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Ironic and Overcompensating Processes Under Avoidance Instructions in Motor Tasks: An Attention Imbalance Model With Golf-Putting Evidence

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Thought-suppression research showed, when asked to suppress a given thought (e.g., a white bear), people ironically report thinking more of the suppressed thought. Testing motor performance given avoidance goals (e.g., avoid putting the ball short of the target in golf) represents an interest to transfer thought-suppression findings to motor tasks. However, instead of revealing an ironic process, motor studies showed mixed results, suggesting a coexistence of ironic and overcompensating processes. The present study investigates the coexistence of ironic and overcompensating processes induced by avoidance goals in motor tasks. Adopting a dual-process framework, an attention imbalance model (AIM) was proposed to conceptualize such a coexistence. Four golf-putting experiments were conducted to test the AIM by manipulating the degree of attentional imbalance. Results indicated the factor of attentional imbalance moderates the likelihood between ironic and overcompensating processes in golf putting, and such a moderating effect exists in both between- and within-individual variation of task performance but demands task-specific considerations. In addition, performance feedback confounded the putting performance by reducing the likelihood of overcompensating process. The implications of the AIM are discussed in an extended context of motor performance under avoidance goals and thought suppression.

Public Significance Statement
This study helps to understand two fundamental processes elicited by avoidance goals in performing motor tasks: the ironic and the overcompensating processes.

Keywords: ironic process, overcompensating process, golf putting, attentional control, avoidance goal

Putting is an important skill in golf performance. In the 2018 PGA season, the use of putter alone accounted for about 46% of total club usage, whereas the other 13 clubs split the remaining 54% (PGA, 2019). Regarding the length of a putt, Pelz (2000) proposed that the ball is most likely to be holed with a speed that makes the ball roll 12–18 in. past the hole. Thus, putting a ball short of the hole would be undesirable, albeit its presence in all levels of golf competition. Being aware of this pitfall in golf putting, one may intuitively tell oneself to "not putt short," raising the question of how such an avoidance goal affects one's putting performance?

The purpose of the present research was to investigate two plausible, yet competing, motor processes in golf putting, which can occur when having the intention of not putting the ball short of target. The first one, *the ironic process* (which is behaviorally manifested as putting the ball shorter than what one normally does when instructed not to putt it short), was conceptually derived from the *ironic processing theory* (IPT; Wegner, 1994). Results of Wegner, Ansfield, and Pilloff's (1998) golf-putting experiment supported the manifested ironic process given an avoidance instruction. The alternative, *the overcompensating process* (which is behaviorally manifested as putting the ball longer than what one

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normally does when instructed not to putt it short), first appeared in a golf study designed to test IPT (Beilock, Afremow, Rabe, & Carr, 2001). The manifested overcompensating process was replicated and conceptualized in the *implicit overcompensation hypothesis* in de la Peña, Murray, and Janelle's (2008) study. The coexistence of these two conflicting processes seems bewildering and no studies have attempted to offer explanations yet. Fusing previous research evidence with results from four experiments involving a carefully designed golf-putting task, we propose an *attention imbalance model* (AIM) to understand the presence of both ironic and overcompensating motor processes given avoidance instructions in motor tasks.

The elaboration of the AIM follows several steps. First, the origin of the ironic-overcompensating issue is presented by reviewing landmark studies in this line of research. Next, we describe the relevant conceptual frameworks with particular attention to the proposed AIM in golf putting under an avoidance instruction, and present results of four golf experiments designed to test and understand the AIM. Finally, the implications of the AIM for conceptualizing the two avoidance-induced motor processes are discussed.

Thought Suppression

Thought suppression research gained momentum after the publication of two experiments by Wegner, Schneider, Carter, and White (1987). In Experiment 1, Wegner et al. (1987) asked two groups of participants to either suppress or express the thought of a white bear during a 5-min period. Afterward, the two groups switched their thought control strategies in a second 5-min period. Results indicated that, when asked to express the thought, the suppress-then-express group ironically reported more thoughts of the white bear than the express-then-suppress group because the group underwent suppression prior to expression. In Experiment 2, Wegner et al. (1987) included the two identical groups of Experiment 1, while having a third group using self-distraction during thought suppression. Members in this group received identical instructions to those in the suppress-then-express group with the exception that, in the suppression period, they were suggested to suppress the white bear by thinking of a red Volkswagen. Experiment 2 results showed that the self-distraction group no longer demonstrated the ironic effect.

Wegner et al. (1987) were criticized for several methodological issues, but later studies with more rigorous designs replicated the ironic effect of thought suppression among college students (Clark, Ball, & Pape, 1991; Clark, Winton, & Thynn, 1993; Lavy & van den Hout, 1990; Merchelbach, Muris, van den Hout, & de Jong, 1991; Wegner, Shortt, Blake, & Page, 1990). The suppression-induced ironic effect was also supported in a meta-analysis of 28 controlled studies with a resulting effect size of small to moderate amplitude ($\bar{d}$ = 0.30; Abramowitz, Tolin, & Street, 2001). Therefore, a large body of evidence indicates that thought suppression results in an ironic process of thought activation, which was explained in the ironic process theory (Wegner, 1994).

Ironic Process Theory

Ironic process theory (IPT; Wegner, 1994) describes the process of attentional control in human beings through a dual-process system operating in a parallel-competitive form (see Evans & Stanovich, 2013). The theory denotes that, for human beings to remain balanced and adaptive, two competing and complementary memory systems are necessary in attentional control: an operator and a monitor (Wegner, 1994). The *operator* is a conscious process for achieving goal-related outcomes and its functioning requires substantial cognitive resources. In contrast, the *monitor* is a subconscious process monitoring failures of the operator (i.e., goal-irrelevant processes) and its functioning is automatic and unrelated to the availability of cognitive resources. To account for the ironic effect of thought suppression, namely suppression-induced thought activation, IPT includes the *complementary searching hypothesis* (CSH; Wegner, 1994, pp. 40–41) to delineate the operator-monitor interaction. CSH is based on the finding that feature-positive searches are much easier to execute than feature-negative ones (Newman, Wolff, & Hearst, 1980). In terms of attentional control, the finding indicates that a given cue's presence is easier to detect than its absence. Because operator and monitor run complimentary searches in attentional control, if one of the two memory processes conducts a feature-positive search, the other must run a feature-negative search (Wegner, 1994). Therefore, depending on attentional control strategies, the memory process running a feature-positive search gains a competing advantage over the other running a feature-negative search in CSH, resulting in enhanced likelihood of influencing a behavioral outcome (Wegner, 1994).

Creating and suppressing thoughts are two frequent attentional control strategies. When one is creating a thought, such as thinking of a white bear, the operator conducts a feature-positive search for a white bear while the monitor runs a feature-negative search for anything that is not a white bear. In this case, the operator will perform the search more efficiently than the monitor, ultimately leading to creating the image of a white bear. However, when one is suppressing, such as avoiding a white bear in mind, the dual-process dynamic is exactly the opposite: The monitor has a feature-positive search for a white bear while the operator assumes a feature-negative search for all but a white bear. This suppressive attention gives the monitor a competing advantage over the operator, eventually giving rise to an enhanced likelihood of the ironic process in activating a white bear thought. This explains the observed ironic effect from thought suppression studies.

Testing IPT in Motor Tasks

Since its inception, IPT has been supported in domains beyond cognitive psychology, such as social psychology (Galinsky & Moskowitz, 2007) and psychopathology (Salkovskis, 1996). In the motor domain, Wegner, Ansfield, and Pilloff (1998) first demonstrated the potential for IPT to predict ironic motor process in golf putting and pendulum holding under avoidance instructions. Interest in testing IPT in various motor tasks started to grow after the translational work by Janelle (1999), who highlighted that performance decline could be a result of attempting motor tasks with suppressive intentions. In less than two decades, scholars working in the motor domain have tested IPT in tasks including baseball pitching (Gray, Orn, & Woodman, 2017), simulated soccer penalty shooting (Bakker, Oudejans, Binsch, & Kamp, 2006; Binsch, Oudejans, Bakker, & Savelsbergh, 2010), hockey penalty shooting (Woodman, Barlow, & Gorgulu, 2015), body balancing (Dugdale

& Eklund, 2003), dart throwing (Oudejans, Binsch, & Bakker, 2013; Woodman et al., 2015), upper limb motion steadiness (Liu, Eklund, & Tenenbaum, 2015), cursor movement control (Russell & Grealy, 2010), reactive motor performance (Gorgulu, Cooke, & Woodman, 2019), and golf putting (Beilock et al., 2001; Binsch, Oudejans, Bakker, & Savelsbergh, 2009; de la Peña et al., 2008; Toner, Moran, & Jackson, 2013; Woodman & Davis, 2008). In all these studies, participants were asked to perform motor tasks under avoidance instructions.

These past studies contributed substantially to the understanding of the ironic process in motor performance. Specifically, studies including eye-tracking technology have shown that participants' visual attention is highly predictive of motor performance in aiming tasks, such as simulated soccer penalty shooting (Bakker et al., 2006; Binsch et al., 2009) and golf putting (Binsch et al., 2009). In other words, participants were likely to fixate on the to-be-avoided area prior to executing ironic motor performance. This finding is further reinforced by a recent meta-analysis revealing the importance of maintaining a final visual fixation on the target for successful motor performance (Lebeau et al., 2016). In addition, studies involving kinematic measurement of motor task execution consistently revealed that performers' kinematic recordings were not likely to be affected by avoidant goals, implying a higher-level source for the ironic process (Gray et al., 2017; Russell & Grealy, 2010; Toner et al., 2013; Woodman et al., 2015). Collectively, this body of evidence suggests that ironic motor performance is more likely to be associated with a failure of attentional control than a perturbation of movement execution. However, compared with results of eye-tracking and kinematics, the evidence for motor performance outcomes is less consistent.

The primary issue is that avoidance instructions often result in an overcompensating process instead of an ironic process in a golf-putting task. That is, despite Wegner et al.'s (1998) supporting evidence for IPT, an overcompensating process under an avoidance instruction in putting performance was observed in Beilock et al. (2001). The overcompensating finding was later supported in de la Peña et al. (2008), who also attempted to conceptualize the overcompensating process in the *implicit overcompensation hypothesis* (IOH). IOH states that "negatively worded instruction triggers an implicit (unconscious) command that exaggerates the negative meaning, causing a compensatory interpretation of target location and/or distance" (p. 1324). Interpreted in the context of a golf-putting task, IOH predicts that one would unconsciously putt the ball longer when instructed not to putt short. Indeed, several follow-up studies (Binsch et al., 2009; Toner et al., 2013; Woodman & Davis, 2008) supported the IOH prediction in golf putting. Thus, previous studies have found that both overcompensating and ironic processes exist in golf putting under avoidance instructions, but an explanation for such a contradictory coexistence is still missing.

Attention Imbalance Model

An AIM is proposed to account for the coexistence of ironic and overcompensating processes in golf putting, and by extension, in all motor tasks. Building on CSH and IOH, AIM posits that overcompensating and ironic processes can be attributed to the attentional control agency of operator and monitor, respectively. In addition, the attentional search for operator and monitor in a thought suppression task is different than that in a motor task regarding the searched space, which is mental and obscure in thought-suppression (e.g., do not think of a white bear) but becomes physical and transparent in motor performance (e.g., do not putt short). The reason for this is that goals of motor tasks are spatially defined (see Bakker et al., 2006; Binsch et al., 2009, 2010). The spatial search competition between operator and monitor reflects two competing action simulations in the neural network prior to task execution, and thereby whichever simulation gains advantage in the competition tends to manifest behaviorally (Hommel, Müsseler, Aschersleben, & Prinz, 2001; Jeannerod, 2001, 2006; Schmidt & Lee, 2005).

For instance, in a laboratory golf-putting task requiring participants not to putt the ball short of a chalked target (e.g., de la Peña et al., 2008), suppressing becomes the given strategy in attentional control, leaving the monitor with a feature-positive search and the operator with a feature-negative search. In addition, it can be argued that the range of search for operator and monitor is limited to the range of the putting surface on an axis specified by the tee and the target center. In other words, monitor would be positively searching the putting surface in front of the target (i.e., short of target) along the axis, and operator would be negatively searching the rest of the surface (i.e., not short of target = target and putting surface beyond target) along the axis. However, such a search load allocation between operator and monitor (i.e., target area + rear area vs. front area) is not likely to give monitor a competing advantage over operator because the attention/spatial allocation is roughly balanced. Recall that, in suppressing the thought of a white bear, monitor searches for only one target of a white bear, whereas operator searches for an unlimited number of targets (i.e., anything other than a white bear). The attention allocation imbalance is thus not comparable between the golf task and the thought suppression task. An AIM-based hypothesis for the golf-putting task could then be suggested. Namely, the operator should be expected to maintain functioning against the monitor by leading someone to putt the ball mostly to the target or longer (i.e., overcompensating). Yet, if the monitor searches a salient and narrow space in contrast to a wide space searched by the operator, the monitor would be more likely to gain competing advantage (through a stronger ironic action simulation in the neural network) over operator in golf putting. Such a situation would sensitize one to an increased chance of putting the ball short of the target (i.e., ironic process).

Evidence from golf studies (that investigate overcompensating and ironic process under avoidance instructions along the tee-target axis) supports AIM. For studies revealing an overcompensating result from avoidance instructions, the attention imbalance criterion for the monitor-advantage was not satisfied. Specifically, Beilock et al. (2001) had participants putt to a 4× 4 cm square-taped target 2 m away on a 3.7-m long carpet. Binsch et al. (2009) had a 10 cm diameter white-sprayed circle 1.8 m away from the tee on a carpet 3.5 m long. Finally, de la Peña et al. (2008) had participants putt to a 10.8 cm diameter chalked circle 1.83 m away from the tee on a carpet 3.66 m long. Thus, the targets were placed in a location either close to or exactly at the carpet center, giving operator and monitor an almost balanced split in the search range. Also, participants in those studies putted golf balls in normally lit laboratory rooms and multiple block-based putts were recorded as performance.

In contrast to previous studies, Experiment 1 of Wegner et al. (1998) was the only golf study showing support for the avoidance-induced ironic process (which is behaviorally manifested as putting the ball longer than what one normally does when instructed to not putt long) when participants were under the mental load of rehearsing a six-digit number, and this could be explained by two unique features. First, Wegner et al.'s (1998) participants putted in a laboratory room lit only by ultraviolet light, with the golf ball and target (a 4-cm diameter dot) glowing yellow and blue, respectively. In addition, Wegner et al. (1998) did not report the carpet size. This may imply that a participant's visual search range could be affected by the room condition in that the ball and the dot became more salient search targets than all other laboratory floor space. Therefore, when given an avoidance instruction, a participant may be more likely to aim with an attention imbalance between the dot and other space prior to putting. Second, Wegner et al. (1998) recorded a single putt to represent a participant's performance. Results of such a single-trial measurement can be different from the trial-block measurement given the finding that one's motor planning is often conditioned on the outcome of a previous attempt (Cooke et al., 2015). Therefore, a concern was that participants' learning from the feedback of previous putts might confound participants' performance from the trial-block measurement (see Schmidt & Lee, 2005).

The Present Study

The goal of the present study was to test the AIM, in that operator-monitor competition is a key factor in moderating the likelihood of ironic and overcompensating processes under avoidance instructions in golf putting. To achieve this goal, four experiments involving a golf-putting task modeled after the setup in de la Peña et al. (2008) were conducted. Experiment 1 introduced a novel manipulation to enhance attentional imbalance (thus increasing monitor advantage in competing with operator) under a general avoidance goal of "not putting short of target." Experiment 2 extended Experiment 1 by minimizing visual and auditory feedback after the putter-ball contact. As such, the putting performance would be less influenced by past performance feedback and more by experimental manipulation of attention. Experiment 3 further extended Experiment 1 by flipping the general avoidance goal from "not putting short of target" to "not putting long of target." Experiment 4 further tested AIM by switching the focus of performance dimension from putting distance to putting direction with a general avoidance goal of "not putting the ball to the left of the target." We postulated two hypotheses. First, given an avoidance instruction, the presence of monitor advantage over operator should result in an enhanced ironic process (or weakened overcompensating process) in golf putting, regardless of performance dimensions (i.e., distance vs. direction). Second, under minimized performance feedback, we expected ironic and overcompensating processes to manifest more consistently within group conditions throughout the experiment.

Experiment 1: Enhancing Attention Imbalance

The purpose of Experiment 1 was to introduce a new experimental feature, the red dot, which helped create a spatial search imbalance between the monitor and the operator in AIM. The spatial search imbalance would enhance the monitor advantage, allowing to test the hypothesis that the presence of the monitor advantage would increase the ironic process likelihood in golf putting. A digit-rehearsal task was added to the main task of golf putting, given that such a secondary task is argued to enhance the ironic process in CSH (Wegner, 1994) but deemed as a tangential factor for the overcompensating process in IOH (de la Peña et al., 2008).

Method

Participants. The sample size decision was based on de la Peña et al.'s (2008) two golf-putting experiments. de la Peña et al. (2008) randomly assigned 48 participants to four groups in Experiment 1 and 36 participants to three groups in Experiment 2. Therefore, the sample size of the current experiment was determined to satisfy that at least 15 participants would be randomly assigned to any experimental group. One-hundred college students from a Southeastern United States university participated in the experiment. All participants gave informed consent that was approved by the university's ethics committee. Participants met several inclusion criteria. Specifically, they were required to be (a) novice golfers (i.e., played golf or minigolf less than three times a year); (b) right-handed; and (c) able to pass a color blindness test. In addition, all participants satisfied a manipulation check based on the secondary digit-rehearsal task. Due to these criteria, the final sample consisted of 79 participants (48F; M_{age} = 25.95, SD_{age} = 7.04).

Task. The golf-putting task was designed to match that of de la Peña et al. (2008). Namely, participants were asked to putt a standard golf ball using a right-handed putter and try to land the ball inside a chalked target (i.e., a white circle with a 10.8-cm diameter). The distance between the tee and the target center was 183 cm. The distance traveled by the ball along the tee-target axis represented the performance in each trial. Moreover, an equal distance of 183 cm was measured behind the target along the length dimension of the putting green. Therefore, the target center was located at the exact center of a 3.66 m (length) × 1.60 m (width) rectangular putting surface measured from a larger surface area (i.e., 4.57 m × 1.60 m). In line with de la Peña et al.'s (2008) protocol, participants performed three 10-trial blocks and rested for 1 min between each block. All participants received the same instruction in the first block that served as the performance baseline. This instruction was to "putt the ball and try to make it land on the circle." At the outset of the second block (i.e., Trial 11), participants received a secondary memory task (by being asked to rehearse mentally the number 526984) before they heard the subsequent condition-wise instructions:

1. Control group (C): "Putt the ball and try to make it land on the circle."
2. Control group with dot (CD): "Putt the ball and try to make it land on the circle."
3. Experimental group (E): "Putt the ball and try to make it land on the circle, but be careful not to putt the ball shy of the circle; don't putt the ball short."

4. Experimental group with dot (ED): "Putt the ball and try to make it land on the circle, but be particularly careful not to land the ball on the red dot; don't land the ball on the red dot."

Task conditions. The C and E conditions were equivalent to those of de la Peña et al.'s (2008) Experiment 2. To induce attention imbalance and test its effect on putting performance, the CD and ED conditions were added. CD and ED had an additional experimental feature. That is, a red dot (4 cm in diameter) was attached to the carpet 25 cm in front of the target center (see Materials and Measures section below for more details on the dot). CD was designed to control for the presence of the dot in the current experiment setting, whereas ED was aimed to create the monitor advantage by coupling the presence of the dot to an avoidance instruction. The red dot was expected to function in a similar way to a thought of white bear in Wegner et al.'s (1987) thought suppression experiment: The red dot is the only search target for the monitor in contrast to a larger search area for the operator.

Materials and measures.

The dot. The red dot was cut from red duct tape using a specially made plastic mold and satisfied several conditions. Regarding its size, the red dot was identical to the glowing target in Wegner et al.'s (1998) Experiment 1 and corresponded to the size of a golf ball (4.27 cm in diameter). Moreover, the dot size forms a visual angle between 0.6° and 0.7° for participants (depending on the height of participants), which is considered an appropriate and a small visual object (Beck & Lavie, 2005). Regarding its color, we decided to use red color because both red and green are primary colors. This makes the dot highly discriminable on the carpet for participants' visual search (Folk & Remington, 1998; Theeuwes, 1991, 1992). Finally, regarding the red dot's location, it was determined by conducting a pilot study during which two factors were considered. First, the dot location must be at least within the parafoveal vision of the participants. Parafovea is defined as the visual regions within 5° boundary of fixation (Rayner, Inhoff, Morrison, Slowiaczek, & Bertera, 1981). However, following more recent findings (Bacon & Egeth, 1994; Beck & Lavie, 2005; Theeuwes, 1991, 1992), we set the dot location to be within 3.5° of the likely visual fixation point (i.e., center of the chalked target). This required the dot to be no longer than 25 cm away from the target center. Second, to make the ED comparable to the E group condition, the dot location must be placed at regions where participants would perceive it to be "short of the target." The pilot study revealed that placing the dot 25 cm in front of the target was an appropriate solution. This choice of the dot location is also consistent with the criterion used in a golf-putting task study (Binsch et al., 2009, p. 630) to define a visual gaze that is short of the target. Figure 1 illustrates how the red dot was arranged on the putting surface in the present study.

Performance measure. After each trial, an experimenter took a picture of the carpet to record putting performance. To take the picture, an experimenter used an iPad 4 (Apple, Cupertino, CA) to remotely control a GoPro Hero 3+ camera (GoPro, San Mateo, CA). The camera was mounted on the ceiling directly above the putting target. Image analysis was conducted using a custom script written and compiled as a standalone executable program using MATLAB R2014b (MathWorks, Natick, MA). The program identified the ball location from a calibrated camera image and compared the location of the ball with the target location, set in the initial calibration. A researcher manually verified a positive identification of both the ball and target to minimize the likelihood of misidentification. Because the size of the carpet is limited, it was determined that, if the ball rolls off the carpet, the ball would be placed at the location where it leaves the carpet for final performance measurement. For example, if a ball rolls beyond the length dimension of the carpet, the ball would be placed at the maximum length (3.66 m).

Color blind test. Six prompts taken from the Ishihara pseudo-isochromatic plate test (Ishihara, 1966) were used to screen for red-green color deficiency. The Ishihara test is the most widely used test to screen for color blindness (Birch, 1997). Participants were shown a number on a circular plate and were asked to identify the number at the center or dictate that they did not see a number. To participate in the experiment, participants were required to correctly identify all six numbers.

Procedure. Participants were asked to voluntarily complete an informed consent form and a demographic form upon arrival at

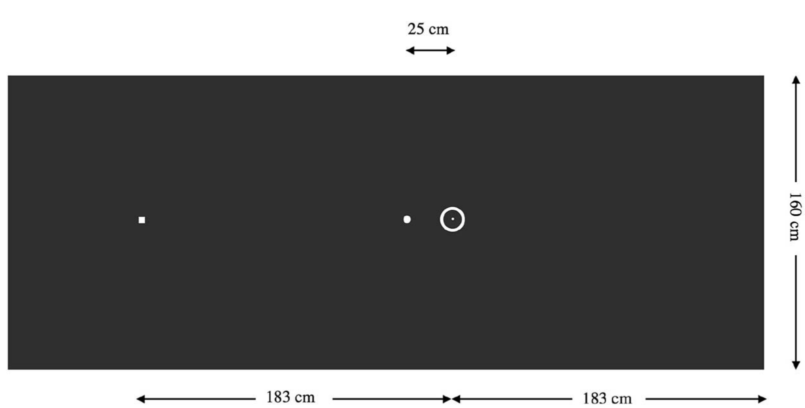

Figure 1. Schematic representation of the putting surface for Experiment 1 and 2: putting green (dark gray rectangle), tee (white square), red dot (white dot, which appears only in control group with dot and experimental group with dot conditions), and target (white ring).

the laboratory. An experimenter then verified that the participant met the inclusion criteria. If qualified, the participant was randomly assigned to one of the four conditions according to a randomization sheet generated by Microsoft Excel. The sheet was hidden from two experimenters in a folder prior to the participant's arrival. The participant performed three practice putts before starting the main task of three 10-trial blocks, with 1-min rest between blocks. During the main task, one experimenter remotely controlled the camera using an iPad, took a picture of the ball once it completely stopped rolling, then collected the ball from the carpet. The second experimenter read the scripted instructions and directed the participant to every putt by placing a new ball at the starting position. Upon completion of the main task, the participant was asked to recall the six-digit number, and then debriefed and thanked.

Analysis. SPSS 20.0 (IBM Corporation, 2011) and R 3.4.0 (R Core Team, 2017) were used to conduct the analyses. Those who were unable to recall the six-digit number correctly at the end of the experiment were excluded from the final dataset. The number of trials that went off the putting green was also recorded.

The main analyses focused on comparing group performance by using both single trials and block averages, making the current results comparable with those of Wegner et al. (1998) and de la Peña et al. (2008). Analysis of covariance (ANCOVA) were performed after checking statistical assumptions (Liu, Lebeau, & Tenenbaum, 2016). In the single-trial analysis, Conditions C, CD, E, and ED were compared on the performance of Trial 11 and Trial 21, respectively, by using the performance of Trial 1 as a covariate.[1] In the block-average analysis, conditions were compared on the performance of Block 2 average and Block 3 average, respectively, with performance of Block 1 average serving as a covariate. Fisher's LSD was used in pairwise comparisons and the α level was set at .05.

Finally, the ironic process likelihood for both E and ED was explored. Specifically, the 20 experimental trials (i.e., Trials 11–30) of each participant were compared with the participant's own baseline block average (i.e., Block 1 average). An individual's proportion of trials shorter than baseline block average was computed as the likelihood for the individual to behaviorally demonstrate ironic processes in putting performance. Later, the ironic process likelihood was linearly averaged among participants within each experimental condition. The same computation was also applied to C and CD so that the result could serve as a reference for E and ED. Because ironic process and overcompensating process are competing with each other for behavioral dominance, the overcompensating process likelihood can be computed by subtracting ironic process likelihood from 100% (i.e., $p_{\text{overcompensating}} = 1 - p_{\text{ironic}}$).

Results

Preliminary procedure. Twenty-one participants were excluded due to incorrect recalls of the six-digit number. The final sample ($N = 79$) consisted of 19 participants in C, 19 in CD, 20 in E, and 21 in ED. In 12 trials the ball rolled beyond the length of the carpet and these trials accounted for 0.51% of all trials.

Condition performance. For the single trial analyses, no experimental condition differences were noted on the covariate variable (i.e., Trial 1), $p > .29$. Figure 2 displays the estimated putting performance of all the conditions in the 11th and 21st trial, respectively. Analysis on Trial 11 revealed a significant condition effect on putting performance, $F(3, 74) = 2.76$, $p = .048$, $\eta_p^2 = .10$. Pairwise comparison results revealed that E ($M = 232.75$, $SD = 49.86$) showed longer putts than C ($M = 188.82$, $SD = 50.50$), $p = .01$, Cohen's $d = 0.88$, and CD ($M = 195.88$, $SD = 50.04$), $p < .03$, Cohen's $d = 0.74$. No other significant difference emerged. A significant condition effect was also revealed on the performance of Trial 21, $F(3, 74) = 9.86$, $p < .001$, $\eta_p^2 = .29$. Similar to the pairwise comparison results on Trial 11, E ($M = 236.30$, $SD = 39.70$) demonstrated longer putts than C ($M = 179.75$, $SD = 40.20$), $p < .001$, Cohen's $d = 1.42$, CD ($M = 174.66$, $SD = 39.84$), $p < .001$, Cohen's $d = 1.55$, and ED ($M = 211.54$, $SD = 39.66$), $p = .055$, Cohen's $d = 0.47$. Additionally, ED showed longer putts than C, $p < .02$, Cohen's $d = 0.5$, and CD, $p < .006$, Cohen's $d = 0.93$.

For the block-average analyses, no condition differences were found on the covariate variable (i.e., Block 1 average), $p > .47$. Figure 3 displays the estimated performance of all conditions on the average of the second and third block, respectively. Analysis on the Block 2 average revealed a significant condition effect, $F(3, 74) = 12.10$, $p < .001$, $\eta_p^2 = .33$. Pairwise comparison results showed that E ($M = 214.93$, $SD = 15.37$) demonstrated longer putts than C ($M = 186.97$, $SD = 15.28$), $p < .001$, Cohen's $d = 1.82$, CD ($M = 192.72$, $SD = 15.36$), $p < .001$, Cohen's $d = 1.45$, and ED ($M = 204.72$, $SD = 15.32$), $p = .04$, Cohen's $d = 0.67$. Similar to the pairwise comparison results on Trial 21, ED showed longer putts than C, $p < .001$, Cohen's $d = 1.16$, and CD, $p < .02$, Cohen's $d = 0.78$. Concerning the performance on Block 3 average, a significant condition effect emerged, $F(3, 74) = 11.58$, $p < .001$, $\eta_p^2 = .32$. Pairwise comparison results again revealed that E ($M = 207.96$, $SD = 15.42$) had longer putts than C ($M = 186.99$, $SD = 15.33$), $p < .001$, Cohen's $d = 1.36$, CD ($M = 180.49$, $SD = 15.41$), $p < .001$, Cohen's $d = 1.78$, and ED ($M = 199.25$, $SD = 15.37$), $p = .08$, Cohen's $d = 0.57$. Moreover, ED showed longer putts than C, $p < .02$, Cohen's $d = 0.80$, and CD, $p < .001$, Cohen's $d = 1.22$. Therefore, regardless of single-trial or block-average analysis, results of the condition performance indicated a three-tier structure (E $>$ ED $>$ C $=$ CD) on putting distance.

Ironic process likelihood. Figure 4 presents the ironic process likelihood for both E and ED with C and CD's computational analogs as references. The ironic process likelihood of ED (39.76%) was descriptively higher than that of E (34.45%), although it was lower than its computational analogs of C (57.11%) and CD (57.37%).

Discussion

In Experiment 1, a novel manipulation based on AIM was introduced to test the hypothesis that the monitor advantage in attentional control would enhance the ironic process (or weaken the overcompensating process) in performing a golf task. Both single trial and block average analyses supported the hypothesis with a three-tier structure in performance of the four conditions. Specifically, E demonstrated a longer putting performance than

[1] The single trials are selected as they have the highest experimental validity by occurring immediately after attentional manipulation, in addition to being free of outcome feedback obtained from previous trials.

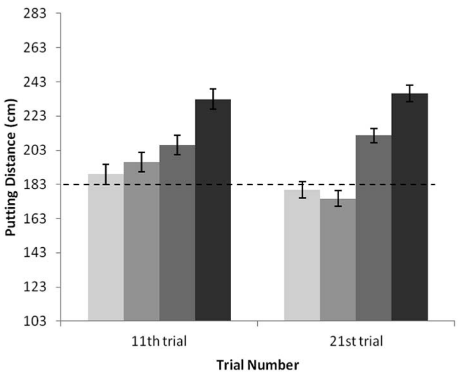

Figure 2. Putting performance (and standard errors) of all the conditions on the 11th and 21st trials in Experiment 1.

ED, which itself had a longer putting performance than C and CD; C and CD did not differ from each other on putting performance. The three-tier structure aligns well with the result of the ironic process likelihood. This three-tier structure replicates de la Peña et al.'s (2008) findings about the overcompensating process from the comparison between E and C. In addition, the lack of difference between C and CD indicates that placing the red dot on the putting green without an avoidance instruction did not affect putting performance. Furthermore, the comparison between E and ED suggests that the monitor advantage in attentional control weakens the overcompensating process under avoidance instructions. The ironic process likelihood result indicates that ED demonstrated a 5.26% increase in the chance of making an ironic putt compared to E. Regarding the single trial analysis results, no condition differences emerged among C, CD, and ED on Trial 11, which is the first experimental trial. However, ED demonstrated a longer putting performance than C and CD on Trial 21. This finding suggests that the ironic process is equally likely compared with overcompensating process on Trial 11 in ED; but in trials to follow, the chance favors the overcompensating process more than the ironic process in ED. It is possible that the observation of the strengthened overcompensating process in ED after Trial 11 was confounded by the performance feedback from previous putts, leading to adjustments in subsequent attempts among participants.

Experiment 2: Minimizing Performance Feedback

To test whether performance feedback would confound results in Experiment 1, Experiment 2 was conducted to minimize performance feedback. Specifically, participants' visual and auditory feedback of their performance was minimized after the ball-putter contact. It was hypothesized that the ironic and overcompensating process would be more consistent within group conditions in Experiment 2 than Experiment 1.

Method

Participants. The sample size decision used in Experiment 2 was identical to that in Experiment 1. A group of 89 college students (who did not participate in Experiment 1) from a Southeastern United States university took part in this experiment. All the participants gave and signed an informed consent that was approved by local ethics committee. Due to identical inclusion criteria to those in Experiment 1, the final sample included 71 participants (44F; M_{age} = 23.76, SD_{age} = 6.34).

Task. The task was identical to that of Experiment 1, with the exception that participants' visual and auditory feedback was minimized. The room light was turned off by an experimenter (so that the room turned completely dark) at the moment of ball-putter contact in all trials (i.e., Trial 1–30). Each participant was instructed to immediately turn around after the room turned completely dark so that the ball and the target were behind the participant. Then, the experimenter turned on the room light so that a second experimenter could measure the performance similarly to Experiment 1. To reduce auditory feedback for participants, the second experimenter collected the putted ball using a special device so that walking and other sounds were avoided or minimized. In addition, to prevent the sound made by the ball in case it rolled off the carpet, sponge-like material was fixated at the

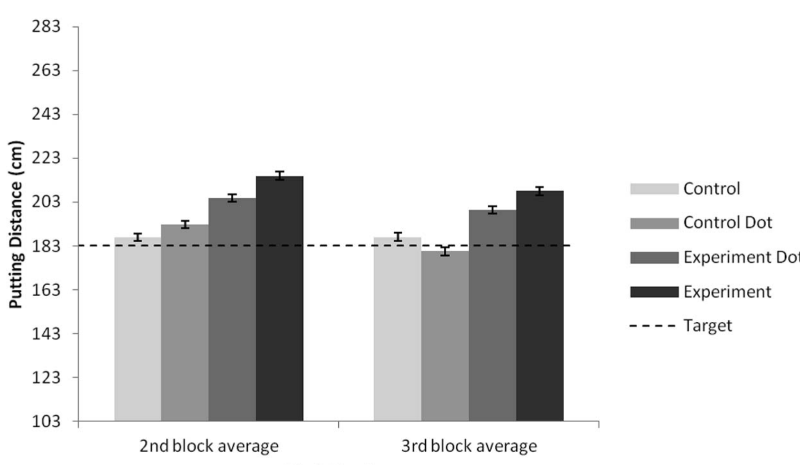

Figure 3. Average putting performance (and standard errors) of all the conditions in Block 2 and Block 3 in Experiment 1.

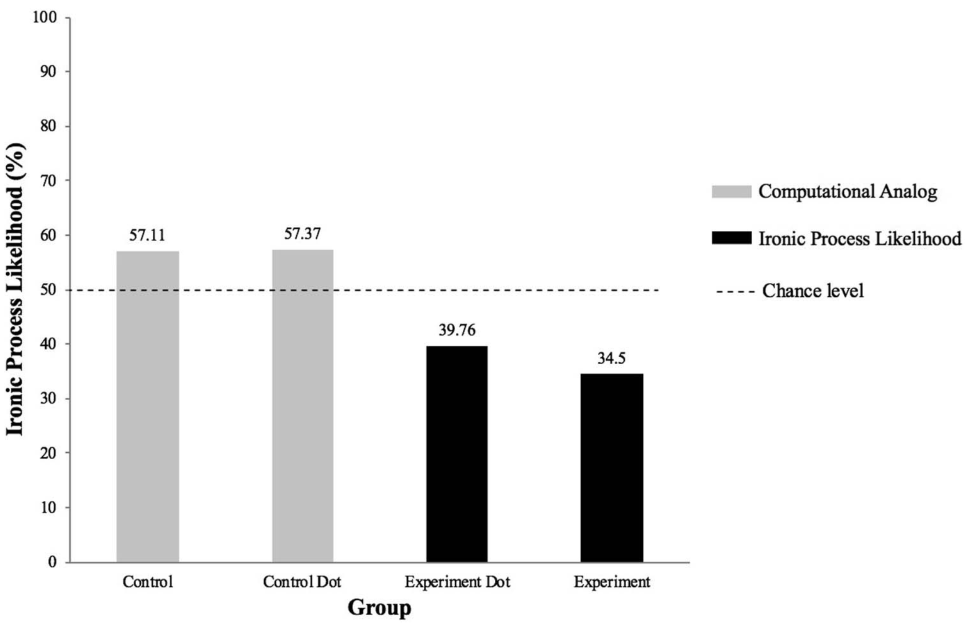

Figure 4. Ironic process likelihood of experimental group and experimental group with dot with computational analogs of control group and control group with dot in Experiment 1.

length limit of the carpet to stop the ball. After the ball was collected from the putting green, the participant could turn back around and continue with the next trial.

Materials and measures. All the materials and measures were identical to those in Experiment 1 except for a postexperiment survey added to check the manipulation of minimized visual feedback. This survey consisted of a question asking participants to indicate how far they could see the ball after putting by indicating the location on a picture of the carpet displayed on an iPad.

Procedure. The procedure was identical to that of Experiment 1 except for the procedures aimed at minimizing visual and auditory performance feedback (i.e., turning off room lights and asking the participant to turn around) in the main task and the postexperiment survey for checking visual feedback.

Analysis. Analyses in Experiment 1 were also conducted in Experiment 2. Additionally, a manipulation check for minimizing visual feedback was conducted by computing the mean of the ball-rolling distance reported in the postexperimental survey.

Results

Preliminary procedure. Eighteen participants were excluded due to incorrect recalls of the six-digit number. The final sample ($N = 71$) consisted of 18 participants in C, 16 in CD, 18 in E, and 19 in ED. Additionally, the ball rolled beyond the length of the carpet in 100 trials and these trials accounted for 4.69% of all trials. Manipulation check on visual feedback revealed that, on average, participants could trace the golf ball up to 18.31 cm ($SD = 14.47$) after putter-ball contact.

Condition performance. For the single trial analyses, no condition difference was found on the covariate (i.e., Trial 1), $p > .97$. Analysis on Trial 11 revealed a nonsignificance effect of condition on putting performance, $F(3, 66) = 1.54$, $p > .21$. Similar to results on Trial 11, analyses on Trial 21 revealed a nonsignificance effect of condition on putting performance, $F(3, 66) = 1.48$, $p > .22$.

For the block average analyses, no condition difference emerged on the covariate (i.e., Block 1 average), $p > .99$. Figure 5 displays the estimated performance for all conditions on the second and third block average, respectively. Analyses on the average putting performance in Block 2 revealed a significant effect of condition, $F(3, 66) = 6.94$, $p < .001$, $\eta_p^2 = .24$. Pairwise comparison results revealed that E ($M = 268.83$, $SD = 38.24$) demonstrated longer putts than C ($M = 212.54$, $SD = 38.25$), $p < .001$, Cohen's $d = 1.46$, CD ($M = 224.38$, $SD = 38.12$), $p < .002$, Cohen's $d = 1.15$, and ED ($M = 243.18$, $SD = 38.31$), $p < .052$, Cohen's $d = 0.66$. Additionally, ED showed longer putts than C, $p = .02$, Cohen's $d = 0.80$. Finally, a significant condition effect emerged for performance average in Block 3, $F(3, 66) = 5.14$, $p < .003$, $\eta_p^2 = .19$. Pairwise comparison results indicated that E ($M = 267.21$, $SD = 46.19$) showed longer putts than those in C ($M = 206.75$, $SD = 46.19$), $p < .001$, Cohen's $d = 1.31$, CD ($M = 225.73$, $SD = 46.03$), $p = .01$, Cohen's $d = 0.90$, and ED ($M = 239.88$, $SD = 46.26$), $p < .09$, Cohen's $d = 0.59$. Furthermore, ED showed longer putts than C, $p < .04$, Cohen's $d = 0.72$. Therefore, although no group differences were identified through single-trial analysis, results from block-average analysis were generally consistent with those in Experiment 1 regarding the three-tier pattern ($E > ED > C = CD$) on putting distance.

Ironic process likelihood. Figure 6 illustrates the ironic process likelihood for both E and ED with computational analogs of C and CD as references. The ironic process likelihood of ED (39.47%) was descriptively higher than that of E (24.17%). However, it was lower than its computational analogs of C (60%) and CD (50.63%).

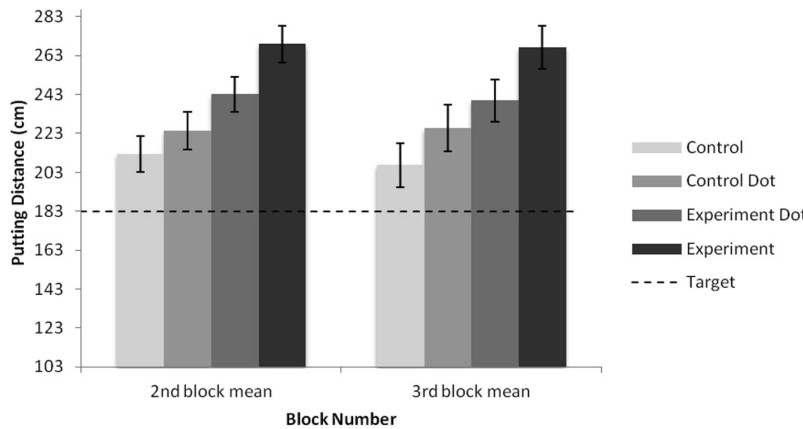

Figure 5. Average putting performance (and standard errors) of all the conditions in Block 2 and Block 3 in Experiment 2.

Discussion

The aim of Experiment 2 was to minimize the performance feedback in the golf-putting task in Experiment 1, because such feedback is likely to confound performance under different experimental conditions. Manipulation check results indicated that participants indeed had limited visual tracing of the ball after putting, and thus their visual feedback was successfully reduced. Although no significant group differences were identified in the single trial analyses (likely due to a lowered statistical power), the results from block average analyses generally replicated the three-tier structure of the group performance observed in Experiment 1. That is, E had longer putting performance than ED, which itself showed longer putts than C and CD.

The three-tier structure can be explained by the results of ironic process likelihood. That is, E is the condition least likely to show ironic process followed by ED, which itself is followed by C and CD. Moreover, in Experiment 2, ED was 15.30% more likely to make ironic putts than E, whereas in Experiment 1 the proportion difference was 5.26%. Therefore, the tripled ED-versus-E difference in ironic process likelihood supported the hypothesis that the ironic and overcompensating processes are harmonized within groups when performance feedback is minimized. A further comparison on the absolute ironic process likelihood between Experiment 1 and 2 lead to two other findings. First, the overcompensation process was more likely to occur than the ironic process in both E and ED because both groups' ironic process likelihood

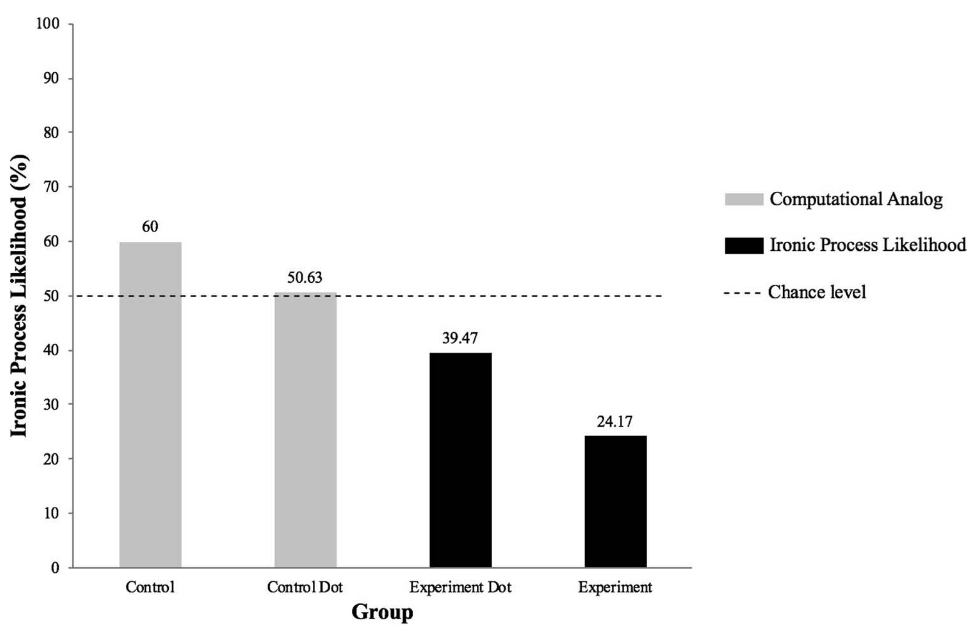

Figure 6. Ironic process likelihood of experimental group and experimental group with dot with computational analogs of control group and control group with dot in Experiment 2.

were under 40%. Second, E's ironic process likelihood was more susceptible to the performance feedback manipulation than that of ED. Specifically, whereas the ironic likelihood of ED stayed stable in the 39%–40% range, that of E dropped from 34% to 24% when performance feedback was limited.

Experiment 3: Flipping the Avoidance Goal

Experiment 3 was aimed at extending the testing of AIM by flipping the avoidance goal from "don't putt short of the target" to "don't putt long of the target." Moreover, the experimental condition was treated as a within-participant factor so that the prediction of AIM could be examined on within-individual variability. The hypothesis remained similar to that of Experiment 1, in that enhancing the monitor advantage through attentional imbalance would increase ironic process likelihood by resulting in longer putting performance.

Method

Participants. The sample size decision was based partially on that in Experiment 1 and on results obtained from the first two experiments of the current study. Specifically, because within-individual comparisons typically enjoy greater statistical power than between-individual comparisons, a sample of 12 participants was planned. A group of 12 right-handed collegiate students (5F; $M_{\text{age}} = 23.92$, $SD_{\text{age}} = 4.98$) from a Midwestern United States university took part in Experiment 3. All the participants gave and signed an informed consent that was approved by local ethics committee. Participants had to meet several inclusion criteria identical to those in Experiment 1.

Task. The current task was performed in a different laboratory than those of the first two experiments. Although the task followed that of Experiment 1, several changes are worth noting. First, given that no differences were identified between the two control conditions (i.e., C and CD) in previous experiments, the control condition with red dot placement (i.e., CD) was dropped in Experiment 3. Second, participants performed 10 putts in each of the three conditions, with the sequence of condition counterbalanced among them. Third, each participant was requested to rehearse a different six-digit number throughout a given condition according to a fixed order (i.e., 830596, 947136, 526894) so that the cognitive load among conditions was comparable. Fourth, the putting carpet used for Experiment 3 (3.66 m × 4.57 m) was wider than the one (1.60 m × 4.57 m) used in Experiment 1 and 2. Lastly, as displayed in Figure 7, the red dot was placed on a location 25 cm behind the target on the target-tee axis. The instruction for each condition was as follows:

1. Control group (C): "Putt the ball and try to make it land inside the circle."

2. Experimental group (E): "Putt the ball and try to make it land inside the circle, but be careful not to putt the ball over of the circle; don't putt the ball long."

3. Experimental group with dot (ED): "Putt the ball and try to make it land inside the circle, but be particularly careful not to land the ball on the red dot; don't land the ball on the red dot."

Materials and measures. A motion capture system consisting of 10 VICON™ F40 cameras capturing data at 100 Hz (Vicon,

Figure 7. Schematic representation of the putting surface for Experiment 3: putting green (dark gray rectangle), tee (white square), red dot (white dot, which appears only in experimental group with dot condition), and target (white ring).

Denver, CO) was used to identify the ball wrapped with infrared reflective tape and record the ball's final location after each putt in an X-Y coordinate system. The origin of the coordinate system was set at the center of the target with the Y axis matching the target-tee dimension on the green. The tee location was always measured for calibration purposes. The coordinates of the final ball location were transformed to putting distance and putting direction. Putting distance was identical to those in the first two experiments and represented the distance (in cm) traveled by the ball from the tee along the target-tee axis. Putting direction referred to the angular deviation (in angular degrees) of ball's final location from the tee-target axis with a perspective facing the target at the tee. Negative values of putting direction indicates that the ball stopped left to the target-tee axis and the opposite was true for positive values. Beyond ball location measures, participants' performance on correctly rehearsing each six-digit number was recorded after (s)he completed every task condition. Immediately after recalling the six-digit number, participants were asked to rate their effort on rehearsing the number while putting on a scale from 0 (*not at all*) to 10 (*maximal effort*).

Procedure. Upon laboratory arrival, participants were randomly assigned to one of the six possible counterbalanced order of conditions according to a randomization sheet generated in Microsoft Excel. Similar to previous experiments, each participant performed five practice putts prior to beginning the main task of three 10-trial blocks, with 1-min rest between blocks. During the main task, one experimenter gave condition-wise instructions and the six-digit number (to rehearse) to the participant by reading a prepared script, as well as retrieved and placed the ball back at the tee after each putt from the participant. A second experimenter sat behind a computer (outside the participant's view) to record the final ball location in each putt via the motion analysis system. Upon completion of each condition (i.e., a 10-trial block), the participant was asked to recall the six-digit number and the accuracy of the recall was recorded. The participant also rated the effort in rehearsing the number.

Analysis. SPSS 20.0 was used to conduct the analyses. In a preliminary analysis, the number of trials wherein the ball went off the putting green was counted, and participants' performance and effort on rehearsing the six-digit numbers were summarized. In the formal analyses, three repeated-measure (RM) ANOVAs with condition as a within-participant factor were performed on the putting performance average. The first RM ANOVA was performed on putting distance. The second RM ANOVA was performed on putting direction and the last RM ANOVA on the absolute values of putting direction. Fisher's LSD was used in pairwise comparisons and the α level was set at .05.

Results

Preliminary procedure. The ball rolled beyond the length limit of the green carpet in only one trial (0.3% of total trials). Moreover, participants had an overall success rate of 69.44% in correctly reporting the rehearsed six-digit numbers and reported putting effort on rehearsing the numbers ($M_{\text{rating}} = 7.17$, $SD_{\text{rating}} = 2.41$).

Putting distance. RM ANOVA revealed a significant effect of condition, $F(2, 22) = 5.55$, $p = .01$, $\eta_p^2 = .34$. Figure 8 displays the condition-wise average. Pairwise comparison results revealed that E ($M = 174.51$, $SD = 16.82$) demonstrated shorter putts than both C ($M = 189.08$, $SD = 13.88$), $p < .004$, Cohen's $d = -1.13$, and ED ($M = 182.93$, $SD = 15.69$), $p = .02$, Cohen's $d = -0.80$. In addition, ED and C were no different from each other on putting distance, $p = .29$, although descriptively ED is shorter than C (Cohen's $d = -0.34$). Therefore, the current result pattern (E $<$ ED $\leq$ C) was consistent with those of the previous experiments and supported the hypothesis that creating monitor advantage through attentional imbalance enhances the likelihood of ironic process.

Putting direction. RM ANOVA analyses indicated null findings regarding the effect of condition on both putting direction ($p > .92$) and the absolute values of putting direction ($p > .47$). Overall right-handed novices demonstrated a tendency to putt slightly toward the left of the target-tee axis ($M = -0.59°$, $SD = 1.30°$).

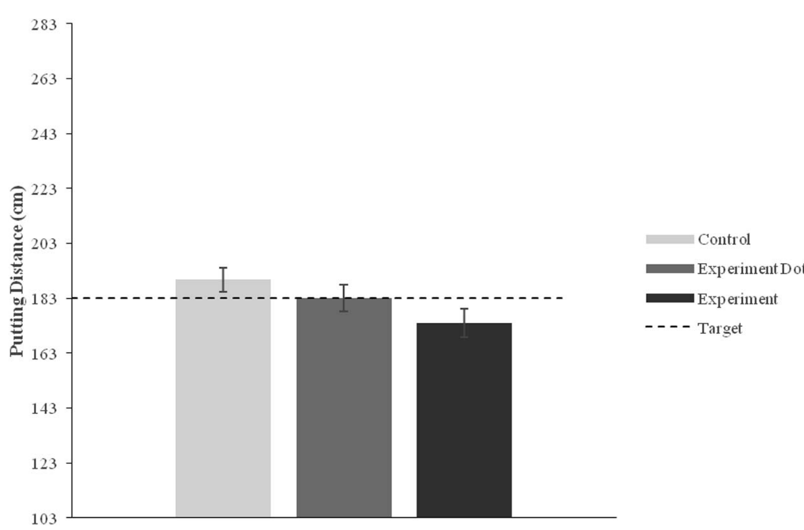

Figure 8. Average putting performance (and standard errors) of all the conditions in Experiment 3.

Discussion

Although the avoidance goal was flipped, the current results replicated those in the first two experiments, supporting the AIM in that creating attentional imbalance enhances ironic process likelihood (or decreases overcompensating process likelihood) in golf putting. This replication is meaningful in expanding the AIM's predictive power toward multiple directions. First, because Experiment 3 was conducted in a different laboratory than the first two experiments, it included a new set of measurement methods, study materials, and participant sources. Obtaining the replication thus makes the finding generalizable to these changing experimental factors. Second, considering the experimental condition is switched from a between-participants factor to a within-participant factor, the replication shows that the AIM can predict performance fluctuations within individuals. Such an understanding is of value to both researchers and practitioners. For instance, researchers can preserve their efforts through reduced sample size by adopting a within-participant design in future AIM-testing experiments; coaches, athletes, and motor task performers can use the AIM to improve goal setting in motor performance. Last but not least, the experiment yielded evidence that manipulating attentional imbalance along the spatial dimension of putting distance does not elicit changes in putting direction. This finding not only evidences the validity of the present attentional manipulation but also sparks interest in testing the AIM in putting direction instead of distance.

Experiment 4: Putting Direction Instead of Distance

Experiment 4 was designed to test whether AIM-based prediction would also be supported on putting direction. Given that right-handed novices tended to putt the ball to the left of the target in Experiment 3, the avoidance goal in Experiment 4 was generally phrased as "don't putt to the left of the target." It is expected that enhancing monitor advantage through attentional imbalance would increase ironic process likelihood by resulting in putts located more left to the target-tee axis.

Method

Participants. The sample size decision was identical to that of Experiment 3. A total of 12 right-handed collegiate students (7F; M_{age} = 22.67, SD_{age} = 2.64) from a Midwestern United States university participated in the experiment. All the participants gave and signed an informed consent that was approved by local ethics committee. Participants had to meet several inclusion criteria identical to those in Experiment 1.

Task. The current task was identical to that in Experiment 3 except for the location of red dot placement and the corresponding experimental instructions. Figure 9 displays the placement of the red dot. The dot was placed at a location 25 cm from the target center and 183 cm from the tee on the left side of the target-tee axis from a perspective at the tee facing the target. The experimental condition instructions were:

1. Control group (C): "Putt the ball and try to make it land inside the circle."

2. Experimental group (E): "Putt the ball and try to make it land inside the circle, but be careful not to putt the ball left of the circle; don't putt the ball to the left."

3. Experimental group with dot (ED): "Putt the ball and try to make it land inside the circle, but be particularly careful not to land the ball on the red dot; do not land the ball on the red dot."

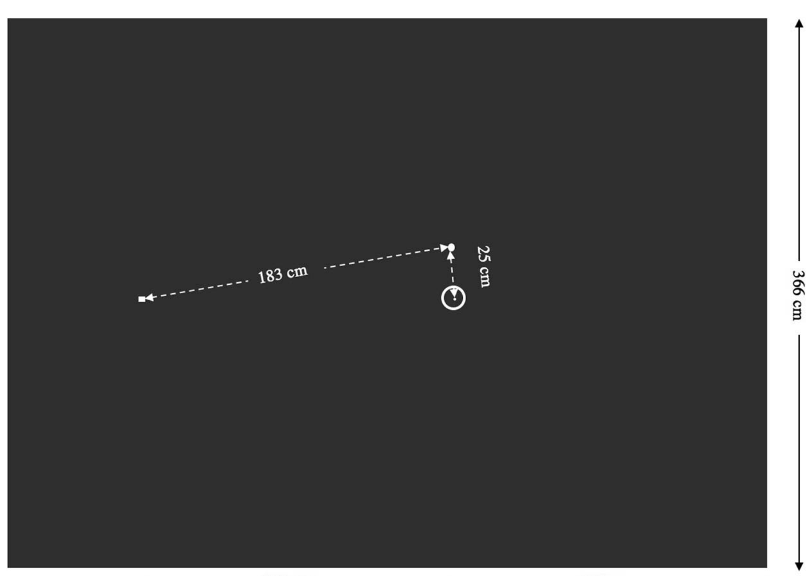

Figure 9. Schematic representation of the putting surface for Experiment 4: putting green (dark gray rectangle), tee (white square), red dot (white dot, which appears only in experimental group with dot condition), and target (white ring).

Materials and measures. The materials and measures were identical to those in Experiment 3.

Procedure. The procedure was identical to that of Experiment 3, with the exception of the red dot placement and corresponding experimental instructions.

Analysis. The statistical analyses were identical to those of Experiment 3 with one exception, wherein a histogram showing the trial distribution of putting direction was plotted using R.

Results

Preliminary procedure. The ball never rolled off the carpet. Moreover, participants had an overall success rate of 94.44% in correctly reporting the rehearsed six-digit numbers and reported putting effort on rehearsing the numbers ($M_{\text{rating}} = 6.89$, $SD_{\text{rating}} = 2.03$).

Putting direction. RM ANOVA generated null findings regarding the effect of condition on both putting direction ($p > .23$) and the absolute values of putting direction ($p > .21$). Similar to the finding in Experiment 3, the right-handed novices demonstrated a tendency to putt slightly toward the left of the target ($M = -0.35°$, $SD = 1.60°$). Figure 10 illustrated the distribution of putting direction across all trials. The distribution evidenced that participants putted the ball inside the angular range of target (i.e., [−1.69°, 1.69°]) in 77.22% of all trials ($n = 360$).

Putting distance. RM ANOVA revealed no effect of condition on putting distance ($p > .95$). Overall the participants demonstrated a tendency to putt the ball longer than the target ($M = 190.93$, $SD = 12.59$).

Discussion

The present null findings highlight that testing the AIM in motor performance demands task-specific considerations. Even in the present putting setting wherein a chalked target (10.8 cm in diameter) lies 183 cm away from the tee on a flat indoor carpet, putting direction may require distinguishable considerations than putting distance. Two such considerations are identified retrospectively. First, switching the testing from distance to direction likely results in changes in task difficulty, which interact with effectiveness of experimental instructions. Figure 10 illustrated that 77.22% of putts were aligned within the angular range of the target, suggesting that achieving satisfactory putting direction is not difficult. Such ease may release participants from paying attention to the avoidance instructions on putting direction and renders the attention manipulation ineffective. The ease may have also facilitated the secondary task of rehearsing six-digit numbers by increasing the success rate of rehearsal from 69.44% in Experiment 3 to 94.44% in Experiment 4. This explanation is supported by the null finding that no overcompensating performance was observed from the E-C comparison. Second, performance on putting direction may be a challenging case to test the AIM due to task-specific constraints. It has been reported that, in contrast to the perceived importance of putting stroke on determining putting direction, the face angle of putter head at ball impact was found to predict about 80% of putting direction variability (Karlsen, Smith, & Nilsson, 2008; Pelz, 2000). This is to say that putting direction in the current task is predominantly decided by how the putter is held by novices at the putter-ball contact rather than kinematic movements in putting stroke. Such task-specific constraints may have restricted the testing of AIM, according to which putting direction was expected to result from putting strokes, which should be further affected by attentional manipulations.

General Discussion

The present study is aimed to investigate the ironic and overcompensating processes under avoidance instructions in motor

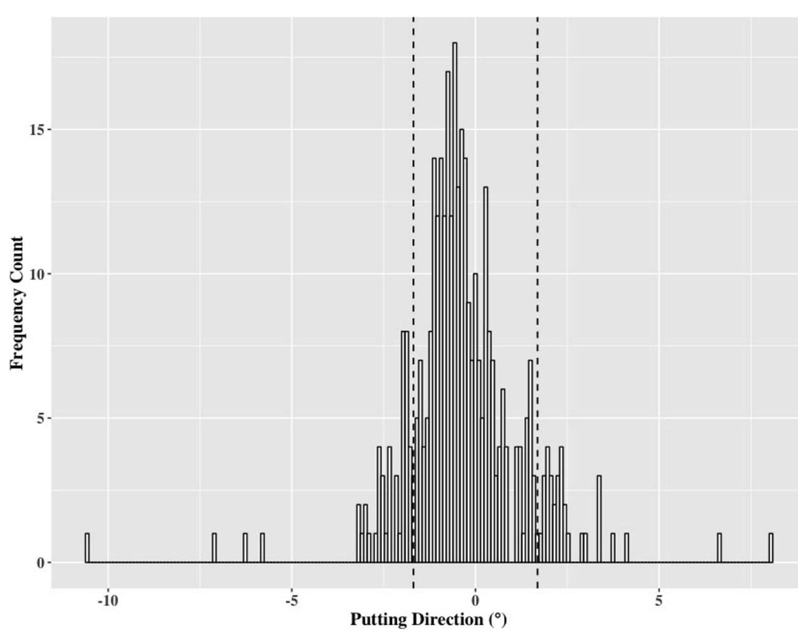

Figure 10. Histogram of putting direction (dashed lines represent the putting directions corresponding to the left and right boundaries of the target when viewed at the tee).

tasks. These two processes are frequently observed in golf putting (e.g., Beilock et al., 2001; Binsch et al., 2009) but remain partially understood. The difficulty lies in how to conceptualize the two processes' coexistence. de la Peña et al. (2008) first attempted to conceptualize the overcompensating process by introducing the IOH. However, the IOH was not based on a given theory and could not account for the ironic process. The IOH is thus limited in its interpretation, development, and prediction. By comparison, the CSH is embedded in the IPT and is detailed in describing the attentional control process, although it is also limited by not including a conceptualization of the overcompensating process. The AIM was thus developed to extend the IOH and CSH, and to help conceptualize observations of both ironic and overcompensating processes under avoidance instructions in motor tasks. The AIM highlights a dual-process attentional control in a parallel-competitive form between the operator and the monitor. Both attentional control processes are presumed to simulate behaviorally subthreshold motor programs in the neural network. The dual-process competition thereby balances the likelihood between ironic and overcompensating processes in motor performance under avoidance goals.

Four golf-putting experiments involving features of those in de la Peña et al. (2008) and Wegner et al. (1998) were conducted to test the AIM. Overall results from Experiments 1–3 supported the AIM in that increasing the monitor advantage in attentional control competition increased the ironic process likelihood, although the overall ironic process likelihood was lower than the overcompensating process likelihood. In addition, results from Experiment 2 indicated that motor planning (based on knowledge of previous putting outcomes) was likely to confound performance measurement by decreasing the overcompensating process likelihood. Lastly, the null results from Experiment 4 highlighted the importance of providing task-specific considerations to experimental designs. Such considerations rely on understandings of the two attentional processes outlined in the AIM.

Ironic Process

Studies testing IPT in the motor domain represent an attempt to transfer and extend the avoidance-induced ironic process from thinking to doing (Janelle, 1999). This transfer may have seemed straightforward—just giving participants an avoidance instruction and a form of cognitive load in a motor task. Unfortunately, such a transfer of research design between task settings can put the cart before the horse by ignoring the underpinning mechanism in attentional control. Given specific task settings, understanding the monitor-operator competition in the AIM helps explain the behavioral manifestation of ironic process in motor tasks. That is, an attention imbalance of target search favoring monitor is necessary for eliciting an observable ironic process. In a thought suppression experiment where one is asked to not think about a given thought, the to-be suppressed thought itself carries important characteristics. Namely, the thought is often distinctive (e.g., a white bear) or is associated with social/clinical significance (e.g., stereotypes) so that its suppression hardly leads to a replacement by an opposite thought (see Galinsky & Moskowitz, 2007). Given this attention imbalance in target search, the monitor would gain a competing advantage against the operator. This advantage is typically further amplified with the presence of cognitive load because the functioning of the operator is more susceptible to limited cognitive resources than the monitor (Wegner, 1994).

In contrast, when eliciting an ironic process in a motor task using the manipulation of an avoidance instruction and a cognitive load, the interpretation of operator-monitor attentional control needs caution. One reason is, in the motor task, the search space for operator and monitor becomes spatially defined. For instance, for the E condition of Experiment 1–3, its manipulation was not creating attention imbalance due to a roughly symmetric search range between operator and monitor. This roughly balanced attention space means that the operator is still likely to maintain functioning by directing attention to searching the target and overcompensating zone, implying a switch from feature-negative search to feature-positive search for the operator in AIM. Thus, it is unsurprising to observe an overcompensating outcome in the E condition. To improve the manipulation of attention imbalance, we added a red dot on the carpet in the ED condition. The red dot was expected to be attentional-control-wise similar to a distinctive thought like a white bear, while its avoidance prompts an action simulation of putting the ball on the red dot (which is short of the target). Results from the first three experiments indicated that ED had less overcompensating performance than E plausibly due to an increased ironic process likelihood, supporting the importance of attention imbalance proposed in AIM.

The concept of attention imbalance must be understood as a continuum in enhancing the ironic process. Lavy and van den Hout (1990) suggested the degree of attention imbalance induced by avoidance instructions can moderate the salience of to-be-suppressed stimulus. Namely, the to-be-avoided information is increasingly likely to be processed as the level of attention imbalance increases. This argument is in tandem with the functioning principle of lower-level receptive neurons (e.g., photoreceptive cells in retina) in that the main determinant of these receptors' firing responses is the contrast between stimuli in the receptive field (Nolte, 2009).

The level of attention imbalance can be affected by both internal and external human factors (Desimone & Duncan, 1995). The present study focused on increasing attention imbalance by means of external factors, such as the contrast of visual angle and color of visual objects. Participants in the ED condition suppressed a small red dot on a green carpet and they were thus expected to have higher degrees of attention imbalance than those in the E condition, who suppressed almost half of the putting surface. Due to the lighting method of the task environment, Wegner et al.'s (1998) participants may have had an even higher level of attention imbalance than those in the ED condition. This might explain Wegner et al.'s (1998) observation of a dominating ironic process in their golf-putting task than that of the current study.

Attention imbalance can also be affected by internal human factors, such as perceptual deficiency and attachment of emotional value. If participants with color blindness were to be included in the ED condition, the degree of attention imbalance would decrease for these participants because of their reduced perceptual acuity of the red dot on the green putting surface. In thought suppression studies, the to-be-suppressed thoughts are often those bearing negative emotional value, such as one associated with posttraumatic stress disorder (Shipherd & Beck, 1999) or obsessive–compulsive disorder (Najmi, Riemann, & Wegner, 2009). However, it is difficult to manipulate attention imbalance using a negative emotional value in motor tasks. A hypothetical situation would be to ask an athlete to avoid performing in an exact way that repeats a prior choking-under-pressure experience. Such a situation would be similar to a thought suppression experiment involving a thought related to posttraumatic stress disorder. Anecdotally, Liu et al. (2015) recounted a case about the United States Olympic marksman, Matthew Emmons, who lost two gold and one silver medal in the same shooting event in three consecutive Olympics. Emmons choked under pressure repetitively in his last trials of the three Olympics. During the press interview, he mentioned using avoidance self-instructions before shooting the last trials (D'Alessandro, 2012, Paragraph 14).

Overcompensating Process

AIM also helps conceptualize the appearance of overcompensating process under avoidance instructions. Specifically, an overcompensating process would be predicted given a low attention imbalance. This prediction is consistent with details from Lavy and van den Hout's (1990) thought suppression study, in which the treatment group was asked to suppress a thought of "vehicles." When describing the instruction to the treatment group, Lavy and van den Hout wrote "they [participants] were to try not to think of 'vehicles' . . . The results of pilot studies showed that it was necessary to add something else to the instructions, namely, that the Ss [student participants] should not use deliberate distraction strategies" (p. 254). Because the thought of "vehicles" was less distinctive than those used in other thought suppression studies (e.g., a white bear), the lowered degree of attention imbalance in Lavy and van den Hout's experiment may have motivated participants to assume a strategy of focusing on a distracting/replacing thought. We argue that the strategy involves the same attentional control mechanism underpinning the overcompensating performance in motor tasks.

The low attention imbalance explanation for overcompensating process is supported by motor evidence beyond golf putting, although the evidence tends to be underpresented in original studies. For instance, Woodman et al. (2015) recently tested the IPT in a hockey penalty-shooting task and dart-throwing task. In hockey penalty shooting, participants were instructed to avoid shooting the puck to a space 138 cm wide measured outside from the right-hand post of the goal (i.e., ironic zone). In addition, the total width of the goal was separated into a 138-cm wide space from inside the left-hand post (i.e., nonironic zone) and a 45-cm wide space (i.e., target zone) by a rope hanged vertically from the horizontal post of the goal. In dart throwing, a quadrant of the dartboard was marked as an avoidant area of performance and this ironic quadrant was rotated through all the four quadrants throughout the task. Although results from both tasks revealed ironic processes under avoidance instructions in that the presence of cognitive load increased likelihood of ironic process, the unmentioned likelihood of overcompensating process was always higher than that of ironic process. Specifically, in the hockey task, participants shot more to the nonironic zone (i.e., an overcompensating zone) than both the target zone and the ironic zone. In the dart-throwing task, participants threw more darts to the dartboard quadrant exactly opposing to the ironic quadrant than the other three quadrants. Note that the spatial definition of Woodman et al.'s motor tasks is similar to those of the golf-putting studies, such that a symmetrical space opposing to the to-be-avoided task space was suggested and available to participants.

AIM further implies that an overcompensating process should not be a subconscious process because the operator is a conscious attentional control agent. This notion is in conflict with de la Peña et al.'s (2008) IOH, which treated the overcompensating process as an implicit (i.e., unconscious) process. Although the level of consciousness is a complicated research topic by itself (Damasio, 1999), preliminary evidence suggests that an overcompensating process is at least conscious in that the overcompensating strategy/intention is accessible to participants' retrospective self-report. For example, Beilock et al.'s (2001) participants were instructed to perform four types of visualization in their minds before putting golf balls to a target. After every putt, Beilock et al. (2001) immediately asked participants to report the image they had in their minds prior to putting. For participants receiving avoidance imagery instructions (i.e., not putt long/short), they reported performing overcompensating visualizations in about 80% of occasions when the ball was not visualized to stop on the target, while behaviorally demonstrating overcompensating putting performance.

A subconscious ironic process and a conscious overcompensating process are also consistent with the present result. Unlike the ironic process, the overcompensating process is sensitive to the performance feedback. Specifically, E demonstrated an increase of overcompensating process likelihood (i.e., $1 - p_{\text{ironic}}$) by 10% after performance feedback was minimized from a comparison between results of Experiment 1 and 2. This change can be understood in a way that participants alter their conscious overcompensating process given the feedback of previously overcompensated trial outcomes. In other words, participants in the E condition in Experiment 1 possibly adjusted performance based on previous trial outcomes compared to their counterparts in Experiment 2. Because they were likely to see overcompensated outcomes and they also held the goal to putt the ball to the target, they may change their motor planning by overcompensating the previously overcompensated putts, resulting in an inflation of ironic process likelihood (see Figure 4). Future studies are thus encouraged to gain evidence in testing whether the overcompensating process is conscious by using, for instance, Ericsson and Simon's (1980) verbal report procedure.

Further Issues and Research Directions

Several issues highlighting additional differences between thought-suppression and motor studies are worth noting. First, unlike thought suppression, motor studies must conceptually differentiate the ironic/overcompensating process from the ironic/overcompensating error. When one thinks the to-be-suppressed thought, ironic process and ironic error are hardly distinguishable concepts because the thinking action can be both a part of neural pathway ("process") and an observable outcome ("error"). In contrast, the AIM advocates that motor studies should treat avoidance-goal-induced ironic and overcompensating processes as two competing action simulations in the neural network prior to task execution, and treat ironic and overcompensating errors as performance outcomes judged according to avoidance goals. "Process" is preferred to "error" in the AIM because of its mechanistic nature and because of the easiness for "error" to get confounded by "nonprocess" factors. For instance, when instructed to avoid putting the ball on the red dot placed in front of the target, the ironic process involves simulating an action of putting on the red dot (which is short of target) in neural network prior to execution, but the ironic error refers to an outcome of landing the ball on the red dot. Observing this ironic error is decided by many factors other than the associated ironic process, such as the technical difficulty of such a putt, the motor planning prompted by previous performance feedback (Experiment 2), and the task-specific constraints (Experiment 4).

The second issue concerns the complexity of task goals. Task goals in thought suppression studies are typically simpler than those in motor studies. For example, Wegner et al.'s (1987) task goal involves only the suppression of a white bear, whereas the goal of the present ED condition includes a to-be-avoided red dot and a chalked circle as the performance target. Because the operator can focus on searching the chalked circle (and thus ignore the overcompensating space) and monitor searching the red dot, the chalked circle may lower the attention imbalance, and thus reduce the ironic process likelihood. Supporting evidence for such an argument can be found in thought suppression studies where more than one task goal exists. For example, in Wegner et al.'s (1987) Experiment 2, participants required to suppress a white bear by distracting themselves with a red Volkswagen did not demonstrate a clear ironic process of thought suppression. However, not all motor tasks have more than one goal. For example, Liu et al. (2015) and Dugdale and Eklund (2003) had their participants focus on suppressing failures in steadying upper and lower limbs, respectively. Both studies revealed only a heightened ironic process of limb unsteadiness induced by avoidance instructions. Therefore, specifying a focused target in addition to specifying a to-be-avoided target seems to attenuate the ironic process likelihood and this issue merits further investigation.

The third issue concerns how performance is measured. Specifically, thought suppression studies focus on measuring the conscious self-report of the to-be-suppressed thought, whereas motor studies involve measurement of all behavioral outcomes that include to-be-avoided space. Such a difference in measurement may have contributed to the difficulty in comparing the results from thought suppression to motor suppression. For instance, the rare appearance of an overcompensating process in thought suppression literature may be due to the fact of solely measuring the to-be-suppressed thought while ignoring other contents in consciousness. That is to say that not all thoughts were measured in the thought suppression tasks. If thought suppression studies could include a way to measure all thought contents, it would be possible to make more comprehensive comparisons between thought suppression and motor studies.

Fourth, because neither overcompensating nor ironic process induced by avoidance goals is favorable in motor tasks, the ebb and flow of avoidant intentions in minds of motor performers warrants research attention. In athletic competitions, for instance, athletes can have avoidant task goals either from coaches or themselves given the motor planning process combined with knowledge of past performance outcomes. How does such a priming of avoidant intention influence one's thinking process prior to task execution? Are there mental strategies to help manage such a priming? These are still open questions because no research has been conducted to gauge such thought control process in athletic settings. Sparrow and Wegner (2006) offered a general hypothesis, in which thought priming is argued as part of a human adaptive system in interacting with environment and the realization of a primed behavior or thought should reduce the priming of corresponding thought or behavior. In other words, a priming-induced manifestation of behavior or conscious thought should result in unpriming. Preliminary evidence from nonathlete populations lent support to this hypothesis, showing that an acceptance-mindfulness strategy helped unprime avoidant thoughts (Ma & Teasdale, 2004; Sparrow & Wegner, 2006).

Lastly, quiet eye training seems to be a viable strategy to help prevent motor performance decline from avoidant task goals. The quiet eye (QE) generally refers to the final visual fixation to target prior to motor task execution (for details see Vickers, 2007). Maintaining a relatively long QE duration has been linked to better motor performance within and between individuals, and training protocols designed to prolong QE duration have been shown to result in large performance enhancements (Lebeau et al., 2016). In addition, QE has been deemed important in attention control: QE strengthens goal-driven attention system while weakening the stimulus-driven attention system (Corbetta, Patel, & Shulman, 2008; Vine, Moore, & Wilson, 2014). Such an attentional control account of QE shares substantial insight with AIM in that both frameworks are dual-process models per se. Thus, within the AIM framework, it can be described that QE enhances operator functioning (especially when the visual target is clear and available) but has an opposite effect on the monitor. In this sense, QE training can be a valuable strategy to attenuate overcompensating or ironic processes resulted from avoidant goals in motor tasks. Therefore, QE training (Vine et al., 2014) is recommended for practitioners working to optimize motor performance through an attentional control approach.

References

Abramowitz, J. S., Tolin, D. F., & Street, G. P. (2001). Paradoxical effects of thought suppression: A meta-analysis of controlled studies. *Clinical Psychology Review, 21,* 683–703. http://dx.doi.org/10.1016/S0272-7358(00)00057-X

Bacon, W. F., & Egeth, H. E. (1994). Overriding stimulus-driven attentional capture. *Perception & Psychophysics, 55,* 485–496. http://dx.doi.org/10.3758/BF03205306

Bakker, F. C., Oudejans, R. R. D., Binsch, O., & Kamp, J. V. D. (2006). Penalty shooting and gaze behavior: Unwanted effects of the wish not to miss. *International Journal of Sport Psychology, 37,* 265–280.

Beck, D. M., & Lavie, N. (2005). Look here but ignore what you see: Effects of distractors at fixation. *Journal of Experimental Psychology: Human Perception and Performance, 31,* 592–607. http://dx.doi.org/10.1037/0096-1523.31.3.592

Beilock, S. L., Afremow, J. A., Rabe, A. L., & Carr, T. H. (2001). "Don't miss!" The debilitating effects of suppressive imagery on golf putting performance. *Journal of Sport & Exercise Psychology, 23,* 200–221. http://dx.doi.org/10.1123/jsep.23.3.200

Binsch, O., Oudejans, R. R. D., Bakker, F. C., & Savelsbergh, G. J. P. (2009). Unwanted effects in aiming actions: The relationship between gaze behavior and performance in a golf putting task. *Psychology of Sport and Exercise, 10,* 628–635. http://dx.doi.org/10.1016/j.psychsport.2009.05.005

Binsch, O., Oudejans, R. R. D., Bakker, F. C., & Savelsbergh, G. J. P. (2010). Ironic effects and final target fixation in a penalty shooting task. *Human Movement Science, 29,* 277–288. http://dx.doi.org/10.1016/j.humov.2009.12.002

Birch, J. (1997). Efficiency of the Ishihara test for identifying red-green colour deficiency. *Ophthalmic & Physiological Optics, 17,* 403–408. http://dx.doi.org/10.1111/j.1475-1313.1997.tb00072.x

Clark, D. M., Ball, S., & Pape, D. (1991). An experimental investigation of thought suppression. *Behaviour Research and Therapy, 29,* 253–257. http://dx.doi.org/10.1016/0005-7967(91)90115-J

Clark, D. M., Winton, E., & Thynn, L. (1993). A further experimental investigation of thought suppression. *Behaviour Research and Therapy, 31,* 207–210. http://dx.doi.org/10.1016/0005-7967(93)90074-5

Cooke, A., Gallicchio, G., Kavussanu, M., Willoughby, A., McIntyre, D., & Ring, C. (2015). Premovement high-alpha power is modulated by previous movement errors: Indirect evidence to endorse high-alpha power as a marker of resource allocation during motor programming. *Psychophysiology, 52,* 977–981. http://dx.doi.org/10.1111/psyp.12414

Corbetta, M., Patel, G., & Shulman, G. L. (2008). The reorienting system of the human brain: From environment to theory of mind. *Neuron, 58,* 306–324. http://dx.doi.org/10.1016/j.neuron.2008.04.017

D'Alessandro, D. (2012, August 6). London Olympics: Matt Emmons, a Browns Mills native, take bronze in 50-meter three-position rifle. *NJ.COM*. Retrieved from https://www.nj.com/olympics/index.ssf/2012/08/london_olympics_matt_emmons_a.html

Damasio, A. R. (1999). *The feeling of what happens: Body and emotion in the making of consciousness*. New York, NY: Harcourt.

de la Peña, D., Murray, N. P., & Janelle, C. M. (2008). Implicit overcompensation: The influence of negative self-instructions on performance of a self-paced motor task. *Journal of Sports Sciences, 26,* 1323–1331. http://dx.doi.org/10.1080/02640410802155138

Desimone, R., & Duncan, J. (1995). Neural mechanisms of selective visual attention. *Annual Review of Neuroscience, 18,* 193–222. http://dx.doi.org/10.1146/annurev.ne.18.030195.001205

Dugdale, J. R., & Eklund, R. C. (2003). Ironic processing and static balance performance in high-expertise performers. *Research Quarterly for Exercise and Sport, 74,* 348–352. http://dx.doi.org/10.1080/02701367.2003.10609102

Ericsson, K. A., & Simon, H. A. (1980). Verbal reports as data. *Psychological Review, 87,* 215–251. http://dx.doi.org/10.1037/0033-295X.87.3.215

Evans, J. S. B. T., & Stanovich, K. E. (2013). Dual-process theories of higher cognition: Advancing the debate. *Perspectives on Psychological Science, 8,* 223–241. http://dx.doi.org/10.1177/1745691612460685

Folk, C. L., & Remington, R. (1998). Selectivity in distraction by irrelevant featural singletons: Evidence for two forms of attentional capture. *Journal of Experimental Psychology: Human Perception and Performance, 24,* 847–858. http://dx.doi.org/10.1037/0096-1523.24.3.847

Galinsky, A. D., & Moskowitz, G. B. (2007). Further ironies of suppression: Stereotype and counterstereotype accessibility. *Journal of Experimental Social Psychology, 43,* 833–841. http://dx.doi.org/10.1016/j.jesp.2006.09.001

Gorgulu, R., Cooke, A., & Woodman, T. (2019). Anxiety and ironic errors of performance: Task instruction matters. *Journal of Sport & Exercise Psychology, 41,* 82–95. http://dx.doi.org/10.1123/jsep.2018-0268

Gray, R., Orn, A., & Woodman, T. (2017). Ironic and reinvestment effects in baseball pitching: How information about an opponent can influence performance under pressure. *Journal of Sport & Exercise Psychology, 39,* 3–12. http://dx.doi.org/10.1123/jsep.2016-0035

Hommel, B., Müsseler, J., Aschersleben, G., & Prinz, W. (2001). The theory of event coding (TEC): A framework for perception and action planning. *Behavioral and Brain Sciences, 24,* 849–878. http://dx.doi.org/10.1017/S0140525X01000103

IBM Corporation. (2011). IBM SPSS statistics for windows (Version 20.0) [Computer software]. Armonk, NY: Author.

Ishihara, S. (1966). *Tests for color-blindness*. Tokyo, Japan: Kanehara Shuppan.

Janelle, C. M. (1999). Ironic mental processes in sport: Implications for sport psychologists. *The Sport Psychologist, 13,* 201–220. http://dx.doi.org/10.1123/tsp.13.2.201

Jeannerod, M. (2001). Neural simulation of action: A unifying mechanism for motor cognition. *NeuroImage, 14,* S103–S109. http://dx.doi.org/10.1006/nimg.2001.0832

Jeannerod, M. (2006). *Motor cognition: What actions tell the self*. Oxford, UK: Oxford University Press. http://dx.doi.org/10.1093/acprof:oso/9780198569657.001.0001

Karlsen, J., Smith, G., & Nilsson, J. (2008). The stroke has only a minor influence on direction consistency in golf putting among elite players. *Journal of Sports Sciences, 26,* 243–250. http://dx.doi.org/10.1080/02640410701530902

Lavy, E. H., & van den Hout, M. A. (1990). Thought suppression induces intrusions. *Behavioural Psychotherapy, 18,* 251–258. http://dx.doi.org/10.1017/S0141347300010351

Lebeau, J. C., Liu, S., Sáenz-Moncaleano, C., Sanduvete-Chaves, S., Chacón-Moscoso, S., Becker, B. J., & Tenenbaum, G. (2016). Quiet eye and performance in sport: A meta-analysis. *Journal of Sport & Exercise Psychology, 38,* 441–457. http://dx.doi.org/10.1123/jsep.2015-0123

Liu, S., Eklund, R. C., & Tenenbaum, G. (2015). Time pressure and attention allocation effect on upper limb motion steadiness. *Journal of Motor Behavior, 47,* 271–281. http://dx.doi.org/10.1080/00222895.2014.977764

Liu, S., Lebeau, J. C., & Tenenbaum, G. (2016). Does exercise improve cognitive performance? A conservative message from Lord's Paradox. *Frontiers in Psychology, 7,* 1092. http://dx.doi.org/10.3389/fpsyg.2016.01092

Ma, S. H., & Teasdale, J. D. (2004). Mindfulness-based cognitive therapy for depression: Replication and exploration of differential relapse prevention effects. *Journal of Consulting and Clinical Psychology, 72,* 31–40. http://dx.doi.org/10.1037/0022-006X.72.1.31

Merchelbach, H., Muris, P., van den Hout, M. A., & de Jong, P. (1991). Rebound effect of thought suppression: Instruction-dependent? *Behavioural Psychotherapy, 19,* 225–238. http://dx.doi.org/10.1017/S0141347300013264

Najmi, S., Riemann, B. C., & Wegner, D. M. (2009). Managing unwanted intrusive thoughts in obsessive-compulsive disorder: Relative effectiveness of suppression, focused distraction, and acceptance. *Behaviour Research and Therapy, 47,* 494–503. http://dx.doi.org/10.1016/j.brat.2009.02.015

Newman, J., Wolff, W. T., & Hearst, E. (1980). The feature-positive effect in adult human subjects. *Journal of Experimental Psychology: Human Learning and Memory, 6,* 630–650. http://dx.doi.org/10.1037/0278-7393.6.5.630

Nolte, J. (2009). *The human brain: An introduction to its functional anatomy*. Philadelphia, PA: Mosby/Elsevier.

Oudejans, R. R. D., Binsch, O., & Bakker, F. C. (2013). Negative instructions and choking under pressure in aiming at a far target. *International Journal of Sport Psychology, 44,* 294–309.

Pelz, D. (2000). *David Pelz's putting bible: The complete guide to mastering the green*. New York, NY: Doubleday.

PGA. (2019). *Statistics*. Retrieved from https://www.pgatour.com/stats/categories.RPUT_INQ.html

Rayner, K., Inhoff, A. W., Morrison, R. E., Slowiaczek, M. L., & Bertera, J. H. (1981). Masking of foveal and parafoveal vision during eye fixations in reading. *Journal of Experimental Psychology: Human Perception and Performance, 7,* 167–179. http://dx.doi.org/10.1037/0096-1523.7.1.167

R Core Team. (2017). *R: A language and environment for statistical computing*. Vienna, Austria: R Foundation for Statistical Computing. Retrieved from https://www.R-project.org/

Russell, C., & Grealy, M. A. (2010). Avoidant instructions induce ironic and overcompensatory movement errors differently between and within individuals. *Quarterly Journal of Experimental Psychology: Human Experimental Psychology, 63,* 1671–1682. http://dx.doi.org/10.1080/17470210903572022

Salkovskis, P. M. (1996). Cognitive-behavioral approaches to the understanding of obsessional problems. In R. Rapee (Ed.), *Current controversies in the anxiety disorders* (pp. 103–133). New York, NY: Guilford Press.

Schmidt, R. A., & Lee, T. D. (2005). *Motor control and learning: A behavioral emphasis* (4th ed.). Champaign, IL: Human kinetics.

Shipherd, J. C., & Beck, J. G. (1999). The effects of suppressing trauma-related thoughts on women with rape-related posttraumatic stress disorder. *Behaviour Research and Therapy, 37,* 99–112. http://dx.doi.org/10.1016/S0005-7967(98)00136-3

Sparrow, B., & Wegner, D. M. (2006). Unpriming: The deactivation of thoughts through expression. *Journal of Personality and Social Psychology, 91,* 1009–1019. http://dx.doi.org/10.1037/0022-3514.91.6.1009

Theeuwes, J. (1991). Cross-dimensional perceptual selectivity. *Perception & Psychophysics, 50,* 184–193. http://dx.doi.org/10.3758/BF03212219

Theeuwes, J. (1992). Perceptual selectivity for color and form. *Perception & Psychophysics, 51,* 599–606. http://dx.doi.org/10.3758/BF03211656

Toner, J., Moran, A., & Jackson, R. (2013). The effects of avoidant instructions on golf putting proficiency and kinematics. *Psychology of Sport and Exercise, 14,* 501–507. http://dx.doi.org/10.1016/j.psychsport.2013.01.008

Vickers, J. N. (2007). *Perception, cognition, and decision training: The quiet eye in action*. Champaign, IL: Human Kinetics.

Vine, S. J., Moore, L. J., & Wilson, M. R. (2014). Quiet eye training: The acquisition, refinement and resilient performance of targeting skills. *European Journal of Sport Science, 14,* S235–S242. http://dx.doi.org/10.1080/17461391.2012.683815

Wegner, D. M. (1994). Ironic processes of mental control. *Psychological Review, 101,* 34–52. http://dx.doi.org/10.1037/0033-295X.101.1.34

Wegner, D. M., Ansfield, M., & Pilloff, D. (1998). The putt and the pendulum: Ironic effects of the mental control of action. *Psychological Science, 9,* 196–199. http://dx.doi.org/10.1111/1467-9280.00037

Wegner, D. M., Schneider, D. J., Carter, S. R., III, & White, T. L. (1987). Paradoxical effects of thought suppression. *Journal of Personality and Social Psychology, 53,* 5–13. http://dx.doi.org/10.1037/0022-3514.53.1.5

Wegner, D. M., Shortt, J. W., Blake, A. W., & Page, M. S. (1990). The suppression of exciting thoughts. *Journal of Personality and Social Psychology, 58,* 409–418. http://dx.doi.org/10.1037/0022-3514.58.3.409

Woodman, T., Barlow, M., & Gorgulu, R. (2015). Don't Miss, don't miss, d'oh! Performance when anxious suffers specifically where least desired. *The Sport Psychologist, 29,* 213–223. http://dx.doi.org/10.1123/tsp.2014-0114

Woodman, T., & Davis, P. A. (2008). The role of repression in the incidence of ironic errors. *The Sport Psychologist, 22,* 183–196. http://dx.doi.org/10.1123/tsp.22.2.183

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