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# Effects of Attentional Focus, Self-Control, and Dyad Training on Motor Learning: Implications for Physical Rehabilitation

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## Abstract

In this article, the authors review recent studies on 3 factors that have been shown to affect the learning of motor skills—the performer's attentional focus, self-control, and practice in dyads—and discuss their implications for rehabilitation. Research has shown that directing learners' attention to the effects of their movements can be more beneficial for learning than directing their attention to the details of their own actions. Furthermore, giving learners some control over the training regimen has been found to enhance learning, unlike prescriptive training protocols that dictate when feedback will be delivered, how often, and the order that tasks will be practiced. Finally, not only can practice in dyads (or larger groups) reduce the costs of training, but it can also result in more effective learning than individual practice sessions. The incorporation of these factors into rehabilitation practice can potentially enhance the effectiveness and efficiency of rehabilitation.

Motor learning Practice Therapy

Motor learning research, with its focus on discovering the laws and principles underlying the acquisition of motor skills, has, in our opinion, had little impact on clinical applications in physical therapy.[1] Recently, at a workshop sponsored by the National Center for Medical Rehabilitation Research, the argument was made that even though "learning is central to medical rehabilitation … most therapists' use of learning principles is intuitive and the result of their personal clinical experience."[2(p557)] Moreover, we contend that this state of affairs will likely persist, if the paucity of current clinical research is any indication. Much of the research on motor learning has used relatively simple, laboratory-type tasks that generally lack the complexity inherent in many real-life skills[3,4] (G Wulf and CH Shea, unpublished research) and have little in common with the types of functional skills patients learn as part of their rehabilitation. In real-life settings, motor skills often consist of various submovements that have to be coordinated and require the control of multiple degrees of freedom. In recent years, researchers have begun to examine the effects of different variables on motor skill learning from the perspective of complex skills. Their findings may have implications for clinical interventions in physical therapy.

In this article, we focus on 3 factors that have recently been shown to have effects on the learning of (complex) motor skills: the performer's focus of attention while executing a motor task, the learner's control over the training regimen, and practice in dyads (or larger groups). Although a number of researchers in these areas have demonstrated the impact of these factors, no attempt has been made to incorporate them into rehabilitation. We will provide an overview of the research on these factors, discuss explanations for their effects, and suggest possible applications.

## Attentional Focus in Motor Skill Learning

Although motor behavior research is often concerned with identifying factors that aid skill acquisition, one area that has received remarkably little interest is the role that instructions play in promoting learning. For many complex motor tasks where the learner is required to coordinate and control the many degrees of freedom associated with performing the task, the instructions delivered by a coach can theoretically simplify a potentially daunting task. The instructions are often geared toward directing the performer's attention to various components of the skill being acquired. The coach can either give instructions on what the performer should pay attention to before the skill is executed or provide feedback during or after the performance.

### Instructions

Anecdotal reports suggest that attention focused on a person's own body movements can be detrimental to the performance of well-learned skills.[5-10] Only recently, however, have researchers begun to examine experimentally the effects of paying attention to one's movements on performance and learning. Wulf and Weigelt[11] (experiment 2) conducted research that supported this contention. In this experiment, performers with no central nervous system (CNS) injuries who had practiced a complex motor skill (slalom-like movements on a ski simulator) over the course of several days were given instructions regarding the optimal movement pattern. Participants were instructed at the start of practice when to exert force within a movement cycle—instructions that presumably directed the performer's attention to her or his own body movements. The investigators found that these instructions resulted in decreases in performance, which they interpreted as evidence for the negative effects of concentrating on one's own movements in well-practiced skills.

Evidence for the detrimental effects of self-attention at advanced stages of learning led some researchers to examine how directing performers' attention to their body movements affects the learning of *new* skills. For example, Singer et al[12] had participants with no known neurological impairments practice a ball-throwing task under different attentional-focus instructions (ie, focus on the movement mechanics versus focus on a relevant, external cue). They found that "nonawareness" strategies, in which learners were instructed to perform the task without consciously attending to the movement pattern, produced a more effective performance during acquisition and transfer (a novel variation on the practiced task) than an "awareness" strategy, which required learners to consciously attend to the movement. Radial error associated with throwing to a target declined, as did variability.

In another experiment, Wulf and Weigelt[11] (experiment 1) gave learners instructions about the optimal movement pattern on a ski simulator at the beginning of practice. They found that participants who received these instructions had poorer performance during practice and in a transfer test (under "stress") in comparison with a group of learners who received no such instructions. That is, providing instructions resulted in poorer learning than providing no instructions at all did. Thus, there is some evidence that directing the performer's attention to his or her own movements can disrupt the execution of automated skills and can have degrading effects on the learning of new skills.

In the light of these findings, Wulf et al[13] examined how instructions could be optimized so that the learner is directed toward the desired movement pattern without degrading performance. In their study, the effectiveness of instructions related to the learner's own body movements (internal focus) versus instructions related to the *effects* of the performer's actions on the environment (ie, the experimental apparatus [external focus]) were examined. They instructed participants with no known impairments who were learning to perform slalom-like movements on the ski simulator when to exert force on the platform of the simulator on which the participant was standing. One group (internal focus group) was instructed to focus on their feet and to try to exert force with the right foot when the platform moved to the right, or vice versa. A second group (external focus group) was instructed to focus on the wheels of the platform that were located directly under their feet and to exert force on the right pair of wheels when the platform moved to the right, or vice versa. The difference in the instructions and in the presumed locus of attention (imagined distance between the imperative "cues" was minimal) between these groups was minor. However, the results indicated that these 2 types of instructions had different effects on learning this task. The external focus condition was much more effective in the production of large movement amplitudes than the internal focus group, which was not different from a control group that received no special instructions for both practice and retention (**Fig. 1**). Thus, the instructions that directed the learners' attention to the effects of their movement were more beneficial than the instructions directing the learners' attention to the movements themselves (or no instructions at all).

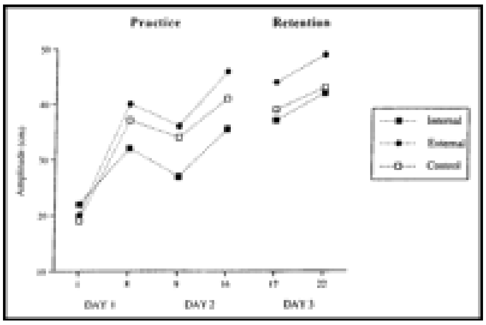


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**Figure 1.**

Movement amplitudes on the ski-simulator task for the internal-focus, external-focus, and control groups in the study by Wulf et al.[14] Reprinted with permission from *Research Quarterly for Exercise and Sport*, volume 70, pages 120–126, copyright 1999 by the American Alliance for Health, Physical Education, Recreation and Dance, 1900 Association Dr, Reston, VA 20191.

These findings were replicated in a second experiment in which participants were required to learn how to maintain their balance on a stabilometer. They were instructed either to try to keep their feet level (internal focus group) or to try to keep 2 markers, which were attached to the stabilometer board directly in front of their feet, horizontal (external focus group). The difference between the 2 sets of instructions and the locus to which learners directed their attention was again minimal. However, in a subsequent retention test in which participants were not provided instructions, those participants who focused on the external effects of their movements (markers on the board) were once again more effective in maintaining their balance than were participants who were instructed to focus on their own movements (feet).

In a subsequent study, Wulf et al[14] examined the advantages of an external focus of attention in the acquisition of a sport skill under field-like (nonlaboratory) conditions. Participants without experience in golf practiced pitch shots. One group was instructed to focus on the swing of their arms (internal focus), and the other group was instructed to focus on the motion of the club head (external focus). Here again, the external focus instructions greatly enhanced the accuracy of the golf shots in practice and in retention in comparison with internal focus instructions. Thus, the advantages of focusing on the movement effects, rather than on the movements themselves, could also be generalized to acquire more real-world skills as well.

In order to examine whether there are individual differences in the preference for, and perhaps in the effectiveness of, the attentional focus or whether the advantage of an external attentional focus is a general phenomenon (G Wulf and colleagues, unpublished research), researchers gave participants the option to adopt either an internal or external focus of attention. Participants learning to balance on a stabilometer were asked to find out for themselves which type of attentional focus seemed to be more effective. In a retention test, participants were asked to adopt either an internal or external attentional focus, depending on which one they had found to be more advantageous during the first 2 days of practice. The results provided further support for the advantages of an external focus of attention: more participants chose to focus on the markers that were located in front of their feet (n=16), than chose to attend to the feet themselves (n=4). Moreover, the participants who chose to focus on the markers were clearly more effective in retention than those who focused on their feet. These results suggest that the beneficial effects of an external attentional focus in comparison with an internal attentional focus are not dependent on individual differences, but rather that it is a general and robust phenomenon.

### Feedback

Shea and Wulf[15] hypothesized that the advantages of focusing on the outcome of one's movements, rather than focusing on the movements themselves, might not only be relevant for the formulation of instructions, they could also have implications for the *feedback* that is given to a learner. They, therefore, examined whether feedback would also be more effective if it directed the performer's attention away from his or her own movements and to the effects of these movements. They used the stabilometer task and presented 2 groups with the *same* concurrent visual feedback, in which the platform movements were displayed on a computer screen. One group of learners was informed that the feedback represented their own movements (internal focus), whereas the other group was told that the feedback represented lines that were marked on the platform in front of each of the performer's feet (external focus).

The results demonstrated that learning was more effective not only when performers were given external focus instructions but also when they were provided with “external” rather than “internal” feedback. That is, even though the feedback display was *identical* for the 2 feedback groups, the feedback group that adopted an external focus of attention performed better than the feedback group that adopted an internal focus of attention. This finding suggests that the feedback given to performers during practice can be more effective if it directs their attention to the movement effects, rather than to the movements themselves.

The feedback provided to learners in the Shea and Wulf[15] study *generally* enhanced performers' ability to maintain their balance in comparison with no feedback—even though it could be argued the feedback was redundant to their intrinsic (visual and kinesthetic) feedback.[16] This added benefit of feedback may be because the feedback served to induce an external focus of attention, independent of the instructions given to learners (ie, internal or external focus). Furthermore, the withdrawal of the feedback display for retention had no detrimental effect on performance. This result is in contrast to the findings of other studies, where the withdrawal of concurrent feedback resulted in clear performance decrements.[17–19] Both the performance-enhancing effects of this type of feedback and the lack of a decrease in performance after the removal of feedback seem to suggest that feedback can have the capacity to induce an external focus of attention, independent of attentional focus instructions, that benefits performance *and* learning.

**Possible Reasons for the Advantages of an External Focus of Attention**

The studies reviewed above suggest that giving learners instructions or feedback that direct their attention to the coordination of their body movements (ie, induce an internal focus of attention), which is often used in athletic or therapeutic settings, might not be optimal for learning. Rather, these studies suggest that motor skill learning can be enhanced by focusing the learners' attention on the *effects* of their movements (ie, by inducing an external attentional focus). The exact reasons for the beneficial effects of an external focus of attention are still relatively unclear. Trying to consciously control one's movements might interfere with automatic motor control processes that would “normally” regulate the movement. Henry[20] demonstrated the ability of the motor system to control movements automatically. In his study, participants were instructed to hold the position of a lever constant and to compensate for changes in pressure applied to the lever by a mechanical device. Henry found that participants responded to minimal changes in the position of the lever. The pressure required for conscious perception of a change was, on average, 20 times as large as the pressure that participants actually responded to. This finding seems to demonstrate the effectiveness of automatic motor control processes in comparison with more conscious control processes.

Recent studies where participants were required to balance on a stabilometer platform provide more direct evidence that focusing on the body movements (feet) results in a lower frequency of postural adjustments than focusing on the movement effects (markers on the platform), which results in low-amplitude, high-frequency adjustments (G Wulf and colleagues and NH McNevin and colleagues, unpublished research). Some researchers (see Newell and Slifkin[21] for a discussion) have characterized increases in response frequency as indicating an increase in the number of active degrees of freedom. When the system is compromised in some way (eg, aging, Parkinson disease), the frequency of hand and finger tremor, for example, decreases while the amplitude increases. Thus, the tremor becomes more perceptible. When the system is not compromised, hand and finger tremor is almost imperceptible because the driving frequency is relatively high, which also results in relatively small amplitudes.

In essence, higher frequency responses represent the potential of the system to respond, and we believe is characteristic of a biological system with more active degrees of freedom. Asking participants to actively intervene in the control of their movements (under internal focus conditions) seems to constrain the motor system and degrade the natural movement, resulting in degraded performance. In our opinion, focusing on the movement effects (external focus), on the other hand, may serve to let unconscious control processes take over, resulting in more effective performance and learning.

### Implications for Physical Therapy

The advantages of having patients focus attention on something other than their movements will not be lost on many therapists. For example, it appears to be a common practice for therapists to have patients focus on reaching for an object while working on weight shifting. They do not instruct the patients to focus on their weight shifting. Instructing patients to focus on their heel-strikes during gait or on the extension pattern of a limb during a reaching task will probably not lead to any appreciable improvements in movement. Based on the attentional focus research, such instructions will probably not be very effective in bringing about the improvement desired, let alone lead to any permanent changes (learning). However, instructing patients to imagine (or perform) kicking a ball during the terminal swing of a gait cycle or knocking an object off a table during a reaching task might allow the patients to perform the desired movements without concerning themselves with the actions required to produce the motion.

The same logic, we believe, explains why the use of metronomes or music during gait training may be beneficial to patients with neurological or musculoskeletal disorders. These patients often ambulate with a slow, asymmetric pattern and possess an excessive double support phase. By instructing patients to move in time with the music or metronome, the patient is encouraged to modify his or her gait (eg, stance-to-swing ratio) without consciously attending to the motor activities required to modify the gait pattern (eg, decrease stance time on the noninvolved leg). This use of music has also been shown to increase the stride length of patients with Parkinson disease whose hypokinesia (slowness) results in an inconsistent and below-normal stride length.[22] Although focusing attention on a metronome increased stride length to within 80% of normal values, a greater benefit (90%) was found when the attention of these patients was focused on an external visual cue (lines marked on the floor).[22,23] Although patients who were instructed to imagine the distance between markers also improved their stride lengths, the attentional demands required to sustain this activity appeared to be a limitation of this particular attentional focus.[23] That is, having to constantly imagine the distance between markers resulted in poorer performance relative to having the markers clearly defined, perhaps because the imagined distances were less salient or subject to greater variability as a result of attentional lapses or poor imagery skills.

Although many therapists may be familiar with these techniques, the rationale behind their use is often anecdotal, rather than research based. Furthermore, the strategy of focusing patients' attention on remote effects, rather than on the actions themselves, is not used consistently in clinical rehabilitation, or it may not be used at all.

Until a patient recovers to a point where “new” or reacquired skills can be integrated within existing motor activity patterns or can be generalized beyond training demands, the activities that the therapist works on are not usually very complex, and the treatment is typically devoted to developing the patient's range of motion, flexibility, muscle force, and endurance. Because of this, the focus of attention is almost entirely internal. For example, instructions provided to a patient with a cerebrovascular accident who is attempting to transfer from a chair to a bed typically focus the patient's attention on the sequence of activities required to accomplish this task (eg, lean forward at the waist, stand up, reach for chair, pivot), rather than focusing attention on the effects these activities will have (eg, sit-to-stand, stand-to-sit). A person with an above-knee amputation who must learn to activate his or her hip extensors just prior to heel-strike in order to slow the advancing limb is usually instructed to focus attention exclusively on activating the hip extensors, rather than on the activity of ambulating. Along similar lines, a person being taught to use a walker must learn to advance the walker, by stepping in with his or her involved leg first, then stepping in with the noninvolved leg. In each case, an internal focus of attention is introduced because focusing on the effects of one's actions would, from the therapist's perspective, defeat the goal of the treatment, which is as much about movement retraining as it is about teaching patients how to perform each activity safely. Despite the advantages associated with an external focus of attention, coordination between activities appears less important at this point than the acquisition of the component activities themselves. Therefore, an internal focus of attention would appear to be the more appropriate strategy to use during early intervention.

During the stages of rehabilitation, where the functional aspects of retraining require the patient to adapt his or her newly learned behaviors to purposeful activities, an external focus of attention may actually enhance performance and learning by directing the patient's attention away from his or her movements. For example, assuming that the goal of a particular treatment session is to increase the step length of a patient, addressing the coordination between the subcomponents of gait might yield more favorable results than addressing the activity of the leg in question would. Thus, although the therapist has often instructed the patient to take longer steps with the involved leg by fully extending the knee and flexing the hip (internal focus), it may be more effective to instruct the patient to move a walker or cane further in front of him or her (external focus), which necessitates a longer step as a by-product of the remote event.

Similar strategies may be used for the patient with hemiplegia who is required to transfer across a variety of surfaces, including obstacles of varying heights and distances apart. The therapist could instruct the patient to focus on what he or she is doing (eg, lifting the foot high enough to clear some obstacle) or instruct the patient to focus on the actual obstacles themselves (eg, the height of an obstacle and the distance between them) or could even tell the patient to focus on some point beyond the obstacle. If the patient is instructed to focus on the activity itself, performance may suffer because doing so encourages the patient to exert conscious control over an action that normally would not require it. On the other hand, an external focus of attention may yield a learning advantage for the activity being practiced because the automatic control processes underlying these activities, such as those associated with balance and stability, are allowed to operate freely.

Many therapists adopt this strategy of external focus within some of their treatment protocols. For example, therapists using therapeutic ball exercises and plyometrics often use external focus strategies while working on balance. Although the goal of balancing on a ball may be to use back extensor and abdominal muscles, the patient is instructed to focus his or her attention on another activity (eg, reaching for an object) rather than on the use of the particular muscles involved in maintaining balance. Children with myodysplagia are often asked to pretend they are walking in "muck" and that they have to pull their feet out of it. This activity works on balance and one-foot standing that the therapist hopes will, in turn, transfer to activities such as stepping over obstacles, and it may also improve hip muscle force and knee flexion. The same logic appears to underlie some of the training equipment used in rehabilitation. Computerized balance systems can be used to train patients to minimize movement around their centers of pressure (or shift their center of pressure in specific directions) by providing concurrent visual feedback regarding their performance. That is, patients direct their attention to an external cue (the cursor displayed on a computer screen), which depicts excursions of their center of pressure.

## Self-Controlled Practice

During many training sessions, a coach or trainer may determine the nature and scope of various exercises and provide the athlete with instructions and feedback. That is, the athlete does—more or less passively—what she or he is instructed to do by the coach and has little or no control over the training session. Yet, in a number of recent studies,[24–27] the effectiveness of training appears to have been enhanced by giving the learner some control over the practice situation in terms of deciding when and how much feedback is provided, when or how often an assistive device is introduced into the practice session, and the scheduling of the practiced tasks themselves. Although most of the literature on the effects of self-control and self-regulation on learning has been concerned with verbal or cognitive learning,[28–31] there is also growing evidence for the effectiveness of self-controlled practice conditions for the motor learning domain, which is concerned with the acquisition of motor coordination and control (that are as much performance-based as learning-based).[24–27] The perception of self-control has been shown to enhance learning,[32–34] presumably because the active involvement of the learner in the learning process leads to a deeper processing of relevant information.

The first study of this phenomenon was done by Titzer et al,[26] who examined the effects of a self-controlled practice schedule on a barrier knockdown task. This task required subjects to strike barriers in a particular sequence as quickly as possible. Using the same task, Shea and Morgan[35] had previously demonstrated that a random order of practicing different tasks produced more effective learning than a blocked order, where all trials on one task were completed before the participant was switched to the next task. However, Titzer et al[26] found that learners who could self-select the order in which they practiced the different versions of a task performed better than the blocked and random groups, as demonstrated by each group's ability to repeat their performance after some interval of time had elapsed and without the benefit of feedback. Both the self-control and random groups also made fewer errors than the blocked practice group.

More recently, Janelle and colleagues[24,25] used more complex throwing tasks to examine the effects of self-selected feedback schedules and experimenter-determined feedback schedules. They found that allowing learners to decide when they wanted to receive feedback enhanced the effectiveness of the feedback. Participants who could self-select their feedback schedule outperformed matched participants who had no control over the provision of feedback, as indicated by retention performance. Learners chose a relatively low feedback frequency (an average relative frequency of 7% in one study by Janelle et al[24] and of 11.5% in the other study by Janelle et al[25]) even though there were no constraints imposed on how much feedback a participant could receive. In addition, subjects requested less and less feedback over time (eg, subjects self-imposed a “fading” schedule on their practice session). Some experts think that a fading schedule combines the benefits of guiding learners into the right “ballpark” early in practice while gradually making them less dependent on the feedback later in practice.[36–39] This sensitivity to what promotes learning demonstrates that participants do not constantly seek external guidance, but rather seem to have a relatively good sense of how to learn effectively.

Wulf and Toole[27] used the ski-simulator task to examine whether the beneficial effects of a learner-controlled practice schedule extended to the use of physical guidance in complex motor skill learning. Following up on the findings of Wulf et al,[40] who showed that providing learners with ski poles during practice not only facilitated performance during practice but also enhanced learning, Wulf and Toole[27] asked whether a self-controlled schedule of physical guidance would be more beneficial than an externally controlled schedule. Two groups of participants practiced the ski-simulator task on 2 consecutive days. The participants of one group were allowed to choose when they wanted to use the poles (self-controlled group), whereas a second (matched) group had no control over their schedule (yoked group). Even though the self-control and yoked groups demonstrated very similar performances (movement amplitudes) during practice, allowing learners to self-select when they wanted to use the poles was clearly more effective for learning, as shown by a (no pole) retention test on the third day (**Fig. 2**). These results demonstrate that the advantages of self-controlled practice schedules appear to be generalizable to physical guidance in complex skill learning (and not just instructional guidance as seen in feedback studies cited earlier). Because there appear to be benefits of self-controlled feedback[24,25] and practice schedules,[26] these results provide converging evidence for the advantages of self-controlled learning situations.

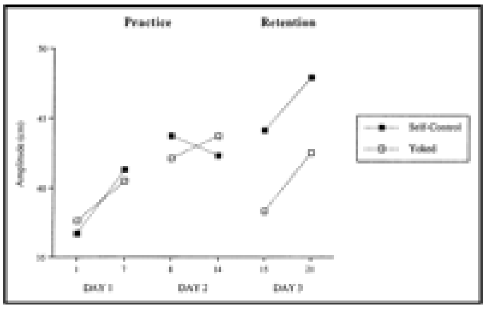


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**Figure 2.**

Movement amplitudes on the ski-simulator task for the self-control and yoked groups in the study by Wulf and Toole.[27] Reprinted with permission from *Research Quarterly for Exercise and Sport*, volume 70, pages 265-272, copyright 1999 by the American Alliance for Health, Physical Education, Recreation and Dance, 1900 Association Dr, Reston, VA 20191.

### Possible Reasons for the Benefits of Self-Controlled Practice

Learners under self-controlled practice conditions apparently process information differently than learners who have no control over their practice schedule, even though the associated advantages might not be observable during practice (see, for example, Wulf and Toole[27]). Winne[41] suggested that self-controlled learners are deliberate about the strategies they use to enhance learning. This would be expected if, for example, the self-controlled learners were given the option to use physical guidance (ski poles) to promote performance. That is, giving learners some responsibility for their learning may encourage them to try out different learning strategies and eventually select one strategy over others, based on how it was able to support progress toward the task goal. Participants who have no control over the practice schedule, on the other hand, are perhaps discouraged from engaging in similar information-processing activities and from taking charge of the learning process.

Support for this view was provided in a study in which one group of participants was allowed to decide when they wanted to use assistive devices (ski poles) on the ski simulator (G Wulf and colleagues, unpublished research). However, contrary to the study by Wulf and Toole,[27] the yoked participants practiced in dyads (pairs in which one participant practiced while the other participant observed) with the self-control participants by taking turns between physical and observational practice. The yoked participants were required to use an assistive device as prescribed by the self-control group; thus, they had no control over when or how often the poles were used. The investigators found no group differences concerning movement features that are easily observable such as movement amplitude and frequency. However, learners who could control when the assistive devices were used developed a more efficient movement pattern than their yoked counterparts in terms of when force was exerted on the platform during the movement cycle. If applied after the platform had crossed the midline of the arced rails, the subject could conserve more energy than if force was applied before the platform crossed the midline. These findings suggest that giving performers some control over the practice situation somehow promotes the effectiveness of information processing. This, in turn, appears to lead to enhanced learning. Perceived control has also been found to be a strong motivator for performance and learning.[42,43] If the locus of control is taken away from the performer, there will be less intrinsic motivation for the learners,[44] and they would presumably reduce the effort they invest in learning.

### Implications for Physical Therapy

Although therapists regularly ask patients what they want to gain from rehabilitation, we believe that therapists generally control how the end results will be achieved. Findings regarding the effectiveness of self-controlled practice schedules[24–27] suggest that learners can be quite effective in selecting practice conditions that are conducive to learning. Whether this is true in people with nervous system damage, however, is not known. With respect to rehabilitation, although some patients may have difficulty identifying and implementing strategies that may aid their learning, 2 situations exist where allowing patients some control over their treatment may be particularly fruitful: the use of assistive devices and the provision of feedback.

For the most part, assistive devices are temporary fixtures in a patient's recovery. The ultimate goal is to encourage the patient to become less dependent on the assistive device once the desired movement can be made. As is the case with the ski-simulator task, there are many ways to interact with an assistive device, but we believe there is really only one correct (or optimal) movement pattern that the patient (or novice skier) is encouraged to strive toward. Therefore, based on results of Wulf and colleagues' studies on people without CNS injuries[27] (G Wulf and colleagues, unpublished research), which showed that self-controlled use of ski poles promoted better learning relative to the no-control condition, it is possible that allowing patients to dictate when and how often they use an assistive device may have beneficial effects, specifically on how well the optimal movement pattern is learned and on how quickly the patient becomes less dependent on the assistive device.

It is important to note that self-control over the use of assistive devices may have little impact on how quickly a patient's performance improves over the duration of treatment sessions. However, even if an assistive device does not help determine how quickly a movement goal is acquired, the fact that self-control promotes better learning implies that fewer mistakes will be made once the device is no longer used, if people with central nervous system injuries perform similarly to people with intact nervous systems[40] (G Wulf and colleagues, unpublished research). Furthermore, allowing the patient to decide when (and when not) to attempt a trial without the use of an assistive device may overcome some of the resistance patients experience when that same decision is made by their physical therapist. In effect, having control over use of an assistive device may promote confidence in performing without it. However, people whose cerebrovascular accidents, for example, have affected their ability to make judgments may not be capable of making these decisions.

Feedback is an additional factor that may be used more beneficially if patients have some control over its frequency and time of delivery. According to Janelle and colleagues,[24,25] learners are sensitive to factors that contribute to their learning and will typically impose a schedule of feedback that offers information when it is needed and constrains the learner to become less dependent on it as a function of practice. Therapists often provide feedback after a patient commits some error in performance, in which case it is informational in nature, or when the patient performs the movement correctly, in which case it enhances motivation. In either case, unless the patient is unaware of what he or she did incorrectly, the feedback provided by the therapist is probably redundant to the intrinsic feedback generated by the patient (whether visual, kinesthetic, proprioceptive, or auditory). Therefore, the feedback supplied by the therapist may not be particularly useful to the patient who has already determined that a mistake has been made and may have a fairly good idea how to correct it on subsequent attempts. However, when the patient is unaware that a mistake has been made and is thus unsure of how his or her performance can be improved, the feedback supplied by the therapist will be much more informative. In essence, therapists should assume that most patients do know whether feedback is necessary on any given trial and should give them some control over when feedback is delivered. Allowing patients whose decision-making abilities are not compromised as a result of a cerebrovascular accident to view the therapist as a resource providing feedback when needed may greatly encourage the problem-solving capabilities of patients and promote faster recovery.

Feedback quantity is also an important variable in learning, because more feedback during early stages of rehabilitation and less during later stages would be expected to promote learning.[24,25] Whether therapists adopt this strategy as part of their normal treatment protocols is not known; however, anecdotal evidence suggests that therapists continue to provide feedback well past the point where it augments a patient's problem-solving capabilities. Constant feedback can have detrimental effects on learning.[38,39] That is, if feedback is supplied after *each* attempt made by a patient, regardless of the stage of learning he or she is in, he or she tends to become dependent upon that feedback as a substitute for his or her own error-detection and error-correction capabilities. This dependency may not pose a problem while the patient is under the supervision of the therapist, but when this feedback is no longer available (eg, when the patient is discharged from the rehabilitation facility) the consequences could be detrimental to the patient's continued recovery. Allowing the patient to control the scheduling of feedback may help offset the dependency on the therapist he or she may develop as a substitute for his or her own ability to monitor performance and may encourage continued recovery if the performance of nonimpaired populations can be generalized to a clinical population. Once again, depending on the degree and nature of the impairment, the decision to allow patients control over the delivery of feedback must be left to the discretion of the therapist.

## Dyad Training

In many real-world situations, providing the patient or performer with individual training sessions is often viewed as enhancing the effectiveness of the training or treatment. Among the arguments for the presumed effectiveness of individual sessions is that the patient has the undivided attention of the therapist and that the patient is free from the distractions that may be created by other patients. Data to support the argument that individual sessions are more effective do not exist at present. The costs of individual sessions could be substantially reduced if the treatment was conducted in dyads or larger groups (eg, pairs of patients who are working on gait or larger groups who are working on wheelchair mobility). In addition, patients may actually profit from the observation of and interaction with other patients. Observational learning has been demonstrated to be an effective means in the teaching of motor skills.[45] Researchers[46,47] have shown that for a model to be effective, the model does not have to be an expert performer; the observation of any other performer can have a beneficial effect on learning.

Some recent studies on people without central nervous system injuries provide support for the notion that having people practice in dyads (or larger groups) not only can be more efficient than individual sessions but also can be as effective as, or even more effective than, individual training.[48] In a series of experiments, Shebilske et al[48] used a special form of dyadic training in the “active interlocked modeling” (AIM) protocol. Their participants practiced a video game (*Space Fortress*), where one partner controlled half of the complex task (eg, keyboard), while the other partner controlled the other half (eg, joystick). While controlling either the keyboard or joystick, the participants were able to observe the other member of the dyad perform their respective task. Presumably, this was possible because the attentional and cognitive demands required to control half of the total task were reduced to the extent that they could allocate mental resources to observation. Hands-on practice of one half of the control procedures and observational practice of the other half of the control procedures were switched from trial to trial. Thus, compared with individuals in the training group who controlled the whole task on all practice trials, participants in the AIM dyad had a reduced the information load. On test games that required control of the whole task, however, there were no differences between groups (ie, both groups showed the same amount of learning).[49] Thus, facilitating practice by reducing the task demands had no detrimental effect on learning, compared with practicing the whole task.

Many tasks—including skills that need to be acquired or reacquired during in rehabilitation—do not lend themselves to dual control. We believe that a potentially efficient and effective training protocol, which involves observation and can be easily applied to many training or treatment environments, can be constructed by having participants alternate between physical and observational practice. Such a protocol should, in our opinion, take advantage of the intervals between trials or sessions; while one learner is engaged in physical practice, the other learner is afforded the opportunity to rest and observe. The participants change roles on subsequent trials. Using such a protocol, Shea et al[50] even found learning advantages of combined observational and physical practice over physical practice alone. They used a 2-hand coordination task, where participants had to learn to alternately press 2 response keys in an attempt to keep an accelerating "dot" centered on a target line. When 50% of the physical practice trials were replaced with observational practice, there were no decreases in retention performance, and performances in a transfer test were even superior compared with those of a group that practiced physically on all practice trials. These findings demonstrate that alternating observational practice with physical practice trials can be more effective than physical practice alone.

Further support for the efficacy of observational and physical practice was provided in a follow-up study by Shea et al.[51] They used a balance task (stabilometer) that, like many other complex, continuous motor tasks, requires intervals between practice trials to avoid fatigue and provide relief from the high attention and concentration demands. All subjects who performed this task were college-aged individuals with no known impairments. In this study, one group of participants worked in dyads in which the partners alternated between physical and observational practice ("dyad-alternate"). Participants were also allowed to engage in undirected dialogue during the rest interval between practice trials. The effectiveness of this training protocol was compared with that of individual training consisting of the same number of physical practice trials ("individual") and with that of another dyad condition, where one partner performed all physical practice trials while the other partner observed, before they switched roles ("dyad-control").

The results of the study by Shea et al[51] showed that alternate practice with a partner was more effective than individual practice or dyad practice where partners did not alternate roles from trial to trial (**Fig. 3**). Even though there was an initial performance decrease during acquisition under both dyad practice conditions, the dyad-alternate group participants quickly caught up with the individual group participants and even tended to be more effective than the individual and dyad-control participants at the end of the acquisition phase. More importantly, dyad-alternate learners showed more effective delayed retention performance than individual learners. This is, in our view, particularly remarkable, because retention trials were performed under individual-performance conditions. That is, the benefits of dyad-alternate training transferred to a situation where participants had to perform individually.

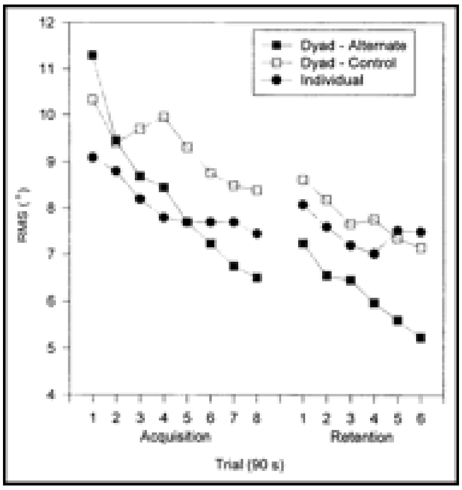


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**Figure 3.**

Average deviations from the horizontal stabilometer platform position (root mean square [RMS] error) under dyad-alternate, dyad-control, and individual practice conditions in the study by Shea et al.[51] Reprinted with permission of the Helen Dwight Reid Educational Foundation from *Journal of Motor Behavior*, volume 31, pages 119–125. Published by Heldref Publications, 1319 18th St NW, Washington, DC 20036-1802. Copyright © 1999.

In summary, it appears that combined observation and physical practice protocols have the potential to greatly increase learning efficiency without sacrificing learning effectiveness. They even have the potential to enhance learning effectiveness, especially if partners take turns between observational and physical practice trials and have a chance to interact with each other during the "rest" intervals. This is especially important for skills that require a considerable amount of training time and resources, such as those typically learned in rehabilitation settings. Research on which this is based, however, was primarily conducted on people without pathology of the nervous system.

### Possible Reasons for the Effectiveness of Dyad Training

Several factors might be responsible for the beneficial effects of having performers or patients practice in groups of 2 or more. Besides the possible benefits gained from observing another performer learning the task,[45,47,52,53] practicing with another person in an interactive way might also act to increase the learners' motivation by adding a competitive component to the practice situation. That is, it might encourage learners to set goals at a higher level of difficulty. Setting goals, especially if they are specific and short-term (eg, outperforming the partner), has been found to benefit the performance and learning of motor skills.[54–57]

In addition, observational practice offers a form of practice in which the cognitive demands are sufficiently reduced because the observer is not required to physically perform the task and can concentrate on its fundamental elements, the relationships between components, and devise or evaluate strategies that result in effective task performance. Thus, the learner has the opportunity to perform information-processing activities that he or she would not be able to do while performing a complex task that demands high attention. The latter types of processing afforded under observation practice should be especially helpful when observation and physical practice are combined.

Finally, training together with a partner and sharing learning strategies as learning progresses[51,58] might increase the participants' feeling of responsibility for and their involvement in the learning and treatment process. Asking learners after each practice trial to exchange ideas in terms of how their performance could be improved may prompt them to invest more cognitive effort and engage in processing activities that they would not engage in otherwise under individual training conditions.

### Implications for Physical Therapy

Individual therapy sessions are very costly, especially if expensive equipment is involved. Treatments conducted in groups of 2 or more participants would cost less. Furthermore, because rest intervals are generally required between practice trials, especially when the task is physically or cognitively demanding, these intervals may offer an opportunity for the patient to observe other patients while still offering relief from the specific demands of the task. The research we summarized in this literature article suggests there may be benefits to these “unproductive” moments because patients may profit from observing other patients who are treated in the same session. In addition to the advantages patients might gain from observing, the dialogue among patients (eg, suggestions, motivation) that could occur between trials could also be beneficial for learning.

Dyad or group training is used by some therapists for skills such as wheelchair mobility, pool therapy, and feeding groups. The use of group therapies, as has been done increasingly over the last 10 to 15 years, has generally been motivated by an economic need rather than the desire to promote learning. There are, however, additional areas where dyad or group training may promote recovery because it offers motivation, encourages the exploration of alternative solutions to problems, or provides the opportunity to observe optimal solutions to specific tasks. As a source of motivation, dyad training may be an effective adjunct to strength and endurance training. Although the therapist's supervision is still necessary for both instruction and safety, the presence and input of a person with similar problems may motivate another patient to invest maximum effort in an activity or to venture beyond some training threshold the patient has specified arbitrarily. In this context, the point of dyad training is not to provide for competition between patients (even though that may have positive effects), but rather to encourage patients to set goals that have some face validity based on the performance of peers. Furthermore, the motivation offered by a peer may be viewed more positively than the motivation offered by a therapist, who some patients might view as a stranger to their situations.

A second area where dyad training may prove beneficial is gait training, where the input from a patient receiving similar training might augment the problem-solving activities of another patient. As several studies[48,51,58] have shown, allowing dyad partners to compare notes and strategies on performance promotes better learning than would be seen for subjects who are left to their own devices. When supplemented by the information from a therapist, interactions between patients may lead to improved performance and learning. If the goal of the treatment session is the acquisition of a specific movement pattern, as would be the case when assistive devices are involved, the input and modeling offered by a dyad partner, who does not have be skilled, may enhance learning beyond that obtained by observing the therapist. In either situation, the role of the therapist may be no different from what it is at present, but, at a minimum, the addition of another patient makes the training session more efficient because 2 patients benefit from the time and resources invested.

## Clinical Limitations

Although we have discussed a number of clinical applications for attentional focus, self-control, and dyad training on enhancing the rehabilitation process, their application is predicated on the assumptions that the cognitive, perceptual, and executive functions of the patient are intact. There are, however, occasions when a patient's neurological impairment, accompanied by impaired executive functioning (attention, memory, problem solving, and judgment), would limit the efficacy of the management strategies discussed earlier. Such impairments would preclude the use of self-control strategies, for example, because the patient would not exercise good judgment in deciding when feedback should be delivered or when an assistive device should be used. Similarly, if the patient possesses a limited attention span (or is easily distracted), an external focus of attention strategy, which requires some degree of vigilance and higher-order processing, may not promote performance or learning gains. Inappropriate affect could also impinge on the efficacy of strategies such as dyad training, where the quality of interaction between individuals dictates the pace of learning. Use of these strategies in the treatment of patients with neurological disorders, therefore, must take into account a patient's unique limitations and abilities. On the other hand, there is a need to identify which clinical populations would benefit from one or more of these strategies.

## Summary and Conclusions

We have discussed 3 factors that have recently received increasing attention in the research literature and that, based on their specific association with the learning of complex motor tasks, may have implications for rehabilitation. These factors—attentional focus, self-control, and dyad training—appear to offer advantages to rehabilitation treatment and are based on results garnered from studies of adults without neurological pathology. The principles that account for their effects on enhancing learning in this group should, in our opinion, apply to clinical populations who, like many individuals confronted with a novel task (or the relearning of an old one), may benefit from things such as the experience of peers, control over some aspects of their training regimen, and an external attentional focus.

To some extent, the factors presented here are incorporated into many of the protocols currently used to treat patients. However, their application is far from universal, and where they are used, they are devoid of any experimental basis for their use. We trust that the overview presented here will not only provide therapists with the scientific justification for the continued use of these learning factors in the clinical setting but also inspire investigation of additional areas where their application may enhance learning. These points seem especially compelling in today's climate, where the physical therapy profession is often challenged to show the benefits of many of the treatment protocols it uses. Because no data on patient populations exist, there is also a need to investigate whether application benefits patients through both formal and informal research by therapists. This research will serve to enhance the role and importance of therapists in patient treatment by encouraging them to become applied motor learning specialists.

## Footnotes

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