External Focus Instructions Reduce Postural Instability in Individuals With Parkinson Disease

Gabriele Wulf, Merrill Landers, Rebecca Lewthwaite, Thomas Töllner

Background. Postural instability while standing, walking, and interacting with objects or the environment places individuals with Parkinson disease (PD) at risk for falls, injuries, and self-imposed restrictions in activity. Recent research with motor skills, including those demanding postural stability, has demonstrated performance and learning advantages when performers are instructed to adopt an external rather than an internal focus of attention. Despite the potential benefits in stability-related risk reduction and enhanced movement effectiveness, attentional focus research in individuals challenged with postural instability is limited.

Objective. The present translational research study examined the generalizability of the attentional focus effect to balance in older adults with PD.

Design. A within-participant design was used to account for potentially substantial individual variations in balancing capabilities.

Methods. Fourteen participants diagnosed with idiopathic PD (Hoehn and Yahr stages II and III) participated in the experiment. They were asked to balance on an unstable surface (inflated rubber disk). In counterbalanced orders, they were instructed to focus on reducing movements of their feet (internal focus) or the disk (external focus), or they were not given attentional focus instructions (control).

Results. The adoption of an external focus resulted in less postural sway relative to both internal focus and control conditions. There was no difference between the internal focus and control conditions.

Limitations. Mental functioning was not formally assessed, and comprehensive clinical profiles of participants were not obtained.

Conclusions. The results are consistent with previous findings on attentional focus in samples of patients and people without disabilities. Subtle wording distinctions that direct attention to movement effects external to the mover reduce postural instability during standing for individuals with PD relative to an internal focus. The findings have potentially important implications for instructions given by clinicians and the reduction of fall risk.

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Postural instability is a cardinal feature of Parkinson disease (PD)[1] and a primary risk factor for falls.[2] About two thirds of individuals with PD reported falling within the past 12 months,[3] and 90% of people with PD will fall at some point in their lives.[4] Some falls lead to severe injuries (eg, head injuries, fractures), which may result in hospitalization[5] or further limitations to mobility. In one study,[6] a cohort of people with PD experienced a hip fracture within 10 years after diagnosis—a 20-fold increase in risk compared with an age-matched control group. Although most falls do not result in serious injuries, they will, at the least, affect the individual's confidence and quality of life.[1] Those factors illustrate the need for developing interventions that can enhance balance in people with PD and, consequently, reduce their risk for falls.

One research approach supports the benefits of providing external cues in individuals with PD. External cues such as visible target lines on the floor or paced auditory signals improve performance in movements during activities such as gait, button-pressing, and handwriting.[7–9] The present study originates from a separate line of work in motor learning[10] that focuses on the pre-performance wording of instructions provided to movers, rather than the continuing presence of external cues. Numerous studies over the past 10 years have shown that an individual's focus of attention has an important influence on both the performance and learning of a variety of motor skills, including balance skills.[10] Specifically, instructions that direct a performer's attention to the effects that his or her movements have on the environment (external focus) have been demonstrated to lead to more-effective learning than directing attention to the movements themselves (internal focus). For example, in learning to balance on a moving platform (stabilometer), asking participants to direct their attention to markers attached to the balance platform in front of their feet (external focus) has been shown to be more beneficial for learning than directing attention to the feet themselves (internal focus).[11,12] It should be noted that participants were instructed not to look at the markers or their feet, but rather to look straight ahead and to simply concentrate on the markers or feet, respectively. Advantages of adopting an external focus also have been found for a variety of other balance skills[13,14] as well as for sport and movement skills such as golf,[15] tennis,[16] volleyball and soccer,[17] and vertical jumping.[18] Importantly, external focus benefits have been shown not only relative to internal focus conditions but also relative to control conditions.[11,19,20] This finding suggests that, left to their own devices, people may direct their attention to less-optimal (possibly internal) foci.

Studies of patient populations also have demonstrated benefits of inducing an external focus.[21,22] Fasoli et al[21] examined the impact of attentional focus on the performance of reaching tasks in patients who had a cerebrovascular accident and in age-matched control participants without impairments. They found that both groups performed various common tasks (eg, taking an apple off a shelf and putting it into a basket, moving an empty coffee mug from a table onto a saucer) more effectively if given external rather than internal focus instructions. Specifically, movement times were shorter and peak velocities were greater on all tasks, suggesting that these patients as well as the control participants preplanned their movements to a greater extent and used more automatic control processes when they focused externally.

Mediolateral posturographic differences have been found between individuals with idiopathic PD and controls who were healthy, even in quiet standing with eyes open.[23] A recent study[19] showed that, for individuals with PD and a history of falls, balance was improved when participants were given external focus instructions as opposed to an internal focus instructions or no instructions. Specifically, in that study, the postural stability of individuals with PD was measured in 3 conditions: (1) standing quietly with eyes open on a stable support surface, (2) standing quietly with eyes closed on a stable support surface, and (3) standing with eyes open on a sway-referenced support surface that tilted forward or backward in accord with shifts in the individual's center of mass. Under all 3 conditions, participants were instructed to focus on rectangles under their feet (external focus) or on their feet (internal focus), or they were not given any focus instructions (baseline). No differences among attentional focus conditions were found on the relatively easy tasks with a stable support surface (conditions 1 and 2). However, on the more challenging task with the swayable support surface, an external focus produced less sway than both internal focus and control conditions. Significant external focus benefits were only found for individuals with a history of falls, whereas this effect did not reach significance for those without a history of falls.

Thus, that study[19] provided preliminary evidence for improved balance through external focus instructions in individuals with PD. The fact that performance advantages were found only for the most difficult condition (sway-referenced support surface) and for those participants who were most challenged (those with a history of falls) is in line with recent evidence that a certain degree of relative task difficulty is a precondition for attentional focus effects to occur.[24]

Nevertheless, we deemed it important to have additional evidence for the influence of attentional focus on balance for those affected by PD. Therefore, the purpose of the present study was to replicate the external focus advantages found by Landers et al,[19] using a different and uniformly more-challenging balance activity. Participants were asked to balance on an unstable surface (inflated rubber disk). We measured the amount of postural sway under different attentional focus conditions. Postural sway, or instability, has been shown to increase with age,[25] to be higher in "fallers" than in "nonfallers,"[26,27] and to increase with the demands of the balance task[24] or of a secondary task in elderly people[25] and people with a history of falls.[26] We used a within-participant design to account for potentially substantial individual variations in balancing capabilities. Participants, in counterbalanced orders, were instructed to focus on reducing movements of either the disk (external focus condition) or their feet (internal focus condition), or they were not given attentional focus instructions (control condition). We expected to see more-effective balance, or less postural sway, under the external focus condition relative to internal focus and control conditions.

Method

Participants

Fourteen (10 male, 4 female) community-dwelling individuals who were diagnosed with idiopathic PD by a neurologist participated in this experiment. They were recruited from a local PD support group and were aged 52 to 80 years (mean= 71.1). As all of the participants were Hoehn and Yahr stage II or III,[28] they exhibited bilateral PD involvement, with minimal to moderate balance impairment. None of the participants exhibited dyskinesias. All participants were independent with ambulation (ie, no use of assistive devices); however, 7 of the participants had a history of falling within the past year. All participants followed their normal medication regimen during testing. Participants were excluded from the study if they had symptoms of dizziness or lightheadedness or other neurological or orthopedic disorders that would have negatively affected balance. Participants also were excluded if they had young-onset PD (<50 years of age), parkinsonian disorders (progressive supranuclear palsy, Shy-Drager syndrome, corticobasal degeneration, nigrostriatal degeneration, olivopontocerebellar atrophy, secondary parkinsonism, or familial parkinsonism), or a history of dementia as reported by the family or caregiver or if they were unable to stand unassisted for 10 minutes without an assistive device. In addition, the participants' ability to follow simple directions, as determined by their responses to questions and instructions, was informally assessed throughout the interview and consent process. Informed consent was received from each participant.

Apparatus, Task, and Procedure

Participants were scheduled for their testing approximately 1 hour after their medication had been taken. Testing was conducted at each participant's home, using a portable force platform (model 9286AA*) situated under the rubber disk. The task required participants to balance on an inflated rubber disk (Disc 'O' Sit†) with a diameter of 33.02 cm (13 in). The disk was placed on the force platform to record data on center of pressure (COP). Participants were instructed to look straight ahead while balancing on the disk (similar to procedures used in previous studies[14,24]).

A repeated-measures, within-subject design was used to assess the differences among conditions. Each participant performed four 15-second trials under each of the 3 attentional focus conditions. Specifically, participants were instructed to "stand still" (control condition), to "focus on minimizing movements of your feet" (internal focus condition), or to "focus on minimizing movements of the disk" (external focus condition). The order of attentional focus conditions was counterbalanced across participants to control for possible order and carryover effects. Participants were randomly assigned to perform under 1 of 3 orders of attentional focus conditions: control-internal-external, internal-external-control, external-control-internal.[14,24]

Precautions were taken because of participants' known balance impairments. A standard wheel-less walker was placed around the balance platform for safety. In addition, a spotter provided standby assistance from behind the participant using a standard gait belt in the event of a fall (Fig. 1).

Dependent Variables and Data Analysis

Center-of-pressure data were recorded at 500 Hz. The data were converted to ASCII format and processed using custom-designed laboratory software. The COP data were adjusted so that the central coordinates were (0, 0). Data then were converted from Cartesian to polar coordinates with the magnitude vector analyzed by calculating the root-mean-square error (RMSE). The RMSE of the COP vector magnitude served as a measure of postural sway. The RMSE is a commonly used measure of postural

* Kistler Instruments AG, Winterthur, Switzerland.

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sway[14,24,25,29–31] that represents the amount of postural sway, or sway area. The relationship of COP RMSE to functional abilities is unknown, although COP sway area recently has been identified as a risk factor for falls.[2]

Most participants were not able to complete all 15 seconds of each trial. That is, they would lose their balance and had to support themselves by holding on to the walker, or they had to be supported by the spotter. Therefore, we analyzed the longest segment of each trial during which the participant was able to stand on the disk without support. The average length of the analyzed segments was similar for the 3 attentional focus conditions (see "Results" section). The RMSE on each trial (independent of whether the entire 15 seconds or a shorter segment was analyzed) was submitted to a 3 (attentional focus condition) × 4 (trial) analysis of variance (ANOVA) for repeated measures on both factors.

As all participants performed under all attentional focus conditions (internal, external, control), there was a possibility that carryover effects might occur. That is, performance under a given condition could be influenced by the previous condition. In contrast, if participants were able to adopt the instructed attentional focus, no such carryover effects should occur. To assess the possible influence of carryover effects, we conducted additional analyses, with attentional focus condition order included as a factor: 2 (group) × 3 (attentional focus condition) × 3 (attentional focus condition order: control-internal-external, internal-external-control, external-control-internal) ANOVAs for repeated measures on the last 2 factors.

Results

The average length of the analyzed trial segments was 11.9 seconds (SD=4.0, range=4–15). The length did not differ significantly among attentional focus conditions (control: 11.9 seconds, internal focus: 11.7 seconds, external focus: 12.0 seconds; $F_{2,26}=<1$). In addition, there was no effect of trial ($F_{3,39}=<1$) or interaction of focus and trial ($F_{6,68}=<1$).

Figure 2 shows the mean RMSE for each attentional focus condition. Postural sway was less under the external focus condition than it was under either the internal focus or control condition. The main effect of attentional focus was significant ($F_{2,26}=5.07$, $P<.05$, $\text{Eta}^2=0.28$, observed power=.77). *Post hoc* tests (Fisher least significant difference tests) indicated that RMSEs were smaller for the external focus condition relative to the internal focus condition ($P<.001$) and the control condition ($P<.05$), whereas there was no difference between the internal focus and control conditions. The main effect of trial ($F_{3,39}=1.27$, $P>.05$) and the interaction of attentional focus condition and trial ($F_{6,78}<1$) were not significant. The interaction between attentional focus condition and condition order was not significant ($F_{4,22}<1$). Thus, participants responded to the distinction between instructional sets, and there were no carryover effects among attentional focus conditions.

Figure 1.
Participant performing the balance task.

Discussion

Participants with PD showed enhanced balance when they were instructed to focus on the disk (external focus condition) compared with when they were instructed to focus on their feet (internal focus condition) or when they were not given focus instructions (control condition). Thus, on this relatively challenging task, participants demonstrated the typical attentional focus effect (found in more than 50 studies[10]), with the external focus condition resulting in more-effective performance than either the internal focus or control condition and with no difference between the latter 2 conditions.[11,18,20] These results replicate the external focus advantages seen in previous studies with young adults who were healthy[10] and with people affected by neurological disorders[19,21] or other disorders[22] affecting balance. The fact that an external focus reduced postural sway in participants with PD may have important implications for balance training, particularly considering recent findings showing that increased

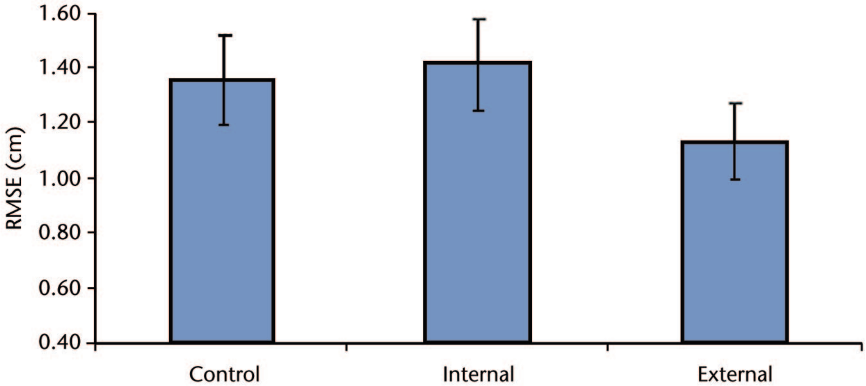

Figure 2.
Magnitude of sway (root-mean-square error [RMSE]) for participants with Parkinson disease as a function of the type of attentional focus (control, internal, or external). Error bars indicate 95% confidence intervals.

postural sway is associated with increased risk for falling in people with PD.[2]

It might be expected that individuals would spontaneously adopt the optimal focus of attention. Interestingly, however, this does not seem to be the case. Several studies[11,19,20] as well as the present study have shown that when participants are not given attentional focus instruction and are left to adopt their own focus (control conditions), their performance is typically similar to that seen under internal focus conditions and less effective than under external focus conditions. These findings suggest that individuals tend to choose a less-than-optimal type of focus. One reason for this might be that individuals adopt the content of self-instructions that are modeled by others. In practical settings that involve the learning or relearning of motor skills (eg, sports, music, physical therapy), instructions that refer to the performer's body movements are common. It may not be surprising, therefore, that individuals spontaneously focus on their own movements. Furthermore, people are presumably inclined to be relatively cautious when confronted with novel and complex motor tasks, especially those involving balance. The problem is that this cautiousness does not result in optimal performance. Ironically, it even exacerbates postural instabilities and balance problems.

It should be noted that, in apparent contrast to our findings, one study involving individuals with PD[32] purported to show performance benefits of an internal focus. Canning[32] examined how directing attention affected participants' gait when carrying a tray with glasses. Specifically, she instructed her participants to either focus on "maintaining big steps while walking" or focus on "balancing the tray and glasses." She found that when participants focused on walking, they walked faster and with longer strides compared with a baseline condition without focus instructions and compared with when they focused on the tray and glasses. In contrast, when participants focused on balancing the tray and glasses, they walked more slowly and with shorter strides than under the baseline condition. Canning argued that the instructions not only directed attention to one task (walking) or the other (carrying the tray), but also induced an internal focus (walking) or an external focus (carrying the tray). Because the former type of attentional focus increased walking speed, while the latter type of focus degraded it, she concluded that "the general suggestion that directing learners' attention to the effects of their movements be incorporated into rehabilitation practice. . .may not be appropriate in all circumstances for people with PD."[32(p98)]

This conclusion, however, is problematic. Importantly, both walking and carrying a tray can be executed under either external or internal attentional focus conditions (walking: distance covered/stride targets on floor or coordination of body segments, respectively; tray carrying: tray surface/objects on tray or hands holding the tray, respectively). Without further insight into the specific foci adopted by participants, it cannot be concluded on the basis of activity type that an internal focus of attention was better than an external focus of attention. Thus, although the conditions and results of the study by Canning[32] do not pose a challenge to the contention that instructions inducing an external focus can enhance balance in people with PD, they do show that there is a need to further examine this issue and to extend the range of balance tasks used in those studies. Furthermore, the particular external foci that might be chosen to optimize performance for any given task remain to be determined empirically. Some work suggests that a focus on a more-distal movement effect results in better performance than effects just outside the body.[33]

Of potential value to the ultimate construction of effective balance training programs, however, is the sorting out of the theoretical or explanatory basis of the superiority of external cueing[7,8] and external focus of attention effects found here. Interestingly, the benefits of external cues are attributed by some authors[8,34] to the desirability of using conscious control mechanisms to guide the movements of individuals with PD whose automatic movement control capacities have been reduced due to basal ganglia damage; external cues are said to render the tasks less regulated by automatic control.[8,34] In contrast, attentional focus researchers[10] contend that instructions that direct the performer's attention to external movement-related effects act to support a more automatic form of motor control, consistent with that seen from expert performers. Internal foci, such as body movements, are thought to be associated with more-conscious and less-automatic, and presumably less-effective, forms of motor control.[10,12] The explanatory difference may be a function of differing definitions of the concept of automaticity.

Some authors[8,34] appear to link the concept of automaticity to "mindless" movements associated with less forethought or systematic planning for potentially risky actions. Attentional focus and motor control researchers use the term "automaticity" to refer to the relatively effortless governance of well-coordinated, fluent movements directed at environmental goals that is demonstrated by expert performers or well-practiced movers. The explanatory difference also might result from an assumption that the intrinsic regulation of sequential movements by the basal ganglia cannot be adequately compensated for by the parkinsonian nervous system, although recent evidence suggests that this assumption may need revision.[35] Support for the beneficial automaticity notion comes from studies showing faster probe reaction times, indicating reduced attentional demands (or a greater degree of automaticity), as well as higher-frequency movement adjustments when individuals adopted an external rather than internal focus.[12] Both are seen as an indication of a more automatic, reflex-type mode of control that is based on faster and more finely tuned integrated movement responses. In addition, electromyographic activity connected with superior performance has been found to be reduced with an external focus.[36] This is seen as an indication of greater movement efficiency, presumably accomplished through more discriminate motor unit recruitment and a reduction of noise in the motor system that hampers fine movement control.[37]

One limitation of this study is that no standardized method of formally assessing mental function was used. As mental focus was a key component of our research design, it is important to ensure that all of the participations have the ability to follow directions and maintain focus. Future researchers might consider formal assessment of cognitive capability (eg, Mini-Mental State Exam[38]) to exclude participants with substantial mental impairment. Additionally, researchers should consider posing post-trial questions to the participants to ensure that the instructions are understood and the focus is maintained. In this translational research[39] study aimed at evaluating potential generalizability of a body of research to this clinical population, we did not obtain the kind of comprehensive clinical profile of participants that would be important in a trial of a clinical intervention. Other clinical measures of balance function, balance confidence, and PD severity would be helpful in characterizing the individuals who might benefit from the application of this research with clinical intervention intent.

Conclusions

Future studies should examine the relative permanency of attentional focus effects (ie, learning), as well as the potential transfer to novel skills.[22,40] As the goal of balance enhancement training is to prepare individuals to more safely and effectively meet the demands of the kinds of balance situations that they encounter during their daily lives, determining the sustainability and generalizability of the practice setting training effects to less-supervised home and community contexts would be important. The potential for individuals with PD at varying levels of severity to regulate or self-manage through self-instruction their own external attentional focus in posture and movement activities deserves investigation and may have the concomitant effect of enhancing a sense of control in their lives. Caregiver as well as clinician training in optimal attentional focus instructions may be of additional benefit in risk reduction for individuals with PD.

Finally, it might be fruitful to examine whether the effects generalize to situations in which the individual is prevented from adopting the specific focus on balance used during practice, by using dual-task procedures.[13,41] Given that, in real-life situations, people will not always maintain an external focus, it would be important to determine whether the effects persist when the focus in no longer cued or consciously adopted.

Dr Wulf provided concept/idea/research design, data analysis, project management, and facilities/equipment. Dr Wulf and Dr Lewthwaite provided writing. Dr Wulf, Dr Landers, and Dr Töllner provided data collection. Dr Landers provided participants. Dr Lewthwaite provided consultation (including review of manuscript before submission).

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