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10 Motor learning through a motivational lens

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Introduction

Practice is generally considered one of the most critical contributors to motor learning in most domains of human activity, including sports (Schmidt & Lee, 2005). However, in addition to the sheer number of practice trials, other factors (e.g., instructions, feedback, movement demonstrations, imagery, action observation) have been shown to influence the extent and rate of learning. In the research literature, these factors are often considered on the basis of the information they convey to the learner. Yet human learners are more than neutral processors of information, and there is accumulating evidence to suggest that learning is optimized by practice conditions that account for motivational factors.

Motivation, movement, and motor share the same Latin root (moveo, to move). On some level, to move implies that one is motivated, and to be motivated implies that one moves toward (or away from) something. Scientifically, the term motivation is used in different ways: (1) as a description of the drive toward some goal, usually in terms of level of intensity and direction of movement; (2) as a field of study or an umbrella concept encompassing not only that drive, but its causes and consequences. The former use is more in keeping with a behaviorist tradition in which behavior is assumed to be reinforced by the outcome of that behavior or the extent to which reward or punishment occurs with the behavior. The latter, more cognitive, conceptualization is most prominent in social and sport psychology and accounts for the study of social-cognitive constructs such as goal orientations, self-efficacy, attitudes, intentions, and emotional and affective states as they relate to motor performance and motor behavior. With some exceptions, researchers examining personality dispositions, social-cognitive variables (cognitions such as self-efficacy affected by social influences present or perceived), or social processes have assumed until recently that these motivational factors exert their influence on motor learning through longer-term pathways that engage interest and encourage continued practice.

A second body of work developing in motivation and motor learning is grounded in neuroscience. This more recent work stems from animal and human studies in motor neurophysiology (D. Brooks, 2001; V. Brooks, 1986), human neuroclinical populations (such as Parkinson's disease; Rowe et al., 2008; Schmidt et al., 2008), and recently neurocomputational modeling of systems and processes involved in
reward and memory (Abe et al., 2011). Relative to the role of motivation in motor learning, these studies suggest linkages between motivation - often in the forms of food or monetary rewards - affective experience (Siessmeier et al., 2006), dopamine release in the corticostriatal system, and modulation or reinforcement of motor learning. Furthermore, the relatively recent discovery of the mirror neuron system that ties motor and premotor neural networks to language, movement, and social behavior has implications for the association of action observation and action execution, a relationship with relevance to motor learning and motivation (Lewthwaite & Wulf, 2010a). We expect that soon there will be a stronger connection with the emerging field of social-cognitive-affective neuroscience as it pertains to movement phenomena. We limit our discussion of the motivation-motor learning neuroscience evidence here and turn to the focus of this chapter on behavioral research that supports a stronger role for motivation than most perspectives on motor learning have recognized.

An integration of these varying scientific traditions with relevance to motor learning has not yet been sufficiently attempted, let alone accomplished. In this chapter, we focus on the behavioral literature relating social-cognitive factors to motor learning. We utilize a meta-theoretical framework on fundamental psychological needs (e.g., Deci & Ryan, 2000, 2008; Ryan & Deci, 2007) as a means to organize our discussion of motivation in the context of motor learning research. We chose this motivational framework for consideration of motor learning research because of the range of factors considered, which may fit well, if loosely, with available literature describing motivational influences. In contrast to the neurophysiologic and neurocomputational research that emanates from animal research origins and generally utilizes extrinsic forms of motivation such as external rewards, the motivation of interest in the psychological needs and self-determination framework centers on intrinsic sources of motivation. Intrinsic motivation refers to an "inherent tendency to seek out novelty and challenges, to extend and exercise one's capacities, to explore, and to learn" (Ryan & Deci, 2000, p. 70). In choosing the psychological needs framework, we do not imply that the enhancement of learning is fueled by intrinsic forms of motivation alone, as the discussion of the neuroscientific literature above would refute. However, although extrinsically induced motivational neuromodulation can affect motor learning in the short term, the literature described below would suggest that social-cognitive influences of a more intrinsic nature can serve this function as well. Persistence in movement behavior - a requirement for expertise and skill development over the longer term - appears to be importantly dependent upon intrinsic forms of motivation (e.g., Pelletier, Fortier, Vallerand, & Briere, 2001).

The fundamental psychological needs framework, and particularly the related Self-Determination Theory (Ryan & Deci, 2000), have been deployed broadly to examine determinants of health and behavioral outcomes, including sport, physical activity, and exercise adherence (e.g., Adie, Duda, & Ntoumanis, 2008; Duncan, Hall, Wilson, & O, 2010; Williams, Niemiec, Patrick, Ryan, & Deci, 2009). Providing evidence that such needs are truly innate or fundamental is beyond the scope of this chapter, and indeed taxes claims for most biological and psychological notions of essential elements, though scholars periodically attempt the task (e.g., Corning, 2000; White, 1959). However, Deci and Ryan's conceptualization of psychological needs provides a useful framework for contemplating categories of motivational variables in social-psychological research. This framework may help readers recognize motivational influences on motor learning. Furthermore, a motivational framework may partially account for a variety of conditions of practice that characterize research in motor learning.

Psychological well-being and optimal functioning and learning in a broad range of domains appear to depend on support for, or satisfaction of, basic needs: competence, autonomy, and social relatedness (e.g., Deci & Ryan, 2000, 2008). These needs have ramifications for the survival and development of living beings. It would be hard to imagine that the pursuit of increasing competence, sufficient autonomy in one's actions, and connectedness to others, who ensure from birth that we can survive and thrive, would not be of fundamental benefit to humans and animals alike. The need for competence refers to the need to experience oneself as capable and competent, whereas autonomy is related to the need to control or actively participate in determining one's own actions and behavior. Social relatedness describes the need to feel connected with others or to experience satisfaction in one's involvement with the social world. For example, greater levels of reported need satisfaction have been found to predict intrinsic motivation in physical education settings (Standage, Duda, & Ntoumanis, 2005), and positive affect in vocational dancers (Quested & Duda, 2010). We contend that psychological needs must be met in order to optimize the learning of sport skills. In this chapter, we review factors that have been demonstrated to enhance motor learning - presumably by addressing or supporting one or more of the basic psychological needs.

Competence

If the behavior of living beings is fueled in part by the need to maintain and enhance competence (e.g., Deci & Ryan, 2000; White, 1959), sport provides many opportunities to build skills as well as the associated perceptions or beliefs that one can overcome challenge, become skilled, or improve skills. Practically speaking, it is hard to separate performance capacity itself from the perceptions that one is capable, as they generally develop in concert. Theoretically (e.g., Bandura, 1977) and experimentally, though, the perception of competence (and related sense of confidence) is separable from the possession of competence and the former may be of greater consequence in motor learning.

Sport is a field in which performance and learning typically take place in public arenas. Skill learning often occurs in groups, and performances frequently happen in the certain or potential presence of other performers, competitors, and audiences. Such venues provide plenty of opportunity for formal and informal feedback, including social comparison: providing individuals with almost instant and often implicit feedback regarding their competence level relative to others. In addition, feedback about their performance or improvement is provided through many sources, including coaches, parents, or fellow athletes. Moreover, sport is a domain
in which good or poor performance is often attributed to an inherent ability, talent, or lack thereof. All of these factors not only provide individuals with a certain sense of competence (or lack of competence), but may also influence the interpretation of their competence (e.g., as being a function of practice, effort, and learning, or inherited abilities).

As we will argue in this section, loss of confidence, concerns about capabilities, and feelings of embarrassment are not conducive to the activities and practice that promote learning. By creating conditions that enhance the learner's feelings of competence, instructors or coaches can speed the learning process and enhance performance. Such conditions involve positive feedback about the learner's performance and information affecting learners' conceptions of ability. Furthermore, conditions that reliably affect skill acquisition itself, such as external attentional focus instructions (e.g., Wulf, 2007a) or modeling (e.g., Clark & Ste-Marie, 2007; Maslovat, Hayes, Horn, & Hodges, 2010), would be expected to contribute indirectly to perceptions of competence.

Positive feedback

In the motor learning literature, most researchers over the past 40 years have been concerned with the informational function of feedback, that is, its role in providing information about an individual's performance in relation to the task goal (for reviews, see Swinnen, 1996; Wulf & Shea, 2004). Similarly, practitioners often see performance feedback from this perspective. A track and field coach, for instance, might identify deviations in throwers' or runners' movement patterns from the optimal technique and instruct them about how to change their movement patterns (i.e., a kind of prescriptive form of feedback). Although prescriptive feedback can play an important role in any learning process, a somewhat underappreciated aspect of feedback by learning researchers has been its influence on the performer's motivational state. In fact, a recent study by Mouratidis, Lens, and Vansteenkiste (2010) demonstrated that the way in which potentially threatening corrective feedback (i.e., information about how to improve performance) is provided by a coach has an important influence on motivation. The perception of such feedback as autonomy-supportive was positively related to the athletes' intrinsic motivation, which, in turn, was positively related to their intentions to persist as well as their well-being (see also the "Autonomy" section below). Recent studies in the motor learning domain provide converging evidence that positive (or negative) feedback affects not only an individual's motivation but also, and arguably not coincidentally, his or her skill learning.

In a series of studies, it was found that providing learners with feedback after "good" trials, compared with "poor" trials, resulted in more effective learning (e.g., Chiviacowsky & Wulf, 2007; Chiviacowsky, Wulf, Wally, & Borges, 2009). In those studies, feedback about task performance (i.e., accuracy of throwing an object at a target) was provided after each block of six practice trials. However, it was provided on only half of those trials. Unbeknownst to the learners, one group of participants was given feedback about their three best trials in that block, whereas another group was provided with feedback on their three worst trials. Participants receiving feedback after their best trials demonstrated more effective learning. This effect was seen not only in young adults (Chiviacowsky & Wulf, 2007) (see Figure 10.1), but also in older (65 years, on average) unimpaired adults (Chiviacowsky et al., 2009). Thus, feedback emphasizing successful performance, while ignoring less successful attempts, benefited learning. A subsequent study linked this effect to participants' enhanced intrinsic motivation when they received feedback after good trials (Badami, Yaez-Mousavi, Wulf, & Namazizadeh, 2011). These researchers found that intrinsic motivation, in general, and perceived competence, in particular, increased with feedback after good trials. Given that learners often have a relatively good feel for how they perform (Chiviacowsky & Wulf, 2002), instructor feedback indicating errors not only may be superfluous, but can also irritate some people or heighten concerns about the self that may hamper learning (Wulf & Lewthwaite, 2010). Deliberately choosing to frame feedback around available positive aspects of performance, or to precede critique with acknowledgment of positive assets, might be expected to enhance the learning of motor skills. Evaluation of these "emphasize the positive" approaches for motor skill learning would be an important area for future systematic investigations.

Self-related concerns or worries may be induced by feedback about learners' capabilities relative to others, or their improvements relative to themselves or others. In experimental studies, the effects of normative feedback - which involves norms such as a peer group's actual or false average performance or improvement scores - have been examined. Information about relative performance may be provided in addition to a participant's personal performance score (Bandura & Jourdan, 1991; Johnson, Turban, Pieper, & Ng, 1996). Providing individuals with normative information, such as the "average" scores of learners on a given motor task, can therefore be a potent basis for evaluation of personal performance. Favorable

![Figure 10.1 Accuracy scores of the groups receiving feedback (FB) after good versus poor trials in the study by Chiviacowsky and Wulf (2007).](image-url)
comparisons with others result in perceptions of competence, increased self-efficacy (situation-specific self-confidence), and motivation to exert effort or practice a skill (Kavussanu & Roberts, 1996), whereas negative comparisons have the opposite effect (Hutchinson, Sherman, Martinovic, & Tenenbaum, 2008; Johnson et al., 1996).

Recently, researchers have demonstrated experimentally that motor learning can be enhanced by (false) positive normative feedback (Wulf, Chiviacowsky, & Lewthwaite, 2010; Lewthwaite & Wulf, 2010b). In one study, two groups of participants practicing a balance task were given normative feedback, in addition to veridical feedback about their performance, after each trial (Lewthwaite & Wulf, 2010b). Participants in the “Better” group were led to believe that their performance was better than average, whereas the opposite was the case for “Worse” group participants. The Better group demonstrated more effective learning than both the Worse and Control groups, whereas there were no differences between the last two conditions (see Figure 10.2). Positive normative feedback not only led to better outcome scores, but produced qualitative differences in participants’ control of movements as well: individuals who received feedback indicating that they performed above average exhibited greater automaticity in movement control. Thus, the mere conviction of being “good” at a particular task, or showing “better” improvement (Wulf et al., 2010), facilitated the learning process. Interestingly, no comparison information (control condition) resulted in similar performance and learning to negative normative feedback—perhaps for different reasons or because both conditions trigger thoughts about the self and ensuing self-protective activities that hamper learning of the primary task (Wulf & Lewthwaite, 2010). Some might wonder if the literature on the effects of normative comparisons and the use of false feedback argues for these kinds of manipulations in practical settings. On ethical grounds, of course, it does not. Furthermore, we would suggest that it is the environmental availability of information implying that one is an effective performer, or the provision of positive, competence-affirming, feedback in conditions of learning, that is critical. This provision is something many practitioners intuitively do, but others may be more focused on correcting errors per se, with unintended impacts on the motivational and thus learning consequences.

It appears that people who are at the initial stages of learning a new motor task, and express low confidence in their ability to acquire a task, quickly benefit from positive feedback (Wulf & Bragg, 2010). Whereas low confidence was indeed associated with dampened improvement across practice and learning of a balance (stabilometer) task, feedback (false) suggesting that performance was above average resulted in performance that was no different from that of participants with initially high confidence in their ability to learn the task quickly. Positive feedback appears to increase the performer’s sense of competence—even in those with low confidence or self-efficacy—reducing self-related concerns and facilitating enhanced task-related attention and learning.

**Conceptions of ability**

Talented and gifted are attributes that are often ascribed to athletes. Irrespective of the extent to which motor performance is based on inherent factors rather than practice and effort, researchers have shown that people’s conceptions of or beliefs regarding the nature of key abilities affect their motivation and performance. Specifically, people’s view of their abilities—or competencies—as something that reflects a fixed capacity versus something that is amenable to change with practice influences their level of achievement in given activities (e.g., Dweck & Leggett, 1988; Mangels, Butterfield, Lamb, Good, & Dweck, 2006). In general, people tend to differ in their beliefs about whether abilities are generally stable and fixed, or learnable and malleable (e.g., Dweck, 1998; Dweck & Leggett, 1988). People in the former group tend to be concerned with proving their ability by outperforming others. Negative feedback is perceived by them as a threat to the self because it reveals an available level of ability that is less than optimal. As a consequence, they show less effort and persistence in difficult situations that may reveal the limits of their ability. Entity theorists, that is people who believe that abilities are fixed, may avoid situations in which they do not perform well. In contrast, people who subscribe to incremental theories (i.e., that abilities are changeable or malleable) are more focused on learning and improving their performance on a given task. They tend to be more intrinsically motivated and to seek challenging situations. When confronted with difficulties, they try to overcome those by increasing their effort. Well-known examples of individuals whose hard work made them world-class athletes—despite initial setbacks—include Michael Jordan (who was cut from his high school basketball team), Jackie Joyner Kersee (who did not win any races for a long time in her early career), and Wilma Rudolph (who had a partially paralyzed leg due to polio). As Rudolph once said, “Some might attribute my transformation to
on optimizing the movement technique, which can be interpreted by some to be a form of (unintended) negative feedback, rather than to acknowledge explicitly a performer’s movement or personal assets for success. It may be tempting to provide immediate feedback when an error occurs. However, error information not only may be superfluous, as learners may already have a good feel for how well they performed (e.g., Chiviacowsky & Wulf, 2002), but has the potential to be perceived as negative, demoralizing in impact, and perhaps indicative of less than desirable levels of personal autonomy. Feedback indicating that performance is below expectations – especially when presented repeatedly – may have immediately as well as ultimately negative effects on learning. Furthermore, people’s conceptions of ability can influence the learning of motor skills. Individuals who view a task as an acquirable skill presumably approach the learning situation with less apprehension than those who see task performance as a reflection of a fixed (lack of) ability. Experimental instructions are able to override dispositional conceptions of ability that participants may hold. Certainly, practitioners should eschew insinuations of fixed abilities. It would seem advantageous to ensure explicitly that problematic assumptions that change is not likely, or difficult to achieve, be explored, discussed, and challenged as part of the training and learning process. Furthermore, instructions or feedback should focus on a performer’s improvements or effort invested in practice. Even simple differences in wording can have an important influence on individuals’ motivation and continued interest in a movement task (Cimpian, Arce, Markman, & Dweck, 2007).

Autonomy

Autonomy refers to people’s basic need to determine and have control of their own behavior. In the past few years, a number of researchers have shown that motor skill learning can be enhanced by giving the learner some control over practice conditions (for a review, see Wulf, 2007b) – that is by satisfying their need for autonomy. This contrasts with many practical settings, including sports practice, in which some instructors and coaches may prescribe the task they want an athlete to perform, the order of different tasks, and the number of sets and repetitions for each. Some practitioners may provide feedback to the learner about correct or incorrect parts of the movement, and may give demonstrations of the goal movement pattern. Thus, while instructions control almost all aspects of the training sessions, the performer assumes a relatively passive role. There is ample evidence to suggest that granting the learner some autonomy in the training process can significantly enhance learning. In this section, we review studies that have examined learner control or self-control with respect to the delivery of feedback, augmented information, the use of physical assistance devices, and demonstrations of the goal movement.

Feedback

Studies examining effects of self-control usually involve a yoking procedure, in which each participant in a self-control group is paired with another participant in a yoked group. A participant in the yoked group would receive feedback, for example,
on the same trials on which his or her counterpart in the self-control group had requested feedback. The purpose of such a yoking procedure is to control for the amount and timing of feedback (or whatever factor is controlled by the learner). Because the average frequency and time of feedback delivery are identical in the self-control and yoked groups, any group differences that emerge on retention or transfer tests can be attributed to the fact that one group had control over a certain variable, whereas the other group did not.

Learning advantages for self-controlled feedback schedules have been found with various movement tasks. For example, some studies have used throwing tasks, in which feedback was provided about movement form (e.g., Janelle, Barba, Frehlich, Tennant, & Cauraugh, 1997) or the accuracy of the throws (Chviacowsky, Wulf, Laroque de Medeiros, Kaefer, & Tani, 2008). Furthermore, self-controlled concurrent feedback has been shown to enhance the learning of perceptual invariants (i.e., adjusting walking speed when walking through virtual opening and closing doors) (Huet, Camachon, Fernandes, Jacobs, & Montagne, 2009) and learning to land a virtual aircraft (Huet, Jacobs, Camachon, Goulon, & Montagne, 2009). Other researchers have found learning advantages of self-controlled feedback for timing tasks (Chen, Hendrick, & Lidor, 2002; Chviacowsky & Wulf, 2002; Patterson & Carter, 2010). Chviacowsky and Wulf (2002) asked participants to press certain keys on a numeric keypad with prescribed time intervals between key presses. On a transfer test with novel goal movement times, the self-controlled feedback group outperformed the yoked group, demonstrating that self-controlled feedback can enhance transfer to novel variations of the skill (see Figure 10.3). In addition, the learning advantages of self-controlled feedback have been shown to generalize to situations in which multiple tasks with different timing goals have to be learned (Patterson & Carter, 2010).

An interesting aspect of some studies (e.g., Chviacowsky & Wulf, 2002; Patterson & Carter, 2010) was questionnaire results which indicated that self-control learners requested feedback mainly after they thought they had had a "good" trial (and that yoked learners would have preferred to receive feedback after good trials). This finding suggests that one reason for the effectiveness of self-controlled feedback may be that it has the potential to enhance learners' feeling of competence (see above).

The percentage of practice trials on which self-control learners requested feedback varied widely between studies, ranging from 11% (Janelle et al., 1997) to 97% (Chen et al., 2002; Chviacowsky & Wulf, 2002: 35%; Chviacowsky et al., 2008: 28%). The frequency of feedback requests might depend on the nature of the task, the type of feedback provided or otherwise available to the learner, or on the exact instructions given to participants (i.e., to what extent they encourage the learner to ask for feedback). Yet, it appears that the feedback frequency is less important than the learner's opportunity to choose or not to choose feedback. Otherwise, it would be difficult to see why learning advantages for self-controlled feedback occurred when the feedback frequency was almost 100% (Chen et al., 2002). This finding suggests that learners' need for autonomy plays an important role in this context.

**Figure 10.3** Timing errors of the self-control and yoked groups during practice and transfer in the study by Chviacowsky and Wulf (2002).

**Augmented task information**

Sometimes information, or reminders, about the movement pattern to be executed are provided to the learner. This process would occur primarily in situations in which remembering the correct sequence of movement elements is challenging, for example, when learning dance routines, manual gestures of sign language, or a typographical script. Patterson and Lee (2010) used a Graffiti language-learning task that involved entering symbols into a personal digital assistant (PDA) when prompted by the English-script cue. A group, allowed to decide when they wanted to view the correct pairing of the English cue and respective symbol, as well as the viewing duration, before entering the symbol, outperformed both a yoked group and a group presented with the correct pairing before each practice trial on a recall test. That is, the "self-regulated" group recalled more symbols than the other two groups. This group also showed equivalent recall to groups (self-regulated, yoked, every-trial) that were presented the pairings after the respective practice trials, providing them with the opportunity to engage in memory retrieval practice. Thus, when the presentation of augmented task information prior to movement execution was controlled by the learner, it did not result in the typically seen detrimental effects due to strong guidance or dependency.

**Assistive devices**

Self-controlled practice advantages have also been seen when learners are given control over the use of physical assistive devices (Hartman, 2007; Wulf, Clauss, Shea, & Whitacre, 2001; Wulf & Toole, 1999). In one study, participants practiced
a ski-simulator task (Wulf & Toole, 1999). The ski-simulator consists of a pair of bowed rails and a platform on wheels attached to the end of the apparatus by rubber belts. The platform, on which the performer stands, can be made to move sideways on the rails by making slalom-type movements. The participant's task was to produce the largest possible amplitudes. The physical assistance devices used in the Wulf and Toole (1999) study were ski poles. These generally facilitate the maintenance of balance and have been shown to enhance the learning of this task (Wulf, Shea, & Whitacre, 1998). The poles were placed on the floor in front of the ski-simulator and remained in contact with the floor throughout the whole trial. Participants in the self-control group were allowed to choose on which trials they wanted to use the poles during practice. Although there were no amplitude differences between this group and a yoked control group during practice, the self-control participants showed more effective learning, as measured by performance on a retention test without the poles, than did their yoked counterparts.

In another study, Hartman (2007) used another balance task (stabilometer) and allowed one group of participants to decide on which trial they wanted to use poles as assistive devices. He found that the self-controlled use of poles again significantly enhanced the learning of this task compared with a yoked condition. This finding is particularly interesting because, in a pilot study, Hartman did not find advantages of using the poles for the learning of this task. This finding suggests that control over an assistive device can have a beneficial effect on learning, even if that device in and of itself is relatively ineffective. To our knowledge, no person has yet examined the provision of self-control over the use of a device or technique (e.g., an internal focus of attention) known to be detrimental to performance to determine the relative impact of these two conditions.

**Movement demonstrations**

Learning through observation, or modeling, is a commonly used technique when it comes to teaching motor skills (for reviews, see Maslovat, Hayes, Horn, & Hodges, 2010; McCullagh & Weiss, 2001). This includes sport settings, in which an instructor might demonstrate the goal movement to the learner. In one study, Wulf, Raupach, and Pfeiffer (2005) examined whether model presentations provided at the learners’ request would enhance learning, compared with providing them without consideration for their preferences. Participants practiced a complex motor skill (basketball jump shot) and a video of a skilled model either could be requested (self-control) or was provided at the same respective times (yoked) during the practice phase. After a 7-day retention interval, the self-control group had significantly higher form scores than the yoked group (shot accuracy did not differ between groups). Interestingly, the differential learning effects occurred despite a relatively low frequency of model presentations (5.8% of the practice trials).

The picture that emerges from self-control studies is that practice conditions that meet people’s needs for autonomy by allowing them to exert some control over the practice situation benefit learning. It should be pointed out that the benefits of self-controlled practice are not always apparent immediately. In many experimental studies, performance differences between self-control and yoked groups did not occur until retention or transfer testing at a later time. Thus, it appears that self-control and yoked conditions have different effects on practice performance versus learning (retention/transfer). As self-controlled practice presumably involves continuous assessments of one’s performance and decision-making processes regarding feedback or movement demonstrations, for example, it might make practice more “difficult,” temporarily depressing performance. Instructers (and learners) should be aware of the fact that the beneficial effects of self-controlled practice may be latent and delayed, and any lack of immediate performance enhancement should not deter them from relinquishing some control over the practice conditions to the performers.

**Social relatedness**

A performer’s basic psychological need to experience satisfaction in interactions with others (social relatedness; Deci & Ryan, 2008; Ryan & Deci, 2007) may to some extent be met through interactions with other learners, teammates, or coaches (e.g., Cox, Duncheon, & McDavid, 2009). A few researchers have shown that participants who practiced motor skills with another learner demonstrated advantages compared with those who practiced individually (e.g., Granados & Wulf, 2007; Shea, Wulf, & Whitacre, 1999). For example, in one study, a dynamic balance task was used to compare the effectiveness of dyad practice (i.e., practice in pairs) versus individual practice (Shea et al., 1999). Participants in the dyad group took turns during practice, such that one partner performed a trial while the other observed, and vice versa. In addition to the opportunity to observe the other person, participants were encouraged to give each other feedback or share certain movement strategies they might have found helpful during the rest intervals. Participants who practiced with a partner (dyad group) learned the task more effectively and were subsequently superior to participants in another group who practiced individually when tested (individually) one day later (see Figure 10.4).

Practice in dyads presumably has several advantages that contribute to its learning benefits. One of those factors is learning through observation. Research has shown that observational practice can make unique and important contributions to learning especially when observation is combined with physical practice (Shea, Wight, Wulf, & Whitacre, 2000; Shebilske, Regian, Arthur, & Jordan, 1992). Neuroimaging experiments suggest that a set of common neural structures are activated during both action production and action observation (Gallese & Goldman, 1998; Grezes & Decety, 2001; Jeannerod, 1994).

However, practicing together with another learner most likely has beneficial effects on learning that go beyond those related to observation per se. Learning benefits of dyad practice are presumably also a result of enhanced motivation, resulting perhaps from comparison with the partner, the setting of higher goals, or the loss of self-consciousness as people fulfill interdependent dyadic roles and find another in the same learning boat. It is perhaps not coincidental that participants in collaborative or cooperative learning situations often anecdotally report more enjoyment
Figure 10.4 Deviations of the balance platform from the horizontal in dyad-practice and individual-practice groups in the study by Shea, Wulf, and Whitacre (1999).

than they have experienced learning alone (Mueller, Georges, & Vaslow, 2007). It is probably also not coincidental that findings regarding the mirror neuron system continue to link action observation, movement production, and social insight (Gallese & Goldman, 1998).

In summary, practice settings that take into account learners' need for social relatedness, for example by providing them with the opportunity to interact and practice with another learner, may be particularly effective, thanks to various direct and indirect effects on the patient's motivation. Such opportunities may also increase the accrual of practice trials beyond those accomplished with the teacher's assistance.

Conclusions and future directions

The findings reviewed here provide evidence of the importance of motivational influences on motor learning, potentially suggesting that factors heretofore presumed to play task-informational roles may operate at least partially through motivational channels. Fundamental psychological needs related to perceptions of competence, autonomy, and social relatedness may govern many of these motivational effects. Just which and how many conventional "conditions of practice" in the motor learning literature may owe some or all of their impacts to motivation is one of the most interesting and potentially important lines of inquiry in future research on motor learning. Instructions and feedback that convey positive messages regarding the learner and the value of effort and practice, or portray abilities and skills as accessible, can help increase individuals' feelings of competence and optimize the conditions for motor learning. It is worth noting that both animal and human studies have found positive learning impacts with more positive reinforcement or augmented feedback (e.g., more food, money, perceptions of greater competence); negative circumstances have not reduced learning below control conditions. As criticism and negative feedback, and the concomitant efforts at self-regulation of thoughts and emotions, abound in real-life performance and instruction setting, it is important to continue to pursue the existence and nature of this possible positive advantage.

Recognizing individuals' need for autonomy and granting them some control over the practice conditions should further enhance their motivation and learning. Competence and autonomy (and social relatedness) needs and satisfying conditions operate concurrently, and supporting one could affect another, positively or negatively. That is, facilitating more athlete autonomy could be done in the context of supporting competence perceptions or deflating them. With awareness and practice, coaches and instructors can provide choices and opportunities for expressing opinions and preferences (i.e., autonomy support) that enhance competence or are within the bounds of athletes' and learners' present (perceptions of) competence level. Providing choices of practice activities or strategies well beyond or below current (perceived) competencies may support one need (autonomy) to the detriment of another (competence).

Finally, the need for social relatedness is presently understudied but it is arguably richly relevant in any sport or movement endeavor. Appreciating the dimensions of this amorphous motivational category is important. Furthermore, critical tests of whether fostering (presumably competence-affirming) interactions with other performers results in beneficial learning effects or not are warranted.

One of the challenges for practitioners in movement skill settings is to balance support of multiple motivational and task-specific informational needs at once. The work described above argues for generally stronger recognition of motivational needs within an optimal learning equation. Whether motivational needs can be effectively supported depends in part on acute recognition that it is the meaning of conditions of practice or communications within the practice setting that determines how learners and athletes will experience them. Although there are common motivational effects (e.g., positive normative feedback, self-control) to be employed in the experimental study of motivational impacts on learning, many other effects of the social environment of motor skills will be more individual in nature and based on the implications of conditions for a given learner's needs for competence, autonomy, or social relatedness or other rewarding conditions. Broader use of questionnaire assessments of subjective cognitive and affective experience, as well as physiological and neuroimaging methods (e.g., Carlson, Greenberg, Rubin, & Mujica-Parodi, 2011) for understanding experienced thoughts and emotions will support motivational inquiries in motor learning.

References


