

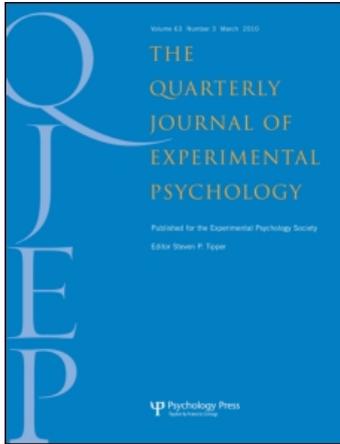
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Social-comparative feedback affects motor skill learning

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This study examined motivational effects of feedback on motor learning. Specifically, we investigated the influence of social-comparative feedback on the learning of a balance task (stabilometer). In addition to veridical feedback (error scores reflecting deviation from the target horizontal platform position) about their own performance after each trial, two groups received false normative information about the “average” score of others on that trial. Average performance scores indicated that the participant’s performance was either above (better group) or below (worse group) the average, respectively. A control group received veridical feedback about trial performance without normative feedback. Learning as a function of social-comparative feedback was determined in a retention test without feedback, performed on a third day following two days of practice. Normative feedback affected the learning of the balance task: The better group demonstrated more effective balance performance than both the worse and control groups on the retention test. Furthermore, high-frequency/low-amplitude balance adjustments, indicative of more automatic control of movement, were greater in the better than in the worse group. The control group exhibited more limited learning and less automaticity than both the better and the worse groups. The findings indicate that positive normative feedback had a facilitatory effect on motor learning.

Keywords: Knowledge of results; Balance; Motivation; Social comparison.

Augmented feedback about movement outcome or quality (knowledge of results or knowledge of performance, respectively) has long been considered one of the most important variables for motor learning (see Salmoni, Schmidt, & Walter, 1984; Schmidt, 1991; Swinnen, 1996; Wulf & Shea, 2004). Augmented feedback in the motor learning literature is assumed to have both informational and motivational functions (e.g., Schmidt & Lee, 2005; Schmidt & Wrisberg, 2008). The

informational function is regarded as providing learners with knowledge about the nature of the task to be learned and guidance for refinements needed in the movement plan and its execution. The motivational function of feedback is thought to energize task interest and encourage continued effort, persistence, and attention to goal accomplishment through evidence of performance progress. Within the motor learning literature, the informational role of feedback has garnered the

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lion's share of research attention. In contrast, motivational aspects have been relatively neglected or they have been assumed to exert generally temporary effects on performance or indirect effects on learning through support for continued practice (e.g., Schmidt & Lee, 2005).

One exception to this trend has been a line of research investigating the effects of self-controlled feedback (see Wulf, 2007b). In these studies, it has been shown that giving learners the opportunity to decide after which trials they want to receive feedback enhances learning, compared with the lack of this opportunity (i.e., yoked conditions; e.g., Chiviawsky & Wulf, 2002; Janelle, Barba, Frehlich, Tennant, & Cauraugh, 1997; Janelle, Kim, & Singer, 1995). Interestingly, postexperimental interviews showed that learners in control of their feedback schedules preferred to receive feedback after they thought they had a relatively successful trial (and indeed chose feedback more frequently after good trials), but not when their performance was relatively poor. Yoked learners echoed the preference for feedback after good trials (Chiviawsky & Wulf, 2002, 2005; Chiviawsky, Wulf, Laroque de Medeiros, & Kaefer, 2008). Chiviawsky and Wulf (2007) found that providing feedback after trials with relatively good performance (i.e., on the three best trials within a six-trial block) resulted in more effective learning than giving feedback after poor trials (i.e., on the three poorest trials; see also Chiviawsky, Wulf, Wally, & Borges, *in press*).

Other findings also point to the motivational influence of feedback on performance and, perhaps, on learning. These findings include studies on normative feedback in cognitive tasks, in which norms such as a peer group's (false) average performance scores were provided in addition to the participant's actual score (Bandura & Jourden, 1991; Johnson, Turban, Pieper, & Ng, 1996; Klein, 1997). Normative feedback, by definition, involves social comparison. Comparing one's performance and attributes (such as looks, attitudes, wealth, skills) to those of others is a ubiquitous, frequent, often necessary, and potentially diagnostic and informational

phenomenon with affective and self-evaluative consequences (e.g., Bandura & Jourden, 1991; Butler, 1992; Festinger, 1954; Klein, 1997). Self-evaluations, based on comparisons with others, have been shown to occur spontaneously, and sometimes without intention or awareness (i.e., when the comparison information is presented subliminally; Stapel & Blanton, 2004).

Motor skills and movement tasks provide unique opportunities to examine the impacts of social-comparative feedback. Though voluntary movement performance is governed by cognitive as well as neuromuscular processes, the quality and quantity of motor behaviour within goal-directed movement activity is observable and inherently available for social evaluation and influence (e.g., Triplett, 1898). Further, explicit social comparison forms the basis for competitive outcomes in many movement activities. Providing individuals with normative information, such as the "average" scores of learners on a novel motor task, can therefore be a potent basis for evaluation of personal performance. If such normative comparisons are favourable for an individual, increased self-efficacy, positive self-reactions, and task interest can result (Hutchinson, Sherman, Martinovic, & Tenenbaum, 2008; Jourden, Bandura, & Banfield, 1991; Kavussanu & Roberts, 1996). In contrast, negative outcomes of comparisons with the "norm" might be expected to lower self-efficacy, produce more negative self-reactions, and reduce motivation to practise a skill. An interesting question, therefore, is whether providing learners with normative feedback on motor tasks, in addition to veridical feedback about their own performance, affects their motor performance. An even more important question is whether those effects, if any, influence performance only temporarily, or whether they create more permanent learning effects.

Another issue of theoretical and ultimately applied significance relates to whether "positive" normative feedback would result in a performance and/or learning benefit, or whether "negative" normative feedback would have detrimental effects on these outcomes, compared with a control condition in which objective personal

performance feedback but no normative feedback was provided. Hutchinson and colleagues (2008) found increased self-efficacy, lower perceived exertion, and greater tolerance for sustained effort in continuous force production for a grip-strength task as a function of positive normative feedback than under both negative feedback and control conditions. In studies involving the cognitive task of providing judgements of the relative aesthetic merit of pairs of pictures, Klein (1997) found that false normative positive feedback produced positive motivational and task choice impacts, whereas normative negative feedback and control conditions without normative feedback did not differ from each other. Research directed at the impact of positive affect, albeit not generated through positive normative feedback, on cognitive processes has documented cognitive flexibility, creativity, and control effects (e.g., Ashby, Isen, & Turken, 1999; Dreisbach & Goschke, 2004).

To our knowledge, the influence of (positive or negative) normative feedback, relative to no normative feedback, on motor skill learning has not yet been investigated. However, given the ubiquity of social comparison in settings that involve the learning of motor skills, the answer to this question would seem important from both theoretical and practical perspectives. The purpose of the present study was therefore to examine whether providing learners with normative feedback would influence the learning of a motor skill. Specifically, we asked whether informing individuals of a (fabricated) average score of other performers, in addition to their own score, would affect learning. We hypothesized that learning would benefit if the feedback indicated to learners that their performance on a given trial was better than that of the "average" performer, relative to feedback denoting that their performance was poorer. In addition, we predicted that positive normative effect would enhance learning relative to a control condition.

Participants in the present study practised a novel balance task (stabilometer) and were given their own veridical performance scores after each trial. In addition, participants in the better and worse groups were provided with the "average"

score of others, which was in fact calculated based on the participant's own score on a given trial and consisted of a score that was either 20% above ("better" group) or 20% below ("worse" group) the participant's score. We assumed that positive feedback would have a beneficial effect on the learners' motivation and thus lead to more effective (practice and) retention performance than negative feedback or the absence of normative feedback. Specifically, we determined participants' average deviations from the horizontal position of the balance platform (root-mean square error, RMSE), which has been used as an overall measure of balance performance (e.g., Wulf, Höß, & Prinz, 1998; Wulf, McNevin, & Shea, 2001a). In addition, we conducted power spectrum (fast Fourier transform) analyses of the platform movements and computed performers' mean power frequency (MPF). MPF is an indicator of the frequency of movement adjustments and has been used as a measure of automaticity in balance-related movement tasks (e.g., McNevin, Shea, & Wulf, 2003; Wulf et al., 2001a; Wulf, Mercer, McNevin, & Guadagnoli, 2004; Wulf, Shea, & Park, 2001b). Higher frequencies of adjustments on balance tasks are presumed to be reflexive, or automatic, rather than cognitively controlled, and have been linked to more effective performance on these tasks. All participants practised the balance task on two days, with normative feedback (for better and worse groups) provided after each trial. Learning was assessed in a retention test without augmented feedback on the third day.

Method

Participants

A total of 36 undergraduate students (24 females, 12 males) with a mean age of 23.0 years (standard deviation: 2.26) participated in this experiment. Informed consent was obtained from all participants. Participants had no prior experience with the experimental task, and they were not aware of our specific purpose in the study. The study was approved by the university's institutional review board. Participants in the better and worse groups were debriefed regarding the false

nature of the normative feedback following their participation in the experiment.

Apparatus and task

The task required participants to stand on and balance on a stabilometer ("stability platform"; Model 16030L, Lafayette Instrument, Lafayette, IN) and to try to keep it in a horizontal position for as long as possible during each 90-s trial. The stabilometer consists of a 65 × 105-cm wooden platform that can sway from side to side with imperfectly balanced posture, with the maximum possible deviation of the platform to either side being 26 degrees. DataLab 2000 Software (Lafayette Instrument, Lafayette, IN 47903, USA) was used for data acquisition and analysis.

Procedure

Participants were informed that the task was to keep the platform in the horizontal position for as long as possible during each 90-s trial. They were also told that, after each trial, they would be given a score that represented their own average deviation of the platform from the horizontal, and (in the better and worse groups) the average performance score on the respective trial produced by participants in previous experiments. Each trial started with the left side of the platform on the ground. At a start signal, the participant attempted to move the platform toward the horizontal, and data collection began. No augmented performance feedback was provided during a trial, but at the end of each trial the experimenter informed the participant of his or her score (i.e., the standard deviation from the horizontal, or RMSE, provided by the DataLab 2000 Software). In addition, in the two normative feedback conditions, the experimenter (calculated and) provided the "average" score, which was 20% higher or lower than each individual's actual score, for the better or worse groups, respectively. Participants in the control condition were provided only with their own scores. All participants completed two days of practice, each consisting of seven 90-s trials with veridical (and, if applicable, normative) feedback after each trial, and a retention test on the third day, consisting of

seven trials without both veridical and normative feedback.

To assess whether, and how, the different types of feedback influenced participants' motivation, participants completed a customized questionnaire at the end of each practice day. The questionnaire asked participants to indicate how motivated they were to learn the task as well as the usefulness of and motivational impact of the feedback. In addition, the questionnaire included a manipulation check in which participants were asked about their (presumed) relative skill on the stabilometer task (see Table 1). Participants in the normative feedback conditions were asked, "Relative to other people, how skilled are you on the stabilometer/balance task?", while control participants were asked: "Relative to other people, how skilled do you think are you on the stabilometer/balance task?" For most items on the questionnaire, participants were asked to circle a number that best reflected how they felt at the present time. The numbers ranged from 1, "not at all (skilled, motivated, useful, etc.)", to 10, "very (skilled, motivated, useful, etc.)". Participants responded to a single question asking for their preference for receiving feedback regarding others' scores with a "yes" or "no" answer.

Following the collection of participants' data, participants were debriefed and were informed that in order to study or understand how positive and negative feedback affect people's performance and learning of motor skills, they had been provided with false information. The error scores that supposedly reflected a peer group's average performance had been fabricated. They were further informed that they had been randomly assigned to either a better or worse condition to examine the potential influence of positive or negative normative feedback on learning.

Data analysis

For each 90-s trial, the average deviation of the platform from the horizontal (RMSE) was calculated and used as a measure of overall balance performance. In addition, a spectral frequency analysis was conducted on the waveform created by the movement of the platform. From this

Table 1. Means of responses to motivational questions completed following each day of practice

Questions		Better		Worse		Control	
		Day 1	Day 2	Day 1	Day 2	Day 1	Day 2
Normative balance ability (manipulation check)	Relative to other people, how skilled are you on the stabilometer/balance task?	7.8 (1.40)	8.6 (0.84)	4.4 (2.12)	4.4 (2.27)	5.6 (2.35)	7.3 (1.48)
Task-related responses	How motivated were you to learn this task?	8.4 (2.50)	8.4 (2.37)	7.7 (1.95)	7.7 (2.16)	8.0 (1.13)	8.5 (1.31)
	How much did you enjoy practising this task?	8.4 (1.71)	8.2 (2.39)	6.9 (2.28)	7.4 (1.71)	7.8 (1.64)	8.2 (0.83)
	How much are you looking forward to the next session?	8.0 (2.98)	8.2 (2.39)	7.1 (2.77)	7.1 (2.69)	8.0 (1.95)	7.8 (1.76)
Feedback-related responses	Did you find the feedback (your score relative to other people's average score) useful?	8.3 (2.50)	9.2 (1.87)	7.6 (3.13)	7.1 (2.64)		
	Did you find the feedback (your score relative to other people's average score) motivating?	8.9 (2.47)	8.7 (2.79)	7.4 (3.20)	7.3 (2.79)		
	Would you have preferred not to receive feedback?	Yes: 0 No: 10	Yes: 0 No: 10	Yes: 1 No: 9	Yes: 3 No: 7		

Note: Responses for each question could range from 1 = "not at all" to 10 = "very". Standard deviations in parentheses.

analysis, the mean power frequency (MPF) was computed. RMSE and MPF were analysed in separate 3 (groups: better, worse, control) \times 2 (days) \times 7 (trials) analyses of variance (ANOVAs) with repeated measures on the last factor for the practice phase, and in separate 3 (groups: better, worse, control) \times 7 (trials) repeated measures ANOVAs for the retention test. Questionnaire responses were analysed with separate one-way ANOVAs.

Results

Balance

RMSE. All groups reduced their deviations from the horizontal across both days of practice (see Figure 1, left and centre panels). The better group demonstrated smaller RMSEs overall than the worse and control groups. The main effects of day, $F(1, 22) = 274.11, p < .001, \eta^2 = .89$, trial, $F(6, 198) = 121.72, p < .001, \eta^2 = .79$, and group $F(2, 33) = 6.68, p < .01, \eta^2 = .35$, were significant. The interaction of days and trials was also significant, $F(6, 198) = 17.23, p < .001, \eta^2 = .34$, indicating generally greater performance gains

on the first than on the second day of practice. Furthermore, the improvements during practice—particularly during Day 1—were greater for the better group than for the two other groups. The Group \times Trial, $F(12, 198) = 2.09, p < .05, \eta^2 = .11$, and the Group \times Day \times Trial interaction, $F(12, 198) = 3.46, p < .01, \eta^2 = .17$, were significant. None of the other interaction effects were significant.

On the retention test without feedback, all groups continued to reduce their deviations from the horizontal (see Figure 1, right panel). The better group again had consistently lower RMSEs than the worse and control groups. The main effects of both trial, $F(6, 198) = 11.58, p < .001, \eta^2 = .26$, and group, $F(1, 33) = 7.41, p < .01, \eta^2 = .31$, were significant. Post hoc tests yielded significant differences between the better and both of the other two groups ($ps < .05$), while there was no significant difference between the worse and control groups ($p > .05$). The Group \times Trial interaction was not significant, $F(6, 198) = 1.11, p > .05$. Thus, the normative feedback provided during the practice phase had

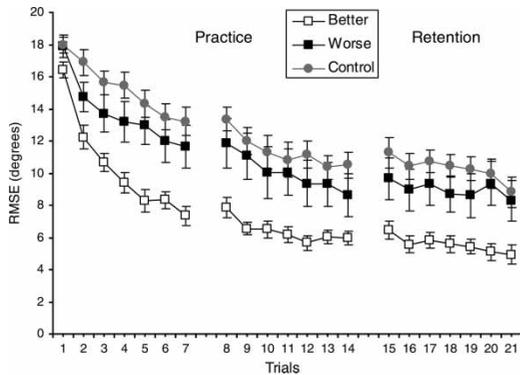


Figure 1. Balance performance (root mean square error, RMSE) of the better, worse, and control groups during practice and retention phases.

effects on learning, as demonstrated by performance when feedback was withdrawn.

MPF. Mean power frequencies of platform movements increased across the two days of practice, indicating a generally greater degree of automaticity in performance as a function of practice (see Figure 2, left and middle). The better group had the highest MPF values, while the control group showed intermediate MPF values on both days. The main effects of both day, $F(1, 33) = 6.71$, $p < .01$, $\eta^2 = .17$, and group, $F(2, 33) = 11.73$, $p < .001$, $\eta^2 = .42$, were significant. Post hoc tests indicated that all groups differed significantly from each other, $ps < .05$. There was no Group \times Day interaction, $F(1, 33) = 2.09$, $p > .05$.

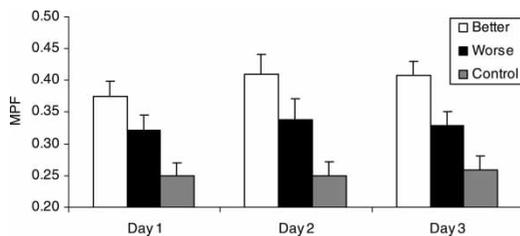


Figure 2. Mean power frequencies (MPF) of platform adjustments of the better, worse, and control groups during practice and retention phases (averaged across 7 trials per day).

On the retention test, the better group again demonstrated the highest frequency responses ($M = 0.41$, $SE = 0.022$), and the worse group ($M = 0.33$, $SE = 0.022$) had higher MPFs than the control group ($M = 0.26$, $SE = 0.021$; see Figure 2, right). The main effect of group was significant, $F(2, 33) = 11.47$, $p < .001$, $\eta^2 = .41$. Post hoc tests confirmed that the differences among all three groups were significant, $ps < .05$.

Motivation

The questionnaire results are shown in Table 1 (questionnaire data were not completed by 4 of the 36 participants, 2 in each of the better and worse groups). The manipulation check of perceived normative ability indicated that the experimental provision of normative feedback was effective: Better group participants believed they were more skilled on this balance task than most people, while the worse group participants assumed the opposite. The control group participants' ratings were intermediate between those of the better and worse groups. The main effect of group on perceived normative skill was significant, with $F(1, 29) = 12.64$, $p < .001$, $\eta^2 = .47$. Post hoc tests indicated that all groups differed significantly from each other ($ps < .05$), with the better group participants rating their skill higher than worse and control participants, and the control group showing higher ratings than the worse group. There was also a significant main effect of day, $F(1, 29) = 10.33$, $p < .01$, $\eta^2 = .26$, and a Group \times Day interaction, $F(2, 29) = 3.67$, $p < .05$, $\eta^2 = .20$. Simple main effect analyses indicated that both the better and control groups rated their relative skill level higher on the second day than on the first day of practice ($ps < .05$), whereas the ratings of the worse group participants remained at the same level.

The task-related questions pertaining to motivation to learn, enjoyment of practising, and how much they were looking forward to the next session did not yield significant main or interaction effects, although the better group tended to have higher ratings on all items than the worse group (with the control group ratings being relatively similar to those of the better group). Group

membership also affected the perceived value of the provided normative feedback. (As no normative feedback was provided in the control group, the feedback-related questions were not included in that group's questionnaire.) There was a significant interaction between group and day, $F(1, 18) = 6.95$, $p < .05$, $\eta^2 = .28$, for the perceived usefulness of normative feedback. This interaction effect indicated that, while the better group's ratings of feedback usefulness increased from Day 1 (8.3) to Day 2 (9.2), the worse group's rating decreased from the first (7.6) to the second day (7.1). Better group participants, more than worse group participants, endorsed the notion that feedback was experienced as motivating, but this effect did not reach significance, $F(1, 18) = 1.35$, $p > .05$. This pattern of results is consistent with participants' preferences for feedback provision; all better group participants preferred to receive feedback, while among the worse group Respondents 1 (Day 1) or 3 (Day 2) would have opted not to receive normative feedback information.

Discussion

While the effects of normative or social comparison feedback have been examined in previous studies relative to motivational processes and performance (e.g., Bandura & Jourden, 1991; Hutchinson et al., 2008; Ilies & Judge, 2005; Johnson et al., 1996), to our knowledge, the present study was the first to examine normative feedback effects in motor skill learning. It is important to point out that all participants were given veridical feedback—that is, feedback about their actual performance after each trial. Aside from the control group, the only difference between the two normative feedback groups was that participants in one group (better) were led to believe that their performance was superior to that of most people, whereas those in the other group (worse) believed that their performance was below average. The conviction that one's performance was better than average was associated with more effective skill learning than the belief that one's performance was below average.

Importantly, positive normative feedback also enhanced learning compared with no normative feedback (control condition), which resulted in similar levels of learning as the negative normative feedback condition.

The effects of the normative feedback on performance were fast acting and almost immediate. Throughout the practice phase, the better group demonstrated more effective balance (i.e., smaller deviations of the balance platform from the horizontal) than the two other groups. Thus, the mere conviction of being “good” or “poor” at this particular task influenced performance—essentially resulting in a self-fulfilling prophecy. Importantly, the performance advantages of the better group were still seen when feedback was withdrawn in retention: The better group continued to outperform both the worse and the control groups on the delayed retention test, suggesting that normative feedback indeed led to different degrees of skill learning. The group differences in mean power frequencies of platform movement suggest that the normative feedback produced qualitative differences in participants' control of movements as well: The better group evidenced higher MPFs in retention, indicative of more automatic movement adjustments, than did worse group participants. This movement control effect may be a functional equivalent of the quality of the analytical thinking differences demonstrated in Bandura and Jourden's (1991) study on complex managerial decision making. In that study, participants who were provided with social-comparative feedback indicating that they were performing well demonstrated more efficient analytical thinking, compared with participants who experienced feedback reflecting normative decline in performance.

The present study extends previous research on motivational influences on achievement outcomes—demonstrating effects on motor skill learning. Other work has examined performance or achievement behaviour as a function of motivational factors or mediators such as effort, persistence, intrinsic motivation, self-efficacy, goal setting, affective responses, cognitive flexibility, and the quality of analytic thinking (Bandura &

Jourden, 1991; Dreisbach & Groschke, 2004; Hutchinson et al., 2008; Ilies & Judge, 2005; Johnson et al., 1996; Jourden et al., 1991; Kavussanu & Roberts, 1996), but has not experimentally examined, nor therefore shown, a facilitatory or detrimental impact on the extent or quality of motor learning *per se*.

Of course, an interesting question concerns the mechanism by which normative feedback affects learning. The case can be made from the present study and others (Bandura & Jourden, 1991; Ilies & Judge, 2005; Muller & Butera, 2007) that the “positive” or “negative” nature of the feedback generates self- and/or task-related cognitive and affective consequences, which, in turn, affect performance and/or learning. For example, studies examining self-controlled feedback have shown that learners prefer to receive feedback, and choose feedback, more frequently after relatively successful trials than after unsuccessful trials (Chiviawosky & Wulf, 2002; Chiviawosky et al., 2008). In fact, feedback after “good” trials has been demonstrated to enhance learning compared to feedback after “poor” trials (Chiviawosky & Wulf, 2007). In the present study, there were also indications that participants preferred feedback when it indicated that their performance was better than average, compared with feedback that noted below-average performance. Especially on the second day of practice, participants in the better group rated the “usefulness” of the normative feedback higher (9.2) than did participants in the worse group (7.1). In addition, no participant in the better group indicated that they would have preferred not to receive feedback, while at least some participants in the worse group felt this way. The findings of the present study and others suggest that participants respond not only to the task-relevant information in augmented feedback but factor in their psychological or motivational needs as learners to receive feedback of performance progress or prowess (Deci & Ryan, 1990, 2000).

It should be noted that our study is not the first to find equivalently inferior performance and learning for “worse” and control groups relative to normatively “better” groups (Hutchinson et al., 2008; Klein, 1997). Interestingly, however,

the movement frequency (MPF) data indicated that even participants who received normatively poor feedback were more automatic in their movement control than participants in the control group. This suggests that there may be counterbalancing effects operating. While negative normative feedback presumably had a number of effects (see below) that interfered with optimal motor control, normative feedback in general (i.e., in both the better and the worse groups) may have energized effort, attention, and goal setting, especially early in the acquisition period. Thus, in the worse condition negative factors were counterbalanced by positive influences, resulting in a learning advantage relative to the control condition, which had no added incentive to improve.

Normative performance success and failure may influence both the cognitive perception of personal capability (i.e., self-efficacy expectations, perceived competence, or perceived normative ability) and the associated cognitive activity (e.g., goal setting; Ilies & Judge, 2005; Williams, Donovan, & Dodge, 2000), as well as positive or negative affect experienced for the self (e.g., Bandura, 1990, 1997; Bandura & Jourden, 1991) or the task with which one has engaged (Conroy, Elliott, & Coatsworth, 2007; Deci & Ryan, 1985). How these variables, in turn, affect performance and learning is an unsettled question with multiple candidate mechanisms and, to date, distinct lines of evidence. Self-efficacy expectations can be affected by normative feedback (Hutchinson et al., 2008; Johnson et al., 1996) and affect the subsequent level of goals set by individuals, effort, and attention to task performance, as well as self-satisfaction or self-dissatisfaction with performance (Bandura, 1990, 1997; Bandura & Jourden, 1991; Hutchinson et al., 2008). Positive affect and negative affect also have been linked to upward and downward goal revisions, respectively (Aarts, Custers, & Holland, 2007; Chartrand & Bargh, 2002; Ilies & Judge, 2005; Stapel & Blanton, 2004), and task-related positive affect to less broad attentional focus (Gable & Harmon-Jones, 2008). Further, neuroscientific evidence links motivational manipulations to modulation of motor learning (Kühn et al., 2008). Positive affect

is linked to the dopamine processing that supports sequence learning (Siessmeier et al., 2006). Negative affect may heighten the need for reallocation of attentional resources to active self-regulatory efforts at thought or affect suppression or substitution (Carver & Scheier, 1978; Schmader, Johns, & Forbes, 2008). Negative affect may also dampen, or interfere with, memory processing (Kuhlmann, Piel, & Wolf, 2005). In this study, we assessed perceived normative ability and task- and feedback-related affect, but not self-efficacy or self-related affect. A reasonable case can be made for the likelihood that self-efficacy was affected by the normative feedback or perceptions of normative ability (e.g., Bandura & Jourden, 1991; Hutchinson et al., 2008; Kavussanu & Roberts, 1996), although we cannot directly address this linkage, nor the relationship of self-efficacy and self-related affect to other downstream neural, cognitive, and behavioural events or processes. These issues need to be examined in future studies.

Participants in our study who believed that their performance was below average may also have adopted a more self-related focus of attention (Wulf & Lewthwaite, in press-b). Concerns about performance have been known to increase conscious effort to control actions in attempts to improve performance (e.g., Baumeister, 1984). The MPF values displayed by participants in the present study suggest that normative feedback may have affected attentional focus (Wulf, 2007a) or other mediators of conscious control and in turn the learning of the balance task. Higher MPFs indicate a higher frequency of movement adjustments, based on reflex-type, automatic control processes, whereas lower MPF values reflect slower and more conscious corrective processes. Knowing that one's performance was above average may have alleviated individuals' performance-related concerns and reduced their active intervention into control processes, thereby allowing automatic processes to govern their balance more effectively. In contrast, the greater self-directed focus presumably induced by the knowledge that one's performance was below average (Schmader et al., 2008) may have constrained the motor system in such a way that the

effectiveness of the system to maintain a relatively stable posture was compromised. As a result, learning was degraded in the worse condition relative to the better condition. Certainly, relationships between motivational and (particularly self-related) variables and motor control are not without precedent (e.g., Gray, 2004; Pijpers, Oudejans, & Bakker, 2005; Slobounov, Yukelson, & O'Brien, 1997; Williams, Vickers, & Rodrigues, 2002). However, to our knowledge, a disruption or facilitation in the learning of more optimal (automatic) movement control has not been shown.

The findings of this and other studies demonstrate that motivational variables affect not only transient motor performance but motor learning as well. Recognition that the process of learning, including motor learning, calls for the effective juggling of self- and task-related thoughts and emotions to maintain energy, effort, motor control, and optimal attention is an important insight for traditional (information processing) motor learning and social-cognitive researchers alike. The task of motor learning is thus not merely the acquisition of a specific movement pattern, but encompasses the self-regulation of cognitive processes, affective reactions, and attentional focus to meet task demands. This may be especially true in the natural and almost inevitably social context of movement (including the laboratory) tasks in which implicit (e.g., Aarts et al., 2007; Chartrand & Bargh, 2002; Stapel & Blanton, 2004) as well as explicit forms of social comparative information are abundant.

Learning about effective self-regulation is expected to be somewhat generalizable across diverse cognitive and motor tasks, but important differences in self-regulatory strategies and interventions to enhance them (e.g., Orlick, 2008; Corrêa, de Souza, & Santos, 2006) may be found, depending upon individual differences as well as the force, accuracy, duration, cognitive, and other demands of motor tasks. Further, the effects of motivational variables on motor learning are probably not limited to normative feedback; other social-cognitive influences on motor learning are expected (e.g., Jourden et al., 1991; Wulf & Lewthwaite, in press-a). Clearly, the interface of

motivational and informational concerns in learning requires additional attention both theoretically and practically.

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