The self: Your own worst enemy? A test of the self-invoking trigger hypothesis

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The self-invoking trigger hypothesis was proposed by Wulf and Lewthwaite [Wulf, G., & Lewthwaite, R. (2010). Effortless motor learning? An external focus of attention enhances movement effectiveness and efficiency. In B. Bruya (Ed.), *Effortless attention: A new perspective in attention and action* (pp. 75–101). Cambridge, MA: MIT Press] as a mechanism underlying the robust effect of attentional focus on motor learning and performance. One component of this hypothesis, relevant beyond the attentional focus effect, suggests that causing individuals to access their self-schema will negatively impact their learning and performance of a motor skill. The purpose of the present two studies was to provide an initial test of the performance and learning aspects of the self-invoking trigger hypothesis by asking participants in one group to think about themselves between trial blocks—presumably activating their self-schema—to compare their performance and learning to that of a control group. In Experiment 1, participants performed 2 blocks of 10 trials on a throwing task. In one condition, participants were asked between blocks to think about their past throwing experience. While a control group maintained their performance across blocks, the self group's performance was degraded on the second block. In Experiment 2, participants were asked to practice a wiffleball hitting task on two separate days. Participants returned on a third day to perform retention and transfer tests without the self-activating manipulation. Results indicated that the self group learned the hitting task less effectively than the control group. The findings reported here provide initial support for the self-invoking trigger hypothesis.

Keywords: Motor learning; Focus of attention; Self-schema; Motor performance.

Wulf and Lewthwaite (2010) proposed a novel hypothesis that may unite diverse motor learning findings under a common framework. They suggested that conscious control of movements and competition for cognitive resources, two processes known to interfere with optimal skill acquisition (Masters & Maxwell, 2008; McMahon & Masters, 2002), may be caused by the mere activation of a learner's self-schema. The self-schema is a network of thoughts, ideas, definitions, and emotions that organize and constitute much of daily existence for most people (Bargh, 1982; Markus, 1977; Strauman & Higgins, 1993). More than a philosophical construct, the self-schema is a functional neural network located anatomically in cortical midline brain structures (Gusnard, Akbudak, Shulman, & Raichle, 2001; Northoff & Bermpohl, 2004; Northoff et al., 2006). In the

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perspective espoused by Wulf and Lewthwaite, environmental or internal cues that cause self-schema activation (hereafter: self-activation) are referred to as "self-invoking triggers". In movement performance contexts, self-invoking triggers may be present in coaching instructions (e.g., internal focus instructions), augmented feedback (e.g., exposure to performance errors), contextual cues (e.g., presence of others or a video camera), stereotype threats (e.g., race, age, or gender-relevant stereotypes about a skill), performance perspectives (e.g., an entity-based conception of ability), and perceptions of ability (e.g., low self-efficacy). Given the myriad potential self-invoking triggers in typical practice environments and the ubiquitous nature of the self-schema in general (Leary, 2004), the self-invoking trigger hypothesis could explain one mechanism responsible for a portion of the effects observed across many motor learning studies.

Perhaps the most obvious forms of self-invoking triggers in motor learning contexts are coaching or teaching instructions and, in particular, instructions that direct learners' attention to themselves. In over a decade and a half of research, numerous studies have examined the performance and learning effects of verbal instructions directing attention toward and away from learners' bodies (for a review, see Wulf, 2013). Consistently, internal focus instructions (focus on the body parts involved in a movement) result in less effective skill learning and performance relative to external focus instructions (focus on the effect of a movement). To explain the effects of focus of attention, Wulf and others (Wulf, McNevin, & Shea, 2001) have proposed the constrained action hypothesis. According to this view, an internal focus of attention constrains the motor system, interfering with efficient, automatic movement. In this perspective, one of the benefits of an external focus is that it prevents the learner from adopting an internal focus.

Evidence for greater movement automaticity with an external focus comes from various findings. These include reduced probe reaction times (Wulf et al., 2001), high-frequency movement corrections suggesting reflexive adjustments (e.g., McNevin, Shea, & Wulf, 2003), increased functional variability (Lohse, Jones, Healy, & Sherwood, 2013),

reduced costs of cognitive (dual) tasks, and greater movement fluidity (Kal, van der Kamp, & Houdijk, 2013). In addition, an external focus has been shown to result in reduced electromyographic (EMG) activity coupled with more effective movement outcomes relative to an internal focus (e.g., Lohse, Sherwood, & Healy, 2010; Vance, Wulf, Töllner, McNevin, & Mercer, 2004; Zachry, Wulf, Mercer, & Bezodis, 2005). Greater EMG activity and inferior performance with an internal focus probably reflect less efficient muscle recruitment and coordination.

While there is converging evidence that an internal focus interferes with motor learning and performance, the self-invoking trigger hypothesis suggests that internal focus instructions referencing the performer's body parts activate the self-schema, which in turn causes the interference. In a number of the attentional focus studies, instructions to internal and external focus groups differ only in a word or two, yet produce differential performance and learning effects (Wulf & Lewthwaite, 2010). For example, participants in internal focus conditions are instructed to focus on "your arms" while those in external focus conditions are instructed to focus on "the club" in a golf swing (e.g., Wulf, Lauterbach, & Toole, 1999; Wulf & Su, 2007). If an external focus of attention is advantageous in part because it prevents self-activation by creating greater "distance" from the self, external foci located farther from the self or body should be more effective than external foci in close proximity to one's body. Studies suggest that may indeed be the case. In one study (McNevin et al., 2003) that involved learning to balance on a platform (stabilometer), participants were asked to concentrate on keeping sets of markers that were attached to the platform horizontal. Learners who were instructed to focus their attention on markers that were farther away from their feet demonstrated more effective learning than those focusing on markers closer to their feet, or on the feet themselves. Since that initial study, the "distance effect" has received additional empirical support. An increased distance of the external focus from the self (body) has been found to result in more effective performance of skills such

as hitting golf balls (Bell & Hardy, 2009), throwing darts (McKay & Wulf, 2012), kayaking (Banks, 2014), and long jumping (Porter, Anton, Wikoff, & Ostrowski, 2013; Porter, Anton, & Wu, 2012). Thus, consistent with the self-invoking trigger hypothesis, physical or psychological distance from the body or self-schema may be a key factor responsible for the external focus benefit.

Presumably, not only is an internal focus the result of specific instructions to focus on body movements, but it may also be promoted by situations that are somehow threatening—be it due to the presence of an audience, evaluation of purported inherent abilities, or fear of confirming a stereotype. Those types of movement performance situations are likely to direct attention to the self, with subsequent attempts at self-regulation. Self-regulatory processes in turn may tax attentional capacity, precipitate conscious control attempts, disrupt automaticity, and promote inefficient muscular activation that result in "microchoking" episodes (Wulf & Lewthwaite, 2010).

While it is plausible that an internal focus of attention causes self-schema activation, it remains unknown whether self-activation alone is detrimental to motor learning and performance. One challenge to testing this question is the inherent difficulty of measuring self-activation directly. We employed a manipulation that did not instruct an internal attentional focus (i.e., reference body parts) but nevertheless seems likely to generate self-activation. Our reasoning supposes that if self-activation is responsible for the typical effects of internal focus instructions, similar effects should be observed when self-activation is encouraged even if an internal focus per se is not. The purpose of the present experiments was to examine the effect of an assumed self-activation manipulation on motor learning and performance. In Experiment 1, we investigated possible immediate effects of assumed self-activation on performance. Participants were asked to perform two blocks of a throwing task with either self-reflecting or control instructions between the two blocks. In Experiment 2, we examined the possible effect of assumed self-activation on learning by asking participants to learn a novel motor task. It was

predicted that participants who engaged in a self-reflecting task during practice would show learning decrements, as measured by delayed retention and transfer tests, relative to a control group. Also, we used a different task to examine the generalizability of the effect, if any.

EXPERIMENT 1

The purpose of the first experiment was to provide an initial and partial test of the self-invoking trigger hypothesis pertaining to the (inverse) self-activation-performance/learning relationship. For this purpose, we asked participants to perform two blocks of a throwing task with their dominant throwing hand, between which we employed a simple and short self-reflection manipulation with one group (self) and no manipulation with another group (control). In line with the self-invoking trigger hypothesis, throwing accuracy following the manipulation was predicted to be degraded relative to the control group.

Method

Participants
Thirty-six graduate and undergraduate students (26 men, 10 women) participated in this experiment. All participants gave their informed consent. The experiment was approved by the university's institutional review board.

Apparatus and task
The experiment was conducted in a standard-sized (40′ long × 20′ wide × 20′ high) indoor racquetball court. Participants were asked to throw racquetballs overhand at a target that was hung in a net (2.1 × 2.1 × 1.4 m; Atec Catch Net; Sparks, Nevada, USA). The distance from which participants threw was 5.8 m. The target consisted of eight concentric circles, and the centre of the bull's eye was 1 m above the ground. The centre circle had a diameter of 7.5 cm, and each successive circle had a radius that was 7.5 cm larger than its smaller neighbour. The largest circle had a diameter of 60 cm. Eight points were given for hitting the

centre circle, 7 points for hitting the 15-cm circle, and so forth. One point was awarded for the 60-cm circle, and 0 points for complete misses of the target.

Procedure
Participants were randomly assigned to the self (12 males, 6 females) or control (14 males, 4 females) groups. Both groups first completed a pretest of 10 trials. All participants were provided a 1-minute break between the pretest and 10-trial posttest, but during this time the experimenter also asked participants in the self group to think about their previous throwing experience including their strengths and weaknesses as a thrower. The experimenter then collected the balls, and participants performed the posttest.

Data analysis
Accuracy scores were averaged across all 10 trials in both pretest and posttest. The data were analysed in a one-way analysis of covariance (ANCOVA) with pretest included as a covariate.

Results
Self ($M = 45.9$, $SD = 11.0$) and control ($M = 44.9$, $SD = 13.1$) groups had similar accuracy scores on the pretest (see Figure 1). On the posttest, the control group ($M = 45.8$, $SD = 11.8$) maintained a similar level of performance, while the self group experienced a decrement in performance
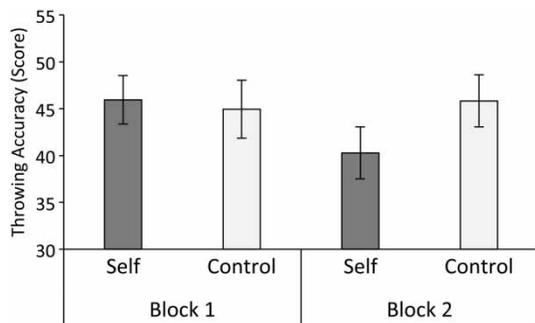

Figure 1. *Mean throwing accuracy scores. Error bars represent standard error.*

($M = 40.3$, $SD = 11.7$). After controlling for pretest performance, the main effect of group was significant, $F(1, 33) = 4.55$, $p = .04$, $\eta_p^2 = .12$. The covariate, pretest performance, was significantly related to posttest performance, $F(1, 33) = 29.09$, $p < .001$, $\eta_p^2 = .47$.

Discussion
A simple manipulation designed to activate the self-schema—asking performers about their task-related experience—was sufficient to degrade performance. While the control group performed similarly in both halves of the experiment, the self group performed significantly less accurately after exposure to the self-reflective manipulation. These results are in line with the self-invoking trigger hypothesis, according to which self-activation would be expected to interfere with the immediate performance of a skill. We intentionally kept the manipulation simple and straightforward to examine whether a single reference to the self, as opposed to none, would be sufficient to cause a performance decrement. Yet, based on the present experiment, we cannot entirely exclude the possibility that any interpolated task, and not the self-directed attention per se, would have resulted in degraded performance.

The purpose of the second experiment therefore was to expand on Experiment 1 in two ways. First, we used a control condition that included other (writing) tasks between blocks of trials, while the self group was given tasks that were designed to activate the self. Second, we wanted to examine the effect of self-reflection on the learning of a novel skill (i.e., wiffleball hitting).

EXPERIMENT 2

The self-activation-performance/learning effect of the self-invoking trigger hypothesis was examined for novel task learning (i.e., hitting wiffleballs) in the second experiment. Throughout the practice phase (i.e., 4 times on each of 2 days), participants in one group (self) were given a writing task that was designed to activate the self-system (Zhu

et al., 2013). In an effort to prevent the control group from drifting into self-activation during the interblock interval, a neutral writing task was assigned at the same time points as the self-reflective task. Temporary performance effects associated with the manipulation were evaluated during the practice phase, while relatively permanent learning effects were compared on retention and transfer tests on a third day.

Method

Participants

Thirty-seven undergraduate students (19 men, 18 women) with a mean age of 22.5 years ($SD = 1.5$) and an average of 8 years previous baseball or softball experience ($SD = 5.9$) participated in this experiment. Participants had not played organized baseball or softball for at least one year prior to participation in the experiment. The participants were assigned to groups based on gender and years of experience. All participants gave their informed consent. The experiment was approved by the university's institutional review board.

Apparatus and task

The hitting task required participants to hit golf ball-sized wiffleballs with a bat that was 32 inches in length and 1 inch in diameter (HitMaster GroBat, Sports Products Consultants, San Diego, CA). The balls were pitched by a Personal Pitcher pitching machine (Sports Products Consultants, San Diego, CA) on the 25 miles-per-hour setting. Hitting performance was measured based on where each ball was hit. The experiment was conducted in a racquetball court modified with visible markings into scoring zones observable by the participant (see Figure 2). Each hit was given a score from 0 (swung but failed to make contact) to 5 (well hit) depending on which zone the ball hit first. Pitches swung at and missed received a score of 0. Pitches that were hit outside the scoring zones received a 1. Forward-moving hits that struck the floor within 20 feet of the participant received a 2. Forward-moving hits that landed past the initial 20-foot zone but did not reach the far wall (35 feet from the hitter) in
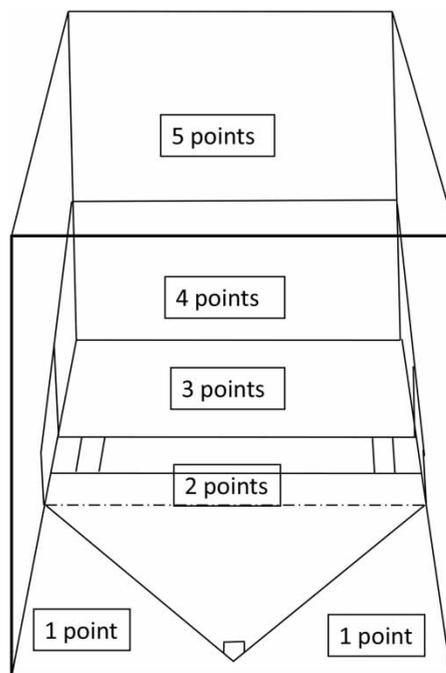

Figure 2. *Racquetball court divided into zones for scoring.*

the air received a 3. Forward hits that contacted the far wall below a line 10 feet from the ground received a score of 4. Hits that struck the far wall above the 10-foot line received a 5.

Procedure

Participants were quasirandomly assigned to the self or control groups, stratified by gender and years of experience. The self (10 males, 9 females) and control (9 males, 9 females) groups did not differ on years of experience (self: $M = 7.9$, $SD = 5.7$; control: $M = 8.1$, $SD = 6.0$). Participants were given 7 days to complete the entire three-session experiment, and the groups did not differ on days between sessions (self: $M = 1.6$, $SD = 0.7$; control: $M = 1.5$, $SD = 0.6$). The practice phase consisted of two sessions on separate days. All participants completed 50 swings per day. They were instructed that they did not have to swing at every pitch, and 10 swings—not pitches—constituted one block of practice. During breaks of approximately 2 min between five blocks of 10 trials,

participants in the self group were asked to write continuously for 1 minute about (a) their experience with baseball or softball (between Blocks 1 and 2), (b) their personal attributes as an athlete (between Blocks 2 and 3), (c) their emotional experiences related to baseball or softball (between Blocks 3 and 4), and (d) their strengths and weaknesses as a hitter (between Blocks 4 and 5). Subsequent to each period of writing, the experimenter visibly read what the self group participants wrote in an effort to increase the assumed self-activating effect of the manipulation. Control group participants wrote for the same length of time and were given the task of grouping as many as possible of the multiple objects present in the laboratory by (a) size (i.e., from the largest to the smallest), (b) alphabetically (i.e., starting with the letter A), (c) colour (i.e., first blue, then red, black, and yellow objects), and (d) shape (i.e., items with straight edges first, then curved, and irregularly shaped items). On a third day, retention and transfer tests were conducted with no writing task between trial blocks. The retention test consisted of 50 swings with 2-minute rest periods after every 10 swings. The transfer task consisted of 20 swings at balls travelling at a new and higher speed of 35 miles per hour with a break after 10 swings.

Data analysis

Practice data were analysed in a 2 (group) × 9 (trial block) ANCOVA with repeated measures on the second factor and initial performance (Practice Block 1) included as a covariate. Retention data were analysed in a 2 (group) × 5 (trial block) ANCOVA with repeated measures on the second factor and initial performance included as a covariate. Transfer data were analysed in a 2 (group) × 2 (trial block) ANCOVA with repeated measures on the second factor and initial performance included as a covariate. Outliers were removed if their standardized residual was greater than $Z = 3.00$ for any of the analyses.

Results

Outliers and assumptions

Upon fitting the ANCOVA model on retention data, one outlier was identified ($Z = 3.45$) and removed. All subsequent analyses are reported without the outlier. Assumptions of normality, homogeneity of variance, sphericity, and parallel slopes were met for each analysis following removal of the outlier.

Practice

The self group ($M = 14.61$, $SD = 6.0$) performed less effectively on average during practice than the control group ($M = 15.8$, $SD = 6.5$; see Figure 3). After controlling for initial performance, the main effect of practice block was not significant, $F_{(8, 264)} = 0.862$, $p = .549$, $\eta_p^2 = .03$. The main effect of group was significant, $F_{(1, 33)} = 6.85$, $p = .013$, $\eta_p^2 = .17$. The Group × Trial Block interaction was not significant, $F_{(1, 33)} = 0.944$, $p > .05$. The covariate, initial performance, was significantly related to practice performance, $F_{(1, 33)} = 33.39$, $p < .001$, $\eta_p^2 = .50$.[1]

Retention and transfer

On a retention test with no writing manipulation, the control group ($M = 18.8$, $SD = 6.3$) again performed more effectively than the self group ($M = 14.5$, $SD = 5.4$). After controlling for initial performance, the main effect of group was significant, $F_{(1, 33)} = 18.81$, $p < .001$, $\eta_p^2 = .36$. The main effect of trial block, $F_{(4, 132)} < 1$, and the Group × Trial Block interaction, $F_{(4, 132)} = 1.5$, $p > .05$, were not significant. The covariate was significantly related to retention performance, $F_{(1, 33)} = 24.65$, $p < .001$, $\eta_p^2 = .43$.

On the transfer test, which required participants to hit balls pitched at a faster than practised velocity, the control group ($M = 17.1$, $SD = 6.9$) again performed more effectively than the self group ($M = 13.4$, $SD = 7.8$). After controlling for initial performance, the main effect of group was significant, $F_{(1, 33)} = 8.02$, $p = .008$, $\eta_p^2 = .20$,

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[1] While the effect of practice block was not significant, participants did improve significantly from pretest to the first retention block, $F_{(1, 35)} = 4.90$, $p = .033$. Thus, participants demonstrated improvement on the novel task as a function of practice.
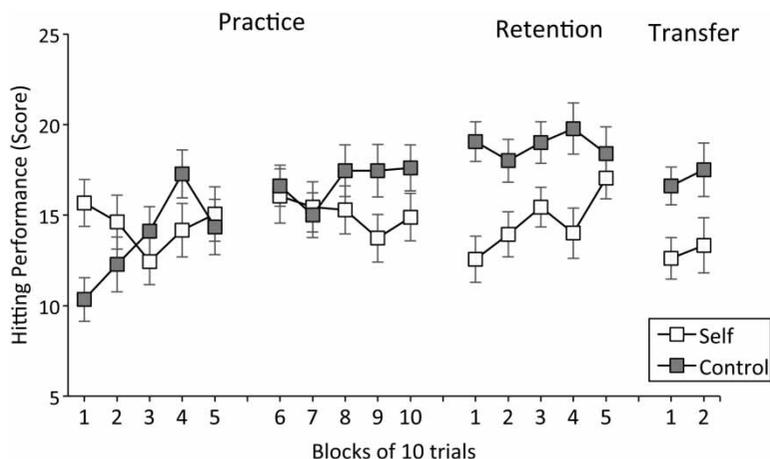
Figure 3. *Mean hitting performance during practice on Days 1 and 2, and retention and transfer on Day 3. Error bars represent standard errors.*

while the main effect of trial block, $F(1, 33) = 1.60$, $p = .216$, and the Trial Block × Group interaction, $F(1, 33) = 1.32$, $p = .126$, were not significant. The covariate was significantly related to transfer performance, $F(1, 33) = 13.59$, $p = .001$, $\eta_p^2 = .292$.

Discussion

Consistent with the self-invoking trigger hypothesis, the self-reflective manipulation caused the self group to hit less effectively than the control group during practice. Importantly, the retention and transfer tests revealed that asking performers to think about their previous hitting experience degraded their learning of this novel task. These results might be somewhat surprising. One could have reasonably predicted that the self group would perform more effectively than a control group. As one participant commented, reminding someone of their "glory days" could have boosted confidence or activated forgotten movement patterns. Instead, the ostensibly innocuous activity of contemplating one's own experiences, emotions, strengths, weakness, and attributes might have activated a lurking neural self-network that interfered with the process of motor learning. Thus, the results of this experiment are consistent with the hypothesized inverse relationship between "mere self-activation" and motor learning and performance. Nevertheless, given that the tasks the self and control groups were asked to perform differed in more than one respect, more similar tasks (i.e., thinking about one's own versus somebody else's strengths and weaknesses) could be used in future studies as an even stronger test of the self-invoking trigger assumption.

GENERAL DISCUSSION

The present experiments provide initial support for one aspect of the self-invoking trigger hypothesis—namely that self-activation impairs motor performance and learning. In Experiment 1, it was observed that asking learners to think about their previous experience with the task at hand had a detrimental effect on their subsequent performance. Since it was unclear whether participants were thinking of their performance in the previous block, of potential movement pattern adjustments, or of their experience with throwing in general, Experiment 2 built on the first experiment by engaging participants with specific questions to answer from their personal history (self) or nonpersonal present environment (control). Further, Experiment 2

employed retention and transfer tests, and, consistent with the self-invoking trigger hypothesis, it was observed that self-reflection degraded learning as well as performance.

A challenge in studies involving putative activation of the self-system is assessment of this potentially fleeting psychological and neural event (Northoff, Pengmin, & Feinberg, 2010). In the present studies, we assume that self-activation occurred with brief instruction (Experiment 1) and more substantial requests for self-directed writing samples (Experiment 2). Selecting an appropriate method to detect self-activation and ensuring that it can be utilized without causing self-activation is a difficult but important task. Importantly, while our experimental manipulations were explicitly delivered, self-system access and activation is probably often implicit (Bargh, 1982; Bargh, Schwader, Hailey, Dyer, & Boothby, 2012). Further, access and reference to the self appear to be associated with the default mode of brain activation (Buckner, Andrews-Hanna, & Schacter, 2008; Lou, Luber, Stanford, & Lisanby, 2010), away from which one must switch for task-related activation (Northoff, Qin, & Nakao, 2010). Testing the extent to which self-activation may moderate motor learning would be a fruitful step toward a better understanding of the role of the self in learning.

Multiple lines of inquiry have identified self-focused attention as detrimental to motor skill learning and performance (e.g., self-focus, Baumeister, 1984; explicit monitoring, Beilock & Carr, 2001; skill-focused attention, Gray, 2004; reinvestment, Masters & Maxwell, 2008; internal focus of attention, Wulf, 2013). While the relationship between self-activation and self-focused attention is not fully explicated, the myriad factors that could engage self-activation or self-related processing make the self-invoking trigger hypothesis intriguing.

In the present experiments, we tested the notion that, regardless of specific self-related content or its positive or negative meanings or emotional impacts, activation of the self-system would be less compatible with optimal performance and learning than non-self-directed instructions or triggers. Because self-directed instructions in Experiment 2 encouraged consideration of past events and experiences of both a positive and a negative nature, we cannot determine whether positive and negative thoughts would have differential effects on motor performance and learning. The literature on positive motivational and self-related effects on motor performance and learning (e.g., Chang et al., 2014; Chiviacowsky & Wulf, 2007; Lewthwaite & Wulf, 2012; McKay, Lewthwaite, & Wulf, 2012; Moritz, Feltz, Fahrbach, & Mack, 2000) might suggest that positive self-related processing, such as might occur with high self-efficacy expectations, positive self-talk, or a sense of personal autonomy, could be performance-enhancing forms of self-activation. A possible distinction, though, is that these motivational factors may apply to future-oriented and task-directed processing rather than processing that directs attention to one's past self or self-system. It is also possible that negative memories may have overpowered positive ones, resulting in a net negative impact of self-related attention. One could speculate that the "distance" between positive and negative thoughts regarding performance is comparatively small, highly fluid, and negatively "tilted", resulting soon in negative leanings regardless of positive beginnings. Further, both are within the self-related processing system as distinct from stimulus or task-specific processing (Northoff & Bermpohl, 2004; Northoff et al., 2006). Future experiments can consider potential differential effects of positive and negative aspects of self-related processing.

While the present data support the notion that self-reflection on the subject of task-related experience can have a detrimental effect on motor learning and performance, additional research is necessary to explore the effect of self-reflection on task-irrelevant experience. A strong version of the self-invoking trigger hypothesis would predict that *any* form of self-reflection would negatively affect motor learning and performance. However, a weak form of the hypothesis would predict that the self-reflection must be adequately "proximal" in content to the motor task to influence learning and performance. Indeed, an exploration of this issue may provide insight into the underlying

mechanisms causing the self-reflection effect we are documenting in the present experiments.

In conclusion, the present experiments are the first to test the effect of a self-reflective manipulation in the absence of different focus instructions, feedback, contextual cues, or manipulated conceptions of ability. While there may be many ways to cause self-activation, these experiments are the first to show that self-reflection alone is sufficient to interfere with motor skill acquisition and performance. Consequently, developing a better understanding of the unique contribution of self-activation to suboptimal learning and performance is crucial for motor behaviour theory and application.

REFERENCES

Banks, S. (2014). *Distal and proximal attentional focus effects on the performance of closed and open continuous motor skills* (Unpublished doctoral dissertation). University of Edinburgh, Edinburgh, UK.

Bargh, J. A. (1982). Attention and automaticity in the processing of self-relevant information. *Journal of Personality and Social Psychology*, 43, 425–436. doi:10.1037/0022-3514.43.3.425

Bargh, J. A., Schwader, K. L., Hailey, S. E., Dyer, R. L., & Boothby, E. J. (2012). Automaticity in social-cognitive processes. *Trends in Cognitive Sciences*, 16, 593–605. doi:10.1016/j.tics.2012.10.002

Baumeister, R. (1984). Choking under pressure: Self-consciousness and paradoxical effects of incentives on skillful performance. *Journal of Personality and Social Psychology*, 46, 610–620. doi:10.1037/0022-3514.46.3.610

Beilock, S. L. & Carr, T. H. (2001). On the fragility of skilled performance: What governs choking under pressure? *Journal of Experimental Psychology: General*, 130(4), 701–725. doi:10.1037/0096-3445.130.4.701

Bell, J. J., & Hardy, J. (2009). Effects of attentional focus on skilled performance in golf. *Journal of Applied Sport Psychology*, 21, 162–177. doi:10.1080/10413200902795323

Buckner, R. L., Andrews-Hanna, J. R., Schacter, D. L. (2008). The brain's default network: Anatomy,

function, and relevance to disease. *Annals of the New York Academy of Sciences*, 1124, 1–38. doi:10.1196/annals.1440.011

Chang, Y.-K., Ho, L.-A., Lu, F. J.-H., Ou, C.-C., Song, T.-F., & Gill, D. L. (2014). Self-talk and softball performance: The role of self-talk nature, motor task characteristics, and self-efficacy in novice softball players. *Psychology of Sport and Exercise*, 15, 139–145. doi:10.1016/j.psychsport.2013.10.004

Chiviacowsky, S., & Wulf, G. (2007). Feedback after good trials enhances learning. *Research Quarterly for Exercise and Sport*, 78, 40–47. doi:10.1080/02701367.2007.10599402

Gray, R. (2004). Attending to the execution of a complex sensorimotor skill: Expertise differences, choking, and slumps. *Journal of Experimental Psychology: Applied*, 10, 42–54. doi:10.1037/1076-898X.10.1.42

Gusnard, D. A., Akbudak, E., Shulman, G. L., & Raichle, M. E. (2001). Medial prefrontal cortex and self-referential mental activity: Relation to a default mode of brain function. *Proceedings of the National Academy of Sciences*, 98, 4259–4264. doi:10.1073/pnas.071043098

Kal, E. C., van der Kamp, J., & Houdijk, H. (2013). External attentional focus enhances movement automatization: A comprehensive test of the constrained action hypothesis. *Human Movement Science*, 32, 527–539. doi:10.1016/j.humov.2013.04.001

Leary, M. R. (2004). *The curse of the self: Self-awareness, egotism, and the quality of human life*. New York: Oxford University Press.

Lewthwaite, R., & Wulf, G. (2012). Motor learning through a motivational lens. In N. J. Hodges & A. M. Williams (Eds.), *Skill acquisition in sport: Research, theory & practice* (2nd ed., pp. 173–191). London: Routlegde.

Lohse, K. R., Jones, M., Healy, A. F., & Sherwood, D. E. (2013). The role of attention in motor control. *Journal of Experimental Psychology: General*, May 6, 2013, Epub ahead of print. doi:10.1037/a0032817

Lohse, K. R., Sherwood, D. E., & Healy, A. F. (2010). How changing the focus of attention affects performance, kinematics, and electromyography in dart throwing. *Human Movement Science*, 29, 542–555. doi:10.1016/j.humov.2010.05.001

Lou, H. C., Luber, B., Stanford, A., & Lisanby, S. H. (2010). Self-specific processing in the default network: A single-pulse TMS study. *Experimental Brain Research*, 207, 27–38. doi:10.1007/s00221-010-2425-x

Markus, H. (1977). Self-schemata and processing information about the self. *Journal of Personality and Social Psychology*, *35*, 63–78. doi:10.1037/0022-3514.35.2.63

Masters, R. & Maxwell, J. (2008). The theory of reinvestment. *International Review of Sport and Exercise Psychology*, *1*(2), 160–183. doi:10.1080/17509840802287218

McKay, B., Lewthwaite, R., & Wulf, G. (2012). Enhanced expectancies improve performance under pressure. *Frontiers in Psychology*, *3* (Article 8). doi:10.3389/fpsyg.2012.00008

McKay, B., & Wulf, G. (2012). A distal external focus enhances novice dart throwing performance. *International Journal of Sport and Exercise Psychology*, *10*, 149–156.

McMahon, K. M. A., & Masters, R. S. W. (2002). The effects of secondary tasks on implicit motor skill performance. *International Journal of Sport Psychology*, *33*, 307–324.

McNevin, N. H., Shea, C. H., & Wulf, G. (2003). Increasing the distance of an external focus of attention enhances learning. *Psychological Research*, *67*, 22–29. doi:10.1007/s00426-002-0093-6

Moritz, S. E., Feltz, D. L., Fahrbach, K., & Mack, D. (2000). The relation of self-efficacy measures to sport performance: A meta-analytic review. *Research Quarterly for Exercise and Sport*, *71*, 280–294. doi:10.1080/02701367.2000.10608908

Northoff, G., & Bermpohl, F. (2004). Cortical midline structures and the self. *Trends in Cognitive Sciences*, *8*, 102–107. doi:10.1016/j.tics.2004.01.004

Northoff, G., Heinzel, A., de Greck, M., Bermpohl, F., Dobrowolny, H., & Panksepp, J. (2006). Self-referential processing in our brain – A meta-analysis of imaging studies of the self. *NeuroImage*, *31*, 440–457. doi:10.1016/j.neuroimage.2005.12.002

Northoff, G., Pengmin, P., & Feinberg, T. E. (2010). Brain imaging of the self – Conceptual, anatomical and methodological issues. *Consciousness and Cognition*, *20*, 52–63. doi:10.1016/j.concog.2010.09.011

Northoff, G., Qin, P., & Nakao, T. (2010). Rest-stimulus interaction in the brain: A review. *Trends in Neurosciences*, *33*, 277–284. doi:10.1016/j.tins.2010.02.006

Porter, J. M., Anton, P. M., Wikoff, N. M., & Ostrowski, J. B. (2013). Instructing skilled athletes to focus their attention externally at greater distances enhances jumping performance. *Journal of Strength and Conditioning Research*, *27*, 2073–2078.

Porter, J. M., Anton, P. M., & Wu, W. F. W. (2012). Increasing the distance of an external focus of attention enhances standing long jump performance. *Journal of Strength and Conditioning Research*, *26*, 2389–2393. doi:10.1519/JSC.0b013e31823f275c

Strauman, T. J., & Higgins, E. T. (1993). The self construct in social cognition: Past, present, and future. In Segal, Z. V. & Blatt, S. J. (Eds.), *The self in emotional distress: Cognitive and psychodynamic perspectives* (pp. 3–41). New York, NY: Guilford Press.

Vance, J., Wulf, G., Töllner, T., McNevin, N. H., & Mercer, J. (2004). EMG activity as a function of the performer's focus of attention. *Journal of Motor Behavior*, *36*(4), 450–459. doi:10.3200/JMBR.36.4.450-459

Wulf, G. (2013). Attentional focus and motor learning: A review of 15 years. *International Review of Sport and Exercise Psychology*, *6*, 77–104. doi:10.1080/1750984X.2012.723728

Wulf, G., Lauterbach, B., & Toole, T. (1999). The Learning advantages of an external focus of attention in golf. *Research Quarterly for Exercise and Sport*, *70*, 120–126. doi:10.1080/02701367.1999.10608029

Wulf, G., & Lewthwaite, R. (2010). Effortless motor learning? An external focus of attention enhances movement effectiveness and efficiency. In B. Bruya (Ed.), *Effortless attention: A new perspective in attention and action* (pp. 75–101). Cambridge, MA: MIT Press.

Wulf, G., McNevin, N., & Shea, C. (2001). The automaticity of complex motor skill learning as a function of attentional focus. *The Quarterly Journal of Experimental Psychology*, *54*, 1143–1154. doi:10.1080/713756012

Wulf, G., & Su, J. (2007). An external focus of attention enhances golf shot accuracy in beginners and experts. *Research Quarterly for Exercise and Sport*, *78*, 384–389. doi:10.1080/02701367.2007.10599436

Zachry, T., Wulf, G., Mercer, J., & Bezodis, N. (2005). Increased movement accuracy and reduced EMG activity as the results of adopting an external focus of attention. *Brain Research Bulletin*, *67*, 304–309. doi:10.1016/j.brainresbull.2005.06.035

Zhu, L., Zheng, L., Chen, M., Guo, X., Li, J., Chen, L., & Yang, Z. (2013). The neural correlates of incidental self-processing induced by handwritten negative words. *Experimental Brain Research*, *228*, 1–8. doi:10.1007/s00221-013-3531-3