

**Examining the Impact of Social Pressure on Golf Putting Performance**

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## Abstract

Fine-motor skills in any domain (e.g., sports, surgery, music) are subject to performance decrements under pressure. A large majority of studies that have examined “choking under pressure” used golf putting as a paradigm to test participants. Golf putting is a fine-motor skill that is highly susceptible to deviations in performance, yet a skill that appears to be deceptively simple without a steep learning curve. The following thesis contained three studies that examined the influence of social evaluative threat on the objective outcome performance (holed or not holed, distance to the hole), as well as the kinematic variables associated with the putting stroke itself. Performance was measured using a high-speed infrared camera called the TOMI® which collected real-time 3D data about a number of different kinematic parameters for each putt that was struck. While it was expected that a learning effect would characterize the longitudinal trajectory of performance, it was also expected that state anxiety would moderate this trajectory.

In Study 1, 35 amateur golfers, completed a self-report measure of state anxiety and performed golf putting tasks under a neutral condition followed by a social-evaluative condition. Somatic anxiety was related to differential performance trajectories, while cognitive anxiety was associated with variability in the backstroke. In Study 2, 27 beginner participants participated in an improved design based on Study 1. Somatic anxiety temporarily moderated performance under pressure for the novices. In Study 3, 55 beginner participants were recruited and randomized to either a stress-free learning task ( $n = 29$ ), or a social-evaluative learning task ( $n = 26$ ), to address research limitations from the first two studies. Furthermore, methodological concerns present in both Study 1 and 2 were addressed, with the aim of contributing to the debate surrounding theoretical mechanisms of how performance decrements occur, specifically under social-evaluative threat. High levels of somatic anxiety moderated the objective performance trajectory of the experimental group, and surprisingly *decreased* the amount of time taken to

prepare for each putt in the social-evaluative task.

In all three studies, somatic anxiety significantly moderated both objective and indirect performance (as indicated by kinematics and routine time). Taken together, these studies suggest that one's interpretation of physiological symptoms while under social evaluative threat can temporarily impair performance trajectories of a fine-motor skill.

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## **Chapter 1: Introduction**

## **Problem Area**

The presence of others influences our ability to perform across many different situations. Any tasks requiring precision movements (e.g., sports, art, surgery, music) are often subject to performance decrements under pressure. A golfer who has a delicate shot around the green that requires more ‘touch’ than power may suddenly feel as though they are unable to hit the shot required while under stressful circumstances (e.g., a large tournament) – even if this same shot has been successfully executed many times under pressure-free conditions. A musician who has to play a well-rehearsed, yet difficult piece in front of an audience may make more errors compared to when played without an audience. While these errors are more penalizing as the stakes get higher (e.g., a tattoo artist, amateur vs. professional sports), they certainly not limited to expert performers.

While it is tempting to focus exclusively on the times that performance decreases dramatically from the norm, it is equally important to note that not all performance decreases under pressure. For some individuals, competitive environments are facilitative and, in many moments, seem to *improve* performance rather than hinder it. The seemingly simple task of rolling a ball towards a hole provides a lifetime of fascination and interest from a problem-solving standpoint. Each putt that a golfer faces is a new task with subtly different circumstances (i.e., length, speed of greens, temperature). Furthermore, golfers are not the same version of themselves in terms of focus, energy levels, emotions, etc. when examining themselves day-in, day-out. When considering the training and development of a new fine-motor skill, understanding the psychological contributions toward either facilitating or hindering performance is vital.

While not all athletes are prone to performance decrements per se, each performer may deviate from their own average during any given performance, in any given direction –

improvement or deterioration. Traditional analysis of performance has tended to rely on between-person associations while treating any within-person variations as error (Beal et al., 2005). While some of these deviations can be explained from the perspective of normal statistical distributions and artifacts (e.g., regression to the mean), a *multi-level modeling* perspective proposes that these within-person deviations in performance can be explained by both stable personal traits, as well as characteristics of the situation where one is performing. As such, the goal of this thesis research is to: a) explore how a fine-motor skill – in this case golf putting – is precisely influenced by social-evaluative pressure, b) examine how sport-specific types of state anxiety moderate the relationship between pressure and performance and c) examine how the performance trajectory (i.e., learning pattern) of novice performers changes as a function of social-evaluative pressure.

## **Chapter 2: Literature Review**

## **Stress and Social-Evaluative Threat**

People are naturally motivated to prevent their social belonging from being jeopardized (Baumeister, Brewer, Tice, & Twenge, 2007). From an evolutionary standpoint, humans have adapted to living in close proximity with others (i.e., in families, communities, etc.). It would therefore make sense to have an innate sensitivity towards threats to social status, as being ostracized from a group could have devastating consequences as to survival. Indeed, studies examining physiological outcomes have suggested that naturally occurring social-evaluative threat during a person's day is implicated in a number of physiological outcomes consistent with a stress response such as increased systolic and diastolic blood pressure (Smith, Birmingham, & Uchino, 2013), elevated cortisol response (Dickerson & Kemeny, 2004), proinflammatory cytokine activity (Dickerson, Gruenwald, & Kemeny, 2004; 2009), and restricted hippocampal activity (Weerda, Muehlhan, Wolf, & Thiel, 2010). Furthermore, nearly 60% of all people report having sub-clinical levels of social anxiety in at least one situation in their lives (e.g., at work, in large groups, etc.; Purdon, Antony, Monteiro, Swinson, 2001; Stein, Walker, & Forde, 1994).

The plausible mechanisms behind why stress increases when being watched are straightforward. When one's sense of social belonging is threatened, motivation to shift attention to social cues increases, presumably to achieve success in subsequent social interactions (Williams, 2007). For example, a person who believes that they need to come off as intelligent in a social interaction may devote more attentional resources to the quality and content of their own speech, while simultaneously looking out for any non-verbal signal from others that they are either being perceived as interesting or losing the attention of the audience. The reasons why a person may hold a belief that intelligence is important is likely influenced by both learned and innate factors (Young, Klosko, & Weishaar, 2003). While perceived social evaluation is largely interpretive, there are indeed physiological reactions associated with these interpretations.

In a large-scale meta-analysis on social-evaluative threat, Dickerson and Kemeny (2004) concluded that social-evaluative situations where core features of the self could be judged in a negative manner elicit greater stress responses than those situations with no social-evaluative component (Cohen's  $d = 0.67$  vs.  $d = 0.15$ ). Specifically – studies in which performance was captured on permanent record (e.g., being filmed), an evaluative audience was present, or a person offering a negative social comparison was present were all shown to elicit a social-evaluative threat response (as evidenced by salivary cortisol). Furthermore, the combination of at least two of these elements resulted in a greater stress response than presenting one of these features alone (Cohen's  $d = 0.86$  vs.  $d = 0.23$ ; Dickerson & Kemeny, 2004). However, studies using a live audience found stronger cortisol responses than those using a video camera.

Laboratory-based sporting tasks can also be conceived as *motivated performance tasks* – situations that involve performance-related demands, in which a person is actively engaged in trying to attain optimal levels of learning or achievement (Blascovich, 2008; Tomaka, Blascovich, Kelsey, & Leitten, 1993). Situations that combine both social-evaluative threat as well as motivated performance issues have been found to elicit stronger stress responses than situations that only include motivated performance issues (Cohen's  $d = 0.35$  vs.  $d = -0.07$ ; Dickerson & Kemeny, 2004). Thus, situations that entail social-evaluative threat seem to be potentially detrimental sources of stress that may inhibit optimal learning and performance in skill-based tasks.

In summary – the practical application of the work of Dickerson and Kemeny (2004) is that relatively simple stress tasks used in psychological research are reliable enough to generate a stress response in participants. Personally, one only needs to recall a moment in their lives in which definitive social evaluation was present to conjure up both a cognitive, and physiological “memory” of the moment – manifested perhaps by flushing of the skin, sweating, an increased

heart rate, as well as a greater internal focus. Whether that stress response is facilitative or debilitating toward performance seemingly depends on the demands of the task, as well as the interpretation of the meaning of both the stress response and the situation.

### **Social Evaluative Threat in Athletes**

Despite the implications that social evaluative threat has negative consequences, historically speaking the prevailing notion has been that the presence of others may actually be beneficial to performance. Indeed, research on the social facilitation effect has been conducted for many decades. Zajonc (1965) reviewed a large body of literature capturing the essence of this phenomenon that now reaches nearly 100 years at the time of writing. Simply summarized, the presence of an audience can be beneficial to fine-motor performance when a skill is automatic, and detrimental when the skill is not well-learned. In his review, much of the work demonstrated a variation of breaking up a study into two phases separated by a few days – practice phase, and test phase. Tasks have ranged from following targets with a stylus, with number of perfect revolutions being the targeted performance, to solving simple math problems, to tracing a maze with a finger. Regardless of the task, Zajonc (1965) asserted that our *dominant* response patterns are brought forth by audience presence. The implication of these findings would suggest that the personal characteristics of an individual matter when considering the influence of an audience on performance.

Although the domains in which social-evaluation could be studied are vast, using sport competition in the laboratory provides a practical way to examine the effects of mild-to-moderate social evaluation on motivated performances. When athletes are competing, they experience many stressors surrounding the competition. Of these stressors, social evaluative threat is experienced by a significant number of athletes (James and Collins, 1997). When trying to simulate competitive pressure in a laboratory, researchers have used a number of different

stimuli (i.e., simulated judgment, financial incentives, experimentally induced self-focus). However, simulating the social-evaluative component of a high-level competition in the laboratory is difficult. The continued contrast between ecological validity and control of relevant variables is an issue that will likely challenge researchers in this area in perpetuity.

When examining the links between pressure and performance, research has typically examined either the situation, *or* the individual. For example, the competitive environment, as well as the stakes of a competition, have both been implicated as significant stressors in both the animal and sports literature (Salvador & Costa, 2009). Furthermore, stressors perceived as uncontrollable, novel, challenging, or threatening all contribute to the stress response (Lazarus & Folkman, 1984). However, as individual *people* are the ones who participate in sport, personal interpretations as to the meaning of these stressors also activate psychological and physiological stress responses. Above and beyond physical danger, competitive stress is primarily a social phenomenon that results from a strong desire to please others combined with low self-presentational efficacy (James & Collins, 1997). Qualitative research in sport has identified many character traits that predict feeling stressed during performances (e.g., James & Collins, 1997; Hill et al., 2010; Mellalieu, Neil, Hanton, & Fletcher, 2009; Neil, Mellalieu, & Hanton, 2009). These characteristics are likely to make individuals more vulnerable to the pressure associated with learning or performing sport-related tasks.

Situational stressors, whether naturally experienced by sport participants or experimentally induced by researchers in lab settings, have been presumed to impair one's capacity to learn and to achieve a desired level of performance. Less attention has been allocated to specific vulnerability (or protective) factors that could modulate the debilitating effects of situational social stressors on sport performance. Moreover, the interaction between individual characteristics and the competitive environment is also not presently well-documented. James

and Collins (1997) conducted a qualitative study of 20 participants (10 males, 10 females) who had been competing in a variety of sports for roughly 10 years who were interviewed about sources of perceived stress in their sport. In all, over two-thirds of all statements made by the athletes in the study contained themes of self-presentation and/or evaluative concerns. Both *significant-other* (e.g., teammate problems, coach pressure, parental demands, and officials), as well as *self-presentational* concerns (e.g., how one's own image or performance is being perceived by others) were among the most cited sources of stress during competition. Interestingly, 90% of participants identified at least one significant other who was a source of stress. Self-presentation concerns have been shown to be related to three factors: 1) obtaining social and material gain, 2) maintaining self-esteem, and 3) developing identity (James & Collins, 1993). For those who have an established athletic identity and depending on the culture of one's environment, any relevant athletic pursuits for these individuals may be seen as more important than other pursuits not in the domain of sport.

It is not entirely surprising that concerns over social evaluation are so prevalent. Sub-clinical levels of social anxiety in the general population are quite common, with incidence estimates between 50% and 61% for people reporting symptomatology in at least one situation (Purdon, Antony, Monteiro, Swinson, 2001; Stein, Walker, & Forde, 1994). In their cognitive model of social anxiety, Clark and Wells (1995) suggest that people who experience social anxiety tend to hyper-focus on themselves as a social object and often experience recurring negative mental images of how they believe they are being perceived by others. Often times, these images represent worst-case scenario situations which confirm their fears and increase their anxiety as a result. In summary, social-evaluative threat is a common situational stressor that faces many people. Furthermore, the majority of athletes seem to focus at least somewhat on evaluative concerns in the context of their sports. If social evaluation is prevalent in the sporting

context, and is associated with predictable stress-responses, what are the associations with performance?

### **What Happens to Performance Under Pressure?**

The breaking down of performance under pressure, often described as “choking”, has been studied for several decades in sport psychology research (e.g., Beilock & Gray, 2007; Hill, Hanton, Matthews, & Fleming, 2010). Choking has been defined as a *catastrophic* deviation from *expected* performance during a pressure-filled situation (Baumeister & Showers, 1984), or more recently by Hill et al. (2009) as “...a process whereby the individual perceives that their resources are insufficient to meet the demands of the situation and concludes with a significant drop in performance - a choke.” (p. 206). Interestingly, Hill et al.’s (2009) definition closely resembles Lazarus and Folkman’s (1984) definition of primary appraisal. In the case of athletes, perhaps the primary appraisal being made is not necessarily related to the demands of the task, but rather the *social* demands associated with the task.

Despite choking being an often-studied construct (Beilock & Gray, 2007), many researchers have criticized the use of the term *choking* when referring to decreased performance that is not indeed catastrophic. It has been argued that most research done on choking has not actually demonstrated catastrophic failure, but rather reasonably expected degradations in performance (e.g., Lewis & Linder, 1997; Mullen et al. 2000). Instead, performance *deviations* from one’s own average – both increases and decreases - are relevant when studying sport performance as it can help foster a better understanding of the situational triggers associated with one’s best and worst athletic performance.

**Choking Theories.** As mentioned, choking has been defined as a *catastrophic deviation* from expected performance during a pressure-filled situation. While several potential explanations in regard to the mechanisms of such changes have been proposed, evidence

suggests that *decreases* in performance primarily occur through attentional disruptions (Beilock & Gray, 2007). Attentional theories rest on the assumption that optimal performance depends not only on maximal attention to task-relevant information relating to the skill, but also the ability to minimize attention to task-irrelevant information (Lewis & Linder, 1997). If these cognitive processes are interfered with, attentional theories predict that decreased performance will result. Most of the evidence surrounds two versions of attentional theories: *distraction theories* (e.g., Eysenck & Calvo, 1992) and *self-focus theories* (e.g., Masters, 1992). Generally speaking, the literature seems to be in favour of self-focus theories as the most plausible mechanism of choking in sport (Hill et al., 2010). However, both distraction and self-focus may play a role depending on the disposition of the performer and the type of skill being performed.

The *explicit monitoring hypothesis* (EPH; Masters, 1992), the *conscious processing hypothesis* (CPH; Beilock & Carr, 2001), and the *constrained action hypothesis* (CAH; Wulf, 2007) all attempt to explain choking from a self-focus perspective. The EPH subsumes that the impaired performance event occurs through the act of cognitively monitoring one's actions. In other words, the simple act of paying attention to the movements that one is making is enough to disrupt the flow of the movement itself. The CPH theorizes a control component where one attends to trying to control the action itself. Lastly, the CAH, almost mimics the CPH directly, but adds explanatory value by differentiating *why* an internal focus may be associated with poorer performance as compared to adopting an external focus (see Wulf, 2007 for an in-depth explanation on attentional focus and motor control).

Conversely, the most notable distraction-based explanation is the *processing efficiency theory* (PET; Eysenck & Calvo, 1992). PET hypothesizes that anxiety associated with a pressure-filled situation leads to cognitive resources (e.g., working memory) being dedicated to the management of the anxiety itself, rather than the task at hand. PET further subsumes that

performance decreases under pressure occur most notably in highly anxious (i.e., trait-anxiety) but non-clinical populations (Eysenck & Calvo, 1992). In other words, the more anxious a person tends to be, the more likely their performance will reduce under pressure. This theory postulates that a hypothetical “control system” exists within the brain that mediates the effects of anxiety on processing information and performance. This control system is influenced by both pre-existing sensitivities to stimuli as well as anxiety resulting from inadequate performance during the task itself. Pre-existing sensitivities, while not explicitly mentioned in the theory, could be assumed to consist of trait-like factors, such as worry, temperament, arousal level, trait anxiety, etc., while stimuli relating to the task refers more to the direct outcome associated with either succeeding or failing.

Depending on the individual, as well as the specific situation, the control system elicits two categories of response: either (1) coping strategies can be put in place to deal with the anxiety; and/or (2) further cognitive resources (e.g., effort and strategy) can be used to decrease the probability of poor execution. Both outcomes are designed to reduce the levels of anxiety experienced by the individual. PET theorizes that highly anxious people will employ a greater amount of cognitive resources activated by the control system compared to people with lower levels of anxiety. Anxious individuals may then demonstrate decreased performance due to limited executive functions being focused on the reduction of worry and other task-irrelevant cues in the environment. However, it is also possible that enough effort may completely mitigate the potential negative consequences associated with anxiety. That being said, the more complex the task being performed, the greater the likelihood that anxiety will interfere with the process. Furthermore, any motivational factors (ego-involvement, financial rewards, etc.) that would normally enhance effort are likely to benefit low-anxious individuals more than high-anxious individuals. As anxiety is hypothesized to also reduce transient storage capacity, it is assumed

that salient environmental information may not be taken into consideration when performing a complex task that requires the synthesis of multiple data points.

Processing efficiency theory was expanded upon by Eysenck et al. (2007) and renamed *attentional control theory* with updated predictions based on advancements in the literature. To understand attentional control theory, it is important to differentiate between *performance effectiveness* and *performance efficiency*. *Performance effectiveness* refers to objective performance on the actual tasks, while *efficiency* refers to the amount of effort and resources required to complete the task. Attentional control theory predicts that anxiety influences efficiency far greater than effectiveness. The theory itself rests on two assumptions: 1) that *worry* is the component of state anxiety that inhibits both effectiveness and efficiency, and 2) the central executive is the working memory system (based on Baddeley's four-part model of working memory; see Baddeley, 2001) that becomes taxed by increased task complexity. The central executive has five main functions: switching attention, planning subtasks to reach a goal, selective attention and inhibition, updating and checking working memory contents, and coding representations in working memory for both time and place (Smith & Jonides, 1999).

Perhaps the biggest difference between the two versions of the theory is the focus on *why* anxious and non-anxious individuals often do not differ in performance, despite anxious individuals reporting significantly more anxiety. Eysenck et al. (2007) hypothesize that threat-related cues in the environment (more specifically, ones related to negative evaluation) impair the ability to maintain focus on task-relevant details through a suppression of the inhibition function of the central executive. In other words, being able to filter out performance-*irrelevant* cues is important for optimal effectiveness. Processing efficiency theory assumed simply that worry interferes with efficiency, while attentional control theory accounts for the distraction effects of anxiety (both internal and external) based on both impaired attentional control and

prioritizing threat-related stimuli over non-threat. As social evaluative threat is a valid ecological threat that many regularly face both in daily life and competition, it is likely that those who are sensitive to threats will be more prone to distraction.

It is important to note that during a catastrophic performance deviation, it is said that an athlete can think clearly and select the appropriate action to take but cannot *execute* the proper movements due to psychological factors (Clark, Tofler, & Lardon, 2005). This is differentiated from a 'slump' which is defined as consistently poor performance that is not necessarily induced from environmental pressure (Grove, 2004). As a result, these "psychological factors" must be considered when examining performance changes in research and many moderating variables have been subject to previous study. For example, Hill et al. (2010) suggested that personality characteristics such as self-consciousness, dispositional reinvestment (i.e., the tendency to focus on one's movement), trait anxiety, skill level, task properties, presence of an audience, stereotype threat, and coping styles all may be associated with choking in their own unique way. By far, state anxiety has been the most studied construct as a moderating factor between pressure and performance.

### **Anxiety and Performance**

State anxiety arising from pressure is often viewed as a debilitating factor that is detrimental to performance. However, empirical evidence for the relationship between anxiety and performance is equivocal with no consistent patterns emerging. Martens, Vealey, and Burton (1990a) published the Multidimensional Anxiety Theory, which in summary states that anxiety can be broken down into two components: *cognitive anxiety* (i.e., anxious thoughts) and *somatic anxiety* (i.e., the physiological/affective aspect). In this theory, cognitive anxiety is analogous to worry, while somatic anxiety is represented as the interpretation of one's own somatic symptoms. While both of these sub-components are measured using self-reported interpretations

of both physiological and narrative aspects of the experience of anxiety, theory and practice would support this theoretical breakdown (see Barlow, 2002 for a comprehensive discussion of the link between the physiological and cognitive aspects of the experience of anxiety).

To assess these two components of anxiety in the context of sport, Martens, Burton, Vealey, Bump, and Smith (1990b) created the Competitive State Anxiety Inventory-2 (CSAI-2) which consists of three subscales: cognitive anxiety, somatic anxiety, and self-confidence. Self-confidence – while not considered to be a component of anxiety – was added as an additional construct that was first thought to be on the opposing end of a spectrum with cognitive anxiety. Martens et al. (1990a) build on Yerkes and Dodson's (1908) theory, hypothesizing a number of relationships between cognitive anxiety, somatic anxiety, self-confidence, and performance. Under their theory, cognitive anxiety is hypothesized to have a negative linear relationship with performance, somatic anxiety is hypothesized to have a quadratic (inverted-U) relationship with performance, and self-confidence is hypothesized to have a positive linear relationship with performance<sup>1</sup>.

Craft, Magyar, Becker, and Feltz (2003) conducted a meta-analysis of 29 studies using the CSAI-2. Results indicated that the overall correlations between both the cognitive and somatic anxiety subscales and performance are not significant. However, several factors seemed to change these relationships. In tasks requiring closed skills (i.e., those performed in a constant, unchanging environment - e.g., dart throwing), no relation was found between cognitive anxiety, somatic anxiety and performance. For open skills (i.e., those performed in a constantly changing

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<sup>1</sup> While interesting in its own right, the construct of self-confidence and associated components is worthy of its own project and therefore beyond the scope of this thesis.

environment - e.g., returning a tennis serve), a significant positive relation was found for both scales and performance. For individual sports, a positive relation between both subscales and performance was found. For team sports, no relations were found. Furthermore, the level at which an athlete competes appears to moderate the relationship. For elite athletes (i.e., professionals, world-class amateurs), both somatic and cognitive anxiety are associated with increased performance, while no relations emerged for recreational athletes. Interestingly, across all samples the moment at which somatic anxiety was measured seemed to moderate the link to performance. When the CSAI-2 was administered 15 min or less before competition somatic anxiety significantly predicted *decreased* performance, while cognitive anxiety and self-confidence was related to *increased* performance.

Woodman and Hardy (2003) conducted another meta-analysis looking at the relation between cognitive anxiety and performance, based on the predictions of Martens et al. (1990) and their article on the development of the CSAI-2. In their paper, Woodman and Hardy (2003) critiqued the predictions that Martens et al. (1990) made in regard to somatic anxiety. As no theoretical explanations were made as to why the *perception* of one's somatic anxiety and the link with performance would be quadratic, Woodman and Hardy (2003) argued that it is of little theoretical value to test the relation between somatic anxiety and performance, as our own perceptions are often not accurate as to our physiological indicators. Of the 43 studies that reported a relationship between cognitive anxiety and performance, 26 (60%) reported a negative relationship, 7 (16%) reported non-significant results and 10 (23%) reported a positive relationship (with the mean effect size overall being  $d = -.10$ ). No significant differences were found between inter- and intra-individual measures of anxiety, or individual vs. team sports.

### **Golf Putting, Anxiety, and Social Evaluative Threat**

Golf putting is routinely used by researchers to study “choking” and the effect of anxiety

because of its gradual learning curve and susceptibility to breaking down under pressure (e.g., Beilock & Carr, 2001; Cooke, Kavussanu, McIntyre, & Ring, 2010; Cooke, Kavussanu, McIntyre, Boardley, & Ring, 2011; Lewis & Linder, 1997; Masters, 1992; Masters, Maxwell, & Eves, 2003). Although significant changes in both kinematic and objective measures of putting performance under stress are often observed, the pattern of results is quite variable and often depends on certain experimental conditions. A thorough (but not exhaustive) search of the literature identified 24 different studies requiring participants to putt under neutral and stressful conditions (see Table 1 for a summary of all studies). The stress conditions in all of the putting studies usually involve a combination of social-evaluative components designed to elicit a stress response<sup>2</sup>. Masters (1992) conducted the first putting study using a social-evaluative paradigm, and subsequent studies seem to follow similar methodology, with slight but unsystematic variations in procedure. Typically, most studies involve the participants' performance being evaluated by a golf-professional (either live or in the future), being filmed, or having financial incentives present based on performance. Although it is unclear which of these components contributes most to the pressure experienced by the participants, combining multiple ingredients in a social-evaluative threat manipulation is consistent with experimental studies generally used outside of sport psychology research. As reviewed earlier, the combination of at least two social-evaluative elements resulted in a greater stress response than exposure to one on its own (Dickerson & Kemeny, 2004).

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<sup>2</sup> Interestingly, despite the significant similarities in the manipulations themselves, no specific rationale has ever been given for the selection of certain stressors. The earliest indication of the “golf pro” manipulation showed up in early work, and a version has been used in most studies ever since.

**Anxiety and Golf Putting Performance.** Despite the relatively benign (i.e., not seemingly stressful) manipulations of social evaluation used, most studies found increases in anxiety for participants in social-evaluation related conditions for novices (e.g., Cooke et al., 2010; Kinrade, Jackson, & Ashford, 2010; Moore et al., 2012; Mullen et al. 2007; Vine & Wilson, 2010), recreational (Gucciardi & Dimmock, 2008; Kingsbury et al., 2011; Wilson, Smith, & Holmes, 2007), and skilled players (Cooke et al., 2011; Land & Tenenbaum, 2012; Vine et al., 2011). Furthermore, putting under social evaluation has been associated with cardiac changes such as increases in heart rate and decreases in heart rate variability in novices (Cooke et al., 2010, Masters, 1992; Moore et al., 2012; Tanaka & Sekiya, 2011; Zhu et al., 2011). That being said, the relationship between anxiety and putting performance is not entirely clear and in fact, *relatively few studies have found a direct link between anxiety and performance* when golfers are putting under social-evaluative threat.

This is an important point to highlight to shed light on context for knowledge development in this area. For example, Wilson et al. (2007) showed that high levels of anxiety were related to an increase in time to initiate backswing, as well as less accuracy while putting under pressure. Kingsbury et al. (2011) found that shyness (a temperament-related version of social anxiety) was associated with poorer performance under pressure, but only for those golfers who exhibited a high level of state anxiety. In regard to the direct link between putting under pressure and performance, results seem to be related to a number of moderating factors. For example, novice golfers who learned the skill of putting explicitly (i.e., with consciously executed verbal instructions) have been shown to either have a decrease in performance (Masters, 1992) or display no improvement in performance under pressure as compared to those who learned the skill implicitly (i.e., with no conscious instructions to focus on; Hardy et al., 1996; Mullen et al., 2007). Putting under pressure, while simultaneously performing a secondary

cognitive task, has also been associated with decreased putting performance in both novices (Beilock & Carr, 2001) and recreational golfers (Mullen et al., 2005). Cooke et al. (2010) found that a sample of novices holed significantly fewer putts under medium and high levels of pressure compared to low pressure. In support of Beilock and Carr's (2001) conscious processing hypothesis, golfers who focused on the execution of the stroke itself have also been shown to suffer from decreased accuracy while putting (Gucciardi & Dimmock, 2008; Kinrade et al., 2010; Mullen & Hardy, 2000).

Not surprisingly, skill level has been shown to moderate putting performance under pressure (Kingsbury et al., 2011; Land & Tenenbaum, 2012; Tanaka & Sekiya, 2010). Skilled golfers also show a differential cardiac profile while putting. Neumann and Thomas (2011) found that compared to novice golfers, experienced and elite golfers showed reduced heart rate (HR), greater heart rate variability (HRV), pronounced HR deceleration prior to the putt, and a greater tendency to exhale prior to the putt. Expert golfers have also been shown to improve their putting accuracy under pressure (Cooke et al., 2011). However, relatively few studies have directly compared beginners and experts in the same study, given the drastic differences in skill level.

In summary, while social-evaluative pressure seems to unequivocally induce a stress response and increase levels of anxiety in a range of golfers, the direct link between social-evaluative pressure and objective performance (i.e., distance a ball finished from a target, # of putts holed) appears to be less clear.

**Anxiety and Golf Putting Kinematics.** While many studies have examined putting performance in regard to where the ball ends up after being hit (i.e., holed or not, radial error), fewer have actually looked at the kinematic parameters of the strokes themselves. Out of those studies that have examined putting kinematics, a variety of methodologies have been used such

as frame-by-frame video analysis (Land & Tenenbaum, 2012; Mullen & Hardy, 2000; Tanakya & Sekiya, 2010; 2011) as well as the use of 3D accelerometer devices (Cooke et al., 2010; 2011; Moore et al., 2012a; 2012b). Recently, a handful of studies have used sophisticated 3D computer analysis traditionally used by teaching professionals (Karlsen, Smith, & Nilsson, 2008; Toner & Moran, 2011; Toner, Moran, & Jackson, 2013). However, no studies have used this type of analysis to examine putting under social-evaluative pressure.

While a number of kinematic parameters can be measured, it has been suggested that they do not hold equal importance in regard to objective performance. Assuming that a golfer makes contact on the center of the ‘sweet spot’, Pelz (2000) indicates that 83% of the variability in a golf ball’s initial direction is influenced by the face angle at impact, with 17% being accounted for by the path of the putter head during the stroke. To further substantiate these findings, Karlsen et al. (2008) recorded the kinematic stroke parameters of 1301 putts hit from 16 feet away from the hole by 71 elite golf players (mean handicap = 1.8). Of the different factors influencing stroke direction consistency, face angle was found to be the most important (80%), followed by putter path (17%) and impact point (3%). The authors suggest that improvements in consistency of putter path and impact point will have very little effect on overall putting direction consistency and should not be prioritized in the training of elite players<sup>3</sup>.

Relatively few studies have examined the associations between anxiety and kinematic parameters. Nevertheless, changes in muscle tone (Cooke et al., 2010; Tanaka & Sekiya, 2010;

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<sup>3</sup> Study 1 of this thesis broadly explored a number of kinematic variables (even those hypothesised to not necessarily be related to object success), while Studies 2 and 3 focused the kinematic analyses to only include face angle at impact.

2011, and putter head acceleration profiles (Cooke et al., 2010; Mullen & Hardy, 2000) have been demonstrated. Mullen and Hardy (2000) found that the putter head reached its top speed on the downswing later during the stroke when putting under social-evaluative pressure as compared to putting under neutral conditions. Cooke et al. (2010) demonstrated increased forearm-muscle tension during the forward stroke under high pressure as compared to low pressure in a sample of novice golfers, while accelerometer data indicated that putter-head acceleration along the X-axis increased from low pressure to high pressure. Tanaka and Sekiya (2010) conducted a study comparing the putting kinematics of 6 male pros and 5 male novice golfers and found a decrease in both arm and clubhead movement for both groups in the stress condition. A year later, Tanaka and Sekiya (2011) found that clubhead acceleration increased, but arm range of motion, club head in forward swing, and total swing time decreased from low to high pressure in a sample of 20 male novices. In other words, golfers' putting strokes became shorter, quicker, and 'jerkier'. Overall, across all of the golf putting studies, it appears as though social-evaluative pressure has consistent, yet undifferentiated effects on the kinematics of the stroke. Therefore, this thesis will focus on both the kinematic parameters and objective performance during subsequent golf putting strokes both under neutral and social evaluative conditions to examine how performing under social evaluative threat may alter the improvement trajectory of individuals. The following section will elaborate on the longitudinal methodology used for each study.

### **A Multilevel and Stress-Diathesis Perspective**

To review from an anecdotal perspective, choking would be akin to scoring on one's own

net in hockey during the playoffs<sup>4</sup>, or a disastrous final hole in a golf tournament<sup>5</sup>. More specifically, choking is a categorically defined term that refers to the extremely rare phenomenon of substantial deviation from expected performance. However, one issue that remains unclear is the point at which a decline in performance is substantive enough to be considered a choke. This categorical perspective is in contrast to the actual distribution of within-person performance<sup>6</sup>. Not only just experts, every person has their mean performance with a measurable amount of personal deviation around their mean. Within-person variations of performance have often been depicted as random error that cannot be explored. However, from a multi-level perspective, these variations can be explained both by time-variant (i.e., situational) and time-invariant (i.e., personal) characteristics (e.g., Beale et al., 2005; Gaudreau, Nicholls, & Levy, 2010). As a result, the current thesis will examine performance as a continuous and fluctuating variable rather than as a categorical one differentiating between choking or not.

Putts performed across successive trials in a lab session or between holes in a game of golf are not totally independent actions as they are performed by the same individual who is capable of adapting motor action based on outcome of previous trials. Traditional statistical analyses force researchers to aggregate putts across all trials, resulting in models that do not incorporate the natural within-person fluctuations of kinematic patterns and putting outcomes. As

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4 Steve Smith of the 1986 Edmonton Oilers; Chris Phillips of the 2007 Ottawa Senators – both during the Stanley Cup Playoffs.

5 Jean Van De Velde's triple-bogey 7 in the 1999 British Open on the 18th hole at Carnoustie; I.K. Kim's missed 1-foot putt on the final hole of the 2012 Kraft Nabisco Championship.

6 Most choking studies have examined performance variations as a continuous phenomenon, which is in sharp contrast to the operational definition of choking. All of these studies can therefore be used as anchor points to conceptualize the effect of situational stressors on within-person variations in performance.

such, a main focal point of this thesis is to use a novel method of statistical analyses that have been less frequently used in sport psychology research to consider the momentary nature of putting outcomes in a multilevel model in which putts are conceived as non-independent instances nested within a person. Putting ability is also influenced by overall golfing skills or what golfers refer to as the golf handicap (e.g., Beilock, Bertenthal, McCoy, & Carr, 2004; Beilock, Weirenga, & Carr, 2002; Tanaka & Sekiya, 2010). Multilevel models can readily incorporate between-person variables, such as golf handicap (e.g., Gaudreau, Nicholls, & Levy, 2010), or state anxiety in order to control for their influence in explaining why certain golfers, overall, obtain better putting outcomes than others.

### **Summary**

As reviewed in this chapter, social-evaluative threat is likely to impact the performance and learning of the golf putting stroke. During episodes of social-evaluative stress (compared to neutral conditions), participants have been found to experience decreases in performance, increased anxiety, and changes in kinematic putting parameters. However, the relation between social-evaluative threat and putting performance may depend on a number of personal factors such as skill level and anxiety. In Study 1, a group of recreational golfers participated in an experiment with a social-evaluative threat manipulation while measuring levels of anxiety and kinematic parameters. Study 2 built upon the results of Study 1 and collected a sample of novices with no golf experience who participated in a similar experiment with a few methodological changes. Study 3 recruited a sample of novice participants and randomized each to either a stress-free learning task, or a social-evaluative learning task, to build upon the findings of both Study 1 and Study 2 while addressing an important methodological limitation identified throughout the research process. Overall, the overarching goal of the three studies is to examine the role of anxiety in predicting the performance trajectory of novice golfers in neutral versus

social-evaluative threat conditions.

## Chapter 1 Tables

*Table 1. Summary of social evaluative golf putting studies organized by publication year.*

Study	Sample Description	Conditions	Variables	Stress Manipulation	Noteworthy Results
Masters (1992)	40 novices (no gender specified)	Implicit learning, explicit learning, explicit control, stressed control, no-stress Control; Low/high pressure	Heart rate, task time, explicit knowledge, # of putts holed	\$\$ gain or loss, evaluation by live golf professional	State anxiety & heart rate increased for stressed groups; implicit learners exhibited no degradation in performance compared to explicit learners; explicit learners took more time to complete task
Hardy, Mullen, & Jones (1996)	32 novices (16 male, 16 female)	Explicit learning, implicit learning, implicit learning dual-task, no-stress control; Low/high pressure	Cognitive and somatic state anxiety, heart rate, task completion time, explicit knowledge, # of putts holed	\$\$ gain or loss, live expert in golf clothes	Increased combined anxiety for groups exposed to stress intervention; performance for implicit learners and controls improved, where the explicit learners did not
Lewis & Linder (1997)	129 males (no indication of skill)	Distraction (low/high), Self-awareness (low/high); Low/high pressure	Mean radial error	\$\$, video tape analysis by multiple people (not present)	For low distraction, non-adapted participants under low pressure, mean radial error = 55.5 cm, under high pressure = 81.5 cm
Bright & Freeman (1998) – Study 1	48 novices (35 female, 13 male)	Implicit learning, explicit learning, implicit learning w/ dual-task; Low/high pressure	State/trait anxiety, # of putts holed	Participants told golf pro watching behind one-way mirror	State/trait anxiety scores increased between conditions; no performance differences under pressure
Bright & Freeman (1998) – Study 2	22 novices (11 female, 11 male)	hard dual-task, easy dual-task; Low/high pressure	State/trait anxiety, # of putts holed	Participants told golf pro watching behind one-way mirror	No performance differences between easy and hard dual-task groups
Mullen & Hardy (2000)	18 experienced male golfers (handicaps between 12-18)	Task-relevant, task-irrelevant, control, poor putters, good putters; Low/high pressure	Cognitive and somatic state anxiety, effort, kinematic analysis, # of putts holed, mean radial error	\$\$, video evaluation by pro (not present), results circulated	Increase in cognitive anxiety between conditions; poorer performance in both low-anxiety relevant/irrelevant groups, and high-anxiety relevant group compare to control; state anxiety related to more effort, better putters showed more effort; group x anxiety kinematic interaction
Beilock & Carr (2001) – study 3	108 novices (no gender specified)	Single-task, distraction, self-consciousness; low/high pressure	Mean radial error	Video tape for self-consciousness group, social comparison and small \$\$ (5\$) for improvement	Both single-task and distraction group performed worse under high pressure; self-conscious group improved under high pressure
Beilock & Carr (2001) – study 4	32 novices (no gender specified)	Distraction, self-consciousness; low/high pressure dual-task, low/high pressure single-task	Mean radial error	Video tape for self-consciousness group, social comparison and small \$\$ (5\$) for improvement	Both self-conscious and distraction group performed worse under dual-task high pressure in early stage of learning; self-conscious group improved under single-task high-pressure

Study	Sample Description	Conditions	Variables	Stress Manipulation	Noteworthy Results
Mullen, Hardy, & Tattersall (2005)	24 experienced golfers (handicaps between 10-21)	Task-relevant/task-irrelevant dual-tasks, single task control; Low/high pressure	Cognitive anxiety, heart rate variability, effort, 2-D error scores, mean radial error, bivariate variable error	\$\$, evaluation by pro, results circulated	Cognitive anxiety increased between conditions, mean radial error higher in high-pressure dual-task conditions; high frequency heart rate variability higher in low-pressure condition for dual-task groups
Mullen, Hardy, & Oldham (2007)	36 novices (18 male, 18 female)	Explicit learning, Implicit learning, Two implicit-dual task groups; Low/high pressure	Cognitive and somatic state anxiety, heart rate, explicit knowledge, # of putts holed	\$\$, video analysis by golf pro (not present)	No differences in heart rate; cognitive anxiety increased between condition for those exposed to intervention; implicit learners improved from final practice day to test, while explicit learners did not
Wilson, Smith & Holmes (2007)	18 experienced golfers (handicaps between 10-18)	Low/high anxiety by median split on cognitive subscale; Low/high pressure	Multidimensional sport trait anxiety, effort, heart rate variability, time to initiate back swing, glances at hole	\$\$, video analysis by golf pro, league results	Anxiety and effort more pronounced for high-anxious golfers under pressure; high-anxious golfers took more time to initiate backswing; all golfers made more glances at hole during high pressure; high-anxious golfers' performance got worse under pressure
Gucciardi & Dimmock (2008)	20 experienced golfers (handicaps between 0-12, 1 female, 19 males)	Task-relevant/task-irrelevant dual-tasks, single swing thought; low/high pressure	Cognitive and somatic state anxiety, mean radial error	\$\$ for top finishers	Increased cognitive anxiety between conditions; performance decrement in task-relevant group compared to others under high-pressure
Cooke, Kavussanu, McIntyre, & Ring (2010)	58 novices (35 female, 23 male)	Low/medium/high pressure	Cognitive and somatic state anxiety, mean radial error, effort, heart rate, heart rate variability, EMG, kinematic parameters	\$\$ gain or loss, social comparison, video camera with image displayed	Fewer putts holed during medium and high pressure conditions; anxiety and effort increased between conditions; heart rate and heart rate variability increased between conditions; increased muscle activity and x-axis acceleration under high pressure
Kinrade, Jackson, & Ashford (2010)	63 novices (40 males, 23 female)	Low/high pressure	Cognitive and somatic state anxiety, perceived pressure, Dispositional reinvestment, arbitrary point-system for performance	Experimenter who filmed the trials	Significant increases in cognitive anxiety and perceived pressure between conditions; no difference in performance between low and high pressure; those high in dispositional reinvestment scored fewer points under pressure
Tanaka & Sekiya (2010)	6 male professional golfers, 5 male novices	Low/high pressure	State/trait anxiety, unpublished movement awareness and distraction questionnaire, heart rate, kinematic parameters, arbitrary point-system for performance	live audience of 5; \$\$ for good performance, video camera (used for genuine analysis)	No changes in performance scores; linear amplitude of left elbow decreased between conditions during back swing and forward swing

Study	Sample Description	Conditions	Variables	Stress Manipulation	Noteworthy Results
Vine & Wilson (2010)	14 novices (all male)	Quiet-eye trained group, control group; low/high pressure	Cognitive anxiety, arbitrary point-system for performance, quiet-eye and putting durations	\$\$ for top performer, social comparison, non-contingent negative feedback	Cognitive anxiety increased between conditions; quiet-eye trained group showed longer preparation and back-swing times; control group performed significantly worse than quiet-eye group under pressure
Cooke, Kavussanu, McIntyre, Boardley, & Ring (2011)	50 experts (44 male, 6 female)	Low/medium/high pressure	Cognitive anxiety, mean radial error, # of putts holed, effort, dispositional reinvestment, heart rate/HRV, EMG, grip force, kinematic parameters	\$\$ gain or loss, social comparison, video camera with image displayed	MRE decreased from low to high pressure, but no differences in # of putts holed; both cognitive anxiety and effort increased from low to high pressure; right hand grip pressure increased from low to high pressure, while left hand pressure decreased; impact velocity reduced during medium pressure
Kingsbury, Coplan, & Reichel (2011)	33 experienced golfers (13 female, 20 male with handicaps ranging from .8 to 42.6)	Low/high pressure	Shyness, state anxiety, coping, arbitrary point-system for performance	Live golf professional who videotaped performance for later analysis, \$\$ incentive based on performance	Strong positive relationship between shyness and state anxiety at low levels of problem-focused coping; at high-levels of state anxiety, shyness associated with decreased performance under pressure; problem-focused coping associated with increased performance under pressure
Tanaka & Sekiya (2011)	20 novices (male)	Low/high pressure	State anxiety, positive/negative affect, movement awareness and distraction questionnaire arbitrary point-system for performance, kinematic parameters, heart rate	\$\$ for performance, electric shock threat for poor performance (!)	Heart rate increased between conditions; forward stroke acceleration increased under high pressure, arm movement and back swing motion decreased under high pressure
Vine, Moore, & Wilson (2011)	22 elite golfers (male)	Quiet-eye trained group, control group; low/high pressure	Cognitive anxiety, mean radial error, % of putts holed, # of putts per round, quiet-eye durations	\$\$ for top performer, social comparison, non-contingent negative feedback	Cognitive anxiety increased between conditions; quiet-eye trained group holed more putts and had lower mean radial error under pressure than control group; quiet-eye trained group showed reduction in putts per round from pre-training to post-training
Zhu, Poolton, Wilson, Maxwell, & Masters (2011) – study 2	18 novices (no gender specified)	Implicit or explicit learning, errorless or errorful learning;	State/trait anxiety, perceived pressure, EEG, heart rate, declarative knowledge, Camera-based scoring system	Pre-recorded video message from professor running the study that their putting performance was to be recorded for analysis	Heart rate and perceived pressure higher under pressure; no differences in putting performance

Study	Sample Description	Conditions	Variables	Stress Manipulation	Noteworthy Results
Land and Tenenbaum (2012)	24 novice golfers (19 women, 5 men); 20 skilled golfers (15 women, 5 men with handicaps < 5)	Single-task, task-irrelevant, and task-relevant attentional focus conditions; low/high pressure	# of putts holed, perceived pressure, determination, kinematic parameters	Video tape evaluation by expert golfer, told that a training video was being made with their performance	Both novice and skilled golfers perceived more pressure under evaluation; skilled golfers holed more putts across all conditions; Skilled golfers holed more putts under pressure during both relevant and irrelevant conditions; skilled performers showed more movement variability during early parts of stroke, but less towards impact; novice performers exhibited less variability overall in the stroke
Moore, Vine, Cooke, Ring, & Wilson (2012)	40 novices (no gender specified)	Quiet-eye trained, technical trained; low/high pressure	Cognitive anxiety, quiet-eye duration, heart rate, heart rate variability, mean radial error, % of putts holed, kinematic parameters, EMG	\$\$ prize for top performer, results comparison, non-contingent negative feedback	Increased cognitive anxiety and heart during pressure condition; quiet-eye group holed more putts overall, no differences between conditions for either group; technical group had higher mean radial error
Moore, Vine, Wilson, & Freeman (2012)	127 novices (63 female, 64 male)	Challenge or threat conditions, only high pressure	Cognitive and somatic state anxiety, Demand/resource evaluations, mean radial error, quiet-eye duration, cardiac output, kinematic parameters, EMG	\$\$ for top performers, video camera analysis, low-performers interviewed, social performance,	Challenge group achieved lower mean radial error, lower cognitive anxiety, longer quiet-eye durations, lower putter head acceleration in x,y,z axes, lower peak acceleration and mean square jerk, and less muscle activity during forward swing and post-contact; challenge group interpreted cognitive anxiety as more facilitative and somatic as less debilitating

**Chapter 3: Study 1**

### Overview

This chapter presents an article that was published in International Journal of Golf Sciences. Dr. Rob Coplan was my former master's supervisor when data was collected. Kate Hill was a fellow graduate student at Carleton University, who assisted with data collection. Lastly, Dr. Patrick Gaudreau supervised and conceptualized the framework of the article. All authors contributed to the manuscript to varying degrees during the writing process.

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**Running head: SOCIAL PRESSURE AND PUTTING**

The Influence of Social Evaluative Threat on the Putting Stroke in Golf

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### **Abstract**

The goal of this study was to examine the multi-level associations between state anxiety and various indicators of golf putting performance. Participants were 35 amateur golfers who completed golf putting tasks under a neutral condition followed by a social-evaluative condition. Participants were equipped with a high-speed infrared camera to measure various putting stroke parameters. Results of multilevel analyses indicated that the social-evaluative condition was associated with less putter rotation and quicker forward stroke times. A cross-level interaction indicated that golfers with low levels of somatic anxiety holed significantly more putts under pressure compared to baseline, whereas those with high levels of somatic anxiety did not. As well, a significant cross-level interaction indicated that high levels of cognitive anxiety were associated with slower back strokes under pressure. Results are discussed in terms of the complex interaction between psychological variables (i.e., state anxiety) and kinematic performance indicators.

**Keywords:** *Social Evaluative Threat, Golf Putting, State Anxiety*

Individuals participating in sport related tasks encounter stressors that activate psychological and physiological stress responses. An abundant program of qualitative research in the sport domain has delineated a host of personal and situational characteristics associated with a phenomenological experience of being stressed (e.g., James & Collins, 1997; Hill, Hanton, Matthews, & Fleming 2010; Mellalieu, Neil, Hanton, & Fletcher, 2009; Neil, Mellalieu, & Hanton, 2009). These characteristics – labeled as stressors or sources of stress – offer a roadmap to detect key features of the sport context that are likely to make some sport participants more vulnerable to the pressure associated with learning or performing sport related tasks. Situational stressors, whether naturally experienced by sport participants or experimentally induced by researchers in lab settings, have been presumed to impair one’s capacity to learn and to achieve a desired level of performance on sport related tasks. Less attention has been allocated to specific vulnerability factors that could exacerbate the debilitating effects of stressors on sport performance. In this study, a *stress-diathesis framework* is proposed to examine how one specific stressor, namely social evaluative threat, can influence the kinematic patterns and the outcome of a putting stroke differentially for sport participants with distinct levels of vulnerability toward sport anxiety.

### **Situational Stressors and Sport Performance**

Several sources of stress have been identified by sport participants in qualitative studies (James & Collins, 1997; Mellalieu et al., 2009). For the most part, however, the relationship between these sources of stress and sport performance remains largely unknown insofar as they have yet to be studied in experimental studies. Past research nonetheless offers a good understanding of key situational features likely to activate the type of psychophysiological responses capable of altering one’s capacity to optimally learn and perform sport-related tasks. Several situational characteristics are capable of eliciting activated cortisol responses (e.g.,

Denson, Spanovic, & Miller, 2009), one of the hormones associated with increased stress in humans. According to the meta-analysis of Dickerson and Kemeny (2004), situations eliciting the likelihood that core features of the self (e.g., one's traits or skills) could be negatively judged by others engender significantly stronger stress responses ( $d = 0.67$  vs.  $d = 0.15$ ) compared to situations that do not elicit such *social evaluative threat*.

Capturing performance on a permanent record (e.g., videotape), performing in front of an evaluative audience, and the presence of negative social comparison are certainly prototypical of situational features of social evaluative threat. For example, an audience consisting of one person posing as a professional golfer (i.e., an evaluative figure) has been sufficient enough to increase levels of anxiety in research participants (e.g., Kingsbury et al., 2011; Lewis & Linder, 1997). Nevertheless, combining at least two of these situational features can result in a greater stress response than presenting one of these features alone ( $d = 0.86$  vs.  $d = 0.23$ ; Dickerson & Kemeny, 2004). Sport related tasks can inherently be conceived as *motivated performance tasks* because they entail performance related demands in which the person is actively engaged in trying to attain optimal levels of learning or achievement. However, situations that combine social evaluative threat and motivated performance issues elicit stronger stress responses than situations that only include motivated performance issues ( $d = 0.35$  vs.  $d = -0.07$ ; Dickerson & Kemeny, 2004). Thus, it seems as though situations that entail social evaluative threat can be seen as potentially detrimental sources of stress that could inhibit the optimal learning and performance of sport related tasks.

The breaking down of performance under pressure, often described as “choking”, has been studied for several decades in sport psychology research (e.g., Beilock & Gray, 2007; Hill, Hanton, Matthews, & Fleming, 2010). Golf putting is routinely used in the choking literature because of its gradual learning curve and the potential susceptibility of breaking down under

pressure (e.g., Beilock & Carr, 2001; Cooke, Kavussanu, McIntyre, & Ring, 2010; Cooke, Kavussanu, McIntyre, Boardley, & Ring, 2011; Lewis & Linder, 1997; Masters, 1992; Masters, Maxwell, & Eves, 2003). Although significant changes in both kinematic and objective measures of putting performance under stress are often observed, the pattern of results is quite variable and often depend on certain experimental conditions. For example, when novices were trained to putt without learning explicit rules associated with putting, putting performance seemed to be buffered from decrements under pressure (e.g., Masters, 1992; Mullen, Hardy, and Oldham, 2007). Furthermore, golfers who underwent a lengthy goal-setting intervention actually *improved* their putting performance under pressure (Kingston & Hardy, 1997).

In subsequent studies, researchers have attempted to examine the extent to which exposition to a stressor is associated with distinct kinematic changes in the putting stroke itself but, so far, the results have remained equivocal. For example, Mullen and Hardy (2000) conducted a kinematic analysis on recreational golfers (i.e., handicap between 12 and 18). Under evaluative stress, golfers who putted under dual-task conditions (i.e., random-letter generation) demonstrated delayed time to peak acceleration in their strokes. Putting under evaluative conditions has also been associated with increased impact velocity for expert golfers (Cooke et al., 2011), decreases in the distance the putter head travelled for both experts and novices (Tanaka & Sekiya, 2010), and increased X-axis acceleration in novices (Cooke et al., 2010). More recently, Land and Tenenbaum (2012) failed to find any differences in a range of measured kinematic parameters in an expert sample when compared between low and high evaluative conditions. Putting under evaluative conditions has also been linked to changes in psychophysiological measures, such as increased heart rate and heart rate variability, increased muscle tension, and increased variability in motor movements (Cooke et al., 2010; 2011; Moore, Vine, Wilson, & Freeman, 2012; Tanaka & Sekiya, 2010; 2011).

### **A Multilevel and Stress-Diathesis Perspective**

Putts performed across successive trials in a lab session or across holes in a game of golf are not totally independent actions insofar as they are performed by the same individual who is also capable of adapting his or her motor actions according to the outcome of previous trials. Traditional statistical analyses force researchers to aggregate putts across all trials, resulting in models that do not incorporate the natural within-person fluctuations of kinematic patterns and putting outcomes. This limitation was addressed in the current study by considering the transient or momentary nature of putting outcomes in a multilevel model in which putts are conceived as non-independent instances nested within a person. Putting is also influenced by overall golfing skills or what golfers refer to as the golf handicap (e.g., Beilock, Bertenthal, McCoy, & Carr, 2004; Beilock, Weirenga, & Carr, 2002; Tanaka & Sekiya, 2010). Multilevel models can readily incorporate between-person variables, such as golf handicap (e.g., Gaudreau, Nicholls, & Levy, 2010), in order to control for their influence in explaining why certain golfers, overall, obtain better putting outcomes than others.

Several lines of research in both sport and clinical psychology indicate that stressors are not inherently debilitating in and out of themselves (Blascovich, 2008; Jones, Meijen, McCarthy, & Sheffield, 2009; Seery, 2011; Skinner & Brewer, 2004). The relationship between stressors and consequential life outcomes have often been conceived within the confines of transactional models in which dialectic person x situation interactions are presumed to explain why some individuals adapt themselves more efficiently than others to a stressful situation (e.g., Lazarus & Folkman, 1984). Clinical psychologists have long identified individual and social characteristics that render certain individuals more vulnerable to the debilitating effects of stressful situations. Some vulnerability factors (e.g., growing in a disadvantaged neighborhood) can create a generalized diathesis that makes the individuals vulnerable to all types of stressful situations

(Belsky & Pluess, 2009). However, vulnerability factors can take a more specialized form that render the individuals vulnerable to specific stressors that are closely matched or associated with their vulnerability (Hewitt & Flett, 1993). In this study, we proposed a stress-diathesis model that posits that the relationship between social evaluative threat and performance on a sport related task is moderated by elevated sport anxiety.

An abundant stream of research has also indicated that state anxiety can relate to performance and achievement in the sport context. Meta-analytical evidence indicates that perceived stress or state anxiety predicts between-person differences in sport achievement (Woodman & Hardy, 2003), particularly in settings that are inherently more competitive. State anxiety has been demonstrated to be elevated in a number of studies on golf putting. For example, cognitive anxiety has been found to have a negative linear relation with the putting performance of recreational golfers (Chamberlain & Hale, 2007). As mentioned previously, simple exposure to an evaluative condition has been associated with kinematic changes regardless of individual characteristics. Cooke et al. (2010) found that golfers holed fewer putts under stress and demonstrated kinematic changes between conditions. Furthermore, cognitive anxiety increased in the golfers between low and high conditions of evaluative stress.

Sport anxiety can also act as an aggravating factor to exacerbate the effect of social evaluative threat on the psychophysiological stress response and performance outcomes. Athletes with elevated sport anxiety tend to use coping actions in which they try to disengage themselves from the process of volitionally pursuing personal goals (e.g., Dias, Cruz, & Fonseca, 2012; Ntoumanis & Biddle, 2000). The effortless nature of their coping efforts might make them more vulnerable to the exacerbating effect of a stressor such as social evaluative threat. According to *processing efficiency theory* (Eysenck & Calvo, 1992), athletes can maintain their performance effectiveness under a stressful situation if they engage in compensatory effort to increase the

amount of attention allocated to the task. Past research in the coping literature indicates that athletes with elevated sport anxiety are more likely to disengage their effort from the task at hand, which is a coping tendency generally associated with suboptimal performance outcomes (e.g., Gaudreau, Nicholls, & Levy, 2010; Nicolas, Gaudreau, & Franche, 2011). Accordingly, it can be expected that athletes with high levels of anxiety are less likely than athletes with low levels of anxiety to maintain a good level of learning and performance during episodes of social evaluative threat. In the parlance of a stress-diathesis framework, elevated sport anxiety could act as a vulnerability factor to inhibit optimal learning and performance during a stressful situation.

### **The Current Study**

In this study, we examined the kinematic parameters of a putting stroke and the objective outcome (i.e., not holed vs. holed) of each of the putts performed across a neutral condition and a condition designed to elicit social evaluative threat. We expected that the kinematic parameters of the putting strokes should significantly differ across the neutral and the social evaluative trials of this study. Given that the neutral trials systematically preceded the social evaluative trials in all participants (i.e., AB design), we expected that a learning effect would characterize the longitudinal trajectory of achievement in this study. Therefore, we did not expect that achievement would break down or significantly diminish in the social evaluative trials compared to the neutral trials. According to our stress-diathesis hypothesis, however, we expected that state anxiety would moderate the relationship between conditions (i.e., neutral vs. social evaluative trials) and the likelihood of not making or making the putts. More precisely, it was hypothesized that golfers with low somatic anxiety would have a higher likelihood of making putts during social evaluative trials compared to the neutral trials whereas the likelihood of making putts of the golfers with high somatic anxiety would not significantly differ between the trials. As such, high levels of state anxiety might inhibit the natural learning effect generally observed across

successive trials of a putting task. Lastly, an examination of the relation between specific putting parameters and the likelihood of holing putts will be explored as a secondary contribution to the kinematic literature. As roughly 80% of the direction of the golf ball is determined by the alignment of the putter's face at impact (Pelz, 2000), a positive relation between this parameter and successfully holing a putt is expected.

## Method

### Participants

Participants in this study were 35 amateur golfers (4 females, 31 males) who were members of a private indoor golf practice facility in (*hidden for peer review purposes*) ( $M_{age} = 53.97$  years,  $SD = 14.67$ , range: 18 to 67). All golfers possessed a valid *Royal Canadian Golf Association* (RCGA) Handicap ( $M = 13.62$ ,  $SD = 7.20$ , ranging from 0 to 30), which was used as a standard measure of golfing ability. For ease of interpretation, a lower handicap represents golfers with higher level of expertise.

### Measures

**Performance.** Each participant's putter was outfitted with a putting analysis tool called the TOMI® (The Optional Motion Instructor; Pure Motion, Inc., Southlake, TX). The TOMI® consists of an infrared camera placed directly in front of the golfer, which picks up four sensors outfitted on the putter. The TOMI® was first designed to serve as a golf-teaching tool to analyze eight different parameters that relate to the putting stroke: alignment at address and impact, putter path, face rotation, loft, impact, speed, and tempo. Mackenzie and Evans (2010) demonstrated that the TOMI® is a valid and reliable measure to use in scientific research, with measurement errors falling within acceptable ranges of computerized 3D-mapping techniques.

**State anxiety.** Participants completed the *Competitive State Anxiety Inventory 2-Revised* (CSAI-2R; Cox, Martens, & Russell, 2003). The CSAI-2R is a widely used measure that assesses

two dimensions of state anxiety in an athlete – cognitive anxiety (e.g., “I am concerned about losing”), and somatic anxiety (e.g., “My heart is racing”) – as well as a measure of self-confidence. For the purposes of this study, only the somatic (7 items;  $M = 15.20$ ,  $SD = 4.22$ ,  $\alpha = .78$ ) and cognitive (5 items;  $M = 17.66$ ,  $SD = 6.18$ ,  $\alpha = .82$ ) subscales were used.

### **Procedure**

For the first set of putts (*neutral trials*), golfers stroked 5 putts, each to a hole from 5 feet away with a straight path to the hole. During these 5 putts, golfers were told by the experimenter that the machine was being “calibrated to their stroke”, and therefore asked to putt as they normally would while trying their best to hole each putt. Before the start of the second set of putts (*social evaluative trials*), golfers were then instructed that we were interested in seeing how many putts they could hole to compare the performance across participants in the study, with the best three performers being awarded one-dozen premium golf balls. In addition, following previous protocols to increase stress during golf (e.g., Kingsbury et al., 2011; Lewis & Linder, 1997), a confederate posing as a golf professional arrived after the neutral trials to observe and videotape each golfer’s putting stroke. The confederate was a person well-versed in the game of golf and was dressed in golf clothing to increase validity of the cover story. Participants were informed that the confederate was there to record their putting stroke later to be analyzed. Just before the social evaluative trials golfers were administered the CSAI-2R before performing the 5 putts under the eye of the confederate. At the end of the study, participants were informed that no comparisons were to be made, no video footage was actually saved, and that all participants were entered into a draw to win the golf balls regardless of their performance. The study received full approval from the institutional Research Ethics Board of (hide name of university for peer review).

### **Results**

## **Preliminary Analyses**

Results from preliminary analyses indicated that handicap scores were significantly related to somatic anxiety ( $r = .389, p = .034$ ) and to one of the kinematic parameters: mean absolute face rotation ( $r = .408, p = .025$ ). As a result, handicap was entered into each regression equation as a control variable. Table 1 highlights the descriptive statistics of each of the putting parameters.

## **Plan of Analyses**

Logistic multilevel modeling (MLM) was conducted using HLM Version 7 (Raudenbush, Brick, & Congdon, 2010) to examine the effects of condition (0 = neutral trials; 1 = social evaluative trials), handicap, state anxiety, and kinematic parameters on the likelihood of not holing (coded as 0) and holing (coded as 1) each of the putts. Furthermore, regular MLM was also used to examine the same effects on each of the kinematic parameters. In all analyses, the condition variable was treated as a Level 1 predictor whereas handicap and state anxiety were treated as Level 2 predictors (for a more complete description of HLM analysis, see Cornelius, Brewer, & Van Raalte, 2007). Intra-class correlations (ICC) indicated that substantial variance in all putting variables could be attributed to between-person variability, indicating the appropriateness of the use of MLM: alignment at address ( $\sigma^2 = 2.997, \tau = 0.864, ICC = .224$ ), alignment at impact ( $\sigma^2 = 0.521, \tau = 0.871, ICC = .626$ ), putter face rotation ( $\sigma^2 = 4.926, \tau = 28.304, ICC = .852$ ), back stroke time ( $\sigma^2 = 0.003, \tau = 0.018, ICC = .845$ ), forward stroke time ( $\sigma^2 = 0.001, \tau = 0.004, ICC = .846$ ), loft at impact ( $\sigma^2 = 0.997, \tau = 6.822, ICC = .873$ ), stroke path ( $\sigma^2 = 3.088, \tau = 13.167, ICC = .810$ ), and putter speed ( $\sigma^2 = 24.758, \tau = 13.204, ICC = .347$ ).

## **Logistic Multilevel Regression Analyses**

The first portion of our analyses consisted of examining the relation between condition (Level 1), kinematics (Level 1), handicap (Level 2) state anxiety (Level 2), and whether each putt was holed or not. To transform the results from a logistic multilevel model into an interpretable number, an exponential transformation was applied to convert the output into a percentage of putts holed. Applying the exponential transformation to the grand mean estimate ( $\beta_{00}$ ) from the null model (Hox, 2010, p. 123;  $e^{\beta_{00}} / 1 + e^{\beta_{00}}$ ) revealed that approximately 44% of the putts were holed across the 10 putts performed by the 35 participants (see Table 3, model 1).

**Putting performance, state anxiety, and social evaluation.** The following equations were used to test the effect of the social evaluative condition on the binary likelihood of whether a putt was holed or not (coded as 1 and 0 respectively) with handicap again entered at Level 2 as a control variable:

$$\text{Logit } \{\text{Pr (HOLING}_{ij})\} = \pi_{0j} + \pi_{1j} (\text{CDT}_{ij}) + e_{ij} \quad (1)$$

$$\pi_{0j} = \beta_{00} + \beta_{01}(\text{HDCP}_j) + \mu_{0j} ,$$

$$\pi_{1j} = \beta_{10} + \mu_{1j} .$$

Putting condition (CDT) was coded as either 0 (neutral) or 1 (social evaluation). The main effect of condition was positive (see Table 3, model 2), meaning that the number of putts hold significantly increased from the baseline (37% putts holed) to the social evaluative condition (51% putts holed), even while controlling for individual differences in handicap. Next, the following equations were used to test the cross-level moderation of cognitive anxiety (model 3a;

see equation 2) and somatic anxiety (model 3b; see equation 3) in the association between condition and performance<sup>7</sup>:

$$\text{Logit } \{\text{Pr (HOLING}_{ij})\} = \pi_{0j} + \pi_{1j} (\text{CDT}_{ij}) + e_{ij} \quad (2)$$

$$\pi_{0j} = \beta_{00} + \beta_{01}(\text{HDCP}_j) + \beta_{02} (\text{COG}_j) + \mu_{0j} ,$$

$$\pi_{1j} = \beta_{10} + \beta_{11} (\text{COG}_j) + \mu_{1j} .$$

$$\text{Logit } \{\text{Pr (HOLING}_{ij})\} = \pi_{0j} + \pi_{1j} (\text{CDT}_{ij}) + e_{ij} \quad (3)$$

$$\pi_{0j} = \beta_{00} + \beta_{01}(\text{HDCP}_j) + \beta_{02} (\text{SOM}_j) + \mu_{0j} ,$$

$$\pi_{1j} = \beta_{10} + \beta_{11} (\text{SOM}_j) + \mu_{1j} .$$

A cross-level interaction was found between somatic anxiety and condition when predicting the likelihood of holing putts (model 3b). Simple slopes analyses revealed that the relationship between condition (0 = neutral, 1 = social evaluation) and the likelihood of holing putts was significant for golfers with low somatic anxiety ( $\beta_{00} = -1.044$ ,  $\beta_{10} = 1.207$ ,  $p < .001$ ) but not significant for golfers with high somatic anxiety ( $\beta_{00} = -0.053$ ,  $\beta_{10} = -0.030$ ,  $p = .903$ ). In other words, golfers with low somatic anxiety had a higher likelihood of making putts under stress compared to the neutral condition whereas the likelihood of making putts for the golfers with high somatic anxiety did not differ between the stressful and the neutral condition (see Figure 1). It can be concluded that golfers with low levels of somatic anxiety managed to improve their performance across trials (learning effect) whereas those with high level of somatic anxiety experienced a flattened learning effect.

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<sup>7</sup> Because of the coding of the condition (0 = neutral; 1 = social evaluative threat), this equation estimates the effect of anxiety when all predictors are zero in the equation; hence, the effect of anxiety during the neutral trials.

**Kinematic parameters and putting performance.** Our final logistic multilevel analysis in this section examined whether any of the kinematic parameters were associated with holing more putts using the following equation:

$$\text{Logit } \{\text{Pr (HOLING}_{ij})\} = \pi_{0j} + \pi_{1j} (\text{PARA}_{ij}) + e_{ij} \quad (4)$$

$$\pi_{0j} = \beta_{00} + \beta_{01}(\text{HDCP}_j) + \mu_{0j} ,$$

$$\pi_{1j} = \beta_{10} + \mu_{1j} .$$

Despite our hypotheses, no kinematic parameter was significantly associated with holing putts.

### Multilevel Regression Analyses of Kinematic Parameters

For the next portion of our analyses, the relationships between anxiety (Level 2), handicap (Level 2), and condition (Level 1) with each of the kinematic parameters were examined using multilevel regression. First, to assess the influence of condition on its own, the following equations were used with handicap entered as a control variable:

$$\text{PARA}_{ij} = \pi_{0j} + \pi_{1j} (\text{CDT}_{ij}) + e_{ij} \quad (5)$$

$$\pi_{0j} = \beta_{00} + \beta_{01}(\text{HDCP}_j) + \mu_{0j} ,$$

$$\pi_{1j} = \beta_{10} + \mu_{1j} .$$

PARA, the dependent variable, represents the individual kinematic parameters measured by the TOMI®, CDT represents the putting condition (i.e., 0 = neutral, 1 = social-evaluation), and HDCP denotes golfers' individual handicap indexes. The social-evaluative condition was significantly associated with decreased putter-face rotation ( $\beta_{10} = -0.663, p = .045$ ), quicker forward stroke times ( $\beta_{10} = -0.011, p = .004$ ), and marginally associated with poorer alignment at impact (i.e., further away from zero degrees at impact;  $\beta_{10} = 0.134, p = .098$ ).

Then, the separate effects of cognitive anxiety (COG; see equation 6), and somatic anxiety (SOM; see equation 7) as well as the cross-level interaction anxiety X condition were

assessed using the following equations with handicap being entered to account for individual differences in skill level:

$$\text{PARA}_{ij} = \pi_{0j} + \pi_{1j}(\text{CDT}_{ij}) + e_{ij} \quad (6)$$

$$\pi_{0j} = \beta_{00} + \beta_{01}(\text{HDCP}_j) + \beta_{02}(\text{COG}_j) + \mu_{0j} ,$$

$$\pi_{1j} = \beta_{10} + \beta_{11}(\text{COG}_j) + \mu_{1j} .$$

$$\text{PARA}_{ij} = \pi_{0j} + \pi_{1j}(\text{CDT}_{ij}) \quad (7)$$

$$\pi_{0j} = \beta_{00} + \beta_{01}(\text{HDCP}_j) + \beta_{02}(\text{SOM}_j) + \mu_{0j} ,$$

$$\pi_{1j} = \beta_{10} + \beta_{11}(\text{SOM}_j) + \mu_{1j} .$$

Cognitive state anxiety was associated with longer back stroke times ( $\beta_{02} = 0.010, p = .015$ ), forward stroke times ( $\beta_{02} = 0.011, p = .013$ ), and marginally associated with better alignment at impact (i.e., closer to zero degrees at impact;  $\beta_{02} = -0.056, p = .083$ ). Only one cross-level interaction was found between cognitive anxiety and condition when predicting back stroke times ( $\beta_{11} = -0.002, p = .033$ ). Simple slopes analysis indicated that the relationship between condition and back stroke times was not significant for golfers with low cognitive anxiety ( $\beta_{00} = 0.606, \beta_{10} = 0.001, p = .953$ ) but was significant and negative for golfers with high cognitive anxiety ( $\beta_{00} = 0.713, \beta_{10} = -0.026, p = .023$ ). In other words, golfers with high cognitive anxiety had quicker back stroke times under stress compared to the neutral condition whereas the back stroke time of golfers with low cognitive anxiety did not differ between the stressful and the neutral condition (see Figure 2). Somatic anxiety was not significantly associated with any kinematic parameter, and no significant cross-level interactions between somatic anxiety and condition were found.

## Discussion

The goal of this study was to examine the multi-level associations between state anxiety and various indicators of golf putting performance. We proposed a multilevel model in which the transient or momentary nature of putting outcomes was taken into consideration by analyzing each putt as a non-independent instance of performance nested within a person. As such, each putt was considered as a performance episode (Beal, Weiss, Barros, & MacDermid, 2005) likely to be influenced by time-invariant personal factors (i.e., golf handicap, anxiety) and time varying features of the social environment (i.e., neutral versus social evaluative threat). This model allowed us to move beyond traditional statistical analyses (i.e., aggregate performance outcomes across all trials) to more deeply examine the natural within-person fluctuations of putting outcomes.

All participants of this study performed a putting task under a neutral condition followed by a social evaluative threat condition. On average, whereas 37% of the putts were holed during the neutral trials, 51% of the putts were holed during the social evaluative threat trials. Participants significantly improved their putting performance, which is consistent with a typical learning effect that occurs when persons repetitively perform the same task over time (Wulf, 2007). However, consistent with our expectations, this effect was significantly moderated by participants' levels of somatic anxiety (see Figure 1). Participants with low levels of somatic anxiety holed significantly more putts (26% versus 54%) in the social evaluate stress trials than in the neutral trials. However, among participants with high somatic anxiety, there was no significant improvement in the subsequent social evaluate stress trials. Thus, despite the stressful nature of the latter part of the experiment, *participants with low somatic anxiety* managed to keep on significantly improving their performance. It can be concluded that the performance of these individuals were protected and perhaps even facilitated by the pressuring nature of the social evaluative threat conditions.

Under neutral conditions, individuals with a high predisposition toward somatic anxiety might be more capable of mobilizing the cognitive and physical resources needed to activate themselves to attain high level of task performance. As such, our results showed that both somatic and cognitive anxiety were positively associated with holing putts during the neutral trials of our experiment<sup>8</sup>. This finding is consistent with the extant literature showing that, under certain circumstances, anxiety can be *positively* associated with sport performance outcomes (Craft, Magyar, Becker, & Feltz, 2003; Woodman & Hardy, 2003). Of greater importance, our results indicated that high somatic anxiety can be a vulnerability factor when individuals are facing social evaluative threat. Contrary to those with low somatic anxiety, the *participants with high somatic anxiety* did not hole significantly more putts (51% versus 51%) in the social evaluate stress trials than in the neutral trials. It is important to outline that individuals with high somatic anxiety did not choke under pressure insofar as they were able to maintain a performance comparable to their baseline level in the neutral trials. The effect of the social evaluative threat on the individuals with high somatic anxiety was nevertheless substantive, because it essentially “eliminated” a learning effect that typically occurs across trials of a repetitive putting task. The performance advantages conferred to individuals with high somatic anxiety (compared to low somatic anxiety) were limited to trials during which they performed under a neutral condition (see Figure 1). More notably, individuals with low somatic anxiety improved their performance during social evaluative threat – a condition that was created to

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<sup>8</sup> The effects reported in Table 2 should be interpreted as the effect of anxiety during the neutral trials given the coding scheme used in our analyses (0 = neutral trials, 1 = social evaluative threat trials).

mimic an evaluative sport environment in which performance matters the most. Performance improvement during the social evaluative threat condition may suggest that individuals with low somatic anxiety are capable of “peaking under pressure” while experiencing the typical learning effect that should naturally occur across trials of a repetitive putting task. However, it is also possible that individuals with low somatic anxiety were “slacking” during the first phase as the motivational relevance was not high. Nevertheless, it is difficult to assess whether this is case without experimental control.

### **Kinematic Parameters**

Putting has often been described as an artful skill that requires precision and finesse. Comparably excellent putters can use different techniques, thus making it difficult to compare golfers to one another (i.e., between-person analyses). In this study, we adopted a multilevel perspective to examine within-person fluctuations of the putting stroke while controlling for the fact that each individual has their own kinematic tendencies. Individuals indeed have their tendencies (ICC of kinematic parameters ranging from .224 to .873), but their kinematic parameters did fluctuate to a non-negligible extent across trials. Furthermore, the within-person fluctuations of four kinematic parameters were significantly associated with the conditions under which participants were putting. During episodes of social evaluative threat, participants had less putter-face rotation, quicker forward strokes, and marginally significant poorer alignment at impact. Results of a cross-level interaction also revealed that the back stroke became quicker during social evaluative threat but only for individuals with high level of cognitive anxiety. Similar to other studies with golfers (e.g., Cooke et al., 2010), these subtle but noticeable within-person changes are meaningful because they indicate that the movement becomes stiffer, jerkier, faster, and less precise during social evaluative threat.

Although social evaluation and anxiety played a role in explaining some of the within-person fluctuations in kinematic parameters, none of these characteristics of the putting movement were related to actually holing putts. From a practical standpoint, these results might suggest that there is more than one way to “get the ball into the hole”. As such, focusing on any different putting parameters (outside of face angle at impact) to improve one’s technique may not necessarily lead to improved performance. Despite such possibilities, Karlsen, Smith, and Nilsson (2008) found that 80% of the variability in the path a golf ball is influenced by the angle of the putter face at impact, followed by putter path (17%) and impact point (3%). As such, the subtle variations in kinematic parameters observed in this study might not be enough to reduce the likelihood of holing a five-foot putt with no curvature under the unchanging condition of an artificial putting green. Future research is needed to examine whether subtle changes in kinematic parameters – in and out of themselves as well as in interaction with time-varying and time invariant psychological predictors – can make more drastic changes in the putting outcome when the putts are longer, more complex, and never twice the same as in a regular golf game.

### **Limitations and Future Directions**

Some important limitations need to be addressed to frame the results appropriately as well to influence future research directions. It is prudent to highlight that the manipulations used in this study (and most others in the sport-stress literature) do not truly simulate the pressure that one would face in a real sport competition. In fact, the social evaluative threat condition should be depicted as a mild stressor in comparison to the demanding challenges of putting a golf ball in front of a crowd on the 72<sup>nd</sup> hole of a prestigious golf tournament. Nevertheless, our results indicate that even a mild stressor in the confines of a laboratory is sufficient to yield non-negligible within-person fluctuations in kinematic parameters of a putting stroke. As such, our results are consistent with studies in which *changes* in performance have been demonstrated

under conditions of social evaluative threat. It has been suggested that variability in movement is, in fact, related to more *consistent* performance. However, the sequential arrangement of where the variability occurs in the task appears to be important. In a recent study of a range of skilled golfers, Land and Tenenbaum (2012) found that although expert performers demonstrated increased variability upon the initiation of a golf putting stroke, movement variability decreased towards the moment of impact. Novice performers, in contrast, demonstrated consistent levels of variability throughout the entire stroke. Taking all strokes into account, however, expert golfers were considerably less variable overall. Future studies could examine the sequential order of the stroke to determine if social evaluative threat is associated with an increase in movement variability and, more importantly, when during the stroke these changes in movement variability occur.

In this study, we relied on a single dichotomous measure of task performance, namely whether a putt was holed or not. This measure, albeit ecologically valid, does not take into account the fact that several good putts are often missed by less than an inch. As a result, most putting research has collected mean radial error (MRE) as an additional measure of performance. If a putt is not holed, the distance that the ball finishes from the hole is of the utmost importance to ensure the likelihood of the next putt being holed. Future research using this paradigm could implement additional indicators of putting performance such as MRE or directional biases in where a putt is missed (i.e., short/long, left/right). Neumann and Thomas (2008) outline a camera-based scoring system that adds richness to putting performance data that was not present in this study (i.e., distance short or long from the hole, length error, angle of error, target line deviation, and total distance from hole).

In our analyses, state anxiety was treated as a time-invariant predictor because it was measured at only one time point (i.e., after the stress instructions were given). From a practical

standpoint, it seemed unrealistic to administer a measure, such as the CSAI-2R, within the interval of a few minutes, immediately before and after the social evaluative threat manipulation. Furthermore, as no manipulation check was conducted, it is unclear whether the social evaluative manipulations were indeed effective. Future studies could take multiple measures of state anxiety using a one-item measure before and after both the neutral condition and the social evaluative threat condition. Although the within-person fluctuations in kinematic parameters of the putting stroke indicate that participants have reacted to our social evaluation stress manipulation, future research should include a series of questions to ensure that participants believed the cover story.

Participants were recruited through convenience sampling (i.e., members of the golf practice facility). The sample contained a majority of males with high heterogeneity in skill level. Although our analyses controlled for golf handicap, future research should either collect homogenous samples in regards to skill level (e.g., professionals/elite amateurs, recreational, complete beginners) or a larger heterogeneous sample to try to replicate the results of this study. Of particular importance, future studies should examine whether skill level moderates the effect of social evaluative threat on putting performance. That being said, MLM analysis uses each person as their own control, which inevitably takes into account these individual differences in skill level. Finally, all participants performed the putting task under a neutral condition followed by a stressful condition. Albeit methodologically desirable, counterbalancing might be an undesirable option insofar as performing the task under a stressful condition could have a carryover effect on the subsequent performance under neutral conditions. Future research could adopt an ABA design to determine whether the performance of participants stagnate or improve once the stressor has been removed. Randomizing participants in neutral versus social stress conditions after the baseline trials would offer another option to disentangle the effect of learning and the effect of the stressor on the likelihood of holing putts.

## **Conclusion**

This study contributes to the sport-stress literature by demonstrating a complex interplay between state anxiety, social evaluative threat, and kinematic putting parameters using a within-person design that allows a person's performance to be compared to their own average, while accounting for individual differences in skill level. Consistent with a stress/diathesis framework, state anxiety moderated the relationship of social evaluative threat with putting performance and one kinematic parameter. More specifically, high somatic anxiety attenuated the improvement of the putting outcome that typically occurs when participants are performing the same task over time. In contrast, participants with low somatic anxiety improved their putting performance despite being confronted with a social evaluative stressor in the latter part of the experiment. Overall, these results indicate that state anxiety can act as a vulnerability factor that exacerbates the effect of social evaluative threat.

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### Study 1 Tables

Table 2.

*Study 1 – Level 1 Descriptive Statistics.*

<b>Putting Parameter</b>	<b>M</b>	<b>SD</b>
Alignment at Address (°) <sup>1</sup>	0.04	2.87
Alignment at Impact (°)	1.35	1.50
Putter Path (°)	-2.17	3.99
Total Face Rotation (°) <sup>2</sup>	32.00	5.70
Loft at Impact (°)	1.04	2.76
Speed (inches/sec)	43.88	6.13
Back Swing Time (sec)	0.66	0.14
Follow Through Time (sec)	0.34	0.07
Total Time (sec)	1.00	0.21

Note.

<sup>1</sup> A negative number for the ° values indicates being closed for the alignment variables, having a putter path coming from outside the target and taking away loft at impact.

<sup>2</sup> Face Rotation was computed by creating absolute values for the amount of face rotation (i.e. degrees open/closed) on the back swing and the follow through, then added together to create a variable to represent the overall amount of movement during the stroke.

Table 3.

*Multilevel Logistic Regression of Likelihood of Holed Putts (0 = not holed; 1 = holed) for Study 1.*

	<b>Model 1</b>		<b>Model 2</b>		<b>Model 3a</b>		<b>Model 3b</b>	
	<b>Estimate (SE)</b>	<b>OR</b>	<b>Estimate (SE)</b>	<b>OR</b>	<b>Estimate (SE)</b>	<b>OR</b>	<b>Estimate (SE)</b>	<b>OR</b>
<i>Fixed effect</i>								
<b>Level 1</b>								
$\beta_{00}$ = Intercept	-0.255 (.157)	1.290 <sup>a</sup>	-0.524** (.181)	1.689 <sup>a</sup>	-0.544** (.173)	1.724 <sup>a</sup>	-0.548** (.169)	1.730 <sup>a</sup>
$\beta_{10}$ = Condition			.558* (.227)	1.748	.580* (.223)	1.786	.582** (.203)	1.790
<b>Level 2</b>								
$\beta_{01}$ = Handicap			-0.011 (.013)	1.012	-0.021 (.014)	1.020 <sup>a</sup>	-0.016 (.013)	1.016 <sup>a</sup>
$\beta_{02}$ = Anxiety <sup>3</sup>					.077** (.027)	1.080	.120** (.043)	1.128
$\beta_{11}$ = Condition X Anxiety					-0.045 (.037)	1.046 <sup>a</sup>	-0.151** (.048)	1.162 <sup>a</sup>
<i>Random effect</i>								
	Variance		Variance		Variance		Variance	
$\mu_0$	.459*		.454*		.284		.337	
$\mu_1$			.337		.322		.109	

*Note.* <sup>a</sup>Reciprocal of the Odds Ratio to facilitate interpretation of effect size. \* $p < .05$ . \*\*  $p < .01$ .

<sup>3</sup> Cognitive anxiety is entered in model 3a; somatic anxiety is entered in model 3

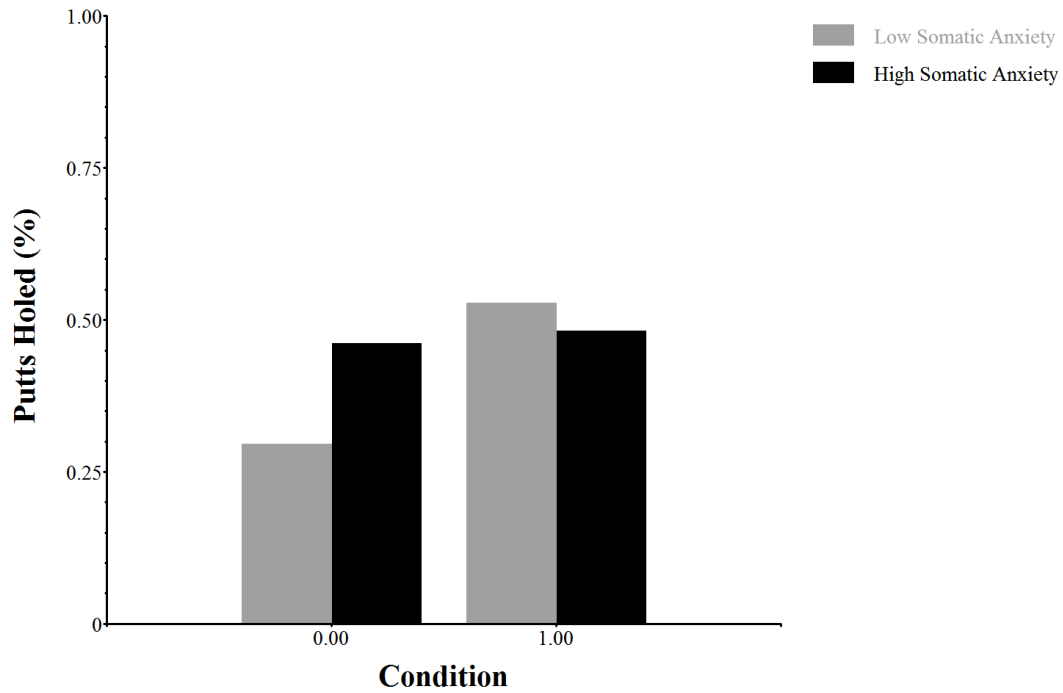
**Study 1 Figures**

Figure 1. *Study 1 - Cross-level interaction between condition and somatic anxiety predicting likelihood of holing putts.*

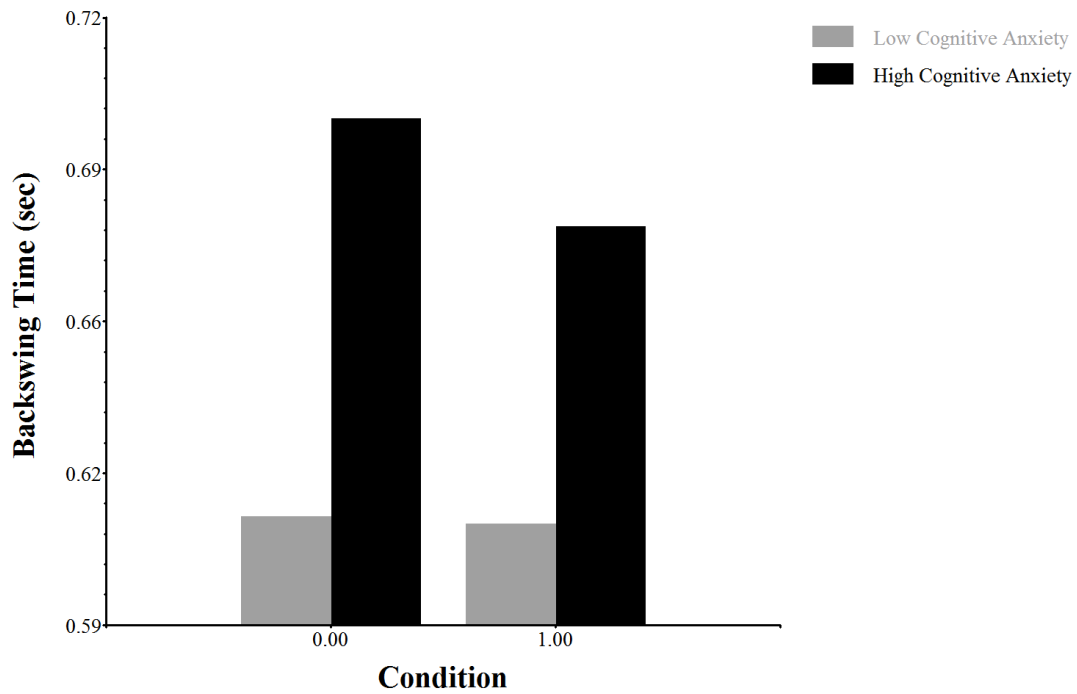


Figure 2. *Study 1 - Cross-level interaction between condition and cognitive anxiety predicting backswing times (in seconds).*

**Chapter 4: Study 2**

## Overview

Study 1 provided evidence that golfers reacted differently to the social-evaluative threat manipulation depending on their level of state anxiety. Although individuals with low state anxiety continued to improve from the neutral to the social-evaluative threat trials, those with high state anxiety did not significantly improve across conditions. It thus seems like high state anxiety can act as a diathesis factor to exacerbate the debilitating effect of social-evaluative threat. Study 2 aimed to expand upon the results of Study 1 in several ways.

First, Study 2 focused only on novice golfers. Study 1 sampled a range of golfers, including a few elite players. Novices differ from competitive golfers in numerous ways relevant to our hypotheses<sup>9</sup>. How the performance of novices with no golf experience is related to social evaluative pressure has yet to be tested using the paradigm outlined in Study 1. Experienced golfers come into the study with the ability to stroke a short putt being automatic, with little between-person variability. However, it was expected that novices would demonstrate both significant within- and between-person variability in all performance measures.

Second, Study 2 tested performance under pressure using a greater number of putts in each of the neutral and stress conditions. In Study 1, participants performed better in the social-evaluative threat trials than during the neutral trials. Participants in Study 1 performed a total of five putts in the neutral trials followed by five putts in the social-evaluative threat trials. As such, the effects reported in Study 1 could be attributed to the fact that participants were still adapting

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<sup>9</sup> An exploratory sample of expert golfers with significant amateur and professional experience indicated dramatically increased performance in terms of both kinematics as well as object outcomes (i.e., number of putts holed).

themselves to the putting task and kept on improving their performance even in the social-evaluative threat trials. In Study 2, participants were asked to perform more putts both in the neutral and in the social-evaluative threat trials. It was thought that increasing the number of putts would enable a more precise assessment of the improvement trajectory of participants during the neutral trials and the social-evaluative threat trials. Furthermore, increasing the number of putts in each condition would increase our power to examine growth trajectories of the participants. It would also enable participants to reach a certain plateau before moving into the social-evaluative threat part of the experiment. *Deterioration in performance early in the social-evaluative threat trial* would indicate that the social-evaluative threat experimental manipulation interfered with the ongoing improvement trajectory of the neutral trials. Conversely, *an improvement in performance early in the social-evaluative threat trial* would indicate that the social-evaluative threat experimental manipulation did not result in any performance deterioration – thus contradicting the basic tenets of the social-evaluative threat paradigm.

Third, Study 2 revised the outcomes measure associated with performance. In Study 1, putting performance was assessed using a binary measure (putt holed vs. not). Intuitively, however, there may be a great deal of unmeasured variability in putting performance among putts that were not holed - consider, for instance, a ball that comes to rest on the lip of a hole versus one that lies 5 feet away. Study 2 aimed to provide an additional, more fine-grained measure of performance by including radial distance to the hole for putts that were not holed. An additional kinematic indicator of performance, face angle at impact, was also considered.

Fourth, experiments for Study 2 were conducted in a university laboratory. In Study 1, data was collected at a private indoor practice facility, but other members were in plain sight of where the data was collected. Although no observers explicitly watched participants in Study 1,

it was thought that the potential confound of bystanders influencing the study would be attenuated by collecting data on individuals in the privacy of the lab.

Finally, the difficulty of the putting task was increased for Study 2 by increasing putting distance and decreasing the size of the hole. With the increased number of putts in this study (i.e. 10 per condition instead of 5), we were concerned that a ceiling effect may emerge where even novice golfers would eventually ‘groove’ their performance to the point that most putts would be holed. With these improvements to methodology in mind, two specific research inquiries were generated:

**1) What is the effect of social evaluative threat on putting performance among novices?**

In general, golfers from Study 1 significantly improved their overall performance from the baseline to social-evaluative condition. However, it is not clear whether this was due to the fact that the golfers had prior golfer experience and were therefore less susceptible to social evaluative threat, or if this was a natural learning effect that would be expected from the majority of those who perform the putting task. Based on previous research with novices (i.e., Cooke et al., 2010) it was expected that performance would be lower under social evaluative threat as compared to neutral conditions. *Changes* in radial distance to the hole and face angle at impact between conditions were also expected as additional indicators of the influence of social evaluative pressure. Finally, it was also hypothesized that perceived stress would significantly increase from baseline under the threat condition.

**2) What is the impact of self-reported state anxiety on putting performance among novice golfers?**

As discussed earlier, the links between state anxiety and performance have been mixed. Meta-analyses (e.g., Craft et al., 2003; Woodman & Hardy, 2003) have demonstrated differential

patterns of results between anxiety and performance, depending on the sample being studied. Study 1 found that high levels of somatic anxiety attenuated a natural learning effect that was present for golfers with low levels of somatic anxiety. Furthermore, high levels of cognitive anxiety were associated with quicker back stroke times under pressure. In Study 2, it is hypothesized that the learning effect of novice golfers will be attenuated by somatic anxiety under pressure, similar to findings for recreational golfers from Study 1.

## Study 2 Methods

### Description of Sample

The final sample consisted of  $n = 30$  novice golfers (10 female, 20 male;  $M_{\text{age}} = 20.15$ ,  $sd = 3.30$ , range = 18 - 32). Participants were recruited through the University of Ottawa's Integrated System for Participation in Research (ISPR). Ethical approval was obtained from the institutional REB for all protocols and data collection methods (File #: 02-11-35). Golfers were considered novices if they indicated that they either did not ever play golf, had only played on a few occasions, or did not currently have a handicap index. Two additional male participants were allowed to take part in the study but were removed from final analyses as they had indicated that they had prior competitive golf experience.

### Measures

**State Anxiety.** For the purposes of this research, the *Competitive State Anxiety Inventory 2-Revised* (CSAI-2R; Cox et al., 2003) was used to assess state anxiety. The CSAI-2R is the most widely used measure of state anxiety in sport psychology research that assesses two dimensions of state anxiety in an athlete - cognitive anxiety (e.g. "I'm concerned about performing poorly"), and somatic anxiety (e.g., "My heart is racing"). The CSAI-2R also has a self-confidence subscale, which was added to the original CSAI measure. Subscale totals are computed by summing relevant items, dividing by the number of items, and multiplying by a

factor of 10 to yield potential scores between 10-40 for each subscale. The CSAI-2 has been shown to have good internal consistency in a validation study, with Cronbach's  $\alpha$  values ranging from .81-.83 for the cognitive subscale, .81-.88 for the somatic subscale, and .86-.91 for the self-confidence subscale (Cox et al., 2003). A meta-analysis on the relation between scores on the CSAI-2 and sports performance demonstrated that the measure is most valid when administered immediately prior to a competition (Craft et al., 2003). In this study, participants filled out the measure right after the instructions for the social-evaluative condition were given and subsequently completed the second putting task immediately after completing the questionnaire.

**Perceived stress.** In the baseline questionnaire package, participants completed a Visual Analogue Scale (VAS) to assess their levels of perceived stress on a scale from 0 (none) to 100 (maximum). The purpose of this VAS was to assess the effectiveness of the stress manipulation. Participants were asked to rate their perceived stress using the VAS scales immediately prior to the beginning of the first phase of the experiment (baseline) and again after the instructions were received for the second phase of the experiment (social-evaluative threat). The VAS has been shown to be a reliable self-report measure of subjective stress (e.g., Bernstein & Garfinkel, 1992). This single-item measure of subjective stress was used to quickly assess changes within perceived stress of the participants between the two phases of the experiment, rather than requiring them to fill out the CSAI-2R a second time. The thermometer method of assessing subjective states has previously been employed to reliably assess perceived stress in a sport-specific situation (Kowalski & Crocker, 2001). As a result, the ease-of-use of the VAS was considered sufficient to use as a manipulation check, while the CSAI-2R will be used in the main analyses.

**Putting performance.** Putting performance was assessed using the distance from the

ball to the hole (if the putt was not holed) in inches was measured to provide an absolute radial error (ARE) score for each putt. Putts that were holed were given a value of 0. Finally, putter face alignment at impact (collected from the TOMI; procedure described below) was considered as a kinematic measure of performance.

### **Procedure**

Before the putting experiment, participants came to the lab and provided informed consent and provided appropriate contact information. The experimental portion of the study was conducted in the lab and was divided into two phases similar to Study 1 – baseline and social evaluation. Both phases of the experiment required the participants to hit putts to a hole from a distance of 7 feet, on an indoor putting mat (TrueLine Greens), with a slight incline (roughly two inches) towards the hole. For the purposes of increasing the overall difficulty of the putting task, all golfers putted to a hole that was reduced in size by approximately 2 centimeters in diameter from the regulation hole size. By decreasing the effective size of the hole, golfers were required to hit their putts at an optimal speed right in the center of the cup, or the putt would ‘lip out’ (i.e., hit the hole, but spin away and stay out). The distance to the hole was set at seven feet. This distance was chosen due to space considerations in the laboratory, as well as the length of the artificial putting surface used. Further, we wanted the degree of difficulty to be easy enough for a novice to be able to quickly adapt to the task, but hard enough for someone to string together a series of putts in a row (a.k.a. “grooving” one’s stroke).

Each participant's putter was hooked up to the TOMI®, a device described in Study 1 that records kinematic parameters of the putting stroke (e.g., tempo, stroke path, face alignment at impact). This device has no contact with the body of the participants and has been shown to be a reliable measure of 3d kinematics in previous work (Mackenzie & Evans, 2010). Before the beginning of putting phase of the experiment, participants were given the option to hit a few

putts to practice, and to get a feel of having the device attached on the putter. Performance data was not collected during this practice phase, but participants were able to see where the ball finished after they stroked the putt. A maximum of five minutes was given for practice to avoid over-preparation (although no participant stroked more than a few practice putts).

After the completion of the putting practice, participants started the first phase of the experiment where they were asked to hit 10 putts, but this time with the instructions that all of the parameters were to be recorded by the putting device. Participants were instructed to try and hole the putt, but if unsuccessful to make sure the ball finished as close as possible to the hole.

After the completion of the *neutral phase*, the participants were given the instructions for the *social-evaluative portion of the experiment* (see page 37 for a complete description from Study 1). The purpose of the social-evaluative manipulation was to simulate real-life conditions during the course of a regular round of golf. A complete round of golf is typically played with three other individuals, with an emphasis on the scores of each golfer. Golfers each take turns playing their shots, with the other players silently observing. By inducing self-focus with the video camera and adding a performance-based incentive, it is believed that the pressure one would regularly feel during the game would be adequately simulated. In this phase, participants were again asked to hit 10 putts but were told that the experiment was being run in conjunction with NCAA Division I golf coaches who were interested in whether body language and ‘fluidity’ of the putting stroke can predict whether a putt is holed, in an effort to help coaches train their own players better. As a result, the participants were instructed that the researcher was to be taking notes and evaluating the overall ‘look’ of the participants putting stroke and was also

video-recording the task to be analyzed by these coaches.<sup>10</sup> Furthermore, the participants were also told that they were to be part of a study-wide competition with the person sinking the greatest number of putts in this portion would win one dozen Titleist© Pro-V1 golf balls (Retail Value: \$59.99), or a \$50 gift card of their choice.

After giving the instructions for the social-evaluative task, participants' verbal consent to continue with the experiment was obtained. After the instructions were given and immediately before hitting the final set of putts, participants were asked to fill out self-report measures of state anxiety and perceived stress on a laboratory computer. Participants then hit 10 putts while being videotaped by a research assistant. After the completion of the task, participants were debriefed, and verbal assent to use their data was obtained after they had been informed of all of the details of the experiment. It is important to note that at this point of the experiment each participant was told of their right to withdrawal their consent if they were uncomfortable with the deception use. None of the video data was kept and was erased in front of each participant. Lastly, all participants were thanked for their participation. The total experiment took roughly 45-60 minutes to complete.

### **Statistical Analyses**

Two performance variables were selected for longitudinal growth analysis: distance to hole (absolute radial error) and putter face angle at impact. Each performance variable was analyzed in a separate analysis. In this study, we conducted a growth model with two intercepts

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<sup>10</sup> This study was jointly run by the author of this study and a trained RA who were both present to assist in data collection. The RA was a student in the laboratory who volunteered their time and was trained in the social-evaluative protocol by the author (i.e., remaining neutral in tone, not sharing any feedback or words of encouragement).

and two slopes. This two-intercept approach was advantageous to clearly separate the discontinuity of the growth model created by the experimental manipulation occurring between the *neutral phase* and the *social-evaluative portion of the experiment*. The **first intercept of the model** was set at the final putt of the neutral phase using the following coding procedure: putt1 = -9, putt2 = -8, putt3 = -7, putt4 = -6, putt5 = -5, putt6 = -4, putt7 = -3, putt8 = -2, putt9 = -1, putt10 = 0. **The first slope of the model** quantifies the change in performance (i.e., reduced distance to the hole) over the putts of the neutral phase of the study. **The second intercept of the model** was set at the first putt of the social-evaluative phase of the study using the following coding procedure: putt1 = 0, putt2 = 1, putt3 = 2, putt4 = 3, putt5 = 4, putt6 = 5, putt7 = 6, putt8 = 7, putt9 = 8, putt10 = 9. **The second slope of the model** quantifies the improvement in performance (i.e., reduced distance to the hole) over the putts of the experimental phase of the study.

Following procedures outlined in numerous resources on longitudinal modeling (Bickel, 2007; Heck, Thomas, & Tabata, 2011; Hox, 2010; Raudenbush & Bryk, 2002; Singer & Willet 2003), each outcome variable followed a systematic procedure to determine a) the growth trajectories with two intercepts and two slopes, and b) the moderating impact of individual state somatic and cognitive anxiety on the individual trajectories. The second model was particularly useful to determine if the performance at the start of the social-evaluation phase (i.e., intercept 2) significantly differed from the performance at the end of the neutral phase (i.e., intercept 1) and if the rates of performance improvement (i.e., slope of phase 2 versus slope of phase 1) were significantly different during the social-evaluation phase. The second model was particularly useful to examine the predictive role of individual state anxiety on the performance at each of the two phases of the study. All models were tested in Mplus 7.3 with the Bayesian estimator. The Bayesian estimator is preferable with small samples of participants (Hox, van de Schoot, &

Mattisse, 2012; Muthén & Asparouhov, 2012) and increasingly used in sport psychology research (Doron & Gaudreau, 2014; Doron & Martinent, 2016; Sterling, Ivarsson, Johnson, & Lindwall, 2015).

## Study 2 Results

### Preliminary analyses

A total of 578 putts were included in the analyses. 22 putts were removed from the putter face angle at impact analysis due to equipment error. Descriptive statistics for variables are shown in Table 4.

Paired samples *t*-tests were conducted to compare the differences in perceived stress between the neutral and social evaluative conditions. Results showed no significant differences in perceived stress between the two conditions,  $t(26) = -0.575, p = .570$ .

### Distance to the Hole

The intra-class correlation (ICC) indicated that 23.2% of the variance in distance to the hole was attributable to between-person differences ( $\sigma^2 = 45.910, \tau = 13.833, ICC = 0.232, p < 0.001$ ). Most of the variance (76.8%) was attributable to change across the 20 putts of the study, thus indicating the added value of examining growth models of putting performance rather than aggregating the putts across the neutral and social-evaluative conditions, respectively.

Results of the two-intercept growth model without predictor (Table 5, model 1) showed that distance to the hole significantly diminished across the 10 putts of the neutral phase. As expected, distance to the hole did not significantly diminish across the 10 putts of the social-evaluative threat phase. The distance to the hole jumped from 8.319 cm at the end of the neutral phase (intercept #1) to 9.513 cm immediately after the social-evaluative threat experimental manipulation (intercept #2) but this discontinuity in the growth model was not statistically significant (difference between intercept #1 and #2 = 1.229,  $SD = 1.893, p = .252$ ). However, the

performance improvement seen during the neutral phase was halted after the social evaluative threat manipulation.

In model 2, we added somatic anxiety as the predictor of the two intercepts and two slopes. Somatic anxiety did not significantly predict the change in the distance to the hole during the neutral phase (i.e., slope #1) nor did it significantly predict distance to the hole on the last putt of this phase (i.e., intercept #1). Consistent with our hypothesis, somatic anxiety became a substantial predictor of the distance to the hole immediately after the social-evaluative threat experimental manipulation (intercept #2). This effect did not reach typical threshold of statistical significance ( $p = .085$ ) but was nonetheless substantial (Pseudo  $R^2 = .063$ ). As shown in Figure 3, participants with different levels of somatic anxiety had very comparable distance to the hole at the end of the neutral phase but their distance to the hole substantially differed after the experimental manipulation. The distance to the hole of the participants with high somatic anxiety rose after the social-evaluative threat experimental manipulation (intercept #2) and this discontinuity in the growth model was substantial (difference between intercept #1 and #2 = 6.685,  $SD = 4.531$ ,  $p = .069$ ). Participants with low (difference between intercept #1 and #2 = -4.653,  $SD = 4.717$ ,  $p = .159$ ) and medium (difference between intercept #1 and intercept #2 = 1.009,  $SD = 1.815$ ,  $p = .280$ ) levels of somatic anxiety did not experience this deterioration in putting performance after the experimental manipulation. Overall, performance deteriorated after the social-evaluative threat manipulation only for participants with high somatic anxiety and this effect slowly disappeared during the second part of the study (see Figure 3). Cognitive anxiety did not significantly moderate the objective putting performance as measured by distance to the hole.

### **Face Angle at Impact**

The ICC indicated that 60.2% of variance was attributable to differences between participants ( $\sigma^2 = 0.0165$ ,  $\tau = 0.025$ ,  $ICC = 0.602$ ,  $p = <0.001$ ). A substantial part of the variance (39.8%) in the face angle at impact was attributable to change across the 20 putts of the study, thus indicating the added value of examining growth models of this putting parameter rather than aggregating the putts across the neutral and social-evaluative conditions, respectively.

Results of the two-intercept growth model without predictor (Table 6, model 1) showed that face angle at impact did not significantly change across the 10 putts of the neutral phase nor across the 10 putts of the social-evaluative threat phase.

In model 2, we added somatic anxiety as the predictor of the two intercepts and two slopes. Somatic anxiety did not significantly predict the change in face angle during the neutral phase (i.e., slope #1) nor did it significantly predict face angle on the last putt of this phase (i.e., intercept #1). Consistent with our hypothesis, somatic anxiety became a substantial predictor of face angle immediately after the social-evaluative threat experimental manipulation (intercept #2). This effect did not reach typical threshold of statistical significance ( $p = .085$ ) but was nonetheless substantial ( $Pseudo-R^2 = .069$ ). As shown in Figure 4, the participants with different levels of somatic anxiety had very comparable face angles at impact at the end of the neutral phase but their face angle substantially differed after the experimental manipulation. The face angle at impact of the participants with high somatic anxiety became higher than the face angle of the participants with average and low levels of somatic anxiety immediately after the experimental manipulation of social-evaluative threat. Overall, the face angle deteriorated after the social-evaluative threat manipulation only for participants with high somatic anxiety and this effect slowly dissipated during the second part of the study (see Figure 4). Similar to distance to the hole, cognitive anxiety did not moderate the face angle at impact variable.

## **Brief Discussion of Study 2**

The goal of Study 2 was to examine the multi-level associations between state anxiety, and a number of indicators of golf putting performance in a group of novice golfers. Similar to the methodology of Study 1, a growth curve model was proposed in which the momentary nature of putting outcomes was taken into consideration by analyzing each putt as a non-independent instance of performance nested within a person. All participants performed a putting task in the laboratory on an artificial putting surface under a neutral condition followed by a social evaluative threat condition.

Study 1 found that high somatic anxiety attenuated the natural learning effect exhibited by those golfers with low somatic anxiety. As expected, improvement in performance was demonstrated across the neutral phase in Study 2 but did not improve during the social evaluative portion of the experiment. Although the distance to hole increased slightly between the last putt in the neutral phase and the first putt in the social evaluative phase, this difference was not statistically significant. When somatic anxiety was added as a moderator, high levels of somatic anxiety again attenuated the expected learning effect in the social evaluative trials (albeit marginally statistically significant). One possibility is that among participants with no golf experience, even the baseline condition (performing a putting task in the laboratory while hooked up to the TOMI) was enough to evoke social-evaluative threat, and thus that a ceiling effect was observed. This is consistent with the finding that perceived stress did not differ between the two conditions.

Examination of face angle at impact provides some complementary information. Angle values ranged between 1.30-1.55 degrees and did not change during the baseline task. Although participants with different levels of somatic anxiety had very comparable face angles at impact at the end of the neutral phase, their face angle substantially differed after the experimental manipulation. The face angle at impact of the participants with high somatic anxiety became

higher than the face angle of the participants with average and low levels of somatic anxiety immediately after the experimental manipulation of social-evaluative threat. This finding suggests that the social evaluative threat did affect novice golfers' putting stroke –albeit not enough to register a significant deficit to performance. It is possible that for longer, more difficult putts, these kinematic differences would translate into an observable performance deficit.

### **Limitations to Study 2 and Bridge to Study 3**

Some important limitations need to be addressed to frame the results appropriately as well to influence future research directions. It is prudent to highlight that the manipulations used in both Study 1 and 2 (as well as most others in the sport-stress literature) do not truly simulate the intensity of the pressure that one would face in a real sport competition. In fact, the social evaluative threat condition should be depicted as a mild stressor in comparison to the demanding challenges of putting a golf ball in front of a crowd on the 72<sup>nd</sup> hole of a prestigious golf tournament such as the Masters. Nevertheless, these results indicate that even a mild stressor in the confines of a laboratory is sufficient to yield non-negligible within-person fluctuations in kinematic parameters of a putting stroke. As such, these results are consistent with studies in which *changes* in performance have been demonstrated under conditions of social evaluative threat. It has been suggested that variability in movement is, in fact, related to more *consistent* performance.

In all previous analyses, state anxiety was treated as a time-invariant predictor because it was measured at only one time point (i.e., after the stress instructions were given). From a practical standpoint, it was unrealistic to administer a measure, such as the CSAI-2R, within the interval of a few minutes, immediately before and after the social-evaluative threat manipulation. No formal manipulation check was conducted in Study 1 and Study 2 did not implement any

manipulation checks other than a comparison between VAS scores from baseline to the social-evaluative task. Although the within-person fluctuations in face angle at impact suggest that participants reacted to our social evaluation stress manipulation, future research should include a series of questions to ensure that participants believed the cover story. As mentioned in the introduction, the processing efficiency theory (Eysenck & Calvo, 1992) predicts that under pressure a person will increase the level of effort placed into task execution to mitigate the negative influence of state anxiety on performance. However, as no measure of effort was used in either of the studies, the potential influence of effort on the pressure performance relation was not examined.

In Study 2, participants were asked to perform more putts during both the neutral and social-evaluative trials in order to offer a more precise assessment of their performance growth trajectory. The results of this study are noteworthy because they illustrate the potential of a multilevel approach in order to take full advantage of the repeated assessment of performance during neutral and experimental trials within an AB design. As such, the following chapter presents Study 3 with attempts at addressing the limitations identified thus far.

### Study 2 Tables

Table 4.

*Study 2 – Descriptive Statistics for putting performance and parameter variables*

<b>Variable</b>	<b>Mean</b>	<b>s.d</b>	<b>s.e.</b>
Distance from Hole (inches)	9.59	4.022	0.789
Putts Holed (%)	0.23	0.18	0.035
Putter Path (°)	-0.242	2.956	0.58
Loft at Impact (°)	0.579	1.341	0.263
Alignment at Address (°)	1.587	0.468	0.092
Alignment at Impact (°)	1.416	0.668	0.131
Putter Velocity (inches/sec)	50.341	5.838	1.145
Backswing Time (sec)	0.574	0.104	0.02
Forwardswing Time (sec)	0.298	0.075	0.015
Total Stroke Time (sec)	0.872	0.175	0.034
Stroke Tempo (backswing/forward)	1.981	0.234	0.046
Face Rotation Back (°)	6.347	2.338	0.458
Face Rotation Follow (°)	5.811	2.838	0.557
Total Face Rotation (°)	12.158	3.614	0.709

Table 5.

*Results of the discontinuous growth models of distance to the hole with two intercepts and slopes*

Parameters and predictor	<u>Model 1</u>			<u>Model 2</u>		
	<i>Estimate</i>	<i>SD</i>	<i>p</i>	<i>Estimate</i>	<i>SD</i>	<i>p</i>
Intercept #1 (putt 10)	8.319	1.396	< .001	8.292	1.456	.000
Somatic anxiety	---	---	---	0.220	3.432	.473
Slope #1	-0.360	0.204	.037	-0.364	0.207	.038
Somatic anxiety	---	---	---	-0.093	0.490	.417
Intercept #2 (putt 11)	9.513	1.891	<.001	9.316	1.859	.000
Somatic anxiety	---	---	---	5.832	4.361	.085
Slope #2	-0.074	0.257	0.391	-0.040	0.246	.433
Somatic anxiety	---	---	---	-0.982	0.575	.043
Variance						
Intercept #1	31.087	19.242	< .001	33.847	21.809	< .001
Slope #1	0.439	0.367	< .001	0.475	0.412	< .001
Intercept #2	69.810	36.520	< .001	65.435	35.787	< .001
Slope #2	1.006	0.651	< .001	0.849	0.606	< .001

Table 6.

*Results of the discontinuous growth models face angle at impact with two intercepts and slopes*

Parameters and predictor	<u>Model 1</u>			<u>Model 2</u>		
	<i>Estimate</i>	<i>SD</i>	<i>p</i>	<i>Estimate</i>	<i>SD</i>	<i>p</i>
Intercept #1 (putt 10)	1.364	0.242	< .001	1.354	0.248	.000
Somatic anxiety	---	---	---	0.538	0.583	.166
Slope #1	-0.013	0.028	.327	-0.012	0.028	.329
Somatic anxiety	---	---	---	-0.002	0.068	.490
Intercept #2 (putt 11)	1.504	0.254	<.001	1.492	0.248	.000
Somatic anxiety	---	---	---	0.748	0.589	.091
Slope #2	-0.019	0.032	0.266	-0.018	0.032	.000
Somatic anxiety	---	---	---	-0.064	0.076	.190
Variance						
Intercept #1	1.157	0.621	< .001	1.164	0.658	< .001
Slope #1	0.009	0.007	< .001	0.010	0.008	< .001
Intercept #2	1.279	0.647	< .001	1.191	0.640	< .001
Slope #2	0.014	0.010	< .001	0.015	0.010	< .001

## Study 2 Figures

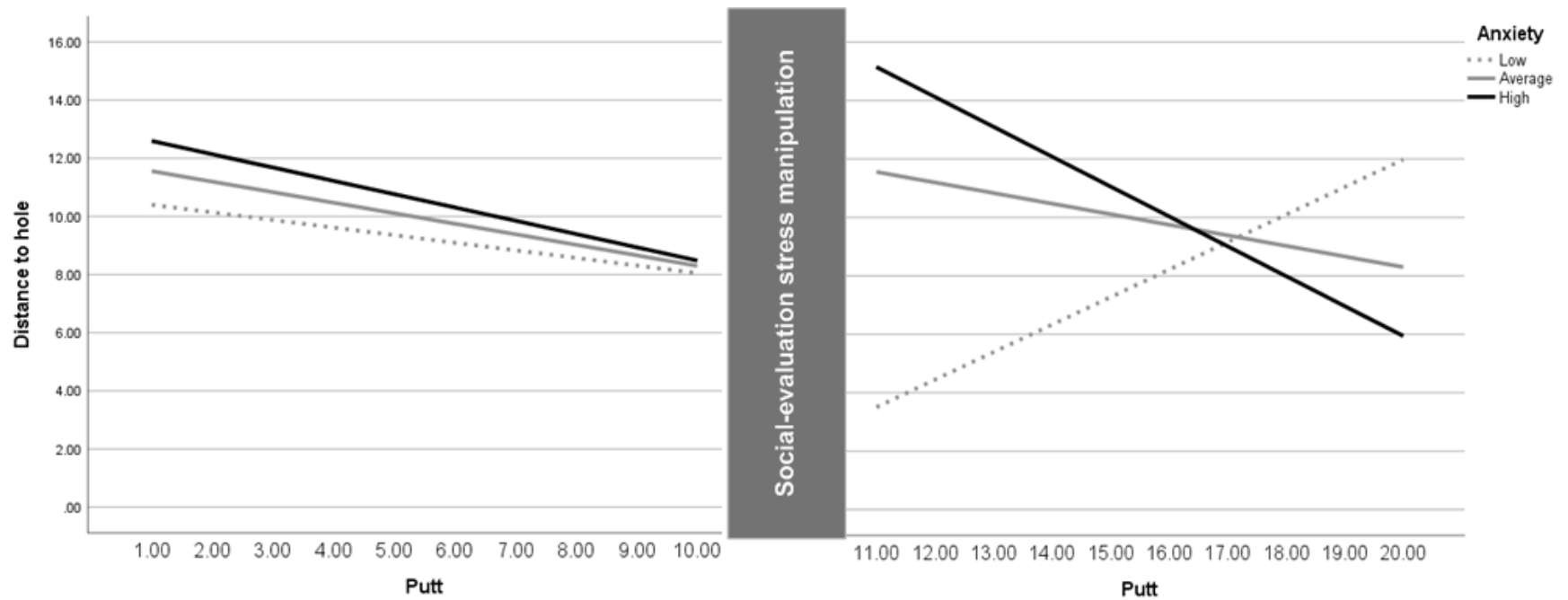


Figure 3. Discontinuous piecewise growth model of distance to the hole with two intercepts (i.e., putt 10 and putt 11) and slopes (i.e., putt 1 to 10; putt 11 to 20). Baseline segments of the model are not predicted by anxiety. Post-manipulation segments of the model are predicted by anxiety.

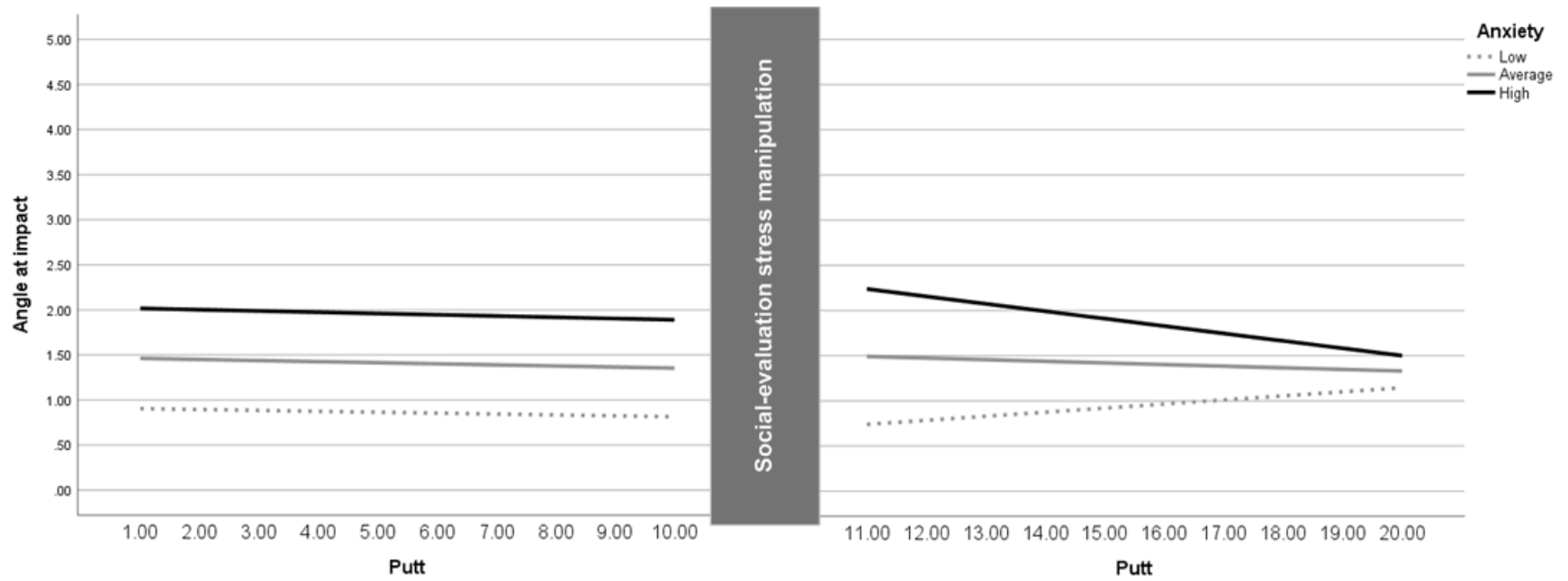


Figure 4. Discontinuous piecewise growth model of angle at impact with two intercepts (i.e., putt 10 and putt 11) and slopes (i.e., putt 1 to 10; putt 11 to 20). Baseline segments of the model are not predicted by anxiety. Intercept #2 of the model is predicted by anxiety.

**Chapter 5: Study 3**

## Overview

Despite the encouraging results of Study 2, it still remains uncertain whether the results reported herein are attributable to the SET experimental manipulation per se or to a naturally occurring learning effect that would have happened regardless of the experimental manipulation. Research on how performance breaks down under pressure is typically focused on either self-focus or distraction-based theories. As such, two additional factors need to be considered that may influence performance, namely *self-focus* and *effort*. The following sections briefly outline the concepts of *dispositional reinvestment* (Masters, 1992), and both the *processing efficiency theory* (Eysenck & Calvo, 1992) and the updated version of the theory, *attentional control theory* (Eysenck et al., 2007).

### Processing Efficiency Theory/Attentional Control Theory

The most notable distraction-based explanation for how performance is disrupted under pressure is the *processing efficiency theory* (PET; Eysenck & Calvo, 1992). PET hypothesizes that anxiety associated with a pressure-filled situation leads to cognitive resources (e.g., working memory) being dedicated to the management of the anxiety itself, rather than the task at hand. Therefore, the greater the anxiety the greater the allocation of cognitive resources would be required to mitigate potential negative effects. Depending on the individual, as well as the specific situation, two categories of response are likely: either (1) coping strategies can be put in place to deal with the anxiety; and/or (2) further cognitive resources (e.g., effort and strategy) can be used to decrease the probability of poor execution. Both outcomes have the goal of reducing anxiety. For a simple task such as golf putting, it is likely that enough effort may mitigate the potential performance impairments.

Eysenck et al. (2007) updated processing efficiency theory and renamed it *attentional control theory*. To understand the differences between the hypotheses, Eysenck et al. (2007)

differentiate between *performance effectiveness* and *performance efficiency*. *Performance effectiveness* refers to objective performance on the actual tasks, while *efficiency* refers to the amount of effort and resources required to complete the task. Attentional control theory predicts that anxiety influences efficiency far greater than effectiveness. The theory itself rests on two assumptions: 1) that *worry* is the component of state anxiety that inhibits both effectiveness and efficiency, and 2) the central executive is the working memory system (based on Baddeley's four-part model of working memory; see Baddeley, 2001) that becomes taxed by increased task complexity. Although the theories seem different, the essence of the influence is merely elaborated upon in the updated version.

### **Movement Awareness**

It has been suggested that consciously trying to control one's movements may be source of performance disruption under pressure. Those individuals who are more likely to control their movements have been termed "dispositional reinvesters", which is a synonym for conscious awareness and subsequent control of movement (Masters, 1992). Kinrade, Jackson, and Ashford (2010) suggest that golf-putting is a complex motor skill that is more likely to break down under pressure when individuals consciously control their movement while executing the stroke. However, as only two variables (proper line and proper speed) are relevant when putting, it seems odd that golf putting would be placed in a category of complex motor skill (especially given the comparisons used to hitting a baseball and throwing free throws in basketball). Nevertheless, Kinrade et al. (2010) found a reduction in golf putting performance in those high in movement awareness while putting under pressure. Two other golf putting studies examined performance under pressure while also measuring movement awareness. Tanka and Sekiya (2010) compared a small sample of six professional golfers to 5 novices and found no relation between movement awareness and performance. Tanaka and Sekiya (2011) conducted a

subsequent study on a sample of 20 novices which included the threat of electric shock for poor putting performance in their paradigm. However, despite the more intensive conditions associated with putting under pressure, no relation was found between movement awareness and performance.

Despite these conflicting results, it would intuitively seem that those high in dispositional self-consciousness would be more likely to focus on themselves under pressure and thus be more susceptible to social evaluation. In an early article written over thirty years ago on the topic of choking, Baumeister (1984, pp. 610-11) alluded to self-consciousness as being the source of choking under pressure:

“Under pressure, a person realizes consciously that it is important to execute the behavior correctly. Consciousness attempts to ensure the correctness of this execution by monitoring the process of performance (e.g., the coordination and precision of muscle movements); but consciousness does not contain the knowledge of these skills, so that it ironically reduces the reliability and success of the performance when it attempts to control it. “

Baumeister hypothesized that under low pressure, people who are self-conscious will perform worse than those who are not self-conscious. Once pressure is induced, however, he suspected that those who are used to being self-conscious will find it *easier* to cope and therefore outperform those who are not used to being self-conscious. Overall, Baumeister (1984) demonstrated through a series of experiments that both self-consciousness and pressure influence performance in a negative way. Although no direct link between pressure and induced self-consciousness was established in any of the experiments, Baumeister (1984) suggested that enhanced self-consciousness may have led to decreased attention to the task itself, and subsequently to lowered performance. Self-consciousness can further be broken down into two sub-categories:

private self-consciousness, and public self-consciousness (Scheier & Carver, 1985). Private self-consciousness refers to having a focus on the internal aspects of the self (e.g., thoughts, feelings, and physiological processes), whereas public self-consciousness refers to having an external focus of the self (e.g., parts that are on display for others to see). Private self-consciousness seems analogous to competitive state anxiety, especially how the CSAI-2 items are worded. Individuals high in state anxiety therefore would be more likely to focus on the internal sensations and thoughts experienced.

### **The Current Study**

The competing theories seem to provide explanations that are semantic rather than fundamentally different. Regardless of the explanation, performance is likely to be impaired if focus is shifted away from the task to another source. Study 3 aims to expand upon the findings of both Study 1 and 2 by refining the methodology used during the social-evaluative condition, as well as to attempt to contribute to the choking literature by adding two measures of effort, as well as a measure of dispositional reinvestment. The purpose of adding these two constructs to our design serves a few specific functions. As mentioned previously, the processing efficiency theory (Eysenck & Calvo, 1992) predicts that external pressure may increase the levels of state anxiety within an individual, which then induces an increase in perceived *effort* by the individual to improve one's performance. Self-monitoring hypotheses (i.e., conscious processing, explicit monitoring, constrained action), on the other hand, predict that *self-focus* may increase under pressure which would lead to performance decrements. Most importantly, it was believed that the two explanations are complementary – that is, a person could increase the level of effort on a task, and also be considered high in movement awareness.

Clearly, the AB design used in Studies 1 and 2 was a suboptimal design to examine the effect of social-evaluative threat on performance because the learning effect might mask or

attenuate the effect of the social-evaluative threat. As a result, Study 3 used a pre-post experimental design in which all golfers started with a neutral trial of 20 putts before being randomized into a control and an experimental group. Participants in the control group then performed 20 additional putts under the same neutral condition. Participants in the experimental condition received the social-evaluative threat manipulation before performing 20 additional putts. It was expected that participants in both conditions will exhibit a linear learning effect from the 1<sup>st</sup> to 20<sup>th</sup> putt of the pre-experimental phase of the study. However, it was expected that the performance of the participants in the control condition will keep on linearly improving before stabilizing at some point during the second set of 20 putts. In contrast, the performance of participants in the social-evaluative threat condition will either deteriorate or not significantly improve during the second set of 20 putts. Based on the predictions of attentional control theory, it was hypothesized that effort would increase between the two phases of putts only for the experimental group. Keeping with the findings of Study 1 and 2, we expected somatic anxiety to moderate performance in the social-evaluative trials for the experimental group only. Lastly, we also hypothesized that those high in movement awareness would have their performance impaired.

### **Study 3 Methods**

#### **Overview**

Study 3 followed the same procedures identified in Study 2, but with the addition of two measures of effort and movement awareness. Secondly, a slight modification to the social-evaluative manipulation was made to increase the potential influence on participants. In Study 2, participants were told by the experimenter that their video footage was to be used by NCAA golf coaches to help them understand how people perform under pressure. For Study 3, a real golf-professional was recruited from a local private golf club to film a short introductory video at his

state-of-the-art teaching facility to increase the ecological validity of the stressor. It is believed that having a true golf professional give the introductory stress-inducing instruction of our study would increase the realism of our stress condition as compared to having the experimenter read off the instructions (see Appendix G for video script).

As the meta-analysis by Dickerson and Kemeny (2004) indicated, the presence of a live evaluative individual was more effective at eliciting a cortisol response than being videotaped. For practical reasons it is not possible to have a truly believable golf professional serve as a live witness as was done in Study 1. That being said, a video recording of a legitimate golf professional from the Ottawa area giving the manipulation instructions increased the validity of the study by delivering the instructions in the exact same way for each participant but also provided an image of a professional to increase the likelihood of the participants indeed feeling evaluated. Rather than having a research assistant deliver the scripted instructions as has traditionally been done in all putting studies, participants in Study 3 (in the social evaluative threat condition) were provided the link to the video after the completion of the baseline putting task.

Lastly, a second camera was used with the image of the participant being broadcast on a TV screen during the task in direct eyesight of the participant, as well as the original camera used in the first study similar to the methodology used by Cooke et al. (2010; 2011). It is important to note that video recordings are not actually saved and participants were made aware of this after the completion of the study.

### **Description of Sample**

A total sample of  $N = 55$  novice golfers (i.e., with little, to no formal golf experience) was recruited from the ISPR and randomized to one of two conditions: social-evaluative ( $n = 29$ ; 12 male, 17 female), or control ( $n = 26$ ; 7 male, 20 female).

## Procedure

The procedure for Study 3 is the same as the protocol outlined in Study 2 with a few changes (see Methods section in Study 2 for complete explanation of the experimental methodology). In the *social-evaluative group*, participants followed the same protocol seen in previous studies - that is, they completed a questionnaire package, and then systematically putt under neutral and social-evaluative pressure (AB design). The *control group*, on the other hand, completed the same questionnaire package, putt under neutral conditions, filled out the same between-condition measures, but instead completed another set of neutral putts (AA design). In other words, the control group did not undergo any explicit social-evaluative manipulation. It was believed that randomizing participants to either a pressure or control condition is the only way to truly disentangle the effects of the social-evaluation and normal deviations in performance.

As mentioned previously, novices were expected to improve on a motor task as subsequent trials are taken. Golfers from Study 1 and 2 all demonstrated improvements in performance. That being said, golfers from Study 1 were only required to hit 10 total putts, whereas golfers in Study 2 were asked to hit 20 total putts. For Study 3, all golfers were asked to hit 20 putts in the baseline condition, and then 20 putts in the experimental (or control) condition, for a total of 40 putts overall. It was believed that by doubling the number of putts required in Study 3 as compared to Study 2, all participants were given enough trials in the baseline task for performance to stabilize before the next condition.

## Measures

**State Anxiety.** As per Study 1 and Study 2.

**Effort.** Two different indices of effort were added to Study 3 – both a behavioural and self-report measure. Firstly, the length of time (in seconds) for each putt was inconspicuously

measured by a research assistant to serve as an indirect marker for the amount of preparation that each golfer is taking over the subsequent putt similar to previous putting studies measuring effort (Wilson et al., 2007). Secondly, after the conclusion of each block of putts, participants completed the *Rating Scale of Mental Effort* (Zijlstra, 1993; see Appendix E) – a single item self-report measure directly asking each participant how much effort was given during the previous task. Participants were asked to rate the level of mental effort that they expended using a vertical scale ranging from 0–150, with nine markers including, at the extremes, 3 (no mental effort at all) and 114 (extreme mental effort). The scale has demonstrated good test-retest reliability, with a correlation coefficient of .78 (Zijlstra, 1993), and has been used successfully to measure mental effort in sport (e.g., Wilson et al., 2007).

**Self-Focus.** The *Movement Self-Consciousness* questionnaire (Masters, Eves, & Maxwell, 2009) was used to provide an estimate of how much the participant tended to focus on themselves and their movement (i.e., the tendency to be aware of and focus on one's movements). The questionnaire is a 10-item measure which asks questions related to one's awareness of their movements (e.g., *I am aware of the way my mind and body works when I am carrying out a movement.*) on a 7-point likert scale from 1 (*not at all*) to 7 (*totally*).

**Manipulation Check.** A formal manipulation questionnaire was created and used as an analogue of social desirability consisting of 8-items (see Appendix G) was designed for the use of this study to explicitly ask the participants about the influence of the social-evaluative manipulation (e.g., *How much did you consider the impression others would have of you while doing the putting task?*) as well as their motivation (e.g., *How important was it for you to do well on this task?*) on a 7-point likert scale from 1 (*not at all*) to 7 (*totally*). As per Study 2, participants also completed two measures of perceived stress using a *Visual Analogue Scale* (VAS) from 0 (none) to 100 (maximum). Participants were again asked to rate their perceived

stress using the VAS scales immediately prior to the beginning of the first phase of the experiment (baseline) and again after the instructions were received for the second phase of the experiment (social-evaluative threat/control).

**Putting Performance and Kinematic Parameters.** As per study 2, distance to the hole and putter face angle at impact (absolute), were analyzed as our objective putting performance measures.

### **Plan of Statistical Analyses**

Two dependent variables were selected for longitudinal growth analysis: distance to hole (absolute radial error) and putter face angle at impact. Each performance variable was analyzed in a separate analysis.

In this study, we conducted a multiple-group (i.e., control and experimental groups) growth model with two intercepts and two slopes in each of the groups. As per Study 2, the two-intercept approach was advantageous to clearly separate the discontinuity of the growth model created by the experimental manipulation occurring between the *neutral phase* and the *social-evaluative portion of the experiment*. In Study 3, the multiple-group approach was advantageous to compare the two intercepts and the two slopes of the control group and the social-evaluative group. The **first intercept of the model** was set at the final putt of the neutral phase using the following coding procedure: putt1 = -19 to putt 20 = 0. **The first slope of the model quantifies** the change in performance (i.e., reduced distance to the hole) over the putts of the neutral phase of the study. **The second intercept of the model** was set at the first putt of second phase of the study using the following coding procedure: putt 21 = 0 to putt 40 = 19. **The second slope of the model** quantifies the improvement in performance (i.e., reduced distance to the hole) during the 20 putts of the second phase of the study. For the control group, this slope denotes the putting performance change in the second phase of the study. For the experimental group, this slope

denotes the putting performance change that occurred after the social-evaluative threat manipulation.

Following procedures outlined in resources on longitudinal modeling (Bickel, 2007; Heck, Thomas, & Tabata, 2011; Hox, 2010; Raudenbush & Bryk, 2002; Singer & Willet 2003), each outcome variable followed a systematic procedure to determine a) the growth trajectory with two intercepts and two slopes, and b) the moderating impact of individual state somatic and cognitive anxiety on the individual trajectories. The second model was particularly useful to determine if the performance at the start of the social-evaluation phase (i.e., intercept 2) significantly differed from the performance at the end of the neutral phase (i.e., intercept 1) and if the rates of performance improvement (i.e., slope of phase 2 versus slope of phase 1) were significantly different during the social-evaluation phase. The second model was particularly useful to examine the predictive role of individual state anxiety (cognitive and somatic), as well as movement awareness on the performance at each of the two phases of the study. All models were tested in Mplus 7.3 with the maximum likelihood robust estimator.

## **Study 3 Results**

### **Preliminary Analysis**

Similar to Study 2, an exploratory set of analyses were conducted to examine the performance and characterological differences between the two groups. For the control group, a total of 1040 putts were measured, with 1160 being measured for the experimental group. Due to limitations with the TOMI equipment, a number of observations were not considered acceptable for analysis due to either equipment error, or strokes not being within the range of what could be measured (i.e., unacceptably long or short strokes, not taking the putter back, etc.). Four putts were removed because of values far exceeding expected limits that were attributed to malfunctioning software, or experimenter measurement error. In total, for the putter face angle at

impact variable, 777 total putts with valid data were included for analysis in the control group, and 920 total putts for the experimental group. However, for distance to the hole and pre-shot routine time, no missing data was present.

Bivariate correlations between predictors for the control group are shown in Table 7, while Table 8 demonstrates the same correlations for the experimental sample. Descriptive statistics for performance variables are shown in Table 9, while Table 10 contains a summary of *t*-tests on the means of the variables between each sample to look for significant differences. No significant mean differences were found between performance outcomes between the groups. Table 11 shows descriptive statistics for predictor variables, while Table 12 displays the results of independent samples *t*-tests comparing the two groups. Significant differences in cognitive anxiety, movement awareness prior to the second set of putts, and scores on the manipulation check questionnaire were found. Overall, the stress group indicated that they had more cognitive anxiety, were more aware of their movements, and more concerned about performing well. Lastly, Table 13 shows means broken down by group and for each set of putts, while Table 14 shows the results of independent *t*-tests comparing performance between both sets.

**Manipulation Check.** Two mixed 2 x 2 ANOVAs were performed to examine both the VAS scores and self-reported effort between groups and conditions to determine the effectiveness of the experimental manipulation. For VAS scores, a significant effect of time was demonstrated ( $F(1,53) = 5.181, p = .027$ ), but no effect for the time x group interaction term ( $F(1,53) = 1.147, p = .289$ ), indicating that although stress increased across conditions for both samples, the effect of the social manipulation on the self-reported stress was not significantly stronger for the experimental group. For self-reported effort, a significant effect of both time ( $F(1,53) = 31.390, p < .001$ ) as well as the time x group interaction term ( $F(1,53) = 4.819, p = .033$ ) were found. Descriptive statistics indicate that the experimental group increased their

levels of perceived effort in the second phase of putts to a larger degree than their counterparts in the control group (see Table 12).

### **Distance to the Hole**

The intra-class correlation (ICC) indicated that 7.8% of the variance in distance was attributable to between-person differences ( $\sigma^2 = 44.250$ ,  $\tau = 3.741$ ,  $ICC = 0.078$ ,  $p = <0.001$ ). Most of the variance (92.2%) was attributable to change across the 40 putts of the study, thus indicating the added value of examining growth models of putting performance rather than aggregating the putts across the neutral and social-evaluative conditions, respectively.

**Model without predictor.** Results of the multiple-group two-intercept growth model without predictor (model 1 in Table 15) showed that distance to the hole significantly diminished across the 20 putts of the neutral phase. This expected improvement in putting performance was significant in both groups. The rate of putting improvement did not significantly differ across the two groups (slope #1 between-group difference = 0.088,  $S.E. = 0.064$ ,  $p = .166$ ) nor did the distance to hole at the end of the neutral phase of the experiment (intercept #1 between-group difference = 0.795,  $S.E. = 0.643$ ,  $p = .382$ ). Overall, these findings indicated that the two groups were sufficiently comparable before the experimental manipulation that occurred immediately after the end of the neutral phase of the study.

After the experimental manipulation, distance to the hole did not significantly diminish across the 20 putts for the participants randomized in the control group ( $\beta = -0.031$ ,  $p = .581$ ) but it significantly did improve for the participants in the social-evaluative threat group ( $\beta = -0.088$ ,  $p = .043$ ). However, the rate of putting improvement did not significantly differ across the two groups (slope #2 between-group difference = -0.056,  $S.E. = 0.072$ ,  $p = 0.432$ ). At the start of phase 2 of the experiment, the distance to the hole was 6.484 cm for participants in the control group and 6.826 cm for those in the experimental group, and this difference was not statistically

significant (intercept #2 between-group difference = 0.341,  $S.E. = 0.950$ ,  $p = .719$ ). In both groups, the putting performance deteriorated from the end of the first phase (intercept #1) to the start of the second phase (intercept #2) but this discontinuity in the growth model was not statistically significant neither in the control group (difference between intercept #1 and #2 = 1.118,  $S.E. = 0.975$ ,  $p = .252$ ) nor in the experimental group (difference between intercept #1 and #2 = 0.664,  $S.E. = 0.735$ ,  $p = .366$ ).

**Model with somatic anxiety as the predictor.** In model 2, we added somatic anxiety as the predictor of the two intercepts and two slopes in each of the control and experimental groups. Consistent with our hypothesis, somatic anxiety did not significantly predict putting performance (intercept #1 and #2) and change in putting performance (slope #1 and slope #2) for the participants randomized in the *control group*. Results from the participants in the *experimental group* partially supported our hypothesis. Somatic anxiety significantly predicted the change in the distance to the hole during the neutral phase (i.e., slope #1) and social-evaluative threat phase (i.e., slope #2) of the experiment. Results of simple slopes at low ( $-1SD$ ) and high ( $+1SD$ ) levels of somatic anxiety showed that the putting performance of participants with high somatic anxiety significantly improved during the neutral phase of the experiment ( $\beta = -0.354$ ,  $S.E. = 0.090$ ,  $p < .001$ ) whereas it did not improve after the social-evaluative threat experimental manipulation ( $\beta = 0.073$ ,  $S.E. = 0.073$ ,  $p = .320$ ). In contrast, the putting performance of participants with low somatic anxiety did not significantly improve during the neutral phase of the experiment ( $\beta = 0.118$ ,  $S.E. = 0.119$ ,  $p = .321$ ) whereas it did significantly improve after the social-evaluative threat experimental manipulation ( $\beta = -0.243$ ,  $S.E. = 0.096$ ,  $p = .011$ ). Overall, the patterns of performance improvement/deterioration of the participants randomized in the experimental condition were different for those with high versus low levels of somatic anxiety, thus providing some support for the hypothesis of this study (see Figure 5).

**Model with movement awareness as the predictor.** We tested a model in which we added movement awareness as the predictor of the two intercepts and two slopes in each of the control and experimental groups. Movement awareness had no significant effect on the two intercepts and two slopes of the model neither in the control group nor in the experimental group. The effect of movement awareness was close to statistical significance ( $\beta = -0.820$ , S.E. = 0.515,  $p = .111$ ) to predict the performance at the end of the neutral phase of the experiment (intercept #1) in the experimental group.

### **Pre-Shot Routine Time**

The intra-class correlation indicated that 52.5% of the variance in time was attributable to between-person differences ( $\sigma^2 = 0.998$ ,  $\tau = 1.101$ , ICC = 0.525,  $p = <0.001$ ). Therefore, 47.5% of variance was attributable to change across the 40 putts of the study, thus indicating the added value of examining growth models rather than aggregating the putts across the neutral and social-evaluative conditions, respectively.

**Model without predictor.** Results of the multiple-group two-intercept growth model without predictor (model 1 in Table 16) showed that pre-shot time significantly diminished across the 20 putts of the neutral phase. This acceleration in pre-shot time was significant in both groups and was not significantly different across the two groups (slope #1 between-group difference = -0.014, S.E. = 0.015,  $p = .359$ ) nor did the pre-shot time at the end of the neutral phase of the experiment (intercept #1 between-group difference = 0.014, S.E. = 0.305,  $p = .963$ ). Overall, these findings indicated that the two groups were sufficiently comparable before the experimental manipulation that occurred immediately after the end of the neutral phase of the study.

During the second phase of the task, the pre-shot time decreased across the 20 putts for the participants randomized in the control group ( $\beta = -0.029$ ,  $p < .001$ ) but it did not significantly

increase for the participants in the social-evaluative threat group ( $\beta = -0.010, p = .251$ ). However, the change in pre-shot times substantially differed across the two groups (slope #2 between-group difference = 0.019,  $S.E. = 0.011, p = .086$ ). At the start of phase 2 of the experiment, the pre-shot time was 4.845 seconds for participants in the control group and 5.071 seconds for those in the experimental group, and this difference was not statistically significant (intercept #2 between-group difference = 0.222,  $S.E. = 0.334, p = .506$ ). In both groups, the pre-shot time increased from the end of the first phase (intercept #1) to the start of the second phase (intercept #2); interestingly, this discontinuity in the growth model was statistically significant for the participants in the experimental group (difference between intercept #1 and #2 = 0.363,  $S.E. = 0.157, p = .021$ ) but not for those in the control group (difference between intercept #1 and #2 = 0.155,  $S.E. = 0.114, p = .174$ ). These findings indicated that the social-evaluative threat manipulation of the participants in the experimental group disrupted their pre-shot routine (more than the break taken between phase 1 and phase 2 of the participants in the control group).

**Model with somatic anxiety as the predictor.** In model 2, we added somatic anxiety as the predictor of the two intercepts and two slopes in each of the control and experimental groups. Consistent with our hypothesis, somatic anxiety did not significantly predict pre-shot time (intercept #1 and #2) and change in pre-shot time during phase 2 of the experiment (slope #2) for the participants randomized in the *control group*. However, unexpectedly, it did significantly predict change in pre-shot time during phase 1 of the experiment. Results of simple slopes at low ( $-1SD$ ) and high ( $+1SD$ ) levels of somatic anxiety showed that the pre-shot time of participants with high somatic anxiety significantly decreased during the neutral phase of the experiment ( $\beta = -0.066, S.E. = 0.025, p = .009$ ) whereas it did not increase for those with low somatic anxiety ( $\beta = 0.018, S.E. = 0.027, p = .517$ ). Results from the participants in the *experimental group* partially supported our hypothesis. Somatic anxiety significantly predicted the change in the pre-shot time

during the social-evaluative threat phase (i.e., slope #2) of the experiment. Results of simple slopes showed that the pre-shot time of participants with high somatic anxiety significantly decreased after the social-evaluative threat experimental manipulation ( $\beta = -0.047$ , S.E. = 0.016,  $p = .003$ ). In contrast, the pre-shot time of participants with low somatic anxiety did not significantly change after the social-evaluative threat experimental manipulation ( $\beta = 0.025$ , S.E. = 0.019,  $p = .178$ ). Overall, the post-manipulation pre-shot time of participants randomized in the experimental condition were different for those with high versus low levels of somatic anxiety, thus providing some support for our hypothesis of this study.

**Model with movement awareness as the predictor.** We tested a model in which we added movement awareness as the predictor of the two intercepts and two slopes in each of the control and experimental groups. Movement awareness had no significant effect on the two intercepts and two slopes of the model in the control group. Interestingly, the effect of movement awareness was substantial to predict change pre-shot time after the social-evaluative threat manipulation (slope #2) in the experimental group ( $\beta = -0.013$ , S.E. = 0.007,  $p = .056$ ). Results of simple slopes at low ( $-1SD$ ) and high ( $+1SD$ ) movement awareness showed that the pre-shot time of participants with high movement awareness significantly decreased after the social-evaluative threat experimental manipulation ( $\beta = -0.020$ , S.E. = 0.009,  $p = .023$ ). In contrast, the pre-shot time of participants with low movement awareness did not significantly change after the social-evaluative threat experimental manipulation ( $\beta = 0.006$ , S.E. = 0.014,  $p = .664$ ). Overall, the post-manipulation pre-shot time of participants randomized in the experimental condition were different for those with high versus low levels of movement awareness, thus providing some support for the hypothesis of this study.

### **Face Angle at Impact**

The intra-class correlation indicated that 15.5% of the variance in face angle was attributable to between-person differences ( $\sigma^2 = 0.658$ ,  $\tau = 0.121$ ,  $ICC = 0.155$ ,  $p = <0.001$ ). Therefore, 84.5% of variance was attributable to change across the 40 putts of the study, thus indicating the added value of examining growth models rather than aggregating the putts across the neutral and social-evaluative conditions, respectively.

**Model without predictor.** Results of the multiple-group two-intercept growth model without predictor (model 1 in Table 17) showed that face angle at impact did not significantly change across the 20 putts of the neutral phase. The change in face angle was substantial in the control group ( $p = .093$ ) but was not significantly different across the two groups (slope #1 between-group difference = 0.009,  $S.E. = 0.011$ ,  $p = .404$ ) nor did the face angle at the end of the neutral phase of the experiment (intercept #1 between-group difference = 0.211,  $S.E. = 0.135$ ,  $p = .119$ ). Overall, these findings indicated that the two groups were sufficiently comparable before the experimental manipulation that occurred immediately after the end of the neutral phase of the study.

During the second phase of the task, the face angle changed across the 20 putts for the participants randomized in the control group ( $\beta = 0.014$ ,  $p = .015$ ) but it did not significantly change for the participants in the social-evaluative threat group ( $\beta = 0.001$ ,  $p = .917$ ). However, the change in face angle at impact substantially differed across the two groups (slope #2 between-group difference = -0.014,  $S.E. = 0.009$ ,  $p = .111$ ). At the start of phase 2 of the experiment, the angle at impact was 0.986 for participants in the control group and 1.113 for those in the experimental group, and this difference was not statistically significant (intercept #2 between-group difference = 0.127,  $S.E. = 0.156$ ,  $p = .414$ ). In both groups, the angle at impact decreased from the end of the first phase (intercept #1) to the start of the second phase (intercept #2). Interestingly, this discontinuity in the growth model was not statistically significant for the

participants in the control (difference between intercept #1 and #2 = -0.028, S.E. = 0.087,  $p = .747$ ) and experimental group (difference between intercept #1 and #2 = -0.112, S.E. = 0.093,  $p = .231$ ). Contrary to our hypothesis, these findings indicated that the social-evaluative threat manipulation of the participants in the experimental group did not significantly disrupt their face angle at impact.

**Model with somatic anxiety as the predictor.** In model 2, we added somatic anxiety as the predictor of the two intercepts and two slopes in each of the control and experimental groups. Consistent with our hypothesis, somatic anxiety did not significantly predict face angle at impact (intercept #2) and change in face angle at impact during phase 2 of the experiment (slope #2) for the participants randomized in the *control group*. However, unexpectedly, it did substantially predict face angle at impact at the end of phase 1 ( $p = .095$ ) and change during phase 1 of the experiment ( $p = .119$ ). Results of simple slopes at low ( $-1SD$ ) and high ( $+1SD$ ) levels of somatic anxiety showed that face angle at impact with low somatic anxiety significantly improved during the neutral phase of the experiment ( $\beta = -0.042$ , S.E. = 0.018,  $p = .022$ ) whereas it did not improve for those with high somatic anxiety ( $\beta = 0.010$ , S.E. = 0.019,  $p = .586$ ). Results from the participants in the *experimental group* partially supported our hypothesis. Somatic anxiety significantly predicted the change in face angle at impact during the social-evaluative threat phase (i.e., slope #2) of the experiment. Results of simple slopes showed that the face angle at impact of participants with high somatic anxiety substantially deteriorated after the social-evaluative threat experimental manipulation ( $\beta = 0.016$ , S.E. = 0.009,  $p = .081$ ). In contrast, the face angle at impact of participants with low somatic anxiety did not significantly change after the social-evaluative threat experimental manipulation ( $\beta = -0.014$ , S.E. = 0.012,  $p = .251$ ). Overall, the post-manipulation face angle at impact of participants randomized in the

experimental condition were different for those with high versus low levels of somatic anxiety, thus providing additional support for the hypotheses of this study.

**Model with movement awareness as the predictor.** We tested a model in which we added movement awareness as the predictor of the two intercepts and two slopes in each of the control and experimental groups. Movement awareness had no significant effect on the two intercepts and two slopes of the model neither in the control group nor in the experimental group. The effect of movement awareness was close to statistical significance ( $\beta = -0.122$ , S.E. = 0.081,  $p = .133$ ) to predict face angle at impact at the end of the neutral phase of the experiment (intercept #1) in the experimental group.

### Brief Discussion for Study 3

The purpose of Study 3 was to experimentally tease out the natural learning effect associated with performance on a fine motor task in a laboratory (in this case, golf putting) and the influence of social evaluative threat on said performance in an AB design. We hypothesized that somatic anxiety would moderate performance (both distance and face angle at impact) in the social-evaluative trials for the experimental group only. Lastly, we also hypothesized that those high in movement awareness would have their performance impaired.

### Preliminary Findings

Interesting preliminary findings emerged which suggested that albeit mild, the social evaluative threat paradigm used in this study indeed seemed to have an effect on the participants, similar to previous golf putting research (i.e., Bright & Freeman, 1998; Cooke et al., 2010; 2011; Hardy et al., 1996; Kinrade et al., 2010; Masters, 1992; Mullen & Hardy, 2000; Vine & Wilson, 2010; Vine et al., 2011). Overall, the experimental group indicated that they had more cognitive anxiety, were more aware of their movements, and more concerned about performing well. Furthermore, the experimental group increased their levels of perceived effort in the second

phase of putts to a larger degree than their counterparts in the control group. These findings would suggest that the social manipulation used in this study was indeed effective enough to elicit a response in those randomized to the social evaluative threat condition. Furthermore, the fact that no significant changes in any of these variables were seen in the control group further suggests that performing in a laboratory in front of the researchers without explicit instructions as to being evaluated indicates the importance of letting the participants know directly.

### **State Anxiety and Performance**

Similar to Studies 1 and 2, participants in both groups significantly improved their performance across the trials in the first condition, and when examined without moderating variables, no differences were present between the groups. Interestingly, social evaluative threat seemed to be facilitative in regards to distance to the hole for the experimental group. This was not surprising as the fact that mild social evaluation provides a facilitative effect has been demonstrated empirically for years (Zajonc, 1965).

That said, somatic anxiety acted as a moderator for the experimental group when examining both distance to the hole and putter face at impact. Similar to findings in Study 1, performance under neutral conditions was predicted by high levels of somatic anxiety, but not under social evaluative threat. In contrast, low levels of somatic anxiety were only associated with improved performance during social evaluative threat, but not neutral conditions. Furthermore, high levels of somatic anxiety were associated with decreasing pre-shot times for the control group in the first phase of the experiment. This finding suggests that the combination of both high somatic arousal and social evaluation seems to mitigate the performance improvements normally seen when performing a motivated task in the laboratory. As state anxiety was only measured at one point (i.e., between the two phases of the experiment), these findings do not suggest a causal relationship. It is entirely possible that performance in the first

condition heavily influenced participants' answers on the state anxiety measure. Perhaps not surprising given the lack of results demonstrated in Studies 1 and 2, cognitive anxiety did moderate any of the performance variables measured in our study. Nevertheless, the reliable influence of somatic anxiety on performance in this study supports our hypothesis that somatic anxiety reliably interacts with social evaluative threat to disrupt performance.

### **Movement Awareness and Performance**

Contrary to our hypothesis, movement awareness did not moderate the relation between social evaluative threat and objective putting performance unlike previous research demonstrating a link (i.e., Kinrade et al., 2010). Two other studies were identified (Tanaka & Sekiya, 2010; 2011) that measured movement awareness in samples of both professional golfers and novices, with neither finding a direct link between movement awareness and performance.

Interestingly, those high in movement awareness showed decreasing pre-shot times for the experimental group in the social evaluative threat trial, but no change was seen for those low in movement awareness. This finding suggests that perhaps those with a tendency to focus on themselves and their own movement patterns may feel a sense of self-consciousness that speeds up the amount of time taken to complete the study. This goes against natural intuition that would suggest a "slowing down" effect associated with paying attention to one's movements. For example, Fitts and Posner (1967) proposed three main stages of motor learning: cognitive, associative, and autonomous stages. In the cognitive stage a person is trying to consciously decide, hypothesize, and test what needs to be done. When people are learning a skill and are in the cognitive phase, they also tend to pay attention to the actual step-by-step execution of the skill itself. For example, "hands high, move the clubhead slowly back, but not *too* far, shift the weight, hold the finish, etc.". Wulf (2007) asserts that conscious control strategies used to control movements tend to be slower, more abrupt, inefficient, and result in inconsistent performances.

Research has consistently shown that while experts are able to simultaneously perform their primary task when distracted by another, novices cannot (e.g., Beilock & Carr, 2001; Mullen et al., 2005). The reason for these findings is said to be that novices are still in the cognitive phase of learning where their attention must be placed on the task being learned. Requiring a novice to count backwards from a high number, or do a visual search task overloads the conscious awareness of the performers, and performance degrades. While our study did not have a dual-task phenomenon by design, the results in this study would suggest that focusing on oneself actually lead to quicker preparation rather than slower, more deliberate as would be suggested.

### **Conclusion**

Study 3 aimed to experimentally tease apart learning trajectories associated with natural improvement, as well as those associated with putting under social evaluative threat. Furthermore, this study attempted to examine both state anxiety and movement awareness as moderators of these relationships. A larger discussion within the context of the entire thesis is discussed in the following section below.

### Study 3 Tables

Table 7.

#### *Study 3 – Correlations between predictors for Control Group*

	1	2	3	4	5	6	7	8
1. pre-VAS		0.673**	0.156	.527**	0.21	0.223	0.120	0.279
2. post-VAS			0.03	0.676**	0.039	0.159	-0.042	0.489*
3. Cognitive Anxiety				0.281	0.214	0.204	0.556*	0.464*
4. Somatic Anxiety					-0.102	0.03	0.289	0.676**
5. Effort 1						0.897**	0.143	-0.002
6. Effort 2							0.180	0.082
7. Movement Awareness								.559**
8. Manipulation Check								

\*\* Correlation is significant at the 0.01 level (2-tailed).

\* Correlation is significant at the 0.05 level (2-tailed).

Table 8.

*Study 3 – Correlations between predictors for Experimental Group*

	1	2	3	4	5	6	7	8
1. pre-VAS		.723**	0.230	-0.093	0.284	0.336	-0.106	0.229
2. post-VAS			0.553**	0.374*	0.227	0.358	0.087	0.346
3. Cognitive Anxiety				0.469*	0.178	0.298	0.375*	0.407
4. Somatic Anxiety					0.122	0.198	0.490**	0.236
5. Effort 1						0.933**	-0.368*	-0.128
6. Effort 2							-0.369*	-0.085
7. Movement Awareness								0.425*
8. Manipulation Check								

\*\* Correlation is significant at the 0.01 level (2-tailed).

\* Correlation is significant at the 0.05 level (2-tailed).

Table 9.

*Study 3 – Comparison of Means Between Groups of Performance Variables*

<b>Variable</b>	<b>Condition</b>	<b>N</b>	<b>Mean</b>	<b>s.d.</b>	<b>s.e.</b>
Distance (MRE)	Control	26	6.74	2.11	0.41
	Experimental	29	6.62	2.35	0.44
Face Angle at Impact (abs)	Control	21	1.14	0.36	0.08
	Experimental	23	1.20	0.39	0.08
Total Completion Time (seconds)	Control	26	4.75	0.97	0.19
	Experimental	29	5.02	1.14	0.21

Table 10.

*Study 3 – Comparisons of Means of Performance Variables (t-tests)*

Variable	t	df	Sig. (2-tailed)	Mean Diff	s.e.	95% C.I.	
						Lower	Upper
Distance (MRE)	0.200	53	0.842	0.12	0.61	-1.09	1.34
Face Angle at Impact	-0.545	42	0.589	-0.06	0.11	-0.29	0.17
Total Completion Time	-0.960	53	0.341	-0.28	0.29	-0.85	0.30

Table 11.

*Study 3 – Comparison of Means Between Predictor Variables*

<b>Variable</b>	<b>Condition</b>	<b>N</b>	<b>Mean</b>	<b>s.d.</b>	<b>s.e.</b>
pre-VAS	Control	26	22.46	19.82	3.89
	Experimental	29	24.48	22.05	4.10
post-VAS	Control	26	25.19	21.05	4.13
	Experimental	29	32.07	23.47	4.36
Cognitive Anxiety	Control	26	1.47	0.48	0.09
	Experimental	29	2.08	0.62	0.12
Somatic Anxiety	Control	26	1.54	0.45	0.09
	Experimental	29	1.51	0.47	0.09
Effort 1	Control	26	63.92	23.45	4.60
	Experimental	29	72.66	29.21	5.43
Effort 2	Control	26	69.42	25.06	4.91
	Experimental	29	85.24	34.25	6.36
Movement Awareness	Control	26	2.94	0.80	0.16
	Experimental	29	3.76	1.14	0.21
Manipulation Check	Control	26	2.51	1.02	0.20
	Experimental	29	3.43	1.49	0.28
VAS Difference	Control	26	2.73	16.55	3.25
	Experimental	29	7.59	16.99	3.15
Effort Difference	Control	26	5.50	11.12	2.18
	Experimental	29	12.59	12.65	2.35

Table 12.

*Study 3 – Comparison of Means Between Groups of Predictor Variables*

Variable	t	df	Sig. (2-tailed)	Mean Diff	s.e.	95% C.I.	
						Lower	Upper
pre-VAS	-0.356	53	0.72	-2.02	5.68	-13.41	9.37
post-VAS	-1.139	53	0.26	-6.88	6.04	-18.99	5.24
Cognitive Anxiety	-4.059	53	<0.001**	-0.61	0.15	-0.92	-0.31
Somatic Anxiety	0.257	53	0.80	0.03	0.12	-0.22	0.28
Effort 1	-1.213	53	0.23	-8.73	7.20	-23.17	5.70
Effort 2	-1.935	53	0.06+	-15.82	8.17	-32.21	0.57
Movement Awareness	-3.06	53	<0.001**	-0.82	0.27	-1.36	-0.28
Manipulation Check	-2.615	53	0.01*	-0.91	0.35	-1.61	-0.21
VAS Difference	-1.071	53	0.29	-4.86	4.53	-13.95	4.24
Effort Difference	-2.195	53	0.03*	-7.09	3.23	-13.56	-0.61

Table 13.

*Study 3 – Comparison of Level 1 Means Between Sets of Putts*

<b>Group</b>		<b>Set</b>	<b>Mean</b>	<b>N</b>	<b>s.d.</b>	<b>s.e. (mean)</b>
Control	Distance (MRE)	Set 1	7.30	26	2.63	0.52
		Set 2	6.19	26	2.17	0.43
	Impact (abs)	Set 1	6.08	18	2.73	0.64
		Set 2	5.53	18	2.75	0.65
	Time	Set 1	4.93	26	1.03	0.20
		Set 2	4.57	26	0.95	0.19
Experimental	Distance (MRE)	Set 1	7.25	29	2.79	0.52
		Set 2	5.99	29	2.54	0.47
	Impact (abs)	Set 1	4.84	23	2.01	0.42
		Set 2	5.16	23	2.76	0.58
	Completion Time	Set 1	5.08	29	0.98	0.18
		Set 2	4.97	29	1.41	0.26

Table 14.

*Study 3 – Comparison of Means Between Sets of Putts (t-tests)*

		<b>Mean Diff</b>	<b>s.e.</b>	<b>95% C.I.</b>		<b>t</b>	<b>df</b>	<b>Sig.</b>
		<b>(Set 1 – Set 2)</b>		<b>Lower</b>	<b>Upper</b>			
Control	Distance (MRE)	1.11	0.46	0.17	2.06	2.43	25	0.02
	Impact (abs)	0.03	0.07	-0.12	0.18	0.48	17	0.64
	Completion Time	0.36	0.07	0.21	0.51	4.87	25	0.00
Experimental	Distance (MRE)	1.26	0.47	0.31	2.21	2.71	28	0.01
	Impact (abs)	0.16	0.08	-0.01	0.32	1.99	22	0.06
	Completion Time	0.10	0.16	-0.22	0.43	0.66	28	0.52

Table 15.

*Results of the multiple-group discontinuous growth models of distance to the hole with two intercepts and slopes*

Parameters and predictors	Model 1						Model 2					
	Control group			Experimental group			Control group			Experimental group		
	Estimate	S.E.	<i>p</i>	Estimate	S.E.	<i>p</i>	Estimate	S.E.	<i>p</i>	Estimate	S.E.	<i>p</i>
Intercept #1 (putt 20)	5.366	0.642	< .001	6.161	0.643	< .001	5.366	0.642	< .001	6.148	0.635	< .001
Somatic anxiety	---	---	---	---	---	---	0.378	1.756	.829	-0.889	1.603	.579
Slope #1	-0.202	0.040	< .001	-0.114	0.049	.020	-0.202	0.040	< .001	-0.118	0.044	.008
Somatic anxiety	---	---	---	---	---	---	0.017	0.099	.860	-0.236	0.096	.015
Intercept #2 (putt 21)	6.484	0.697	<.001	6.826	0.646	<.001	6.477	0.686	<.001	6.822	0.636	<.001
Somatic anxiety	---	---	---	---	---	---	0.414	1.588	.794	-0.252	1.351	.852
Slope #2	-0.031	0.057	.581	-0.088	0.043	.043	-0.031	0.056	0.576	-0.085	0.041	.037
Somatic anxiety	---	---	---	---	---	---	0.001	0.119	.994	0.158	0.075	.035

Table 16.

*Results of the multiple-group discontinuous growth models of pre-shot time with two intercepts and slopes*

Parameters and predictors	Model 1						Model 2					
	Control group			Experimental group			Control group			Experimental group		
	Estimate	S.E.	<i>p</i>	Estimate	S.E.	<i>p</i>	Estimate	S.E.	<i>p</i>	Estimate	S.E.	<i>p</i>
Intercept #1 (putt 20)	4.694	0.236	< .001	4.708	0.193	< .001	4.699	0.235	< .001	4.701	0.187	< .001
Somatic anxiety	---	---	---	---	---	---	-0.313	0.371	.399	-0.423	0.409	.301
Slope #1	-0.025	0.013	.052	-0.039	0.008	< .001	-0.024	0.012	.049	-0.039	0.008	< .001
Somatic anxiety	---	---	---	---	---	---	-0.042	0.023	.073	-0.012	0.018	.531
Intercept #2 (putt 21)	4.848	0.210	<.001	5.071	0.260	<.001	4.850	0.210	<.001	5.067	0.255	<.001
Somatic anxiety	---	---	---	---	---	---	-0.093	0.333	.777	-0.219	0.682	.748
Slope #2	-0.029	0.007	<.001	-0.010	0.009	.251	-0.030	0.006	<.001	-0.011	0.008	.196
Somatic anxiety	---	---	---	---	---	---	0.011	0.013	.370	-0.036	0.015	.017

Table 17.

*Results of the multiple-group discontinuous growth models of face angle at impact with two intercepts and slopes*

Parameters and predictors	Model 1						Model 2					
	Control group			Experimental group			Control group			Experimental group		
	Estimate	S.E.	<i>p</i>	Estimate	S.E.	<i>p</i>	Estimate	S.E.	<i>p</i>	Estimate	S.E.	<i>p</i>
Intercept #1 (putt 20)	1.014	0.085	< .001	1.225	0.105	< .001	1.000	0.082	< .001	1.216	0.104	< .001
Somatic anxiety	---	---	---	---	---	---	0.235	0.141	.095	-0.167	0.130	.199
Slope #1	-0.014	0.009	.093	-0.005	0.007	.441	-0.016	0.008	.048	-0.006	0.007	.383
Somatic anxiety	---	---	---	---	---	---	0.026	0.017	.119	-0.009	0.013	.506
Intercept #2 (putt 21)	0.986	0.101	< .001	1.113	0.117	< .001	0.983	0.105	< .001	1.103	0.111	< .001
Somatic anxiety	---	---	---	---	---	---	0.043	0.260	.870	-0.187	0.199	.346
Slope #2	0.014	0.006	.015	0.001	0.006	.917	0.015	0.006	.011	0.001	0.006	.805
Somatic anxiety	---	---	---	---	---	---	-0.015	0.014	.293	0.015	0.009	.092

Study 3 Figures

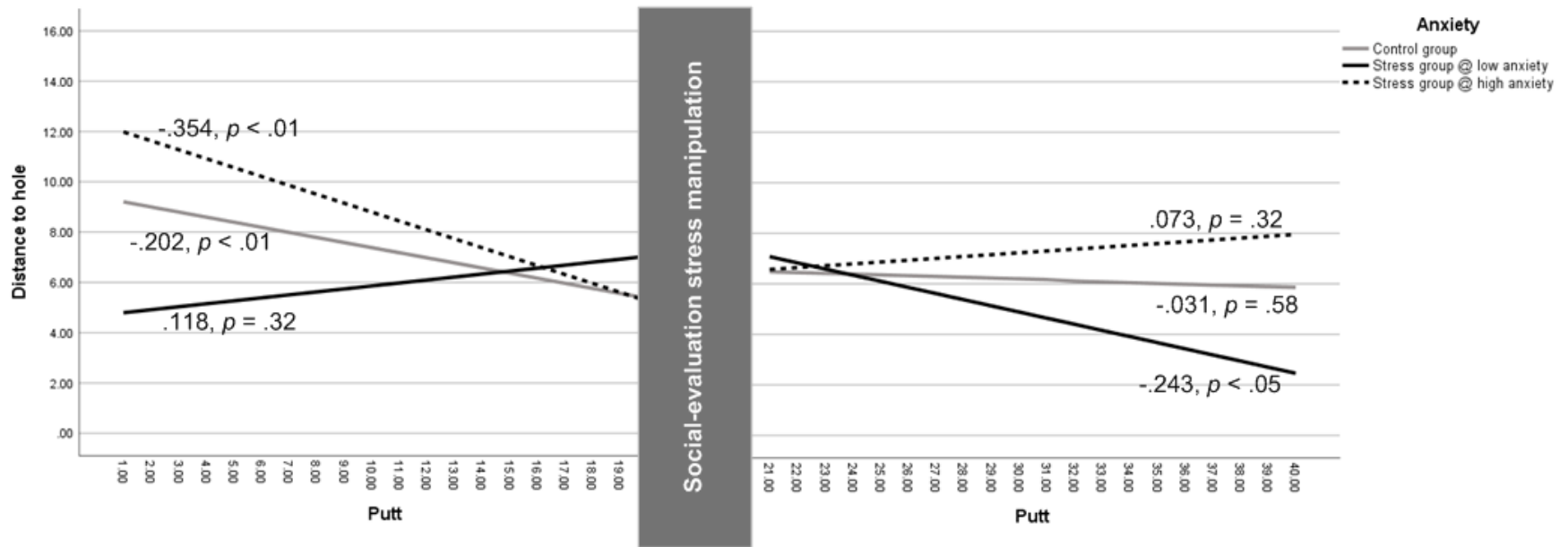


Figure 5. Discontinuous multiple-group growth model of distance to the hole with two intercepts (i.e., putt 20 and putt 21) and slopes (i.e., putt 1 to 20; putt 21 to 40). Intercepts of the model are not predicted by anxiety nor the control/experimental groups. Somatic anxiety predicts the slopes of the model differently across the control and experimental groups.

**Chapter 5: General Discussion**

## **Thesis Objectives**

This thesis contained three separate studies examining the objective putting performance of recreational golfers, and beginners with no golf experience under both neutral and social evaluative conditions. Furthermore, the kinematics of the putting stroke were also measured to see whether changes in the putting stroke itself would be associated with social-evaluative threat. As such, the goal of this thesis research was to: a) explore how a fine-motor skill – in this case golf putting – is precisely influenced by social-evaluative pressure, b) examine how sport-specific types of state anxiety moderate the relationship between pressure and performance and c) examine how the learning pattern of novice performers changes as a function of social-evaluative pressure. In all three studies, somatic anxiety significantly moderated both objective and indirect performance (as indicated by kinematics and routine time). Taken together, these studies suggest that one's *interpretation* of their physiological symptoms under social evaluative threat seem to have a temporary influence on performance.

## **Overview of Study Hypotheses and Results**

**Study 1.** In Study 1, it was hypothesized that a learning effect would characterize performance across the study, given the recreational experience of the participants. (as measured by the binary objective outcome of holed vs not-holed putts). It was expected that state anxiety would moderate this learning effect. In partial support of our hypotheses, Study 1 found that somatic anxiety attenuated the natural learning effect seen in golfers who had low somatic anxiety. During episodes of social evaluative threat, participants had less putter-face rotation, quicker forward strokes, and marginally significant poorer alignment at impact. Results of a cross-level interaction also revealed that the back stroke became quicker during social evaluative threat but only for individuals with high level of cognitive anxiety. In other words, having worrisome thoughts in your head (e.g., this is for par, this is a quick green, don't blow it by the

hole, etc.) was related to quicker backstrokes. However, despite these changes to the stroke, a direct link between kinematics and objective performance was not found, despite our predictions. Most surprising in Study 1 was that somatic anxiety was not associated with any changes in the kinematics. It was believed that increase levels of tension would produce distinct kinematic changes, but this was not the case.

**Study 2.** Study 2 improved on Study 1 by increasing the homogeneity of the sample, and improving the methodology used by adding greater control, as well as an increased number of trials. Based on previous research with novices (i.e., Cooke et al., 2010) we expected that novices would demonstrate improvements in performance under neutral conditions, but not under social evaluative threat. It was expected that performance would stagnate during the social evaluative trials, and that both cognitive and somatic anxiety would negatively impact performance. As expected, improved performance (i.e., a learning effect) was demonstrated across the neutral phase but in general did not significantly improve during the social evaluative trials. More notably, performance was again moderated by high levels of somatic anxiety during the social evaluative portion of the experiment. When somatic anxiety was added as a moderator, high levels of somatic anxiety again attenuated the expected learning effect in the social evaluative trails (albeit marginally statistically significant). Furthermore, somatic anxiety moderated face angle at impact, where values substantially rose from zero at the initial portion of the experiment, only to then return to expected values towards the end of the trials. Contrary to our hypothesis however, cognitive anxiety did not moderate any of these relationships.

**Study 3.** Lastly, Study 3 incorporated an experimental design into the golf putting paradigm to tease out the effect of the social evaluative manipulation from natural performance improvements. We hypothesized that participants in both conditions would exhibit a linear learning effect from the 1<sup>st</sup> to 20<sup>th</sup> putt of the pre-experimental phase of the study but would

stagnate for the experimental group as compared to the control group in Block 2. Contrary to our hypotheses, those in the experimental group improved their performance during the social evaluative task, while those in the control group did not. However, the difference in improvement between groups was not significant. Similar to Study 1, when somatic anxiety was added as a moderator, those with high levels of somatic anxiety improved during the neutral phase of the experiment but not the social evaluative stage for the experimental group. Interestingly, those with low anxiety did not show improvement during the neutral phase but did show improvement during the social evaluative phase. When examining face angle at impact in the experimental group, participants with high somatic anxiety showed substantial deterioration (but on threshold of significance) after the social-evaluative threat experimental manipulation, while those with low somatic anxiety showed no change.

Lastly when examining pre-shot routine time, the control group demonstrated quicker routine times during the second phase of the experiment while the experimental group, while the experimental group maintained a slightly longer and consistent level of preparation for each putt across the final set of 20 putts. Unexpectedly when somatic anxiety was added as a moderator, those with high levels of anxiety significantly *decreased* the amount of time taken during the social evaluative phase in the experimental group, while those with low levels did not. In a similar pattern, when movement awareness was added as a moderating variable, those with high levels showed a *decrease* in times while those with low levels of awareness did not.

### **Integration of Main Study Findings**

Taken together, the results of the thesis research increased current knowledge about how fine-motor skill performance is influenced by social evaluative threat. Moreover, time-invariant personal characteristics of participants interacted with the social evaluative paradigm in unique, and unexpected ways. As such, the implications of these patterns are discussed, along with an

integration of current theoretical knowledge on performance disruptions under pressure.

In all three studies, somatic anxiety significantly moderated both objective and indirect performance (as indicated by kinematics and routine time). In Studies 2 and 3 when somatic anxiety was added to the models, the gap in performance immediately at the beginning of the social evaluative trials was notable for those with high somatic anxiety. Furthermore, Study 1 demonstrated a diminished learning effect (as measured through mean holed %). While performance trajectories in both Study 2 and 3 did indeed converge after an initial delay, the immediate post instruction phase is notable especially given how somatic anxiety was measured as a self-report of negative physiological *interpretations* of bodily sensations. While cognitive anxiety (i.e., worry about the competition) was not associated with performance, it can be argued that cognition itself seems to be the distraction variable of interest here given that participants were invoked to consider interpretations regarding their own arousal—cognitions in their own right.

Although the words themselves used in the CSAI-2 to assess physiological arousal could be described as *observational* without valence in terms of judgment (i.e., feeling *jittery*, sensations of *sinking* in stomach, general bodily *tension*, *racing* heart, clammy hands, *tight* sensation in body), it would be difficult to picture an individual who endorses high levels of these symptoms interpreting them in a neutral, mindful, manner. It is important to note that self-reported physiological activation may not necessarily correspond with accurate, objective indicators. In other words, whether the perception of “tightness” in one’s body accurately corresponds to a more objective indicator of muscular tension can be debated. Nevertheless, high scores on a self-report measure of somatic state anxiety provides a quick snapshot of an individual who is at the very least aware of an internal change of their physiological state.

In a meta-analysis conducted by Craft et al. (2003) neither cognitive nor somatic anxiety

were associated with performance of closed skills (i.e., those performed in a constant, unchanging environment - e.g., dart throwing). Although the definition of a closed skill does not exactly apply to golf putting, the amount of time allotted and non-reactionary nature of the task would suggest that golf putting would indeed somewhat be described as closed, yet with a perpetually changing environment. For the purposes of our studies however, the task itself remained unchanged across all of the trials. The fact that no relations between cognitive anxiety and direct performance in our studies were found is not surprising, given the findings of Woodman and Hardy (2003) that demonstrated an overall weak but negative effect size. That said, the meta-analysis also indicated that individually performed skills *were* associated with both cognitive and somatic anxiety. Consistent with our findings, the meta-analysis of Woodman and Hardy (2003) noted that the closer the time that the CSAI-2 was administered to performance, somatic anxiety seems to predict stronger performance disruptions.

As discussed in the introduction, most of the evidence surrounding performance breakdowns center around two versions of attentional theories: *distraction theories* (e.g., Eysenck & Calvo, 1992) and *self-focus theories* (e.g., Masters, 1992). Although the literature seems to be in favour of self-focus theories as to why performance is impaired (Hill et al., 2010), our findings provide partial support for both distraction and self-focus. Contrary to our hypothesis, movement awareness did not influence objective putting performance. However, movement awareness was associated with *quicker* pre-shot routine times in Study 3 for the experimental group in the social-evaluative phase of putts. It would seem that higher internal awareness of one's movements led to participants slightly "rushing" the preparatory phase. This is a finding that was mirrored for those with high levels of somatic anxiety. Interestingly, pre-shot routine times for the experimental group stagnated in Block 2 and maintained a flattened trajectory indicating a relatively consistent and stable effect of approximately .5 seconds slower

than the control group. Although a half of a second may seem trivial, this finding lends indirect support for *attentional control theory* (Eysenck et al., 2007) by suggesting that an increase in effort is indeed present. Furthermore, increased self-reported effort seen in participants in the experimental group further provides support for the theory as participants seemed to be both consciously and subconsciously “trying harder”.

Both Eysenck et al.’s (2007) *attentional control theory* and Fitts and Posner’s (1967) model of motor learning seem to provide a framework as to why performance would be disrupted in our novice participants under pressure. Fitts and Posner (1967) indicate that beginner learners use conscious processing during skill acquisition before moving into increasingly automatic execution of performance. Eysenck et al. (2007) hypothesize that under pressure, *worry* triggers cognitive resources to be devoted to either managing the worry or increasing one’s level of effort. Although cognitive anxiety (as measured by the self-reported CSAI-2) was not directly associated with objective performance, somatic anxiety consistently influenced performance across all three studies. Of note, only in the sample that consisted of experienced golfers (Study 1) did cognitive anxiety influence any of our dependent variables of interest.

As it is assumed that the novice participants would be in the *cognitive* stage of learning when it comes to golf putting, it is entirely plausible that fixating on the thoughts associated with physiological activation would be enough to account for the slight disruptions in performance seen in those with high somatic anxiety. That said, as no continual measure of the contents of the participants’ mind existed in our studies (e.g., by asking participants to verbalize their inner dialogue), this interpretation remains speculative. However, Wulf’s (2007) assertion that athletes who tend to focus on internal aspects of movement show decreased performance under pressure suggests that distraction from the task itself (which was to hole the putt or finish as close as

possible) may also be applicable in explaining the results of our studies. For example, those reporting high levels of somatic anxiety would naturally be more aware of their internal sensations. As a result, even if not the intention, an increase in awareness of one's internal state may have temporarily disrupted performance for the first few putts in the social evaluative trials.

Furthermore, the finding that high somatic anxiety attenuated an improvement in performance in Study 1 also indirectly provides support for attentional control theory if the social evaluative threat "overloaded" an already activated individual. As performance was notably higher than those with low anxiety under neutral conditions, the mild evaluation may have blunted any improvement in performance that would have been expected. Furthermore, those in the experimental condition in Study 3 demonstrated increased levels of perceived effort as compared to the control group.

Taken together, these studies suggest that one's interpretation of their physiological symptoms under social evaluative threat have a temporary influence on performance in the laboratory. These findings are similar to past research that has demonstrated a link between somatic anxiety and a reduction in performance (Wilson et al., 2007). However, cognitive anxiety was not associated with performance in Study 2 or 3, and only associated with a kinematic measure that is generally uncorrelated with objective putting performance (i.e., back-swing times of participants in Study 1). Not measuring the CSAI-2 at multiple time-points in any of the studies did not allow us to assess the *change* in competitive anxiety scores between the baseline and social evaluative conditions. To minimize the potential for any study-induced priming of sports-specific language when assessing anxiety, we decided to use analogue measures of anxiety and arousal as an indication of trait levels of affect (i.e., VAS scale, self-reported and subtly measured effort) in Studies 2 and 3.

### **The Temporary Influence of Anxiety**

For those with low somatic anxiety, performance during the first portion of the social evaluative trials improved temporarily, before steadily declining towards the end. This leaves one to question whether low anxiety only *temporarily* has a facilitative effect. It is also possible that participants without any perceived anxiety may have felt bored or disinterested in the task itself. An anxious mind under pressure would likely ensure that all steps were diligently followed, all coaching-advice adhered to, and every action possible is considered. In the case of golf putting, where only the elusive potential of a rules violation for slow play would be imposed, a golfer theoretically has an ample amount of time to deliberate, make a decision, and prepare themselves for execution. During a simple task in a laboratory, this anxiety may increase effort to point where performance is improved for the duration of the task, with no ill-effects on subsequent trials. However, in a round of golf a player is required to maintain a high level of focus with the goal of having the same level of intensity and sharpness on the final hole as they did on the first.

Participants in our studies executed the same putt across a number of trials in unchanging conditions. It would make sense then to infer that the cognitive demands after a few trials would diminish once the proper speed and movement required was learned. During an actual round of golf, one is required to hit a shot with uniquely associated demands, followed by a delay of several minutes to either wait for competitors to execute their shots and then the subsequent travel required to the location of the ball. The cognitive demands associated with a round of golf would naturally be higher as each shot poses a new problem to assess. Based on this, it is easy to deduce that perhaps a lag effect would exist where the hypotheses of Eysenck et al.'s (2007) attentional control theory become more likely as both cognitive and physical fatigue sets in over the duration of a round of golf, or cumulative rounds in a large tournament.

As the participants in our study were not required to be in the lab for the duration of a

normal round of golf, perhaps an increase in effort during the social evaluative trials was enough to maintain performance at least temporarily. It would be interesting to find an empirical way to incorporate a number of different measures of effort, while accounting for fitness, blood sugar levels, and subsequent performance.

### **Limitations and Future Directions**

Several limitations need to be addressed that were identified in this thesis, along with potential solutions to address these gaps in future research. Although limitations have been alluded to or briefly mentioned elsewhere in this document, the following subsections highlight key areas that are indeed worthy of discussion and frame the implications of the results appropriately.

**Social-evaluative manipulation effectiveness.** All three studies in this thesis used a common paradigm where social evaluation was induced using a combination of elements designed to elicit a stress response. As a general trend across all three studies, a modest (but robust) performance enhancement was seen regardless of the social evaluative effect. In Study 3, it would seem that adding the live feed of the participant performing on the TV within eyesight increased self-focus in our experimental group. It is important to keep in mind that we utilized a “kitchen-sink” approach where multiple methods were used to increase evaluative-apprehension as per Dickerson and Kemeny (2004; e.g., verbal instructions, video of golf coach, and image of movement). While the main focus of interest in this thesis was the general influence of social apprehension, it is nevertheless interesting to consider the isolated effects of each component on future iterations of these experiments. However, from a broader applicability standpoint, teasing out the true effects of the barrage of stimuli (social media, friends, family, colleagues, etc.) one would face in an evaluative setting would indeed prove to be incredibly difficult. With the exception of Study 1, Studies 2 and 3 were not able to induce a significant increase in perceived

stress based on the social-evaluative instructions. Study 3 however demonstrated a significant difference in cognitive anxiety for the experimental group as compared to the control group. Furthermore, the experimental group also reported increased movement awareness, and increased levels of effort as compared to the control group. These findings are similar to previous studies that have found increases in anxiety for participants in social-evaluation in novices (e.g., Cooke et al., 2010; Kinrade, Jackson, & Ashford, 2010; Moore et al., 2012; Mullen et al. 2007; Vine & Wilson, 2010), recreational (Gucciardi & Dimmock, 2008; Kingsbury et al., 2011; Wilson, Smith, & Holmes, 2007), and skilled players (Cooke et al., 2011; Land & Tenenbaum, 2012; Vine et al., 2011).

Another important consideration is the fact that the “cognitive load” of each participant was not represented by any measures in the studies. As both Studies 2 and 3 consisted of undergraduate students, it is entirely possible that school-based stressors (e.g., assignments, exams, staying up all night to study, etc.) or general stressors in life could have contributed to performance indirectly. While it may be unfeasible to completely assess all of the potential sources of external contributions towards the stress response, an option in future studies would be to add either a pre-screening protocol, or a self-report of current stressors to include as a predictor.

Dickerson and Kemeny (2004) note that social evaluative threat is induced on *motivated performance tasks*. It is important to note that only one of the samples in our studies (Study 1) consisted of participants that would have identified themselves as golfers, while Studies 2 and 3 consisted of samples of participants who did not. As a result, it is not clear whether the manipulations themselves would be strong enough to induce motivated performance based on negative evaluation. Indeed, Blascovich (2008) would suggest that for either a threat-based or challenged-based state to become activated (as represented by cardiovascular output), the

performance task must be motivationally relevant for an individual. Theoretically, while any laboratory induced social evaluative stressor should induce a sense of apprehension, it is entirely possible that some of the participants of beginners did not feel motivated to perform well given the lack of identity with the task. However, for those individuals who value status and being perceived as highly functioning individuals, performing poorly on *any* task in front of others may be enough of a motivational force to perform well. Nevertheless, future studies could add a number of measures that were not included such as self-discrepancy, social-dominance orientation, fear of negative evaluation, perfectionism, etc. to help further understand the origins of individual motivation.

Although Study 3 included a formal manipulation check, Study 1 and 2 did not. As a result, only the self-reported increase in VAS scores could be used as an indicator of motivation. As perceived stress self-reported by the participants in Study 2 did not increase between the neutral and social evaluative trials, it may be inferred that the manipulation itself was not sufficient. As no physiological measures of stress were collected, it is not clear whether subtle apprehension would have been present in the sample. It was believed that increasing the believability of the cover story in Study 3 may have increased the effectiveness of the manipulation. Indeed, when examining the effectiveness of the manipulation Study 3 using the “improved” social manipulation, cognitive anxiety, effort, and awareness of movements during putting was significantly higher in the experimental group, none of these variables moderated the performance of participants. Future studies could indeed add a measure of cardiac reactivity to assess whether participants indeed are reacting to the tasks themselves. Across all three studies, participants’ performance during social evaluative threat manipulations were mixed, and depended largely upon levels of moderating time-invariant personal characteristics.

Considering these points, a larger question about the effectiveness of the traditional golf

putting evaluative paradigm needs to be addressed. Despite many attempts to induce pressure, the lack of significant implications associated with poor performance may render the entire paradigm as ineffective. Simulating accurate external pressure one would experience in sport is a problem that warrants further discussion and perhaps more creative solutions to induce realistic stress responses. For example, adding the possibility of financial incentives that could be lost as a result of poor performance may also be of importance in future work. If participants were indeed putting for a larger sum of money or compensation, it could possibly be motivating enough to elicit a stronger stress response. It is unclear whether participants in our study were truly motivated by the financial incentive associated with the task.

Recently, it has been suggested that cortisol responses are elicited by cognitive load, rather than social evaluative threat (Woody et al., 2018). It is not clear whether the demands of our task were cognitively demanding, nor whether the social evaluative threat paradigm elicited the stress responses in our participants. Future studies in the realm of sport performance could add additional measures of cardiovascular response, salivary cortisol, and interpretation of arousal symptoms to more precisely measure the effectiveness of the social evaluative paradigms used in this area of research. Furthermore, cognitive anxiety items on the CSAI-2 that measure implications of a poor performance related to the competition (i.e., concerns about not doing well, losing, choking under pressure, performing poorly, others being disappointed) also seem to span a number of areas that could be further teased apart. Further trait measures of social anxiety, competitiveness, and sources of motivation could be collected to decipher the deeper source of worry that one might feel in a competition.

The ability to infer personality traits in professional golfers through behavioural observation, while using a large-scale data set of their performance may be a way to empirically test these ideas in a more organic setting. The PGA Tour in 2003 began an initiative called

*ShotLink* – a statistical “large-data” project which records every single shot hit during a PGA Tour tournament. Variables such as distance per drive, proximity to hole, location of ball (e.g., tee, rough, fairway, green, water, sand, etc.), and score on each hole is available for every single tournament since 2003 to any sanctioned academic institution who submits a proposal (currently available at the University of Ottawa). Despite the enormity of the data collected to date, the possibilities of well-reasoned analysis of the data are only limited by the number of researchers focused on asking the right questions.

**The interaction between cognitive and somatic anxiety.** Despite the lack of predictions regarding the interaction between cognitive and somatic anxiety, Craft et al. (2003) found that cognitive anxiety is associated with *improved* performance in the days leading up to a competition when somatic anxiety is low. However, mixed effects (depending on the task) are typically seen on the actual day of competition when somatic anxiety increases (Parfitt, Jones, & Hardy, 1990). Lew Hardy (1996) developed the *Cusp Catastrophe Model* (CCM) that describes how a dependent variable (in our case, *performance*) can demonstrate both continuous, as well as *discontinuous* changes depending on the continuous changes in two separate independent variables.

Hardy (1996) hypothesizes that pure physiological arousal (e.g., increased muscle tension, heart rate, etc.) can influence performance either via a “direct hit” route by altering the availability of certain resources used for performance, or by influencing a person’s interpretation of one’s symptoms (i.e., either as facilitative or debilitating). Furthermore, it is possible that somatic anxiety can only really influence performance if the level of anxiety is so great that a person becomes pre-occupied with their symptomatology. In essence, the CCM predicts that at low levels of cognitive anxiety, physiological arousal will have an inverted-U relationship with performance. At high levels of cognitive anxiety however, there will be a point at intermediate

levels of physiological arousal where performance will drastically drop. Furthermore, at low levels of physiological arousal, cognitive anxiety will be associated with improved performance. After the cusp point at high levels of physiological arousal, cognitive anxiety will be associated with decreased performance.

Despite these intuitive and intellectually stimulating predictions, the cusp catastrophe model is difficult to empirically test with the precision required in fine-motor skill performance research. Hardy (1996) proposes that the low somatic- x cognitive-anxiety relationship works on the scale of *days* rather than moment-to-moment aspects of a competition. Furthermore, mathematically graphing the complex surface model requires a continual up-to-date measure of both cognitive and somatic anxiety, as the model describes *changes* in each variable influencing performance. This would be likened to a golfer who is playing a practice round while experiencing lots of worry and concern about the future event but not entirely activated because the initial event has not yet occurred. Nevertheless, the CCM predicts a sharp decrease in performance (i.e., a cusp) which, at the time of writing, no seemingly feasible way exists to empirically test these predictions accurately. As this study only assessed cognitive and somatic state anxiety as a time-invariant factor, we were not able to measure the *changes* associated with each of these factors. Future studies could indeed assess both of these components at multiple time points to be able to truly assess the predictions of the model. However, the notion that cognitive and somatic anxiety likely interact in a polynomial fashion is an intriguing idea that certainly adds value to the current research literature on anxiety and performance under pressure.

**Repetitive task representation.** The monotony of our laboratory task did not capture the true nature of golf, especially given the same putt being repeated numerous times. As a result, the ever-changing complexity of the game was not properly represented. Compared to physical skills such as sprinting, Olympic weightlifting, or even the “power” game associated with golf in

the full swing, golf putting is an incredibly simple physical movement that is far more associated with attentional demands, balance, concentration. To this degree, being able to co-ordinate finger control to execute a skill in a video game is no less difficult than the task of physically putting. With increased difficulty levels, golf simulators run physics engines that require not only nuanced touch, but also realistic feedback of how golf putting works with the implicit learning of templates (e.g., for every inch of elevation on the green, aim a foot further than target; aim at the tangent of the apex of displayed curve to find optimal left-right break aimpoint). Future studies using a video game simulation of putting may be able to separate the green reading skills, and ability to adjust to changing conditions in a pragmatic and interesting way in the laboratory.

**Gender Differences.** It is also important to note that gender differences were not examined in any of our studies. Future versions of these studies could make a point to recruit equal sample sizes to determine gender-based differences in both the time-variant and time-invariant measures. However, upon examination of the gender distribution of golf putting studies mentioned in this dissertation, none of the expert samples included any female participants except for two (Cooke et al., 2011; Land & Tenenbaum, 2012). For the novice participants on the other hand, gender distribution tended to be variable depending on where the samples were recruited. This problem may simply be reflected in the statistical distribution of elite women golfers compared to men. According to the United States Golf Association, male golfers who carry an index of less of 3.0 comprise of 3.25% of the entire male golfing population in the US. Conversely, female golfers of the same calibre make up only .31% of all female golfers. While there are no numbers available for the distribution of golf skill in Canada, it is believed that these numbers would be even lower, based on an audit of local clubs in the area. Nevertheless, this is an important limitation that reflects a greater societal trend of golf traditionally being a male-dominated game.

**Power and statistical analyses.** While the results of our studies did not necessarily demonstrate dramatic changes across the conditions, the types of analyses used have a tremendous amount of applicability in arguably any sequential self-paced sport (i.e., baseball, chess, curling, etc.). Even more generally, the methodology could also be applied to health-outcome data for athletes such as weight fluctuation, sleep latency/total number of hours slept, number of calories consumed, and so forth<sup>11</sup>. That said, our sample size for both groups did not permit higher-order polynomial analysis that may characterize the true episodic fluctuations seen in subsequent performance. While linear and quadratic analyses can often fit the patterns of the data, extremely large databases may allow for a much more complex performance-sequence analysis using the pre/post piecewise methodology.

Our current studies did not account for the “streak” effect of performance, where previous success or failure was considered as a factor. More recently, Doron and Gaudreau (2014) were able to demonstrate that serial dependency in performance varied as a result of performance time in fencing using Bayesian multilevel structural equation modeling. Although performance in their study was not associated with any psychological factor, winning a point influenced subsequent ratings of negative affect. In golf, the current position a player stands either relative to par or the field in a tournament likely affects the internal state of player, and even more specifically, the core beliefs about winning vs. losing, the potential gains of performance, and their overall means of coping. Using the multilevel methodology in these

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<sup>11</sup> Any interested sport reader is encouraged to read Bickel, 2007; Heck, Thomas, & Tabata, 2011; Hox, 2010; Raudenbush & Bryk, 2002; Singer & Willet 2003; for more information

studies in a real-world context with multiple ratings of internal states would provide an additional insight into the challenges that can be accounted for by a lack of ecological validity.

Lastly, a number of our conclusions come from results that just failed to meet the standard threshold of  $p = .05$  but fell within ranges between .05-.10. Hopkins, Cole, and Mason (1998) note that the use of inferential statistics as a guiding principal of the effectiveness of a research paradigm is not without limitation. While frequentist statistics have dominated the scientific literature (especially in sport), future studies examining Bayesian analysis could be incorporated into this experimental paradigm to move past the traditional method of scientific research (see Doron & Gaudreau, 2014, for an example).

### **Implications for Intervention**

In the spirit of this research project, identifying psychological performance *barriers* is only the first step. Coming from an applied program of training, the specifics surrounding intervention creation and interpretation of research is indeed a significant problem. Although perhaps over-simplified, the following quote from Zajonc (1965) still seems to capture the essence of what many people do when preparing for any evaluated performance:

“If one were to draw one practical suggestion from the review of the social-facilitation effects which are summarized in this article [one] would advise the student to study all alone, preferably in an isolated cubicle, and to arrange to take their examinations in the company of many other students, on stage, and in the presence of a large audience. The results of their examination would be beyond their wildest expectations, provided of course, they had learned their material quite thoroughly.” (Zajonc, 1965, pp. 274).

What this advice fails to capture are the moderating effects of personal characteristics. Clearly, it would seem that either a pre-occupation with somatic symptoms (or somatic symptoms themselves) play a role in evaluated performance situations.

Psychological interventions as a rule take time to have an effect. While perhaps some personal change may only require a brief moment of insight which seems to shift one from being stuck despite effort, to insight worthy of a quick yet profound shift. However, average duration of evidence-based treatment, and the chronicity of anxiety and depressive disorders would suggest that growth in character, as well as shift in cognitive and behavioural patterns would suggest otherwise (Beck, 2011; Young et al., 2003). Changes in either a habitual way of thinking or behaving are often imperceptible when compared day-to-day. Furthermore, it has also been suggested by some that once in place, true habits of emotional, cognitive, and behavioural response can never really be *unlearned* once present (Hayes et al., 2012). Regardless of one's theoretical orientation, meaningful changes are often noticed at far larger time points than between holes, games, rounds, events, etc. For example, sticking with a detailed practice plan at the beginning of the season, and comparing both subjective and objective results only at the end of the season – this is when change is noticeable.

At a deeper level, perhaps it is also a naïve assumption that any specific psychological intervention would be powerful enough to reliably increase objective performance. In isolation, how could it be shown that going through a goal-setting intervention, or relaxation protocol would be enough to increase golf putting accuracy or shooting percentages in a sport such as curling? The improvement of performance accuracy is a multi-faceted problem consisting of a thorough analysis of present skill, technical issues, environmental causes, arousal under pressure, etc. Even if more comprehensive longitudinal studies were undertaken, it would be pragmatically and statistically difficult to pinpoint any one component in isolation.

**Sport-specific cognitions as treatment targets.** The key treatment target in a sport-specific CBT intervention for those athletes who acknowledge suffering from social anxiety (and subsequent physiological manifestations), would be the interpretations of high physiological

arousal. Under pressure, people who are more sensitive to evaluation will tend to have an increase in both cognitive and somatic anxiety. In turn, this anxiety serves as a warning flag that the situation is important, which predictably leads to increases in effort and focus (Eysenck et al., 2007). Without practice and focus training however, it is difficult for most people to sustain these increases in deliberate effort. Cognitive effort to maintain attention and focus is a resource that depletes quickly. Increases in effort leads to an increased awareness of one's own performance. Many athletes are under the illusion that being consciously aware of their movements allows for controlled adjustment. However, conscious control strategies used to control movements tend to result in movements that are slower, more abrupt, less efficient, and less consistent.

When learning a new skill, people typically learn a task by acquiring verbal instructions. Whether from parents, coaches, the internet, etc. In the case of coaching, athletes are often provided corrective feedback when practicing to aid in the development of an ideal performance state, or to maintain that state once a person is there. However, Wulf (2007) asserts that there is no consistent body of evidence to suggest that getting novices to direct their attention to the precise execution of the skill is beneficial. In other words, do athletes really need to understand the precise sequence of steps required to perform well? In fact, could this information actually be *detrimental* when a performer is under competitive pressure? There is general agreement in the literature that expert performance is negatively affected when attention is directed towards movement (Wulf, 2007). Furthermore, self-focused attention seems to be detrimental towards novice's learning trajectory when exposed to a new skill. Several lines of reasoning would suggest that this would be the case (as mentioned in prior sections on choking).

An experimental intervention for athletes called the Mindfulness-Acceptance and Commitment Program (MAC; Gardner & Moore 2006) focuses on enhancing performance

through the regulation of *attention* and *poise*. Enhanced attention is the ability to pay attention to task-relevant information as needed. Poise is defined as ability to act in service of goals and values despite negative internal states that an athlete may be experiencing. Furthermore, the program aims to develop one's ability to notice negative experiences come and go and allow them to occur naturally – the biggest difference between this and other programs which are designed to reduce or eliminate any negative affective states. More specifically, the program trains *mindful awareness* – a process where one learns to notice and accept a variety of thoughts and emotions as naturally occurring phenomena that are not necessary to control, and *mindful attention* – the ability to self-regulate task-attention. An example would be to help these athletes understand their own beliefs about performance, and practices changing internal dialogue from such statements as “I want to perform well *but* I’m thinking badly” to “I want to perform well *and* I’m thinking badly”.

### **A Word on Extreme Dysfunction in Athletes**

This thesis did not collect any data on the mental health or well-being of any of the participants. While REB protocol allowed for a procedure to be followed in case of the identification of extreme emotional distress, it is not currently known whether any of the participants were exhibiting any serious signs of emotional distress. Despite the potential research benefits associated with measuring these traits (e.g., assessing the links between depressive states and blunted cardiovascular responses), it is believed that the entire discipline of sport psychology practice would benefit from implementing a more rigorous approach using the principles of clinical thinking. As long as clear rules exist as to when a mental skills consultant can continue with their work, or when they would need to refer to a mental health care professional would be required, the practice of sport psychology in Canada could be drastically improved.

Although this thesis did not examine elite athletes, all of our participants were sampled from a group of golfers who were able to afford a winter membership at an indoor practice facility, or university students from a post-secondary institution. In this regard, all of our participants could be classified as “high functioning” in some way. Despite the commonly held belief that a high-functioning individual in one domain is often equally functional in other areas of life – both clinical experience, and research would suggest otherwise. While indeed it can be argued that elite performance necessitates basic skills of daily living, athletes themselves are prone to unique mental health struggles above and beyond “basic” issues. For example, athletes are at risk for substance abuse, body image concerns, eating disorders, and both anxiety and mood disorders (Gardner & Moore, 2006). Simply put, knowledge of the unique manifestations of dysfunction associated with being an athlete are required when doing psychological work of any kind. It is important to note that the practice of diagnosing a mental health disorder (e.g., major depressive disorder, bipolar disorder-II, etc.) is not itself without controversy (Frances, 2013). Rather than categorizing people into groups of “well” or “unwell”, it is far more realistic to view human dysfunction on a continuum of functioning to non-functioning.

An effective way to determine whether an athlete is functional or not is to examine *all* of the domains of their lives: work, home, family, interpersonal relationships, general overall health). If a person is no longer able to work, interact with family/friends, regularly using substances, harming themselves, or at risk for suicidal/violent behaviour, they are no longer in the realm of merely requiring performance enhancement. Much more importantly, further professional help is needed for the treatment of these conditions. However, just because a mental performance consultant is not qualified to specifically treat these severe forms of human dysfunction, this does not mean that they are therefore not obligated to recognize, assess, and refer out when warranted. In fact, it could be argued that front-line mental performance

consultants should be ethically mandated to receive training in recognizing more severe problems. If a problem arises that is outside of the competency of the consultant, this does not mean that the work with the athlete must cease. In fact, by recognizing that perhaps an athlete needs substance use treatment, help for obsessive and intrusive thoughts, etc., the work primarily focusing on performance enhancement will undoubtedly *improve*, assuming the appropriate referrals to a licensed mental health professional are made.

Nevertheless, applied consultants and coaches should be continually aware whether there are any serious mental health difficulties that need to be addressed outside of the sporting environment (i.e., anything needing a referral to a mental health treatment professional such as, concerns regarding eating, self-harm, anxiety, depression, substance use, abuse, trauma, etc.). More complex assessments to screen for more severe impairments associated with attention (i.e., ADHD), mood, anxiety, and substance use would benefit organizations to identify difficulties that may presently be masked.

**ADHD and Sport Performance.** As attention is a primary topic in this thesis, an important future area of focus would be to examine the impact of more severe forms of attentional disruption as it may relate to sport performance. Attention-Deficit/Hyperactivity Disorder (ADHD) is a neuro-developmental condition manifested by significant periods of inattention, impulsivity, and/or hyperactivity that typically develop early in childhood (before the age of 12). The nature of the disorder is often chronic, resulting in significant impairments in many life domains (Barkley, 1990). Historically a diagnosis thought to be exclusive to children and adolescents, symptoms indeed persist into adulthood (Castellanos, Kelly, & Milham, 2009; Hervey, Epstein, & Curry, 2004). Despite the lack of pure transition from childhood frameworks to adults, research suggests that approximately 30-50% of children with ADHD will maintain similar symptoms and impairments as adults (Mannuzza, Klein, & Addalli, 1991; Schweitzer et

al., 2000). Although many adult individuals present in private practice clinics with obvious attentional and/or organizational difficulties, many of them have either never been formally assessed or diagnosed, while many others were provided a provisional diagnosis based exclusively on self-reported symptoms. These diagnoses are typically made by the primary care physician, who will often prescribe stimulant medication. Although ADHD is a thoroughly studied and debated diagnosis (Rohde et al., 2005), current consensus is that ADHD has a neurobiological basis with symptoms being primarily linked to cortical activity in the frontal areas of the brain (Giedd, Blumenthal, Molloy, & Castellanos, 2001; Schneider et al., 2010, Stahl, 2009). That said, much of the understanding of adult ADHD is derived from early work in younger children and as such, no gold standard assessment procedure currently exists to diagnose ADHD in the adult population.

Based on the predictions of *attentional control theory* (Eysenck et al., 2007), high-functioning individuals may have learned how to cope with their symptoms by either learning coping strategies, or significantly increasing the level of effort required to complete a task. High demands of any stressful environment (e.g., school, work, a first date) predictably lead to heightened anxiety in many individuals. From this heightened state, limited cognitive resources are then divided between regulating one's arousal, increasing effort, and keeping focused on the task. Many high-functioning individuals can emotionally regulate, increase effort, and achieve at least an acceptable (but not necessarily optimal) level of performance. While there is indeed a curvilinear relationship between these variables, increases (or decreases) in one of said variables can lead to discrepancies in performance. Although attentional control theory has not been identified as a pre-cursor or explanatory mechanism for ADHD, the clinical applications of this knowledge may help understand why certain people can maintain a demanding job, or achieve success in tasks which require gratification delay, focus, etc.

As a golfer it is easy to experience joy and positive feelings when things are going well in the pursuit. However, unpleasant emotions are an inevitable part of the game of golf. Indeed, the more a person is able to embrace their own shot variability, the easier it is to accept the undesired outcome. However, managing the random distribution of errors, bad-breaks, wind gusts, lip outs are all the precise obstacles that determine who is the most “formidable” player during a specific week. Consistency of shot patterns, focus, and minimization of error variability is what is most rewarded in this game. Cognitively, a round of golf is a 5-hour test of your patience, attentional control, focus, and awareness of fluctuating emotional/physical changes. Development as a player comes from a relentless pursuit towards improving one’s technical skills, understanding of game from both a strategic, and historic perspective (i.e., being a “student” of the game), and improving one’s psychological approach.

### **Stress, Anxiety, and Performance**

A certain amount of physiological and psychological activation under pressure is inevitable, especially during high-pressure scenarios. That being said, the amount of *extra* stress contributed through dysfunctional habits of feeling, thinking, and behaving is often an unrecognized barrier to performance on demand. Unless an athlete takes the proper steps to invest in self-awareness, and challenge our current ways of perceiving things, it will be difficult to minimize the influence of irrelevant triggers (e.g., bad thoughts about the self, doubting one’s skill level, concern over social status, physical appearance, and hyper-awareness of what other people think). Perhaps more importantly, our ability to *self-regulate* – in other words, things such as sticking to our routine, maintaining relevant visual search patterns, and recovering from emotional outbursts all become *less* likely under prolonged periods of even minor stress.

As golf is a precision sport, the difference of a less than a centimeter in terms of centeredness of strike, arc, etc. are not only important, but essentially the very nature of this

game. Developing trust in a golf swing is a complex psychological habit, but one that can readily be developed by *all* performers – both beginner and elite.

### **Conclusion**

“Part of the charm of putting, indeed of the game of golf itself, is the occasional unfairness of the results versus the quality of the swings. Put another way, some of the best-stroked putts in history have not gone into the hole, while some of the worst have. And you know what? I think that's charming. Unfair, but charming. Because I think golf is, and should always be, a test of more than your athletic ability and your swing plane. The challenge of putting includes an examination of your ability to accept adversity and move on.” (Pelz, p. 14, 2000)

Despite our attempts, no reliable or compelling evidence was found that would suggest that mild social evaluation is *catastrophically* detrimental to performance on simple tasks in the laboratory as much of the choking literature would imply. The use of the term “choking” seems to be misleading in research as extreme deviations from expected performance are rarely (if ever) demonstrated empirically. Choking itself may indeed be a culturally induced “illusion” where the performances of great athletes are interpreted as unexpected given the situation, but nevertheless normal deviations inherent across the distribution of an entire career. Nevertheless, this thesis contributes significantly to the performance under pressure literature by isolating a key psychological characteristic (i.e., somatic state anxiety) that consistently demonstrated a modest but important attenuation effect immediately after the exposure to a mild social evaluative stressor in the laboratory.

The paradox of successful performance under pressure is learning how to detach oneself from the meaning of performing in the first place. We prop up our athletes and place a considerable amount pressure on them by doing so. On the one hand, a strong identity with

one's nation, city, team, etc. is highly motivating for maintaining consistent and deliberate practice habits. On the other hand, *unnecessary* activation during performance leads to a mindset that is not efficient, or sustainable for long periods of time. Social threat is indeed a variable that often times can be considered unnecessary. While we cannot eliminate the importance of high-stakes events, we *can* figure out if that importance is leading to inefficiencies during performance.

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## Appendices

### Appendix A. Demographics Questionnaire

#### Background information

##### 1. Gender

Please indicate your sex      Male    Female

##### 2. Language

What is your native language      English                      French              Other

##### 3. Age

What is your age:      \_\_\_\_\_

##### 4. Ethnicity

How do you describe yourself in terms of your cultural background?

Aboriginal/native    Caucasian (white)    African-American (black)    Hispanic (latino)    Asian      Arabic

Other ethnic or cultural groups

If you selected "other", please specify: \_\_\_\_\_

Do you have any golf experience?    \_\_\_ Yes    \_\_\_ No

If so, do you have a golf handicap? \_\_\_\_\_

On average, how many strokes do you take on 18-hole golf round? \_\_\_\_\_

How many rounds of golf do you play on a yearly basis? \_\_\_\_\_

How many rounds of mini-putt have you played in your life? \_\_\_\_\_

Are you left handed or right handed?

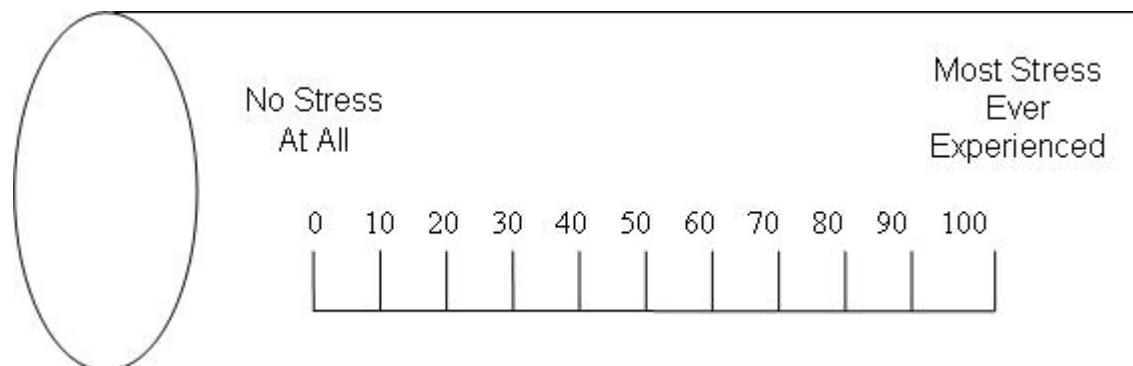
Do you consider yourself as a golfer?

### Appendix B. CSAI-2R (Cox et al., 2003)

A number of statements that athletes have used to describe their feelings before competition are given below. Read each statement and then circle the appropriate number to the right of the statement to indicate how you feel right now – at this moment. There are no right or wrong answers. Do not spend too much time on any one statement, but choose the answer which describes your feelings right now.

1	2	3	4
Not At All	Somewhat	Moderately So	Very Much So

1. I feel jittery
2. I am concerned that I may not do as well in this competition as I could
3. I feel self-confident
4. My body feels tense
5. I am concerned about losing
6. I feel tense in my stomach
7. I'm confident I can meet the challenge
8. I am concerned about choking under pressure
9. My heart is racing
10. I'm confident about performing well
11. I'm concerned about performing poorly
12. I feel my stomach sinking
13. I'm confident because I mentally picture myself reaching my goal
14. I'm concerned that others will be disappointed with my performance
15. My hands are clammy
16. I'm confident of coming through under pressure
17. My body feels tight

**Appendix C. Visual Analogue Scale (Kowalski & Crocker, 2001)**

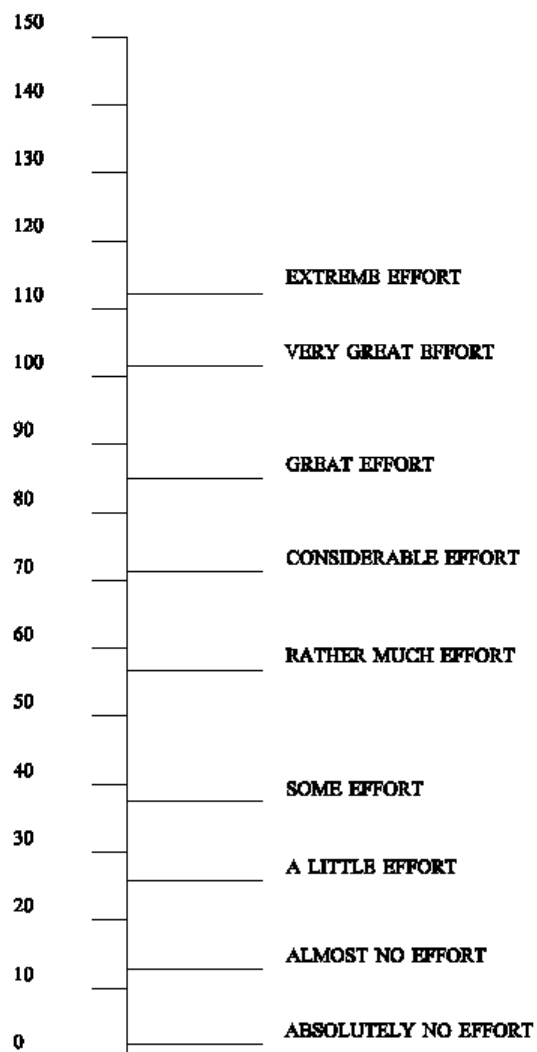
Using the above image as a guide, please rate your current stress level on a scale from 0 to 100:

**Appendix D. Rating Scale for Mental Effort (Zijlstra, 1993)**

# Rating Scale Mental Effort

Please indicate, by marking the vertical axis below, how much effort it took for you to complete the task you've just finished

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**Appendix E. Movement Self-Consciousness (Masters, Eves, & Maxwell, 2009)**

1 – Not at all	2 – Very slightly	3 – Slightly	4 – Moderately	5 – Strongly	6 – Very Strongly	7 – Totally
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I am concerned about my style of moving.

I am self-conscious about the way I look when I am moving.

I am concerned about what people think about me when I am moving.

If I see my reflection in a shop window, I will examine my movements.

I sometimes have the feeling that I am watching myself move.

I reflect about my movement a lot.

I am always trying to figure out why my actions failed.

I am always trying to think about my movements when I carry them out.

I am aware of the way my mind and body works when I am carrying out a movement.

I rarely forget the times when my movements have failed me, however slight the failure

### Appendix F. Manipulation Questionnaire

1 – Not at all	2 – Very slightly	3 – Slightly	4 – Moderately	5 – Strongly	6 – Very Strongly	7 – Totally
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How important was it for you to do well on this task?

How much did you notice that you were being filmed while putting?

Taking the whole experiment into account, how distracted were you by the cameras or your image on the television screen?

How much did you consider the impression others would have of you while doing the putting task?

Do you think you would have performed better on this task without all of these distractors?

Did you feel as though you were more monitored than usual while doing this task?

How uncomfortable were with the idea of having your behavior and performance reviewed by a golf professional?

How uncomfortable were you with being filmed and watched?

### **Appendix G. Video Script**

Hi, my name is Matt Robinson and I am the director of golf instruction at the Rideau View Golf Club in Manotick, Ontario. Our teaching facility is dedicated to excellence and one of the ways that we believe we can advance our knowledge of the game is to utilize scientific information to better help our students. As a result, we have partnered with Dr. Patrick Gaudreau and Adam Kingsbury – a PhD. student in clinical psychology - to conduct a research study for us looking at how various people perform under pressure. Each of your putting strokes will be video-taped by two different cameras and independently analyzed by all members of the teaching team to judge the overall quality of each individual stroke. This information will be used to help us look out for both good and bad habits that golfers may have while putting. Once all of the data has been collected, we will rank each participant and distribute these rankings to everyone who participated in the study. If you have any questions, please don't hesitate to ask your research assistant. Thanks for participating, and good luck.