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Abstract

We present two novel tests of Wegner's (1994) theory of ironic processes of mental control using a hockey penalty shooting task (Study 1) and a dart throwing task (Study 2). In Study 1 we aimed to address a significant limitation of ironic effects research in a performance setting by differentiating *non-ironic performance error* from specifically *ironic performance error*. When instructed not to miss in a specific direction, anxious performers did so a significantly greater number of times; importantly, there was no difference in non-ironic error, which provides the first specific support for Wegner's theory in a performance setting. In Study 2, we present the first examination of the precision of ironic errors. When anxious, participants performed not only more ironically but also performed more precisely in the to-be-avoided zone than when they were not anxious. We discuss the results in the context of the importance of specific instructions in coaching environments.

Keywords: stress, anxiety, hockey, ironic error, darts.

Don't miss, don't miss, d'oh! Performance when anxious suffers specifically where least desired

Researchers interested in the relationship between anxiety and performance have largely focused on theories of conscious processing (Baumeister, 1984; Masters, 1992) and attentional control (Eysenck, Derakshan, Santos, & Calvo, 2007) or on catastrophe models (Hardy, Beattie, & Woodman, 2007; Hardy, Woodman, & Carrington, 2004). One theory that has received less attention is Wegner's (1989, 1994, 1997, 2009) theory of ironic processes of mental control.

With specific regard to the hypothesized effects of anxiety on performance, the theory of conscious processing (Masters, 1992) and the theory of ironic processes of mental control (Wegner, 1994) are largely indiscriminate. That is, both theories propose that anxiety impairs efficient functioning of processing thoughts, which leads individuals to focus on thoughts that will be detrimental to their performance (Woodman & Hardy, 2001). However, an important difference between the theories is that Wegner's (1994) theory predicts that performance when anxious will break down in a precise manner. The precision of that hypothesized performance breakdown when anxious is the focus of the present research.

Wegner (1994) proposed his theory of ironic processes of mental control on the premise that mental control requires two processes in order to work effectively. First, according to Wegner, the intentional *operating process* carries out effortful regulation by consciously searching for, and directing the person toward, mental contents that will yield a sought-after emotional state or a preferred outcome; known as the desired state. The engagement in this mentally demanding search increases the likelihood that regulation will be maintained and that the desired state will be reached. Conversely, the second process – the *monitoring process* – subconsciously searches for mental contents that indicate a failure to achieve the desired state. If such a failure is identified by this subconscious *monitor* it

reactivates the *operating process*, which aims to bring about regulation by filling the mind with mental contents that are pertinent to the desired state. Under normal circumstances, this dual-process system works effectively and the individual enjoys mental control. In other words, one does what one intends to do and one does not do what one does not intend to do.

Under mental load, some of the cognitive space that is required for the operating process to operate effectively is taken up by competing resources (e.g., working memory, anxiety). As such, the operating process becomes less effective at introducing the desired content into awareness. Conversely, the monitoring process becomes more salient under mental load and the search for thoughts or sensations that conflict with the desired state are sometimes enough to bring them into consciousness and thus undermine the intended control. This is *ironic* because the (monitoring) process that normally ensures that the to-be-avoided state is kept at bay is the very process that increases the awareness and likelihood of the to-be-avoided state. The result is that one is more likely to do specifically what one intends not to do, when one least wants to do it – which is ironic.

Wegner and his colleagues have amassed an impressive body of evidence in support of this theory of ironic effects, most notably in the area of thought suppression (e.g., Dalgleish, Yiend, Schweizer, & Dunn, 2009; Lane & Wegner, 1995; Smart & Wegner, 1999; Wegner & Erber, 1992; Wegner, Erber, & Zanakos, 1993). Typical tests of the theory in this context involve asking participants to think of something and not to think of something else while subjecting them to either a high or a low mental load (cf. Wegner, 1994). The results of these studies consistently reveal that people tend to think more of the to-be-avoided thought when under mental load. That is, they suffer from ironic thoughts. Although there are other, more behavioral, contexts within which researchers have provided support for the theory (e.g., Denzler, Förster, Liberman, & Rozenman, 2010; Erskine & Georgiou, 2011; Russell & Grealy, 2010; Wegner, 2009; Wegner, Broome, & Blumberg, 1997), thought suppression

remains the most widely investigated. In contrast, potential ironic effects of movement have received surprisingly little research attention despite anecdotal evidence of distinctly perverse counter-intentional performance errors. For example, in his discussion of Wegner's theory, Janelle (1999) provided the example of the anxious golfer who is so preoccupied with the lake to the right that this thought leads to the ball being sliced perfectly into the lake.

Wegner, Ansfield, and Pilloff (1998) provided some promising initial research evidence for such performance irony. In two laboratory experiments, participants were instructed either not to over-shoot a golf ball or not to move a hand-held pendulum along a particular axis. In both experiments, under either mental or physical load, participants suffered more ironic errors. Further, Dugdale and Eklund (2003) found that dancers were less stable on a wobble board when instructed not to wobble under mental load. More recently, using a golf-putting task, researchers found that repressors putted the ball significantly farther beyond the hole when instructed specifically not to do so under stress (Woodman & Davis, 2008; see also Russell & Grealy, 2010) and that changes in visual attention might play an important role in the production of such undesired putting errors (Binsch, Oudejans, Bakker, & Savelsbergh, 2009, 2010).

From the perspective of applying the theory of ironic processes of mental control to a performance setting, there are two main shortcomings in the limited research on ironic performance error to date. First, researchers have not sufficiently differentiated ironic error from non-ironic error. For example, in tasks such as the wobble board (Dugdale & Eklund, 2003) or golf putting (Woodman & Davis, 2008), researchers asked participants to perform a desired action and not to perform an undesired action. In such designs, it is unclear whether a participant's undesired actions specifically reflect ironic error or rather simply reflect generic performance deterioration under mental load. In other words, is ironic error truly *ironic error* or simply *error* of a more generic nature? For a more robust test of ironic effects, one needs

to incorporate a measure of ironic error and a measure of other non-ironic error to determine the degree to which errors are being committed ironically or simply uniformly under anxiety. For example, is the golfer who is specifically trying to suppress thoughts of slicing her ball into the lake on the right more likely to hit the ball precisely into the lake or just as likely to make any other mistake, such as drive the ball into the bunker on the left? This distinction is important because at present we do not know whether thought suppression or negative priming instructions lead to a greater likelihood of specifically to-be-avoided actions or simply to a greater likelihood of performing less well in general.

A second limitation of previous research is that the mental load has been largely cognitive with little relevance to performance contexts (e.g., Binsch et al., 2009). That is, participants are typically given a mental load task that serves to tax working memory (e.g., counting backward). Exceptions include Wegner et al.'s (1998) study where participants were subjected to a physical load and Woodman and Davis's (2008) study in which participants were provided a financial incentive. This latter method is a worthy advancement for two reasons. First, financial incentives have been shown to cause anxiety (e.g., Bell & Hardy, 2009; Wright, Killebrew, & Pimpalapure, 2002). Second, a reward-based competition (i.e., the opportunity to gain a financial reward as recompense for performance accomplishments) is a more ecologically valid mental load in a competitive sporting environment.

In summary, tests of ironic errors in a performance context have typically failed to control for non-ironic error and have depended on largely cognitive mental loads (e.g., counting backward) that lack ecological validity. We aimed to address these limitations in an investigation of Wegner's (1994) theory. Specifically, across two studies, we aimed to address these limitations by testing for both *non-ironic* error and *ironic* error via an ecologically valid stressor (i.e., a competition). We hypothesized that performance would suffer in a specifically ironic fashion when performers were anxious. Conversely, and

importantly in terms of providing specific support for the theory of ironic processes, non-ironic error should not change across anxiety conditions. Additionally, in Study 2, we aimed to provide the first test of the precision of irony in the occurrence of ironic effects. That is, we sought to examine whether individuals' ironic errors whilst anxious are more precisely ironic compared to when they are not anxious.

Study 1

Method

Participants. Before a team training session, we approached male university hockey players and invited them to participate in the study. The inclusion criteria were that volunteers represent one of the top four squads at the University and train and/or compete at least once per week throughout the competitive season. The final sample comprised 40 male university hockey players (M_{age} = 20.25 years, SD = 1.06).

Measures.

Anxiety. We measured anxiety using the Mental Readiness Form-3 (MRF-3; Krane, 1994). The MRF-3, which comprises three single-item factors, requires participants to express how they feel *right now* by placing a mark on three separate 10cm visual-analog scales. From left to right the scales are anchored: *worried – not worried* (cognitive anxiety); *tense – not tense* (somatic anxiety); and *confident – not confident* (self-confidence). Thus, high scores represent low cognitive anxiety, low somatic anxiety and low self-confidence. Krane (1994) reported significant correlations between the MRF-3 and the Competitive State Anxiety Inventory-2 (Martens, Burton, Vealey, Bump, & Smith, 1990): .58 (*cognitive anxiety*), .59 (*somatic anxiety*), and .77 (*self-confidence*). We wanted to ensure that we captured the measures of anxiety as close as possible to the experimental instructions and the subsequent performance. As such, we preferred the more expedient and less intrusive MRF-3 over the CSAI-2. Furthermore, we preferred the MRF-3 for its use of the word "*worried*"

compared to the use of the more ambiguous term "*concern*" in the CSAI-2 and the revised CSAI-2 (Cox, Martens, & Russell, 2003). Indeed, the essence of the research revolves around the experience of *anxiety*, which is better captured by the term "worry" than by the term "concern" (see also Woodman & Hardy, 2001). The MRF-3 has also been used in previous studies to assess anxiety in competitive settings (e.g., Robazza, Bortoli, & Nougier, 2000; Woodman & Davis, 2008).

Performance. We measured performance using a field hockey shooting task on a flat Astroturf surface. A *target* zone within a regulation hockey goal (183cm wide) was delimited by a rope that hung vertically from the hockey crossbar to the ground, 45cm from the right-hand post (see Figure 1). We operationalized the remaining goal area to the left of the target zone (138cm wide) as the *non-ironic error* zone; and an equivalent area to the right of the *target* zone, demarked with a cone, as the *ironic error* zone (138cm wide). We instructed participants to strike the ball from the edge of the shooting circle, 16 yards from the center of the goal line. We operationalized performance as the number of shots hit into each zone (target zone; non-ironic error zone; ironic error zone), which were recorded by an experienced hockey player who stood directly behind the strike of the ball. All shots were observed as unambiguously entering one of the three distinct zones.

Procedure. We first obtained institutional ethics approval for the study. On arrival at the test site the experimenter, using a standardized instructional set, informed each participant of the procedure, obtained participant informed consent, and described the scoring system for the hockey shooting task. Each participant was told he would score 1 point for hitting the target zone, zero points for hitting to the left of the target zone (non-ironic error zone), and minus 1 point for hitting to the right of the target zone (ironic error zone). These verbal instructions concluded with the priming phrase, "Try to hit the target zone. Be particularly careful not to hit the ball to the right of the right-hand post, as you will score minus 1 point

each time you do." Participants underwent a warm-up consisting of a five-minute jog and 15 practice shots, the scores of which were not recorded. We used the warm up for warm-up purposes only. That is, given the experience of the players, there was no need to employ a learning paradigm to familiarize the participants with the hockey shooting task – they were fully familiar with this fundamental hockey task.

We counter balanced the order of presentation of the anxiety conditions across participants and gave a two-minute break between each condition. Immediately before striking the first ball in the low-anxiety condition we reminded participants of the instructional set. They then completed the MRF-3 before we repeated the priming phrase to them. The same procedure was used in the high-anxiety condition with one exception: Before completing the MRF-3, we informed participants that we would award £100 (approx. US$155) to the participant with the highest performance score. Each participant completed the shooting task individually, performing 30 shots in the high-anxiety condition and 30 shots in the low-anxiety condition.

Results

Anxiety manipulation. Paired samples *t*-tests on the MRF-3 data confirmed that the anxiety manipulation was successful. Specifically, participants' cognitive anxiety was higher in the high-anxiety condition ($M = 6.83$, $SD = 2.46$) compared to the low-anxiety condition ($M = 8.50$, $SD = 1.90$; $t_{39} = 4.87$, $p < .001$). Somatic anxiety was higher in the high-anxiety condition ($M = 6.38$, $SD = 2.49$) compared to low-anxiety condition ($M = 7.83$, $SD = 2.30$; $t_{39} = 3.55$, $p < .001$). Self-confidence was significantly lower in the high-anxiety condition ($M = 6.80$, $SD = 2.09$) compared to low-anxiety condition ($M = 5.23$, $SD = 2.02$; $t_{39} = 6.36$, $p < .001$).

Performance. A 2 (anxiety: low, high) × 3 (zone: non-ironic error zone, ironic error zone, target zone) fully repeated measures ANOVA yielded no significant main effect for

anxiety, $F(1, 39) = 1.00$, $p = .32$, a significant main effect for zone, $F(2, 78) = 8.70$, $p < .001$, and a significant anxiety × zone interaction, $F(2, 78) = 6.25$, $p < .01$ (see Table 1). The sphericity assumption was satisfied. Bonferroni-corrected follow-up paired samples *t*-tests revealed that when anxious participants hit significantly fewer shots in the *target* zone ($t_{39} = 3.46$, $p < .001$) and significantly more shots in the *ironic* error zone ($t_{39} = 3.02$, $p < .01$), as hypothesized. Importantly, also as hypothesized, there was no significant *non-ironic error* performance difference between the high- and low-anxiety conditions ($t_{39} = .00$, $p > .5$).

Discussion

In Study 1 we addressed two shortcomings of the limited extant literature examining Wegner's (1994) ironic processes of mental control in a performance setting. Specifically, we differentiated non-ironic performance error from ironic performance error and we utilized a more ecologically valid method of inducing competition anxiety. In support of Wegner's (1994) theory, participants' performance suffered under anxiety, not only by hitting significantly fewer shots in the *target* zone but also by hitting significantly more shots in the specifically to-be-avoided zone. Importantly, the incidence of *non-ironic* error did not significantly change across anxiety conditions.

Although the present study is an ecological advancement on previous research given the nature of the stressor, the study lacks performance ecological validity in that there was no goalkeeper to avoid during the penalties. This can clearly be remedied in future research (see Navarro, van der Kamp, Ranvaud, & Savelsbergh, 2013) and is worthy of research attention. A further limitation, which warrants addressing, is that the location of the ironic error zone remained consistent in relation to the target zone and non-ironic error zone for all participants. Specifically, it could be argued that the observed significant increase in the number of ironic error zone hits when anxious does not represent ironic error *per se* but rather is indicative of a consistent performance bias when anxious. For example, one could argue

that anxious hockey players who are aiming at the right-hand corner of the goal (i.e., the designated target zone) are more likely to slice the ball wide-right of the goal (i.e., the designated ironic error zone) than to hook the ball into the middle of the goal (i.e., the designated non-ironic error zone), where the goalkeeper would typically be located in a match scenario. With the design that we employed in Study 1 this explanation cannot be ruled out and thus we aim to address this limitation in Study 2.

Despite this limitation, specifically distinguishing non-ironic error from ironic error is an important advancement for understanding ironic performance errors. Questions remain, however, regarding the precise nature of these observed ironic errors. For example, the fairly crude performance measure that we employed in Study 1 did not allow us to ascertain whether anxious performers specifically hit farther into the ironic zone when anxious compared to when they were not anxious. That is, one would expect anxious participants' ironic error zone hits to be farther away from the target zone and more precisely within the ironic zone compared to such hits when not anxious. There is thus a need to test the degree to which ironic breakdown is specifically and precisely ironic. Conversely, a hit that lands within the ironic error zone but misses the target zone by the narrowest of margins is arguably *less ironic* in nature; both conceptually and from a real-world standpoint. In Study 2, we aimed to explore the degree to which anxious performers perform specifically more ironically within a to-be-avoided area compared to when they are not anxious.

Study 2

The aim of Study 2 was twofold: (a) to replicate the findings of Study 1 using a dart throwing task and (b) to understand the precise nature of ironic performance errors when anxious. In support of Wegner's theory (1994) and the findings of Study 1, we hypothesized that participants would perform fewer target hits and more ironic errors when anxious – compared to when they are less anxious. Again, we hypothesized that there would be no

change across anxiety conditions for non-ironic errors. Regarding the precise nature of ironic errors, we hypothesized that ironic error zone hits would be *farther away from the target zone* and *more precisely within the ironic error zone* when anxious compared to when not anxious.

In Study 2 we adopted four methodological modifications to improve on Study 1 and to refine the measurement of ironic error in a performance setting. First, we included an additional stressor – social evaluation – to improve further the ecological validity of the mental load in a competitive sporting environment. Researchers have previously successfully employed social evaluation to increase anxiety (Bell & Hardy, 2009; Hardy, Mullen & Jones, 1996). Second, to glean a more reliable manipulation of anxiety, we included an indicator of participants' physiological arousal. Third, to address the limitation from Study 1 regarding the static location of the ironic zone, we varied the location of the ironic error zone across participants. Fourth, to further elucidate the potential incidence of a specific non-ironic error in contrast to ironic error, we measured non-ironic error in three distinct zones.

Method

Participants. The sample comprised 73 individuals (45 men, 28 women; M_{age} = 22.82, *SD* = 4.07; 71 right handed, 2 left handed). Participants responded to poster adverts and had no previous darts experience (*n* = 28) or had played darts fewer than 10 times (*n* = 45).

Measures.

Anxiety. To measure *physiological arousal* we recorded *heart rate* (HR) and *heart rate variability* (HRV) using a Polar RS800CX heart rate monitor (Quintana, Heathers & Kemp, 2012). Researchers have previously used HR and HRV as a successful indicator of a participant's physiological response to anxiety (e.g., Cervantes, Rodas, & Capdevila, 2009; Janelle, Singer & Williams, 1999; Laborde, Brull, Weber, & Anders, 2011; Mateo, Lafarga, Navarro, Guzman & Zabala, 2012; Murray & Raedeke, 2008; Rainville, Bechara, Naqvi, &

Damasio, 2006). Additionally, we administered the MRF-3 (Krane, 1994), as described in Study 1, to measure *cognitive anxiety*, *somatic anxiety* and *self-confidence*.

Performance. We measured performance using a dart throwing task employing a regulation dartboard and darts. We positioned the center of the dartboard 1.73cm from the floor and 2.37m horizontally from the Oche (throwing line). Following removal of the standard wireframe, we placed a paper coversheet that matched the dimensions of the dartboard over the dartboard (see Figure 2). On the dart board cover sheet we presented a central circle – the target zone – which measured 6cm in diameter. Participants scored nine points for hitting the target zone. Darts landing in the next concentric circle scored eight points. Darts landing in the next concentric circle scored seven points. The scoring system continued in the same manner to the outermost concentric circle, which scored one point. All concentric circles were 2.1cm wide, except the outermost one, which was 3.9cm wide to accommodate the cover sheet to the edge of the dart board. A single quadrant (e.g., top left quadrant of the dart board excluding the area of the target zone that fell within the quadrant) was operationalized as the ironic error zone. Participants were informed that they would score zero points for any darts landing within this zone. We conceptualized the remaining three quadrants as non-ironic error zones but we did not mention them to the participants. Hits in these zones scored between one and eight points dependent on the proximity to the target zone.

We designated the ironic error zone as the top-right quadrant for the first participant. We then rotated clockwise the location of the ironic error zone by one quadrant for each subsequent participant. Thus, for the second participant the ironic error zone was the bottom right quadrant. The non-ironic error zones varied accordingly.

Procedure. Using a standardized instructional set, the experimenter informed each participant of the procedure, as approved by the university ethics committee, and described

the scoring system for the dart throwing task. Participants completed an informed consent form with additional demographic data (age, sex, and experience) and wore a heart rate chest strap transmitter. Before the task, we conducted a warm up that consisted of 15 practice throws, the scores of which were not recorded. As in Study 1, these 15 shots primarily served as a warm-up rather than as a meaningful task familiarization; that is, despite all participants being inexperienced darts players, we did not consider the task to be difficult to become familiar with.

Our pilot testing revealed that (similarly inexperienced) participants who initially performed in the high-anxiety condition often remained highly anxious, even after a two-minute break, when subsequently participating under conditions of supposed low anxiety. As such, to minimize any anxiety carryover effect, we fixed the order of the presentation of anxiety conditions for all participants as low-anxiety first and high-anxiety second (cf. Hardy & Hutchinson, 2007). Thus, the task consisted of each participant performing 24 throws in the low-anxiety condition, followed by a two-minute break and 24 throws in the high-anxiety condition. Each participant completed the dart throwing task individually.

Immediately before the first dart throw, in the low-anxiety condition, we repeated the instructional set to the participants who then completed the MRF-3. These verbal instructions concluded with the priming phrase, “Please try to hit the target zone, or as close to the target zone as possible, in order to gain maximal points but be particularly careful not to hit the [top right quarter][1] of the dart board, as you will score zero points each time you do.” The same procedure was used in the high-anxiety condition with one exception: Before completing the MRF-3, participants were informed that, for one week, we would display all scores publically

[1] The priming phrase was modified to reflect the changing position of the ironic error zone between participants: (a) bottom right quarter (b) bottom left quarter (c) top left quarter.

on a television screen located in a busy indoor thoroughfare of the university. Additionally, the highest scoring participant would receive £50 (approx. US$80).

Results

Anxiety manipulation. Both physiological arousal and self-report anxiety measures confirmed the successful anxiety manipulation. Specifically, paired samples *t*-tests on the MRF-3 data demonstrated that participants' cognitive anxiety was higher in the high-anxiety condition ($M = 6.37$, $SD = 2.86$) compared to the low-anxiety condition ($M = 8.10$, $SD = 2.48$; $t_{72} = 6.03$, $p < .001$). Somatic anxiety was higher in the high-anxiety condition ($M = 6.09$, $SD = 2.57$) compared to low-anxiety condition ($M = 7.63$, $SD = 2.60$; $t_{72} = 4.93$, $p < .001$). Self-confidence was significantly lower in the high-anxiety condition ($M = 6.17$, $SD = 2.22$) compared to low-anxiety condition ($M = 5.46$, $SD = 2.06$; $t_{72} = 2.94$, $p < .01$). Additionally, participants' HR was significantly higher ($M = 97.79$, $SD = 16.15$) compared to low-anxiety condition ($M = 85.49$, $SD = 12.96$; $t_{72} = 10.78$, $p < .001$) and their HRV was significantly lower ($M = 641.46$, $SD = 99.22$) in the high-anxiety condition compared to the low-anxiety condition ($M = 726.52$, $SD = 126.55$; $t_{72} = 9.71$, $p < .001$).

Performance. We conducted a 2 (condition: low anxiety: high anxiety) × 3 (zone: non-ironic error, ironic error, target) fully repeated measures ANOVA. As the sphericity assumption was violated, we applied a Greenhouse-Geisser correction factor to the degrees of freedom. Results revealed no significant main effect for anxiety, $F(1, 72) = .125$, $p > .5$, $\eta^2 = .002$, a significant main effect for zone, $F(1.69, 121.30) = 71.46$, $p < .001$, $\eta^2 = .49$, and a significant anxiety × zone interaction, $F(1.74, 125.12) = 24.12$, $p < .001$, $\eta^2 = .25$. Bonferroni-corrected follow-up paired samples *t*-tests revealed that, when anxious, participants hit significantly fewer shots in the *target* zone ($t_{72} = 5.32$, $p < .001$) and significantly more shots in the *ironic* error zone ($t_{72} = 5.65$, $p < .001$), as hypothesized. Importantly, also as hypothesized, there was no significant *non-ironic error* difference

between the high- and low-anxiety conditions regardless of which of the three remaining quadrants was conceptualized as non-ironic error (ts < 1, ps > .5).

How ironic. To test the hypothesis that participants would perform in a more precisely ironic fashion when anxious, we conducted a repeated measures MANOVA specifically on the ironic error data under low- and high-anxiety conditions. We conceptualized the precision of the ironic error for each ironic error hit via two measures of irony. First, we took each participant's mean radial error within the ironic zone as the measure of the *distance from the target zone*. Second, we took each participant's mean arc-length within the ironic zone (from the closest non-ironic zone) as the measure of the *distance into the ironic zone* (see Figure 3).

The multivariate difference between low- and high-anxiety conditions was significant, Wilks' $\Lambda = 0.78$, $F(2, 61) = 8.55$, $p = .001$, as hypothesized. Univariate follow-up F tests revealed that both the arc-length of the ironic errors, $F(1, 62) = 14.61$, $p < .001$, and the radial error within the ironic error zone, $F(1, 62) = 14.51$, $p < .001$, were significantly greater in the high-anxiety condition compared to the low-anxiety condition.

Discussion

The primary purpose of Study 2 was to examine the precision of ironic errors in a performance setting. As hypothesized, in the high-anxiety condition, compared to the low-anxiety condition, participants' ironic error hits were significantly farther from the target zone and significantly farther into the ironic error zone. In other words, when anxious, participants performed ironically, and more precisely ironically. The results of Study 2 also confirm those of Study 1. Specifically, participants' performance suffered when they were anxious, not only by throwing significantly fewer darts into the *target* zone but also by throwing significantly more darts into the specifically to-be-avoided zone. Importantly, the incidence of non-ironic performance error did not significantly change across anxiety

conditions regardless of which of the three remaining quadrants we conceptualized as non-ironic error. Unlike in Study 1, in Study 2 we varied the location of the ironic error zone across participants and measured non-ironic error in three distinct zones. In this way we demonstrated that the greater number of hits in the specifically to-be-avoided zone represents a specific and precise ironic performance breakdown rather than a more generic anxiety-derived performance error.

General Discussion

The aim of the present research was twofold: (a) to address two shortcomings of the limited extant literature examining Wegner's (1994) ironic processes of mental control in a performance setting; and (b) to better understand the nature of ironic performance errors by examining how precisely ironic such errors are. In Study 1 we differentiated non-ironic performance error from ironic performance error in a hockey shooting task, and we adopted a more ecologically valid method of inducing mental load (i.e., competition anxiety). In support of Wegner's (1994) theory, participants' performance suffered when anxious, not only by hitting significantly fewer shots in the *target zone* but also by hitting significantly more shots in the specifically *to-be-avoided zone*. Importantly, the incidence of non-ironic error did not change across anxiety conditions. The results of Study 2 confirmed these findings and – by modifying the location of the ironic and non-ironic zones across participants – confirmed that any ironic performance errors could not be accounted for simply by a consistent anxiety-induced performance bias. When considered conjointly, these two studies provide the first compelling evidence for the application of Wegner's (1994) theory to sport performance environments with specific support for ironic (rather than generic) performance breakdown. Furthermore, Study 2 provides the first evidence that, when anxious, ironic errors are more precisely ironic.

To date, ironic error has frequently been conceptualized as a discrete phenomenon that may become diluted as individuals adapt to the task (Binsch et al., 2009; De la Peña, Murray, & Janelle, 2008; Toner, Moran, & Jackson, 2013). As such, researchers (e.g., Wegner et al., 1998; Woodman & Davis, 2008) have previously sometimes measured ironic error on a single trial, likely with the aim of attempting to capture a fairly elusive ironic effect. The present research, however, demonstrates that ironic performance errors can be observed over numerous trials and is a meaningful and robust potential concern for performers who are required to perform under pressure.

The mechanisms that might underpin the increased likelihood of ironic performance when anxious remain poorly understood. It is possible that performers' gaze behavior will provide some initial clues as to these specific mechanisms (cf. Binsch et al., 2009, 2010). However, gaze behavior may not reflect the thought processes that precede behavior. For example, a performer may have anxiety-invoked thoughts about missing a penalty in a specific manner but may equally retain the ability to focus her gaze on a desirable target area. Thus, in the context of Wegner's (1994) theory it is likely that performers' specific thoughts and self-talk will provide further clues regarding these mechanisms. Furthermore, the nature of any negatively phrased instruction deserves attention in the context of applied work. For example, in the present studies we used terms such as, "Be particularly careful not to…" and it is increasingly established that cognitive processes handle positive information more efficiently than negative information (e.g., Unkelbach, Fiedler, Bayer, Stegmüller, & Danner, 2008). Also, the performance of movement is more efficient when (self-) instructions pertain to what *to do* as opposed to what *to avoid* (e.g., Harvey, Van Raalte, & Brewer, 2002). Thus, practitioners, coaches, and instructors would do well to word their instructions carefully to avoid unintended errors of performance when they are least desired.

From a purely theoretical stance, the anxious individual could render the monitoring process less debilitative by deliberately (and of course paradoxically) focusing on *not* hitting the target (Janelle, 1999). In this way the monitoring process would search for cues that are incompatible with hitting the target and, thus, ironically increase the likelihood of a target hit (Janelle, 1999; Woodman & Hardy, 2001). Of course, due to the lack of confirmatory empirical evidence, such paradoxical interventions should be viewed with great caution (Hall, Hardy, & Gammage, 1999). This caution is important, not least because under conditions of low anxiety – when the operating and monitoring processes are functioning as an adaptive dual-feedback unit – such paradoxical thought processes would clearly be detrimental to performance. Furthermore, as high- and low-anxiety are not two sides of a single dichotomous dyad, it would be unclear which strategy (paradoxical or otherwise) would be best to deploy at a given time. Thus, although paradoxical interventions have theoretical appeal, they have considerably less applied appeal. As such, researchers would do well to explore strategies that would prove beneficial to the performer under conditions of high- or low-anxiety.

The most parsimonious applied implication for performers who suffer from ironic effects of performance is to help them control their anxiety. Indeed, given that ironic effects occur significantly more when anxiety is high, a reduction in anxiety should help to reduce the likelihood of ironic errors. However, since an optimal amount of anxiety can be facilitative in enhancing performance (e.g., Hardy et al., 2004), attempts at uniformly minimizing anxiety may be rather an ineffective performance strategy when compared to an anxiety *restructuring* approach (cf. Thomas, Mellalieu, & Hanton, 2009). Indeed, performers who perceive that situational demands are within their control, who perceive that they are able to cope with their anxiety symptoms, and who perceive that they are likely to achieve their goals, have been shown to *restructure* their anxiety and interpret it as facilitative –

rather than debilitative – to performance (Jones, 1995). Thus, the extent to which anxiety restructuring – by equipping performers with the requisite skills and resources to view their anxiety as facilitative – can decrease ironic performance error under conditions of high-anxiety is worthy of further investigation. Other approaches are also worth considering. For example, cognitive behavioral (CB) interventions aimed at decreasing an individual's *performance interfering thoughts* (Sarason, Pierce, & Sarason, 2009) have been shown to enhance sport performance (e.g., Meyers, Whelan, & Murphy, 1996). Future studies would do well to establish the extent to which such CB strategies can be applied specifically to reduce the likelihood for individuals to suffer anxiety-induced ironic performance breakdown. Such strategies would be particularly worth considering for those who have a tendency to experience high anxiety under pressure.

Although the present results have provided support for Wegner's (1994) theory, other studies have revealed conflicting results. For example, De la Peña et al. (2008) found that golfers who were instructed not to putt short of the hole *overcompensated* when under mental load, and putted significantly farther than under conditions of no load. Specific differences between the present research and that of De la Peña et al. (2008) may serve to elucidate these inconsistent findings and inform future research on investigations of ironic effects. First, as De la Peña et al. (2008) acknowledged, their various methods of inducing mental load may have failed to tax sufficiently cognitive resources. In other words, in their research, participants' dual-process system may have continued to work effectively enabling them successfully to avoid the to-be-avoided state. In the present research, we successfully significantly manipulated anxiety using multiple ecologically valid performance stressors (i.e., competitive environment, financial incentive, and social evaluation). Thus, future investigations of ironic performance errors should continue to ensure that participants' cognitive resources are significantly taxed in an ecologically valid manner. Second, unlike De

la Peña et al., we made the tasks competitive and included a financial incentive for optimal performance, which would have incentivized good performance and actively discouraged systematic *overcompensation*. In other words, future research would benefit from attempts to mimic the competitive environment that sportspeople find themselves in. Put simply, competitors typically have clear goals and clear anti-goals, which may be more or less explicit. Researchers (and practitioners) should make every effort to mimic those conditions as much as possible. If such mimicking fails and there is little to gain, then an effective response in the context of the dart throwing task would be to aim as far away from the to-be-avoided zone as possible. Thus, future research should carefully consider incentivizing accuracy of performance and discouraging consistent overcompensation.

The main limitation of the present research is the lack of consideration of individual differences in the occurrence of anxiety-induced ironic performance errors (cf. Russell & Grealy, 2010; Woodman & Davis, 2008). For example, compared to their low-narcissism counterparts, narcissistic individuals thrive in competitive situations as a consequence of the opportunity for glory that such environments provide (Roberts & Woodman, 2015; Roberts, Woodman, Hardy, Davis, & Wallace, 2013; Wallace & Baumeister, 2002; Woodman, Roberts, Hardy, Callow, & Rogers, 2011). Thus, the extent to which narcissism moderates the incidence of ironic performance errors in competitive performance environments is worthy of future consideration. Neuroticism also certainly seems worthy of research attention in the specific context of ironic effects because research suggests that neurotic individuals experience anxiety more frequently (Bolger & Schilling, 1991), demonstrate greater sensitivity to criticism and negative stimuli (O'Sullivan, Zuckerman, & Kraft, 1998; Tellegen, 1985), have lower self-confidence (Bandura, 1977) and have greater negative reactions to anxiety (Bolger & Zuckerman, 1995; Ormel & Wohlfarth, 1991). This chronic negative affective state of the neurotic individual may itself act as a mental load, soaking up

some of the mental resources necessary to maintain mental control (Dalgleish et al., 2009) even under conditions of relatively low anxiety. Regardless, coaches and practitioners would do well to be particularly careful with the specific words that they use as part of their instructions when helping performers to ensure that they do not contribute to the likelihood of mental control backfiring when it matters most to the performer (e.g., under the pressure of competition).

In summary, across two studies we found that performers suffered significant and specific ironic errors of performance when they were anxious. When negatively primed, anxious performers do not suffer error of a diffuse nature but rather suffer specifically the to-be-avoided error. The results of Study 2 provide the first evidence that anxious individuals make ironic errors that are more precisely ironic compared to when they are not anxious. The combination of a high-pressure situation and negative instructions is potentially fraught with undesired performance consequences that are perversely predictable.

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Table 1.

Mean number of hits (*SD*) in the target, ironic and non-ironic error zones, in the low-anxiety and high-anxiety conditions, in Study 1 and Study 2.

	Study 1		Study 2	
Zone	Low anxiety	High anxiety	Low anxiety	High anxiety
Target	11.70 (3.44)	9.85 (3.61)***	4.83 (2.81)	3.00 (2.63)***
Ironic error	6.95 (2.94)	8.77 (4.02)**	2.16 (1.74)	3.58 (1.92)***
Non-ironic error 1	11.53 (4.00)	11.53 (4.50)	7.30 (2.93)	7.58 (2.55)
Non-ironic error 2	-	-	4.27 (2.43)	4.47 (2.26)
Non-ironic error 3	-	-	5.42 (2.94)	5.35 (3.38)

Note. Non-ironic error 1 = the quadrant opposite the ironic error zone. Non-ironic error 2 = the adjacent quadrant, clockwise, relative to the ironic error zone. Non-ironic error 3 = the adjacent quadrant, anti-clockwise, relative to the ironic error zone.

* $p < .05$
** $p < .01$
*** $p < .001$

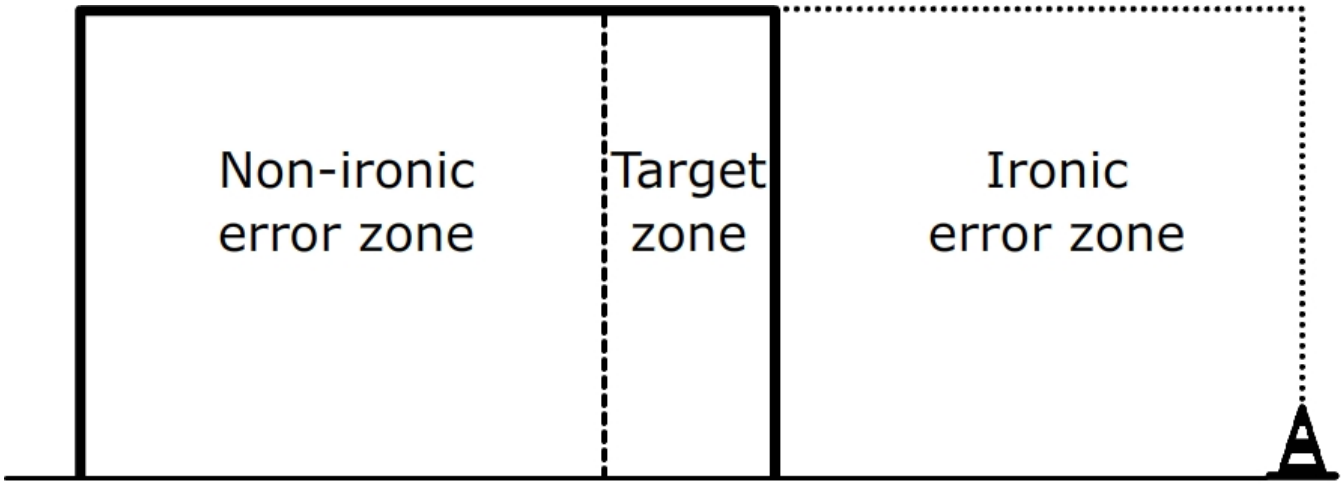

Figure 1. The hockey shooting target.

Note: The thick solid lines represent the hockey goal posts and crossbar. The non-ironic error zone and the target zone were delimited by the posts and crossbar of a regulation hockey goal and separated by a rope hanging from the crossbar (dashed line). The ironic error zone was delimited by a cone. The dotted line represents the limits of this zone but was not visible to participants.

Figure 2. The dart throwing task target.

Note: The dart board cover sheet indicates the available scores based on proximity of the dart to the central target zone (which scored nine points). The designated ironic error zone was one of the four quadrants (e.g., top right quadrant) and was balanced across participants. We informed participants that hits landing in the designated ironic error zone would score zero points regardless of the proximity to the target zone.

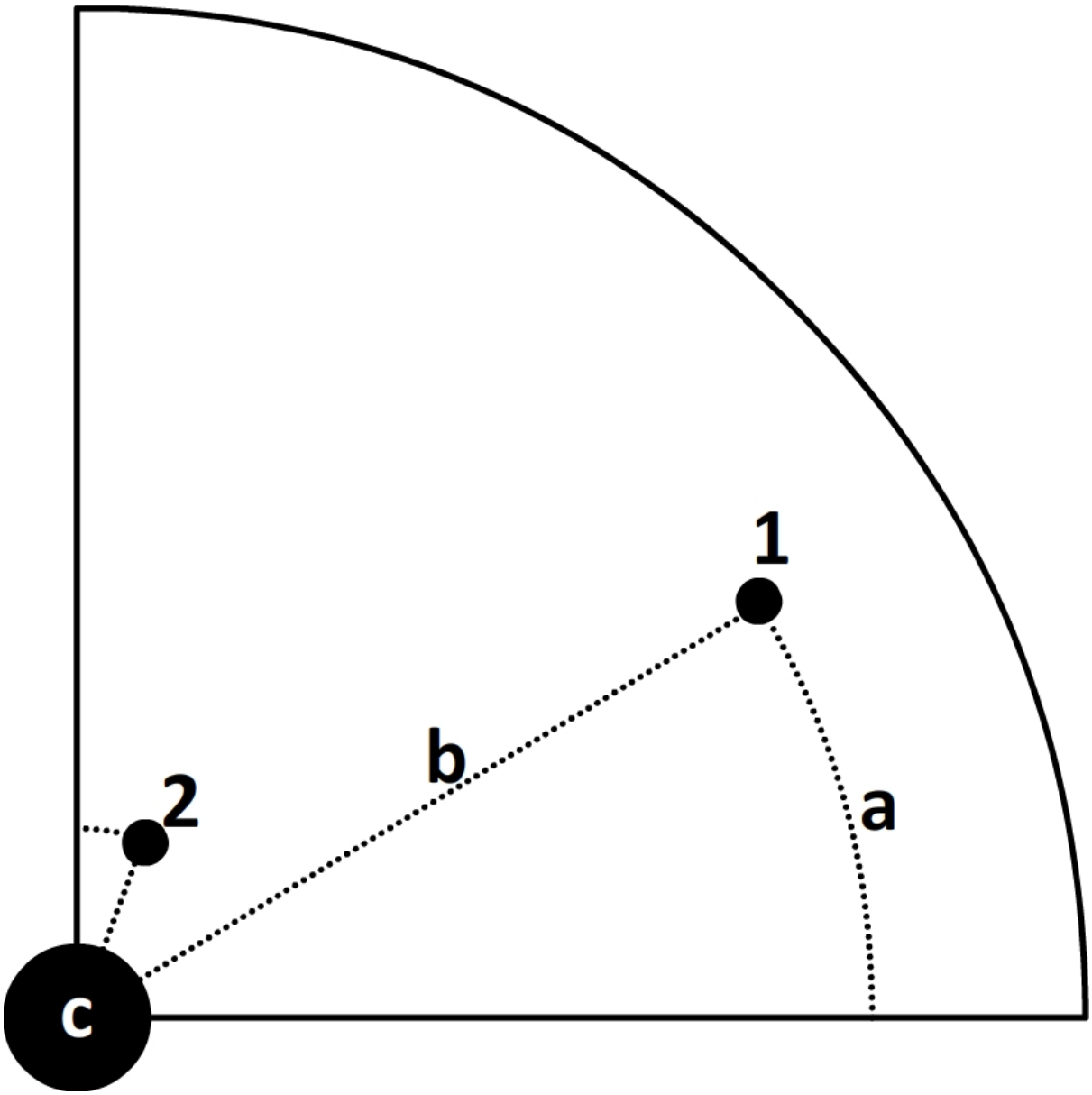

Figure 3. The measurement of arc-length and radial error in the dart throwing task of Study 2.

Note. The quadrant represents the ironic error zone. The points that are labeled 1 and 2 represent two hypothetical dart strikes, which have landed within the ironic error zone. We considered Dart 1 to be precisely more ironic than Dart 2 because it has both a greater *arc length* (a; the arc-length from the closest non-ironic error zone) and a greater *radial error* (b; the radial distance from the target zone c).

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