indexed by RMSE in retention and a general "damping" in the frequency of responding.

In conclusion, the study presented here brings us closer to understanding the learning advantages associated with an external focus of attention. Our results suggest that one critical factor underlying this learning advantage is the distance between the action and its effect. Our findings also suggest that when instructed to focus on the body (feet) or proximal effects, the regulation of control processes involved in maintaining balance are constrained, resulting in performance and learning decrements. Increasing the distance of the effect from the movement producing it, however, seems to allow performance to be mediated by automatic control processes that results in enhanced learning.

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