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Effects of a Single Diaphragmatic Breath on Anxiety, Gaze, and Performance

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EFFECTS OF A SINGLE DIAPHRAGMATIC BREATH

ON ANXIETY, GAZE, AND PERFORMANCE

By
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Abstract

Anxiety is an emotion frequently experienced by athletes in competitive situations (Lazarus, 2000). Attentional control theory (Eysenck et al., 2007) explains that anxiety affects performance by occupying limited attentional resources, which reduces the efficiency and effectiveness of athletes. Efficient gaze patterns are linked to high levels of performance (e.g., Vickers, 1992). As athletes become more anxious, their gaze patterns become less efficient; specifically, they have more fixations of shorter duration and shorter quiet eye fixation duration (e g., Wilson, Vine & Wood, 2009). The purpose of the current study was to test if a common anxiety reduction intervention, the diaphragmatic breath, affects the anxiety, gaze efficiency, and performance of novice golfers completing a golf putting task. Currently, there is no research to support that a single diaphragmatic breath can aid performance, affect gaze patterns, and reduce anxiety of novices during competition, though sport psychology practitioners commonly apply this intervention. Undergraduate university students (n=30) with little to no golf putting experience and normal vision were block randomized into diaphragmatic breath (DB) and control groups. The protocol consisted of completing a pretest block of 20 putts, an intervention, 60 practice putts, then a posttest block of 20 putts where their anxiety was manipulated. The DB group was taught to take a diaphragmatic breath before each putt. Diaphragmatic breathing instructions were adapted from Lehrer, Vaschillo, and Vaschillo's (2000) abdominal breathing manual. Anxiety was measured using the somatic and cognitive subscales of the Mental Readiness Form-3 (MRF-3: Krane), which were administered after each putt. Gaze efficiency was measured using Tobii Pro Glasses 2. No statistically significant multivariate effects of the grouped independent variables on the grouped dependent variables were found. Results also showed no statistically significant interaction effect for group and time on anxiety or

performance, suggesting that the diaphragmatic breath intervention did not manage participant anxiety levels or affect the performance of the DB group compared to the control group. While not statistically significant, a large effect size was found for the interaction of group and time on average fixation length, and a moderate effect size was found for the interaction of group and time on quiet eye duration. Trends in the data showed that the control groups' average fixation duration and quiet eye duration increased, while the DB groups' average fixation duration and average quiet eye duration increased. These findings suggest that implementing a diaphragmatic breath intervention does not seem to manage anxiety or enhance gaze efficiency. While more research is needed on the effects of DB on anxiety, performance, and gaze efficiency, trends in the data from the current study suggest that a single DB may not be an effective strategy for novices faced with pressure situations in sport.

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Chapter I

The Problem and Its Scope

Introduction

Most athletes rely heavily on their vision to accomplish a variety of tasks. Until recently, how athletes use their eyes to successfully accomplish the goals of their sport has been a mystery because researchers could only subjectively guess where the athletes were looking. Advances in technology have allowed researchers to measure where athletes' eyes are focused, or fixated. A fixation occurs when the part of the retina that is responsible for the detailed part of our vision, the fovea, is focused on a certain location long enough for our nervous system to process the information in a way that it can be useful (Carl & Gellman, 1987). There is strong research evidence that efficient gaze patterns, defined as less fixations of longer duration, are characteristic of expert performance in sporting tasks that involve projecting an object to a faraway target, such as making a pass in soccer, throwing a pass in football, or making a putt in golf (Vickers, 2016). Along with efficient fixation patterns, one specific type of fixation that researchers have found related to successful and expert performance in far aiming targeting tasks is referred to as "quiet eye". A quiet eye fixation is the final fixation that starts before the motor movement critical to the execution of a sport skill, like the backswing in golf, flexion of the knee in a soccer kick, and elbow extension in the basketball shot, and ends when the fovea deviates from the fixation location (Vickers, 2007). The evidence that efficient gaze patterns are important to high levels of performance is so strong that training has been developed to help athletes replicate the efficient gaze patterns of experts in their sport to increase their sport performances (Harle & Vickers, 2001), and results indicate that such training is effective (Vickers, 2016).

One roadblock that prevents athletes from performing at their highest level is anxiety, an emotional and physiological response to threatening stimuli (Tomas, Mellalieu, & Hanton, 2009). Eysenck et al. (2007) theorized that anxiety reduces how effective athletes are during performance by influencing the central executive, which controls attention. The central executive is an abstract function of the brain with a limited capacity of resources that processes information from short and long-term memory to select where attention is allocated, switches attention between stimuli, inhibits irrelevant stimuli from being processed, and updates any changes in stimuli (Baddeley, 2001). Eysenck et al. (2007) hypothesized that heightened levels of anxiety affect athletes in two ways, by decreasing their processing efficiency (i.e., how much effort they must use to reach a certain level of performance) and their performance effectiveness (i.e., the level of performance) in sport. First, when anxiety is elevated, athletes use some of their limited processing resources to think worrisome thoughts. The increase in the amount of processing resources used by worrisome thoughts, plus resources to pay attention to the task, causes athletes' central executives to be less efficient (Eysenck et al., 2007). Second, if worrisome thoughts take up enough of the central executive's limited resources and leave insufficient resources to execute a certain sporting task, performance effectiveness will decrease (Eysenck et al., 2007).

High anxiety levels have been shown to increase the frequency of fixations and shorten fixation duration, making gaze less efficient during tasks that use the central executive (Janelle, 2002). Per attentional control theory (Eysenck et al., 2007), increased anxiety decreases processing efficiency and performance effectiveness by increasing the influence of the bottom-up attentional system, which is drawn to threatening stimuli in the environment, at the expense of the top-down attentional system, which is controlled by individuals to help them plan and make decisions. When the bottom-up attentional system's influence is increased by elevated anxiety levels, the eyes begin scanning for threatening stimuli with a gaze pattern of short fixations to many different places (Wilson, Vine, & Wood, 2009). These gaze patterns are detrimental when athletes need to control their gaze to specific stimuli that are important to their sport. For example, a golfer with low anxiety uses her top-down attentional system to direct her eyes to information that will help her set up the optimal shot; however, when her anxiety increases, the bottom-up attentional system's influence might draw her attention toward worrisome thoughts and threats like water hazards or media members that could write ego-deflating stories. Paying attention to these threatening, task-irrelevant stimuli reduces her processing efficiency and may cause her performance effectiveness to suffer if an insufficient amount of processing resources remain to successfully execute her next stroke.

Because anxiety is prevalent in sport due to its competitive nature (Lazarus, 2000) managing anxiety is a topic widely discussed in performance psychology literature (Janelle, 2002). While there is plenty of evidence that increased anxiety has deleterious effects on gaze efficiency, there are few research studies that have explored the effects of anxiety reduction interventions on gaze. A psychological intervention commonly used to reduce anxiety in performance situations is controlled deep breathing (Williams & Krane, 2015). Different controlled breathing techniques have been used to promote relaxation (Monnazzi, Leri, Guizzardi, Mattioli, & Patacchioli, 2002; Telles, Singh, & Balkrishna, 2011; Uebelacker & Broughton, 2016; Wells, Outhred, Heathers, Quintana, & Kemp, 2012) and improve performance (Pelka, Kolling, Ferrauti, Meyer, Pfeiffer, & Kellmann, 2017; Telles, et al., 2007, Telles et al., 2013) in a variety of research tasks and populations. Controlled slow breathing is said to cause changes in the autonomic nervous system by increasing the influence of the parasympathetic nervous system (PNS) and decreasing the influence of the sympathetic nervous system (SNS), which promotes relaxation (Prinsloo, Derman, Lambert, & Rauch, 2013; Song & Lehrer 2003; Telles & Naveen, 2008).

Several types of controlled breathing techniques have been studied (Telles & Naveen, 2008). Of the breathing techniques studied, Heart Rate Variability Biofeedback (HRVB) has consistently been shown to promote relaxation (Prinsloo et al., 2011; Prinsloo et al., 2013; Song & Lehrer, 2003) and aid performance (Prinsloo et al., 2011) through a variety of psychological and physiological mechanisms (Lehrer & Gevirtz, 2014). Diaphragmatic breathing is considered an easy way to temporarily decrease anxiety (Mason, 1980) and is the key component to HRVB. Heart Rate Variability Biofeedback (Lehrer, Vaschillo, & Vaschillo, 2000) works on the premise that breathing can affect heart rate, causing the heart to speed up during inhalation and slow down during exhalation. The variance in the length of time between heartbeats is called heart rate variability. Oscillations caused by the variation in time between heart beats, known as Respiratory Sinus Arrhythmia (RSA), are used to measure homeostasis of the body and the influence of the SNS and PNS (Pumprla, Howorka, Groves, Chester, & Nolan, 2002). To achieve rhythmic high amplitude RSA, which is a sign of autonomic nervous system balance, individuals can synchronize diaphragmatic breathing to biofeedback of their heart rate variability (Lehrer et al., 2000). It has been found that most people achieve optimal RSA when breathing at a frequency between 3.5-6.5 breaths/minute, with the majority of individuals having high amplitude oscillations indicating high heart rate variability breathing at a rate of six breaths/minute (Vaschillo, Vaschillo, & Lehrer, 2006). Practicing HRVB has shown to cause large increases in relaxation, mindfulness, and general positive feelings under stressful conditions, even after one 10-minute session (Prinsloo et al., 2013). Also, long-term practice of

HRVB has shown to decrease anxiety and increase performance in research on elite basketball players (Paul & Garg, 2012), and case studies on a Division I university golfer (Lagos et al., 2011) and a high school golfer (Lagos et al., 2008). HRVB shows promise as a breathing technique that can help athletes perform at high levels under the anxiety inducing situations inherent in sport.

Less formal methods of deep breathing also appear to aid performance in sporting situations. Pelka et al. (2017) found that participants who practiced 10 minutes of systematic breathing once a week for six weeks were able to significantly increase their performance on a sprinting task compared to a control group. Similarly, Mesagno and Mullane-Grant (2010) found that experienced Australian Footballer players who were taught to take a deep breath before execution of a penalty kick performed better than control group participants who were in the same pressure situation.

Taken together, there is convincing evidence from controlled breathing research that use of controlled breathing, even in small doses, can affect anxiety and performance levels. Unfortunately, most of the research protocols testing the effects of controlled breathing have used experienced yoga practitioners or experienced athletes as participants. No studies to date have measured the effects of taking a deep breath before the execution of a sport task in novice athletes. Sport psychology practitioners are teaching deep breathing to athletes with little evidence that it provides any benefits to their performance. Novices are desirable to study because they are the least likely to have established performance routines; disturbing established performance routines can negatively affect performance (Cotterill, 2011). The current study will address a gap in the controlled breathing and gaze literatures by testing the effects of a single diaphragmatic breath on anxiety, performance, and gaze efficiency in novice golfers.

Purpose of the Study

The current study was used to test the effects of diaphragmatic breathing on anxiety, performance, and gaze efficiency during a competitive golf-putting task. More specifically, using participants who were block randomized into control or diaphragmatic breath groups, the current study was used to test the effects of completing a single diaphragmatic breath before each putt on anxiety, fixation duration, number of fixations, quiet eye duration, and performance. Within and between subject comparisons were made to understand how the dependent variables were influenced by the independent variables.

Null Hypothesis

The null hypothesis of the current study is that participants who are in the diaphragmatic breath group will have no significant differences from those who are in the control group on measures of cognitive anxiety, somatic anxiety, average fixation duration, average number of fixations per putt, average quiet eye duration, and performance during a putting task.

Significance of the Study

This study is significant for three main reasons 1) it will be used to test the effects of taking a diaphragmatic breath on anxiety measured during competition, 2) it will be used to test if taking a diaphragmatic breath affects the performance of novices, 3) it will be used to test the effects of a psychological intervention on gaze.

During the current study, researchers will measure the somatic and cognitive anxiety levels of each participant after each putt during pretest and posttest sessions to see if a diaphragmatic breath has an effect on novice golfers' anxiety throughout a competition. Often researchers measure anxiety before competition, which makes it harder to detect anxiety levels after competition has begun. By measuring anxiety throughout the competition it can be determined if taking a diaphragmatic breath affects average anxiety levels during competitive situations instead of pre-competition anxiety levels, which are commonly measured in research on anxiety.

While attentional control theory's hypotheses have been tested in a one-way manner, meaning that the effects of increased anxiety on gaze efficiency have been studied (Wilson et al., 2009), there has been no published research that has tested the effects of anxiety reduction interventions on gaze efficiency. If the relationship between anxiety is bi-directional, then decreasing anxiety should make attentional processes, like visual attention as measured by gaze, more efficient. This relationship is important to understand because it may be a mechanism by which anxiety reduction interventions can enhance performance. The current study will determine if a common anxiety reduction intervention, the diaphragmatic breath, causes novice performers to have more efficient gaze patterns and better performance.

Limitations of the Study

1. Confounding variables may be present due to the fact that the development of performance routines can occur naturally. Therefore, it is possible that participants in the control group might have taken deep breaths before their putts or subjects in all groups may have used other mental skills that could have affected the results of the study.
2. Similarly, it is difficult to know how much effort participants in the diaphragmatic breath group put into implementing the diaphragmatic breathing intervention.
3. Novice golfers may not have considered performing well on the putting task to be important to them, which could have affected the amount of threat, and therefore anxiety, they experienced (Folkman & Lazarus, 1974).

4. Because novice golfers were used, these findings may not be applicable to expert populations.
5. The study was conducted in a lab setting, limiting the external validity of the results.
6. Another limit of external validity is that participants had to wear the eye tracking glasses while putting. Although efforts were made to increase comfort with the glasses, golfers would not wear this type of technology during competition.
7. For this study, a convenience sample of college students was used; therefore, participants cannot be assumed to be truly representative of the entire novice golfer population.

Definition of Terms

Cognitive Anxiety- The amount of worry an individual is experiencing (Krane, 1994).

Diaphragmatic Breath- A deep breath where an individual inhales in through the nostrils deeply by using the diaphragm and exhales through the mouth. For this study, a diaphragmatic breath was defined as inhaling through the nostrils into the abdomen using the diaphragm for a count of four seconds, then actively exhaling through the mouth for a count of six seconds.

Backswing- The first movement of the putter away from the ball when initiating a golf putt.

Fixation- A period of time that the eye is stable for 100 ms without reaching a movement velocity threshold of 30°/ms, as recommended by Tobii (2012).

Fixation Duration- The average length of all fixations that occur during the pretest or posttest block of putts.

Fixation Frequency- The average number of fixations occurring during each putt for the pretest or posttest putting blocks.

Fixation Offset- The end of a fixation where gaze deviates of the fixation location more than 3° for more than 100 ms.

Fixation Onset- The start of a fixation.

Processing Efficiency- The amount of effort used to achieve a certain level of task effectiveness (Eysenck & Calvo, 1992).

Quiet Eye- The specific final fixation with an onset that occurs prior to the backswing phase of the putt (Vickers, 2007).

Somatic Anxiety- The amount of tension experienced by an individual (Krane, 1994).

Task Effectiveness- The quality of performance as determined by standards set by society (Eysenck & Calvo, 1992).

Chapter II

Review of Literature

Introduction

According to processing efficiency theory (Eysenck & Calvo, 1992) and attentional control theory (Eysenck et al., 2007), when individuals have heightened state anxiety their attentional processes are negatively affected. One way to measure the effects of anxiety on visual attention is through measurements of gaze, or where one's eyes are looking. Visual attention, as measured by gaze, is instrumental to expert performance in activities requiring precision in cue selection (Vickers, 2011). One such category of activities that require precise task-relevant cue selection are far aiming targeting tasks such as shooting in basketball, field goal kicking in football, and putting in golf. When anxiety is elevated, there are deleterious effects on visual attention (Vine, Moore, & Wilson, 2014).

Therefore, decreasing anxiety may have beneficial consequences on the visual attention system. In competitive situations, anxiety is common (Lazarus, 2000). So, athletes often are taught relaxation interventions to help regulate their anxiety levels. Diaphragmatic breathing is a common anxiety reduction technique incorporated into athletes' performance routines in competitive situations (Williams & Krane, 2015). While diaphragmatic breathing is a common arousal regulation technique, there are few studies that have tested if a diaphragmatic breathing intervention alone is effective in reducing anxiety in competitive situations. If diaphragmatic breathing is effective at reducing anxiety, it may have beneficial consequences on the visual attention system. Yet, presently, researchers have not tested the effects of a relaxation intervention, like diaphragmatic breathing, on the visual attention system. Therefore, to address this gap in the literature, the current study will test the effects of a diaphragmatic breath on gaze patterns and performance in a putting task.

Arousal, Stress, and Anxiety: Theories and Definitions

Optimal performance is what athletes often strive for during practice and game situations. Frustratingly, levels of performance effectiveness can vary from moment to moment and game to game. Lazarus (2000) attributed this variance in athletic performance to emotions that arise during competition.

Explanations of how emotions come to be have fluctuated over the history of the study of psychology. Lange and James (1922) theorized that specific physiological reactions to stimuli activate certain combinations of neurons all over the cortices of the brain, and those combinations are interpreted as specific emotions. According to the James-Lange theory (Lange & James, 1922), over the course of time, humans evolved to react to stimuli in the environment in specific ways. For example, muscles tense up in the presence of danger or faces relax and smile when around loved ones. According to their theory, these bodily reactions precede emotions and, without them, emotions are no more than thoughts. Proponents of the James-Lange theory would agree that it would be hard to imagine being frightened with no increased heartrate or experiencing sorrow while having genuine a smile. Only after feeling these reactions can someone truly experience an emotion.

Cannon (1927) developed a theory to disprove the James-Lange theory. He noted that when cats' brain stems were separated in surgery from the sensory organs and cerebral cortices of the brain, the animals still displayed emotional reactions. This finding showed that emotion and organ sensation are somewhat independent (Bard, 1928). Cannon (1927) argued that changes in the body due to activation of the sympathetic nervous system happen during a multitude of different situations, such as fever, hypoglycemia, and asphyxia. If the James-Lange theory of emotion was true, then these ailments should make individuals feel certain emotions due to the activation or inhibition of certain organs. However, they do not. Changes in the viscera are commonly unnoticeable, gashes or holes in intestines cannot be felt, and some of the smooth type of muscles in the visceral can take minutes to be stimulated; for example, the vagus has a latent period of 6 minutes (Cannon, 1927). If these changes in the body can go unnoticed and take place slowly, then they cannot explain emotions that occur immediately after certain experiences. While Lange and James (1922) attributed activation of differing combinations of the cortex to emotional expression, Cannon (1927) and Bard (1928) concluded that emotional expression happens in the hypothalamus. Instead of stimuli affecting bodily changes, which are then interpreted by the cortex as emotion (as in the James-Lange theory), Cannon-Bard theory asserted that stimuli are interpreted by the thalamus and made into emotion while simultaneously causing physiological reactions related to that emotion (Cannon, 1927).

James-Lange theory (Lange & James, 1922) and Cannon-Bard theory (Cannon, 1927; Bard, 1928) explain that emotions are created based on our interpretations of the arousal levels of different body systems. The problem with these theories is that they discount the effect that our cognitions have on what emotions we feel. To address this missing component, Lazarus and Folkman (1984) created the cognitive appraisal model in order to explain how our cognitions help determine what emotions we feel. According to the cognitive appraisal model, two individuals faced with the same situation can appraise the environmental demands or threats of that situation differently, causing their emotional reactions to differ. These differences in appraisals are often seen in golf. For example, one golfer may feel confident about his driving ability, making teeing off on a par five enjoyable for him, whereas a different golfer may not think he can handle the demands of the long fairway and so he feels anxious about teeing off.

According to Lazarus and Folkman (1984), the process of appraisal involves a *primary appraisal*, which consists of the individual determining if a situation is irrelevant, benign-positive, or stressful. Irrelevant situations are those in which the individual has no investment in the possible outcomes of the situation. When situations are appraised as positive or enhancing to the well-being of the individual, they are considered *benign-positive*. *Stressful appraisals* can be further divided into appraisals of harm, threat, or challenge. *Harm appraisals* occur when damage has already been done to an individual, such as an athlete that tears a ligament in his knee. *Threat appraisals* concern harm that is anticipated to occur in the future, such as a tennis player expecting to hit a game-winning serve into the net. According to Lazarus and Folkman (1984), harm and threat appraisals usually lead to negative emotions. *Challenge appraisals* happen when an individual expects gain or growth from the situation and are associated with more positive emotions (Lazarus & Folkman, 1984). For example, a group of professional ping pong players, who all find it important to win every game of ping pong they play, might appraise a game of ping pong to be stressful, challenging, and anxiety inducing. By contrast, a group of amateurs out on the town playing ping pong in a social setting who do not think winning ping pong is important, will probably appraise the game to be benign and fun.

Secondary appraisals involve the individual deciding if he or she possesses the proper coping resources in order to deal with situations that are appraised as challenging or threatening (Lazarus & Folkman, 1984). Secondary appraisals can happen simultaneously with primary appraisals and are equally important, contrary to what their names might suggest. This appraisal process is constant, dynamic, and can affect the emotions one feels. Take, for instance, a playoff football game. A quarterback may start the game making the primary appraisal that the game will be challenging and a secondary appraisal that he has the skills to lead the offense in successful scoring drives. These appraisals cause the quarterback to experience positive emotions. Later in the game, when his team is losing, he may make the primary appraisal that the game is potentially threatening and make a secondary appraisal that he does not have the skills to lead to his team on a scoring drive. According to the cognitive appraisal model (Lazarus & Folkman, 1984), his appraisal that he is about to let his team down in an important game, contributes to his negative emotions.

The previously discussed theories explain how all emotions come about, but the specific emotion of anxiety is important to understand because it is commonly experienced in competitive context of sport (Lazarus, 2000). When an individual perceives he or she does not have the ability to meet the demands of personally valued situations, *stress* is experienced (Lazarus & Folkman, 1984). A common response to stress is *anxiety*, which is a broad term for a variety of emotional and physiological reactions that occur when an individual interprets stimuli as threatening (Tomas, Mellalieu, & Hanton, 2009). When values and goals that are important to an individual are threatened and the individual is uncertain if they have the resources to overcome the threat, stress, and therefore anxiety, may increase (Lazarus, 2000). Competitive anxiety refers to anxiety experienced before or during competition **(**Tomas et al., 2009). Lazarus (2000) stated that competitive anxiety is common in sport because the comparative nature of competition will reveal the competence of a participating athlete. At any moment, an athlete's level of performance could vary. Variance in performance level is so common that an athlete is often uncertain how well she will perform during upcoming competitive situations, which is a major source of anxiety (Lazarus, 2000). The possibility that the athlete will be perceived as incompetent in competition can be threatening to the athlete's well-being and cause anxiety. Also, anxiety generated from sources outside of competition, such as marriage problems, fiscal crisis, or conflicts with team management, can add to anxiety experienced during competition (Lazarus, 2000).

Arousal is a term that is commonly associated with anxiety. In order to understand research in the field of anxiety, it is important to understand what is meant by arousal. Arousal exists on a continuum of intensity with one end of the continuum being a deep sleep and the other end of the continuum being the most intense excitement (Martens et al., 1990). Where an athlete falls on this continuum is referred to as his arousal level. During the offseason while taking a nap on the beach, an NBA player might experience his lowest level of arousal of the year. Rewind a few weeks to the deciding game of a playoff series, and the athlete's increased heartrate, dilated pupils, tense muscles, constricted veins, and cognitive anticipation of the tipoff would represent the height of his in-season arousal.

The conceptualization of anxiety changed when Spielberger (1966) identified two distinguishable components of anxiety, *trait anxiety* and *state anxiety*. State anxiety is an immediate but transient reaction one experiences when situation specific external stimuli or internal cues are interpreted as dangerous or threatening. How threatening an individual appraises a situation to be, combined with the level of trait anxiety of the individual, determines state anxiety. Trait anxiety is a stable disposition of an individual's personality that influences if he or she interprets situations as threatening and dangerous and responds with an anxiety state (Spielberger, 1996). If an individual has high trait anxiety she is more likely to present with symptoms of anxiety across a variety of situations. For example, a golfer with high trait anxiety would be predisposed to appraise more situations, competitive or not, as threatening. This golfer would likely respond with anxiety symptoms of greater intensity when compared to a person with low trait anxiety (Martens et al., 1990).

Anxiety is also viewed as a multidimensional construct, meaning that anxiety can be experienced either cognitively or somatically (Martens et al., 1990). *Cognitive anxiety* is mental and comes from negative expectations and negative self-evaluations (Martens et al., 1990). In sport, cognitive anxiety may manifest in thoughts such as, “I am going to lose again to the top ranked player” or “I am the slowest person at this track meet.” *Somatic anxiety* is experienced through physiological and affective symptoms caused by the arousal of the autonomic nervous system, such as excessive sweating, “butterflies” in one’s stomach, or an increased heart rate.

While anxiety often gets associated with its negative effects, it is not always debilitative. According to Lazarus (2000), anxiety can have either positive or negative effects on performance depending on the individual and situation. Facilitative anxiety motivates and mobilizes athletes to action. If anxiety about an upcoming game causes an athlete to increase her dedication to practice and preparation, then it can hardly be labeled as a bad emotion. Therefore, it is important to consider both the facilitative and debilitative effects of anxiety on athletes’ performance and wellbeing.

When playing sports, there are endless situations that can be interpreted as threatening and cause uncertainty, worrisome thoughts, or sympathetic activation. This means that most, if not all, athletes have experienced some component or dimension of anxiety. In the next section, theories about the relationship between anxiety and performance will be discussed.

Theories on the Anxiety-Performance Relationship

Theories about how anxiety affects performance have become more complex and detailed over time. Two early views on the performance-arousal relationship include drive theory and the inverted-U hypothesis. Drive theory (Hull, 1943; Spence & Spence, 1966) was created to explain that the relationship between arousal and performance exists on a positive linear slope. Drive theory explains that higher arousal corresponds to higher performance in skills where the performer has trained the correct dominant and automatic response. However, there are many situations where drive theory does not hold up, because not all people perform better when they are highly aroused. In fact, high arousal can be detrimental to performance based on the individual and the task he or she is performing.

Alternatively, the inverted-U hypothesis was created on the basis that as arousal increases, so does performance, but only up to a certain optimal level of arousal (Yerkes & Dodson, 1908). Yerkes and Dodson (1908) considered an intermediate amount of arousal to be optimal, and once arousal elevates beyond the optimal and intermediate arousal level, performance will steadily decline. When graphed, the inverted-U model resembles an upside-down U, which is where it gets its name. Later, the inverted-U model was adapted to indicate that the optimal arousal level is determined by the characteristics of the task and individual (Hanton, Mellalieu, & Williams, 2015). Simple tasks that require strength, speed, and gross motor movements, such as sprinting, might be performed better under high arousal while other tasks that require fine motor movement and decision-making skills, such as target shooting or setting in volleyball, may be better suited to be performed at a low arousal level. Individual characteristics that influence the optimal arousal level would be the individual's personality, skill level, and experience.

Drive theory and the inverted-U hypothesis have been replaced by more contemporary theories and models in the field of sport psychology because they are considered too simplistic to explanation the performance-arousal relationship (Hanton et al., 2015). Hanin's (1997) individual zones of optimal functioning (IZOF) model was originally designed to explain the relationship between precompetitive state anxiety and performance in the elite athlete population. Hanin (1997) expanded the theory to explain how differing levels of all emotions can facilitate or debilitate performance within individual athletes. In Hanin's (1997) model, emotions can be classified by individuals into two factors: positivity-negativity and optimality-dysfunctionality. Each positive or negative emotion's intensity, whether it be low, medium, or high, can put an athlete into a zone where the emotion facilitates optimal performance (in zone) or into a zone where it facilitates dysfunctional performance (out of zone). Each individual athlete has different intensities of emotions that put them "in zone" or "out of zone". According to the IZOF model, one soccer goalie may perform better with high precompetitive state anxiety while the opposing goalie may be "in zone" when her intensity of precompetitive anxiety is low.

While the IZOF model (Hanin, 1997) explains how various levels of anxiety can facilitate performance for different people, it does not take into account the multidimensional nature of anxiety. The multidimensional anxiety theory (Martens et al., 1990), explains that the relationship between state somatic anxiety and performance when graphed looks like an inverted U, with performance and state somatic anxiety increasing together up to an optimal level. Increases in state somatic anxiety beyond the optimal level lead to a proportional drop off in performance. However, state cognitive anxiety is thought to have a negative linear relationship with performance, where performance decreases as cognitive anxiety increases. Similar to multidimensional anxiety theory, because it takes into account both dimensions of anxiety, is the cusp catastrophe model (Hardy, 1990). According to the cusp catastrophe model, when cognitive anxiety is low, physiological arousal has an inverted-U relationship with performance. If cognitive anxiety and physiological arousal become concurrently high, it leads to a steep drop off in performance level, (the "catastrophe"), as opposed to gradual performance decrements as predicted in the inverted-U model and the multidimensional model of anxiety. Competing under high cognitive anxiety is viewed as the main factor in experiencing a performance catastrophe according to this model.

As these models emphasize, different dimensions and levels of arousal and anxiety are connected to performance. These models attempt to explain what intensities of anxiety and arousal are best for different athletes to excel in their sport. The more recent theories may be more useful explaining the performance anxiety relationship because they consider both dimensions of anxiety and seem to better explain sport performance.

Processing Efficiency Theory

While previous models and theories were created to explain the relationship between anxiety and performance, there was little attempt to explain the mechanism by which anxiety *affects* performance. Processing efficiency theory (Eysenck & Calvo, 1992) was created to explain how state anxiety affects performance. It is intended for general application, and may have particular relevance to non-clinical, as opposed to clinical, populations in test or evaluative situations, including sport competition.

As important information enters our brain, cognitive psychologists contend that it exists in our minds in something referred to as short term memory (Breedlove, Watson, & Rosenzweig, 2010). Short term memory is a limited form of memory that only lasts a few seconds, or as long as the information is continually refreshed by vocal or sub-vocal repetition in the short term memory, a process referred to as rehearsal (Breedlove et al., 2010). The prefrontal cortex and parahippocampal cortex are the main brain regions involved in creating short term memories (Winocur, 1990). Information in the short term memory that is salient or continually rehearsed is processed by the hippocampus and transferred to corresponding parts of the cortex where the information is stored as long term memory (Breedlove et al., 2010). Long term memory has a high capacity and information stored in long term memory can last days, months, or years (Breedlove et al., 2010). Working memory is a buffer that holds information from short and long term memory so that information can be to be ready to use in order to perform daily tasks (Baddeley, 2003). The brain areas involved in working memory seem to be the parts of the brain that were responsible for processing the initial information, for example, visual memories used by working memory are processed in the occipital lobe (Kesner, Bolland & Dakis, 1993).

According to processing efficiency theory, anxiety affects the working memory system (Eysenck & Calvo, 1992). Baddeley (2001) identified four components of the human working memory system. First, the *phonological loop* processes and stores verbal and acoustic information. The phonological loop consists of two subsystems, a phonological store and articulatory rehearsal system. Articulatory information, or information involving sounds used in speech, is kept in the phonological store for a period of about two seconds before the information is forgotten, unless the information is refreshed by the articulatory rehearsal system. Second, the *visuospatial sketch pad* specializes in temporarily retaining and manipulating visual and spatial information collected from the senses. Baddeley (2001) concluded that the capacity of the visuospatial sketchpad is about five digits or words in digit and word span tasks. This means that participants, on average, can recall five words or numbers they have heard or seen from a list by using their short term memories. The phonological loop and visuospatial sketchpad are controlled by the *central executive*, the third component of working memory (Baddeley, 2001). The central executive focuses attention and decides what information from the slave systems is important to the performance of every activity we participate in and what information needs to be inhibited. The central executive also switches attention between different sensory information (Baddeley, 2001). Information from the long term memory is integrated into short term memory using the fourth component of the working memory system, the *episodic buffer*. Using information from long term memory can increase the efficiency of the working memory system by taking information in the phonological loop and visuospatial sketchpad and chunking together the information into units with meaning. For example, a person may be able to only remember five random and unassociated words, but if those words form a sentence with meaning to their long term memory, the episodic buffer can integrate the words with long term memory, enabling the person to remember a sentence of approximately 15 words (Baddeley, 2001).

The response of an ice hockey goalie with an opposing team converging to shoot on his net can illustrate how the working memory system is used in sport. The goalie will use his phonological loop to store auditory information including what his teammates are saying, the sounds of the puck and ice skates, his coach yelling instructions, technical instructions he is telling himself in his head, and crowd noise. The visuospatial sketchpad stores information taken in from his eyes, such as the jersey colors of the players approaching him and the location of the puck and players on the ice. The central executive is used to focus his attention on the information he needs to defend the goal and block out irrelevant information, such as crowd noise or the location of players at the other end of the ice, divide attention between the puck and an opponent's body position, and switch his attention between his body placement and the opponent's body placement. He also uses the episodic buffer to retrieve information from long term memory, such as opposing players' tendencies that he has studied in game film sessions or learned from previously defending the goal from specific player. He integrates that information with his opponents' current hand placement, stick placement, and body placement into information that may reveal how his opponent will try to score.

Of fundamental importance to processing efficiency theory is the distinction between *performance effectiveness* and *processing efficiency* (Eysenck & Calvo, 1992). Performance effectiveness refers to the quality of performance. Quality is usually determined by comparing a performance to the standards of performance set by others, for instance, if a golfer plays 18 holes of golf with a score below par he would have a higher level of performance effectiveness than a golfer who plays a round of golf taking 20 shots over par. Processing efficiency refers to the amount of effort used to achieve a certain level of performance effectiveness (Eysenck & Calvo, 1992). Effort is a process by which an individual intentionally regulates his or her arousal level (Schonpflug, 1992). Therefore, processing efficiency is determined by the relationship between performance effectiveness and task effort. If high effort is needed to achieve a certain level of performance effectiveness then efficiency is low, while if low effort is needed to achieve the same level of effectiveness then efficiency is high. A football lineman who uses little effort to pass block a defender is going to have higher task efficiency than a lineman who needs to use maximal effort in order to pass block for his quarterback. When highly anxious individuals have elevated levels of anxiety, they must use sufficient processing resources to perform the task at hand and also recruit additional processing resources from the working memory system, as long as there are processing resources to spare, to process anxious thoughts and feelings, while an individual who is less anxious only needs to use processing resources to perform the task at hand (Eysenck & Calvo, 1992). As a consequence, individuals with high anxiety are less efficient with their processing resources when achieving the same performance outcomes.

Worry, a cognitive symptom of anxiety, occupies processing and storage resources, mainly affecting the central executive (Eysenck & Calvo, 1992). Worry can cause performance decrements on tasks that put high demands on the working memory system, such as a quarterback needing to interpret the play call, read the defense, call an audible, and then successfully start the execution of the play all before the play clock expires. According to processing efficiency theory (Eysenck & Calvo, 1992), anxiety can also benefit performance. Highly anxious individuals can become more motivated, causing them to increase their effort, recruit additional resources to increase working memory capacity, and develop strategies to overcome threats and improve performance (Eysenck & Calvo, 1992; Lazarus, 2000).

Processing efficiency theory has two main predictions (Eysenck & Calvo, 1992). First, anxiety will usually impair processing efficiency more than performance effectiveness. Second, anxiety adversely affects task performance more as the task demands on working memory capacity increase due to tasks becoming increasingly complex. Processing efficiency theory's assumptions give us a basic understanding as to why and how anxiety affects the performance of competitors. Advances in the anxiety-performance research led to new findings that allowed for a more in-depth theory, attentional control theory (Eysenck, Derakshan, Santos, & Calvo, 2007).

Attentional Control Theory

Attentional control theory (Eysenck et al., 2007) builds upon the most basic assumption of processing efficiency theory (Eysenck & Calvo, 1992); to understand how anxiety affects performance one must understand the effects of anxiety on attentional processes (Eysenck, et al., 2007). When anxiety is increased in threatening situations, attention is allocated to finding the cause of the threat and reducing it. When attention is directed toward detecting threats and planning how to overcome them, there are less attentional resources available to be allocated to the cues vital to achieving the current goal.

One reason that individuals are less able to focus their attention on the task at hand when they are highly anxious may be because they show an attentional preference toward threatening stimuli (Eysenck et al., 2007). Threatening stimuli can be internal, such as thoughts that one is not good enough to beat a high caliber opponent or worrying about what the crowd may think if a critical error is made, or external, such as a goalie trying to block a shot or the especially loud taunting of a fan. The assumption that highly anxious individuals' attention gravitates toward threatening stimuli is related to the view that there are two attentional systems (Corbetta & Shulman, 2002). One system is goal-directed (top-down) and influenced by an individual's prior knowledge of what needs to be done to achieve his or her goals. Through the goal-directed attentional system we are able to control our attention to specific stimuli that are important when trying to complete a task or achieve a goal. The second attentional system is a stimulus-driven (bottom-up) system that is responsive to stimuli in the environment (Corbetta & Shulman, 2002). When attention is top-down individuals are controlling what they pay attention to and when attention is bottom-up their attention is captured by certain stimuli. When anxiety is high, the balance between the goal-directed and stimulus-driven attentional systems is disrupted (Eysenck et al., 2007), and attention becomes increasingly influenced by the stimulus-driven attentional system at the expense of the goal-directed attentional system. Inhibition of the goal-directed system while performing has negative effects on performance because individuals are less able to implement strategy and attend to task relevant information. This imbalance in attentional systems causes threat related stimuli, both internal and external, to become more salient to highly anxious individuals than task-relevant stimuli. When threatening stimuli are not task relevant, the stimuli can become distracting and influence attention at the cost of the goal-directed attentional system that is important to achieve performance goals. For instance, in order for a basketball player to successfully make a free throw, he must focus on his shot preparation and then switch his attention to his target, usually the backboard or rim. Focusing on the preparation of the shot and execution of the shooting movement is a top-down process. If that player is taking those free throws in the last moments of a close game and becomes increasingly anxious, his attention may become more bottom-up, allocating his attention to threating thoughts about failure or an opponent trying to distract him. According to attentional control theory (Eysenck et al., 2007), because his bottom-up attentional system is dominant (due to his elevated anxiety), he is less likely to focus on his shot preparation and more likely to have his performance suffer.

While processing efficiency theory explained that anxiety has effects on the functioning of the central executive (Eysenck & Calvo, 1992), it was unclear what central executive functions were affected by anxiety. Attentional control theory identifies three basic functions of the central executive: inhibition, shifting, and updating (Eysenck et al., 2007). *Inhibition* is the function of the central executive that allows us to direct attention to task-relevant information and block out task-irrelevant information that is not useful (e.g., a basketball player blocking out distracting fan movement and noise in order to focus on the target of his free throw). *Shifting* is the switching of attention back and forth between different tasks (e.g., a pitcher reading the signal from the catcher, switching his attention to getting the appropriate grip for the pitch, then switching his attention to where he will be throwing the ball). *Updating* involves using memory to keep track of new information as it is presented (e.g., a defender in soccer learning the tendencies of an opposing offensive player as a game progresses).

Hypotheses of Attentional Control Theory and Supporting Evidence

Based on the assumptions and framework of attentional control theory, there are six main hypotheses about the relationship between anxiety and attention that have been empirically tested (Eysenck et al., 2007). The six hypothesis are (1) anxiety has greater detrimental effects on processing efficiency than performance effectiveness in tasks that involve the central executive, (2) negative effects of anxiety on performance are magnified as the task demands on the central executive are increased, (3) anxiety negatively affects attentional control by increasing the influence of the stimulus-driven attentional system, (4) anxiety impairs processing efficiency in tasks that use the inhibition function, especially when threatening stimuli are present, (5) anxiety impairs processing efficiency on tasks that involve the use of the shifting function of the central executive, and (6) anxiety impairs processing efficiency when tasks use the updating function, but only under stressful conditions (Eysenck et al., 2007). This review will focus on the first three hypotheses as the final three hypotheses are beyond the scope of this thesis.

Hypothesis I: Anxiety has greater detrimental effects on processing efficiency than performance effectiveness in tasks that involve the central executive. In line with processing efficiency theory, attentional control theory builds upon the assumption that anxiety has a greater effect on performance efficiency than performance effectiveness when tasks involve the central executive (Eysenck et al., 2007). As detailed below, there are three main pieces of evidence that support this hypothesis. First, in studies where performance effectiveness is measured by accuracy and performance efficiency is measured by response time, high anxiety was related to comparable performance accuracy but increased reaction time (e.g., Darke 1988, Derakshan & Eysenck, 1998; Elliman, Green, Rodgers, & Finch, 1997; Iwanga & Seiwa, 1996; MacLeod &

Donnellan, 1993; Markham & Darke,1991; Nieuwenhuys, Pijpers, Oudejans, & Bakker, 2008; Richards, French, Keogh, & Carter, 2000). Second, individuals with high anxiety report using greater effort in order to achieve similar performance effectiveness (Calvo, 1985, Calvo, Szabo, & Capafons, 1996; Di Bartolo, Brown, & Barlow, 1997; Eysenck, 1985; Hadwin, Brogan, & Stevenson, 2005; Smith, Bellamy, Collins, & Newell, 2001). The third type of evidence comes from studies where high anxiety participants' performance of probe tasks was lower than the performance of low anxiety participants, even though performance on a main task was similar between groups (Eysenck, 1989; Williams, Vickers, & Rodrigues, 2002).

The first type of evidence that supports hypothesis I is that having high anxiety, whether it is state or trait, causes individuals to take longer to complete tasks in order to maintain the same level of performance as their counterparts with lower anxiety (Darke,1988, Markham & Darke, 1991). This has shown to be the case across a variety of different tasks. For example, male and female undergraduate students who scored higher on the Test Anxiety Scale (TAS) took longer to complete a verbal reasoning task when they were asked questions about inferences (Darke, 1988) and relational propositions (Darke,1988; Markham & Darke, 1991). The inferences and relational propositions were of varying difficulty, which put differing loads on working memory. Participants who scored high on the TAS were slower at completing the task when compared to the participants who scored low on the TAS. In both studies, the verbal tasks involved reading a short text containing either necessary inferences, unnecessary inferences, or relational propositions in the beginning sentences with the last sentence being a true or false question about regarding information contained in the previous sentences.

The same effects of anxiety occurred in studies where participants were required to complete a verbal reasoning task (Derakshan & Eysenck, 1998; MacLeod & Donnellan, 1993).

Participants were asked to remember a string of digits, then answer verbal reasoning questions regarding the sequential relationship between two letters presented on a computer, and finally identify if a second string of digits was identical to the first. Participants all had low error rates on the task, but the high anxiety group took longer to give their answers (Derakshan & Eysenck, 1998; MacLeod & Donnellan, 1993). Based on these findings, verbal tasks of higher difficulty take longer to complete when individuals have high anxiety, showing that anxiety decreases processing efficiency in these types of tasks.

Participants' longer memorization and memory recall times also support the assumptions of attentional control theory that anxiety affects the memory systems (Eysenck et al., 2007). For example, male and female participants with high scores on the TAS spent more time memorizing a string of digits before a verbal reasoning task than participants who scored low on the TAS, even though both groups performed similarly when recalling the digits (Richards et al., 2000). In another study, Ikeda, Iwanga, and Seiwa (1996) found that Japanese undergraduate students took longer to recall previously memorized groups of words when anxiety was induced by manipulating conditions of evaluation. Once again, accuracy on the task was not different between high and low anxiety conditions. These findings indicate that anxiety affects how quickly individuals can pick up information and also the speed they can retrieve and process it. Increased memorization and memory recall effects have been found to be present in both western participants (Richards et al., 2000) and eastern participants (Iwanga & Seiwa, 1996), suggesting that the effects of anxiety are relatively consistent between cultures.

Reading involves storing information in working memory in order to link information found in previous sentences with information gathered later in the reading (Daneman & Carpenter, 1980), which makes reading a good task for testing the effects of anxiety. To test the effects of anxiety on reading comprehension, Calvo et al. (1994) had high and low anxiety participants read texts, then asked them questions about the text to evaluate their comprehension. Participants in high anxiety conditions took longer to read the text, but comprehended the text just as well as the participants in the low anxiety condition. The researchers found that the high anxiety group's slower reading times were because the high anxiety participants spent more time in reading regressions, or going back over previously read text. According to this study, anxiety may increase the time it takes for highly anxious individuals to perform at high levels because they use compensatory strategies to make up for their low processing efficiency. Calvo et al. (1994) speculated that anxious readers may need to revisit old text if anxious thoughts replace information important to understanding the information they are reading. Likewise, an anxious soccer player may take longer to prepare for a penalty kick if she must use coping strategies to decrease her anxiety while planning where she needs to place her shot to score.

Motor performance also seems to be slowed when anxiety is high. In one study, 72 English speaking participants had to pay attention to consecutive letters and numbers presented one at a time on a screen and press a key when a specific sequence of letters or numbers was presented; the time it took high anxiety participants to press the key was significantly longer than the low anxiety participants (Elliman et al., 1997). These effects on motor performance have also been seen observed in the sporting world. Nieuwenhuys et al. (2008) had rock climbers traverse two identical climbing courses. One of the courses was high off the ground to induce anxiety, while the other was just above the ground. Participants took longer to traverse the high course than the low course, despite them being identical in difficulty. These results have particular importance to application of attentional control theory to athletics, where motor movement reaction times are important to high performance. Slow reaction times due to anxiety might cause a basketball center to react slower while playing help defense, allowing an opponent to get an easy layup, or cause a short stop to react too slow and miss catching a line drive hit close to him in order to get a game saving out.

A second way that Eysenck et al. (2007) measured processing efficiency was by measuring individuals' effort. Individuals high in anxiety have reported using greater effort, as measured by self-report effort questionnaires, to achieve performance results that were similar to individuals with lower anxiety levels. In one study of effort and anxiety across a competitive season, Smith et al. (2001) measured anxiety before sets and mental effort during sets using 12 male English professional volleyball players with low and high trait anxiety. Sets were categorized by their criticality (how close the final score of the set was) and momentum (which team had one more sets). Players in the high anxiety group experienced more anxiety when they were playing sets where their team was behind or tied in the number of sets won. Both groups increased their mental effort as match scores became closer, but the high anxiety group reported significantly more effort than the low anxiety in matches where the final score was within three to six points, even though performance was similar. The increased mental effort reported by the high anxiety group in moderately critical sets that those athletes were less efficient in their performance during these game situations than their low anxiety teammates. Players with low anxiety in the study were able to sustain their performance in more threatening situations by increasing their effort. Another study tested the processing efficiency and performance effectiveness of children from ages nine to ten (Hadwin et al., 2005). The participants were put into high and low anxiety groups and took part in digit recall and spatial working memory tasks. The high anxiety group had longer reaction times and reported using more effort on the tasks than the low anxiety group, while task performance remained similar between groups. In sport, it is often hard to measure the effort of athletes while they compete. If effort were observable, spectators might notice that some players, no matter what age, need to expend more energy to increase or stabilize how well they perform.

An alternative to using self-report scales to measure effort is to monitor objective psychophysiological reactions to anxiety (Di Bartolo et al., 1997), which may be superior to the subjective nature of self-report scales. For example, Di Bartolo et al., (1997) compared the heartrates of 15 participants with no anxiety diagnoses to 15 participants with generalized anxiety disorder. The task involved participants pressing a computer key when one of two simultaneous, three letter word sets, presented on a screen, contained a vowel, and then random negative feedback given to the participants after each time they pressed the key. The researchers found that participants from both groups had higher heartrates; additionally, heart rate was significantly higher in the later part of the task, when participants' anxiety was increased by ego threat. Ego threat occurs during situations that cause a person's self-esteem or self-concept to be negatively challenged (Leary, Terry, Allen, & Tate, 2009). In a study designed to test the effects of anxiety on individuals of differing fitness levels, Calvo et al., (1996) found that even healthy undergraduate students who were put through a physical training regime had elevated heartrates when performing stressful tasks of basic arithmetic, a motor steadiness task, and giving a speech. Athletes, no matter how physically fit they are, or their levels of trait anxiety, have less efficient cardiovascular systems when under stressful conditions, which causes their hearts to have to expend more effort in order to get the body ready to perform.

Increased effort has also been studied by offering monetary incentives. Calvo (1985) and Eysenck (1985) found that low trait anxiety participants increased their performance effectiveness in cognitive tasks when given monetary incentives while high trait anxiety participants' performances were unaffected by incentives. According to attentional control theory (Eysenck et al., 2007), individuals low in anxiety are able to recruit unused processing resources by increasing their effort to improve or maintain performance in order to obtain an incentive. High anxiety individuals, on the other hand, have their spare processing resources occupied by anxious thoughts and task irrelevant stimuli, reducing or eliminating spare processing resources. Increasing effort for high anxious individuals appears to be in vain because extra effort cannot lead to the recruitment of more processing resources due to most of the processing resources already being occupied. Therefore, if a highly anxious golfer is provided a monetary incentive if she makes a difficult putt, it is unlikely that she would be able to improve her performance. This may be because most of her processing resources are occupied by thoughts of failure, the slope of the green, and the movement of the putter. Even if she could increase her effort, the limited spare resources recruited might not be enough to achieve a high level of putting performance.

The third and final type of evidence that supports hypothesis I is that when participants with high anxiety are given a primary task and a secondary probe task, performance on the primary task remains high while their performance on the secondary task suffers (Eysenck, 1989). High anxiety individuals have to use more attentional resources to complete the primary task, leaving fewer resources for the secondary task. These effects of anxiety were noted in a study by Eysenck (1989) where a letter transformation task was used as the primary task and recall of a digit string was used as the probe task. The high trait anxious participants in the study had longer reaction times when completing the probe task while performance on the primary task was similar between groups. The author suggested that the high trait anxious participants had less spare processing resources to devote to the probe task than the low trait anxious participants.

These effects have also been observed in studies where motor tasks were used as the primary task. Williams et al., (2002) had eight male and female participants participate in a table tennis task where the participants had to return balls to specific targets on the table while concurrently completing a secondary task. The secondary task involved the participants responding as quickly as possible to an auditory beep. When anxiety was high, as manipulated by the degree of difficulty of the table tennis task, performance suffered and probe reaction times were slower than when the participants' anxiety was low. In conclusion, a variety of methods have been used to show that performance efficiency is lower when anxiety levels are high. This could mean that even when athletes are able to perform at a high level under stressful conditions, they are becoming less efficient.

Hypothesis II: Negative effects of anxiety on performance are magnified as the task demands on the central executive are increased. The second hypothesis of attentional control theory is that the adverse effects of anxiety on performance increase as central executive demands increase (Eysenck et al., 2007). Individuals can increase effort, thereby reducing processing efficiency, to keep performance levels high (Calvo, 1985; Calvo et al., 1996; Di Bartolo et al., 1997). However, attentional control theory (Eysenck et al., 2007) hypothesizes that if the demands of the central executive are too high, there might not be enough attentional resources available to allocate to the task in order to remain at the same level of performance. When an individual does not possess the required central executive resources required to complete a task, performance becomes adversely affected.

In a study of the effects of anxiety on a verbal reasoning task, Darke (1988) and Richards et al. (2000) found that high and low anxiety groups had similar reaction times when comprehending verbal syllogisms that used less processing resources. As the researchers increased the difficulty of the task to put more demands on working memory, the gap between the reaction times of the high and low groups expanded; high anxiety participants reaction times became longer, which is an adverse effect of anxiety. In another study that manipulated task demands on working memory, Calvo and Carreiras (1993) tested how anxiety affected graduate students' comprehension of text. They found that the influence of anxiety on reading time for the high anxiety group was dependent on the characteristics of the text. High and low anxiety participants both spent the same amount of time reading the start of clauses, when there is less information to hold in the working memory system. As the high anxiety participants progressed through the reading, they took significantly longer to read the end of the passage clauses, where more information was present and the information had to be integrated. Because information from the beginning of the passage had to be integrated with new information obtained later in the text, a higher demand was placed on the central executive in order to comprehend it. In a similar study, Eysenck (1985) used letter transformation tasks of different length to manipulate the demands on working memory. He found that the more letters the participants were required to transform the larger the detrimental effects on performance. The results from these studies provide evidence that as task difficulty increases, so do the negative effects of anxiety. Therefore, athletes who play sports or positions that put high demands on their working memory systems may be more susceptible to anxiety inducing situations.

While the previous researchers manipulated the difficulty of the experimental task to increase the demands of the central executive, Ashcraft and Kirk (2001) used a dual-task design to achieve similar demands. Participants in their study were required to memorize different lengths of digit strings while completing arithmetic problems of varying difficulty. The task was designed so that the researchers could use different length of digit strings to manipulate the load on working memory. When completing the tasks separately, there were no significant effects on the participant's performance of the letter memorization or arithmetic tasks, but participants high in anxiety were significantly less accurate in dual task conditions designed to tax the working memory system.

In conclusion, according to hypothesis II, increasing the demands of the central executive during high pressure competitive situations by either increasing the difficulty of the task or requiring the athlete to do multiple tasks at concurrent times may create situations where anxiety is likely to reduce the efficiency and effectiveness of the athlete. The more taxing the task is on the working memory system, the greater the negative effects of high anxiety.

Hypothesis III: Anxiety negatively affects attentional control by increasing the influence of the stimulus-driven attentional system. Hypothesis III of attentional control theory is that attentional control is impaired by anxiety because anxiety increases the influence of the stimulus-driven attentional system (Eysenck et al., 2007). When a highly demanding primary task and a secondary task are presented, highly anxious individuals will perform worse on the secondary task when the secondary task has less salient stimuli or stimuli of comparable salience because of the high demands of the primary task, but when the secondary task contains stimuli that are more meaningful, performance on the secondary task may increase. Threat-related stimuli become more salient to the stimulus-driven attentional system when anxious. In a study of male university level soccer players, Wilson, Wood, and Vine (2009) found that in high anxiety conditions the soccer players were quicker to fixate on the goalkeeper and spent more time fixated on the goalkeeper. In this study, the goalkeeper was a threatening stimuli because his job was to thwart the performance of the soccer players. It is likely that because the soccer players fixated more on the goalie when under pressure their kicks were located toward the center of the goal, which allowed the goalkeeper to make more saves. This study is an example of how bottom up processing can increase athletes' likelihood to attend to threatening stimuli at the expense of paying attention to task related targets; in this case, the target would have been the corners of the goal. When competing, athletes are surrounded by stimuli that could be considered threatening. Some examples include worrisome thoughts, hostile fans, competitors, or scouts. According to attentional control theory (Eysenck et al., 2007), the presence of hostile stimuli may grab an anxious athletes' attention because of the increased influence of the bottom-up attentional system. When visual attention is influenced by the bottom up attentional system, athletes may lose focus of the stimuli that are important, which can lead to less successful performance (Wilson et al., 2009). As such, it would be beneficial for athletes to find ways that they can lower anxiety, which may decrease the influence of the bottom-up attentional system and allow them to control their vision so they may remain effective.

Hypotheses IV, V, and VI. Hypothesis four, five, and six of attentional control theory together explain that anxiety effects the efficiency, and often the effectiveness, of tasks involving inhibition, shifting, and updating functions (Eysenck et al., 2007). This can be especially true for tasks involving inhibition of threat-related stimuli. If task irrelevant threat-related stimuli are present, more attentional resources are needed to inhibit the threat related stimuli, decreasing processing efficiency. If attentional resources are not enough to effectively inhibit threat-related task-irrelevant stimuli, the individual becomes distracted and performance suffers. These final three hypotheses, however, are beyond the scope of the current study and thus will not be discussed in detail (see Eysenck et al., 2007 for a review).

Gaze as a Measure of Visual Attention

Measuring visual attention by examining gaze patterns is a practical way of testing the assumptions made by attentional control theory that anxiety affects performance efficiency and, if the task puts high demands on the central executive, performance effectiveness (Wilson et al, 2009). Our eyes are sensory organs that pick up light waves and send the gathered sensory information to our brain, where it is interpreted and used to create the images that make up our visual world (Vickers, 2007). Athletes use the information collected from the eyes to plan and execute movements necessary to achieve the goals of their sport. Using visual information to direct motor movement is known as visuomotor control (Vickers, 2007). In the process of visuomotor control, visual information is picked up using the eyes (Kolb & Whishaw, 2001). The pupils expand and contract to let appropriate amounts of light into the eye where the light is focused as it passes through the lens onto the retina. Picking up on the focused light, the visual receptors in the retina convert light into energy. A specific part of the retina, the fovea, is responsible for the 2° to 3° of a visual angle we can see in acute detail out of our entire visual field, which for the average person is about 190° (Vickers, 2007; Wong & Bartels, 2015). For reference, if you fully extend your arm in front of you and give yourself a thumbs up, the area of your thumbnail is about the area that you are able to see clearly and in detail with your fovea (Vickers, 2007). Consequentially, athletes must constantly move their eyes to different focal points to pick up on the details of what is going on in the space around them. In sport, an athlete must choose where to focus her gaze at appropriate times to gather task relevant details while leaving the rest of the visual stimuli around her in the blurry peripherals of their vision or out of sight. Focusing vision on distracting or task irrelevant information during critical gameplay moments could be devastating to and individual's performance or the performance of his or her team (Wood et al., 2009).

Athletes' ability to process light waves and use them to compete in sport, requires a complex process. Once the visual receptors have been stimulated and converted the light into energy, they transmit the information to the occipital lobe, via the optic nerve, where the visual input is processed (Milner & Goodale, 1995). Once processed, the information is distributed to other regions of the brain along the dorsal and ventral pathways to be further processed. Signals are sent from the occipital lobe to the parietal lobe along the dorsal pathway. Once the signals arrive at the parietal lobe, they are used to orient gaze, sustain attention, and direct attention in space (Posner & Raichle, 1994). Also, the parietal lobe processes gaze information that lets us know where our body is in space. The orientation and location of the body in space and coordination of movements require rapid and constant updating by the parietal lobe of information provided by the occipital lobe along the dorsal pathway. Using visual information, the parietal lobe creates a map that athletes use to navigate their playing fields and move their bodies to execute appropriate sport movements (Treisman, 1999). Information is sent from the occipital lobe to the temporal lobe through the ventral pathway. In the temporal lobe, meaning is given to what we see. Visual information is also processed to anticipate what might happen and make plans. Processing in the ventral stream is slower relative to the rapid processing conducted via the dorsal stream (Milner & Goodale, 1995).

Converging in the frontal lobe, information from the ventral and dorsal pathways is used for advanced thinking, planning, and language (Kolb & Whishaw, 2001). Motor movements are planned in the prefrontal cortex, organized in the premotor cortex, and then distributed down the spinal cord to the appropriate efferent motor neurons by the motor cortex (Kolb & Whishaw, 2001). Sensory receptors are then responsible for providing feedback to the brain by sending signals to the basal ganglia and cerebellum to correct any movement errors. Finally, the sensory cortex receives the information that the movement has been executed (Kolb & Whishaw, 2001).

It has been found that when gaze is shifted and focused to a new location it is a reliable indication that attention has shifted to that location, even though once gaze has been oriented to a new location attention may be dissociated from gaze. (Deubel & Schneider, 1996; Vickers, 2007, 2009). A common way of measuring visual attention is through the analysis of foveal fixations using gaze tracking devices. Fixations occur when the detailed gaze of the fovea is held on a location within 3° of a visual angle, due to that being the limit of the amount of the visual field humans can see in acute detail (Carl & Gellman, 1987). Also, gaze must be held in that area for a minimum of 100 ms, which is the amount of time it takes for a person to process visual information or become aware of a stimuli (Carl & Gellman, 1987). *Quiet eye* refers to the specific and final fixation of the fovea with an onset that occurs prior to the initiation of the common motor movement phase critical to the execution of that specific skill (Vickers, 2007; 2009). Offset of a quiet eye fixation occurs naturally when the foveal fixation deviates from the location more than 3° of a visual angle for a duration greater than 100 milliseconds (Vickers, 2007; 2009). Examples of common motor movement phases that must be completed in order to perform a sport task are the backswing in golf putting (Vickers, 1992) and elbow extension (there is often elbow flexion involved in the free throw, but not all players include this in their free throw shooting technique, so it is not considered a common movement movement) in basketball free throw shooting (Vickers, 1996). When moving quickly from fixation to fixation, the eye engages in saccades. Saccades are rapid transitions between fixations and visual information is suppressed when they occur (Vickers, 2007).

Gaze and Skill Level in Far Aiming Targeting

At high levels of sport competition most athletes have logged thousands of hours of physical practice, but there are still discrepancies between athletes in how successful they are at executing sport specific motor movements. Mann et al. (2007) conducted a meta-analysis and found three predictors of expert performance in sporting tasks: quiet eye duration, location of gaze, and a low frequency of fixations. Experts have the ability to control their gaze in a distinct and efficient manner during performance that allows them to acquire spatial information, organize the information using neural structures involved in motor movement, and then execute movements optimally. Fixations of experts have an early onset, long duration, and are focused on task-relevant information before the start of skill specific movements (Vickers, 2011). In research supporting that gaze strategies play a large role in expert performance, Vickers (1996) studied the differences in gaze during free throws between eight expert and eight near expert free throw shooters. During preparation for their shots, the experts focused on the target for longer durations and had less fixations than the near expert group, allowing them to set the parameters of the motor movements required to successfully complete a free throw. The expert group also had significantly longer quiet eye fixations during made free throws. Williams, Singer, and Frehlich (2002) found similar results while comparing skilled to less skilled billiards players. Skilled billiards players had less fixations of longer mean fixation time while preparing billiards shots, and specifically had longer quiet eye fixations, than less skilled players.

While experts tend to have less fixations of longer duration, there is some variance in the types of gaze patterns used by experts depending on the skill that is being executed. For example, Vickers (1996) found that the offset of quiet eye in basketball free throw shooting occurred for expert participants during the upward movement of the hands when the ball was at about chin level. Vickers (1996) inferred that offset of the gaze early in the arm extension was an expert tactic used to suppress the visual information of the hands and ball coming into the visual field of the shooter. The shooter's hands or a moving basketball entering the visual field, if payed attention to, could distract the shooter from the basket or backboard, which are optimal fixation points for free throw shooting. Billiards players did not have the same pattern of quiet eye offset early in the execution phase (Williams et al., 2002). Early offset of quiet eye seemed to be related to far aiming tasks where the execution of the throw or shot involved distracting visual stimuli, such as a hand or ball, entering and blocking the target from the visual field (Vickers, 1996). If the visual field was not blocked and participants were allowed to remain fixated on their target, they tended to remain fixated until the completion of the motor movement (Williams et al., 2002). Therefore, experts appear to have adapted their gaze patterns to their specific skill; therefore, the optimal location, duration, onset, and offset of gaze of each sport specific task needs to be taken into consideration. Knowing what types of gaze patterns lead to high levels of performance effectiveness may allow sport psychology practitioners to develop interventions that train athletes to replicate these expert gaze patterns.

Experts have shown to have earlier onsets and longer quiet eye durations than their near expert counterparts (Vickers, 1996; Vine, et al., 2014; Williams et al. 2002). There are two main theories as to why picking up task relevant visual information early and efficiently may lead to expert performance. The first explains that longer quiet eye durations allow ample time for visual information to be processed to coordinate appropriate and effective movements (Behan & Wilson, 2008; Vickers, 1996; Williams et al., 2002). Vickers (2011) suggested that longer periods of quiet eye displayed by experts allows them to process the appropriate spatial coordinates needed to correctly position the body, effectively and efficiently move, and balance the body during execution. The second explanation is that obtaining visual information efficiently allows for athletes to orient themselves with their environment more effectively, which leads to movements in the correct direction with the correct force (Oudejans et al., 2005). Janelle's (2002) review of the literature also suggests that experts are better able to regulate emotional and physiological fluctuations during pressure situations. No matter what explanation or combination of explanations is accurate, it seems beneficial to train athletes that participate in far aiming tasks to replicate the quiet eye fixations of experts. Identifying the attentional processes and techniques of experts and teaching novices or near experts to replicate expert attentional habits is key to train more effective and efficient athletes in long distance targeting activities (Janelle, 2002).

Gaze Control in Golf Putting

An average 18-hole golf course is designed to be complete in 72 strokes, with approximately half of the strokes devoted to putts, making putting proficiency essential to high quality performance during a round of golf. Putting is an abstract far aiming targeting task, meaning that there are hidden qualities that must be accounted for by a golfer in multiple visual workspaces including his target, the line he wants the ball to travel on, and where he will strike the ball with his putter (Vickers, 2007). The golf putt may seem simple, but it is one of the most sophisticated sport skills, even though the mechanics of the swing can be executed by almost anyone (Vickers, 2004). To test if gaze patterns made a difference in golf performance Vickers (1992) measured where golfers of different skill levels were looking and compared their gaze patterns; 12 tournament golfers ranging in age from 20-65 were included in the study. Five participants were placed in the low handicap (LH) group (mean handicap = 6.2), and seven golfers were put into the high handicap (HH) group (mean handicap = 14.1). The participants were fitted with a gaze tracker and required to putt a ball on astro-turf into a cup three meters away until they had made and missed 10 putts. The participants were given brief rests after the execution of 12 putts. Each putt was broken down in to four phases, preparation, backswing/foreswing, contact, and follow-through. After analyzing 10 missed and 10 successful putts from each participant, data showed that the LH participants had fewer shifts in gaze while spending less time in the preparation phase. The HH participants fixated on more task irrelevant cues while the LH participants narrowed their gaze to a few primary task relevant locations (i.e., the ball, their target, and the line they wished their ball to follow). The LH group fixated on the ball more often and for longer durations, had fewer saccades and fixations to the cup, and fewer fixations on the club than the HH group during the execution of their putts. During the backswing/foreswing phase, the LH golfers had significantly fewer fixations, most notably they only fixated once on the ball for a longer period of time; this phase is where the quiet eye fixation occurs in golf putting (Vickers, 2007). Optimal quiet eye fixation in golf appears to start about two seconds before the beginning of the backstroke and has a late offset after the ball has moved out of the fixations limits. During the contact phase, the participants' gaze, regardless of group, was either tracking the club when it was in contact with the ball or fixated on the surface where the ball once was; the latter pattern was characteristic of successful putts. In the follow-through phase, the frequency of fixations was similar for both groups, but the low handicap golfers spent more time tracking the ball after hitting it.

Vickers (1992) found that low handicap golfers displayed more efficient gaze patterns as shown by their increased fixations on task relevant cues during preparation and backswing/foreswing phases. This allowed the more skilled golfers to prepare their shots faster and fixate on optimal cues, in this case the ball, during the execution of their swing. Vickers

(1992) argued that it is important for golfers to be efficient when using their eyes to pick up information in golf because it helps them prepare and execute their shot faster, which reduces decay of information regarding the location and distance of the hole when they are looking at the ball. If the mechanics of putting are easily executed by anyone, how the golfer picks up visual information that is critical to the planning of the swing by the brain and execution of the swing by the motor system may be the difference between the skill levels of putters.

The Effects of Anxiety on Gaze

As discussed in the previous sections, in far aiming targeting tasks, more efficient gaze patterns consisting of less frequent fixations of longer durations have been linked to increased performance effectiveness, especially increased quiet eye fixation length with an early onset. According to attentional control theory, increased anxiety should cause task-related attentional patterns to become sub-optimal, leading to decreased efficiency of gaze patterns and, if attentional resources are limited, decreased performance effectiveness in targeting tasks (Eysenck et al., 2007).

Anxiety reduces gaze efficiency. In a review of literature, Janelle (2002) concluded that gaze patterns become less efficient when anxiety is elevated. The effects of elevated anxiety on gaze were seen in a study of 22 video game novices participating in an archery video game targeting task (Behan & Wilson, 2008). Once the participants could complete the task at a high standard in practice, they took part a high anxiety condition. To increase anxiety, the researchers told participants that their scores would be posted on leaderboards, their scores would be used to determine if their team received a monetary prize, and their performance was a good indication of their hand eye coordination, and low anxiety condition, where they were told their scores would be kept private and the purpose was to test the eye tracking equipment, in a counterbalanced sequence. When anxiety was high, as measured by administration of the Competitive State Anxiety Inventory-2 (CSAI-2) before each condition, participants' quiet eye durations decreased. Quiet eye was found to be shorter during inaccurate shots compared to accurate shots and shorter during high anxiety conditions when compared to low anxiety conditions. Unlike most of the other literature concerning anxiety's effects on gaze, the researchers did not measure all fixations; they only measured quiet eye. These results indicate that under pressure, quiet eye duration may become shorter, which can have negative outcomes for performance (Behan & Wilson, 2008).

To better understand how pressure influences quiet eye duration and to examine if reduced quiet eye duration explains misses in a shootout golf putting task, Vine et al., (2013) conducted a study on 50 expert right handed golfers. The participants had a mean handicap of 3.6. In a shootout putting task, participants were asked to putt from a distance of five feet until they missed a shot. This format of task, combined with monetary incentives and ego threat, provided a situation that significantly increased participants' anxiety during the task compared to their baseline measures of anxiety. The researchers compared the gaze of each participant's first putt, penultimate putt, and final missed putt. Quiet eye duration was significantly longer during the first and penultimate putts, compared to the final missed putt. Quiet eye duration did not differ during the preparation phase of the putt, but it was significantly shorter during the backstroke and forward stroke phase of the final missed putt. These findings support other research in that the determined that quiet eye is shorter during unsuccessful shots. The results also imply that anxiety may cause performers to shorten quiet eye duration by taking their gaze off the ball too early, which may lead to performance decrements under pressure (Vine et al., 2013). Once again, the results suggest that having optimal quiet eye fixation duration may be a characteristic of successful performance under pressure.

Anxiety seems to not only affect the efficiency of a single quiet eye fixation, but also reduce the efficiency of gaze and movement while completing markedly longer tasks. In research performed by Nieuwenhuys et al. (2008), participants had to complete a rock climbing traversing task. Two identical climbing courses were presented, but one was much higher off the ground and caused significant increase in anxiety and heartrate. Participants in the high anxiety condition took longer to complete the course, had less efficient movement patterns, decreased fixation duration, and increased number of foveal fixations while successfully completing the task (Nieuwenhuys et al, 2008). There was no change in performance effectiveness between groups, as all participants completed each task, but efficiency of gaze patterns and time taken to execute the task was significantly reduced in the high anxiety conditions. The reduced efficiency of the participants in multiple measurements, supports attentional control theory's hypothesis that anxiety can reduce performance efficiency while performance effectiveness stays consistent (Eysenck et al., 2007). These findings suggest that there is a relationship between efficient gaze patterns and efficient movement patterns. Also, it can be deduced from these research findings that less efficient movements may be detrimental, and even dangerous in sports like rock climbing where muscle endurance is needed, because athletes may waste energy by making unnecessary movements and paying attention to task irrelevant information.

Of particular interest to the current research are the effects of anxiety on gaze during the preparation and execution of far aiming targeting skills. In a study of the effects of anxiety on gaze free throw shooting, Wilson, Vine and Wood (2009) measured the anxiety, fixations, and quiet eye of 10 male university basketball players during high and low anxiety conditions during different phases of free throw shooting. After initial practice rounds of 30 free throws total, the participants were fitted with an eye tracker and took pairs of free throws with small breaks in between to simulate in game conditions, where, more often than not, free throws are taken in groups of two. Participants shot until they had made and missed 10 free throws. Anxiety was manipulated in counterbalanced high threat and control conditions. In the control condition, participants were told to do their best but their performance would not be compared to other participants. In the high threat condition, several manipulations were used to increase anxiety including comparison to teammates and other teams in their league, financial rewards, and feedback that their practice free throw percentage was in the bottom 30% of the participants in the study. The manipulations used were successful, as state cognitive anxiety and state somatic anxiety were both increased and self-confidence was decreased in the high threat condition as measured using the Mental Readiness Form-3. Analysis of the gaze tracking information showed that the participants had significantly increased number of fixations that were shorter in duration and significantly shorter quiet eye fixations in the high threat condition. The high threat condition caused quiet eye duration to significantly decrease, which was characteristic of missed shots. Quiet eye was also significantly longer on made free throw than missed free throws in both conditions. While the previously discussed study of Behan and Wilson (2008), provided evidence that anxiety can reduce quiet eye efficiency in a virtual task, Wilson, Vine, and Wood's (2009) study supported the finding that anxiety has effects on gaze efficiency in conditions designed to simulate game situations during a sport related task. On a more positive note, when athletes used efficient gaze patterns, the detrimental effects of anxiety on their performance effectiveness were negated.

Biathlon shooting is another far aiming targeting skill where the effects of anxiety have been tested. Biathlon athletes mix high intensity cardiovascular exercise with rifle shooting, an obvious far aiming targeting task. In a study of 10 members of Canada's junior and senior biathlon teams, Vickers and Williams (2007) tested the effects of anxiety and exercise induced physiological arousal on rifle marksmanship performance. In the high pressure condition the participants' coach was present and the participants were told the data would be used for team selection. In the low pressure situation they were told gaze information would be used to give them information about where they were looking. During trials where pressure was high and the athletes exercised at a greater percentage of their maximum oxygen intake, or power output, their quiet eye duration decreased, causing a decrease in shooting accuracy. During trials where pressure was high but power output was low, non-choking athletes had shorter quiet eye duration, suggesting some sort of automatic response by experts. Once power output was increased to 100% in the high pressure condition, quiet eye increased for the athletes that did not choke. Results from this study suggest that pressure situations combined with high power output, common in elite sporting events where high endurance is needed, can have detrimental effects on performance. Also, having efficient gaze patterns can help athletes avoid choking in high pressure situations where physical exhaustion may be setting in.

Anxiety causes increases fixation to task-irrelevant and threatening stimuli. The previous studies indicate that gaze efficiency is reduced when anxiety levels are elevated. However, the previously described studies did not assess what makes athletes' gaze patterns inefficient, which is useful to understand. To help clarify the cause of inefficiency, Wilson, Wood, and Vine (2009) studied university level male soccer players' visual attention in a threatening situation. In the high threat condition, where the players were told there would be a monetary incentive for the best score and that scores would be shared between all participants, the participants had more fixations and there was an increase in the speed they first fixated on the goalie. They spent more time fixated on the goalie, a threatening stimulus considering his job was to keep the players from accomplishing their goal of scoring, than the corners of the goal, which were considered task relevant stimuli and the optimal fixation point by the researchers. Subsequently, when threat was high, participants tended to kick the ball closer to the center of the net, near the goalie. The results of this study suggest that not only does anxiety increase the likelihood of athletes being distracted by threatening stimuli, but attending to threatening stimuli can cause motor movements to be influenced in negative ways by those threatening stimuli.

While threatening stimuli become especially salient to athletes with high anxiety, non-threatening task-irrelevant stimuli can be distracting when anxiety is elevated. Using a flight simulation task, Allsop and Gray, (2014) found that participants with high anxiety, as measured by the CSAI-2 Revised (Cox, Martens, & Russell, 2003), spent more time with their gaze focused on the external world (which was not relevant to successfully landing the plane in the simulation) and their scan patterns of the plane controls became more random. These results support the assumption of attentional control theory that increased anxiety increases the influence of the stimulus-driven attentional system and decreases the influence of the task-driven attentional system in athletes, causing anxious individuals to sometimes focus on task-irrelevant stimuli (Eysenck et al., 2007). These distracted gaze patterns can be considered less efficient because they it requires increased effort to move the eyes to more fixation points when fixation number increases and fixation duration decreases. Also, having more fixations of less duration means that more eye movements are required to get the information required to complete the task (Vickers, 1992).

Anxiety, which is common in sporting situations (Lazarus, 2000), appears to reduce the efficiency of gaze patterns, which leads to suboptimal performance (Behan & Wilson, 2008; Wilson, Vine & Wood, 2009; Vine et al., 2013). The increased influence of the stimulus-driven attentional system has been shown to increase fixations to threatening and task-irrelevant information, which is distracting (Allsop & Gray, 2014), and causes motor movement coordination to be adversely affected (Wilson, Wood, & Vine, 2009). These findings provide support to attentional control theory's hypotheses (Eysenck et al., 2007). Also, important to note is that research suggests that efficient gaze patterns have protective effects against the deleterious effects of anxiety on gaze efficiency and performance effectiveness, which, according to attentional control theory (Eysenck et al., 2007), are caused by anxiety's effects on the central executive (Behan & Wilson, 2008). The next section will outline researchers' attempts to study the effects of training athletes to have more efficient gaze patterns.

Quiet Eye Training

To replicate the efficient gaze patterns of experts, research has been conducted on quiet eye training. Quiet eye training involves showing an athlete the differences in gaze patterns between him and an expert and then having her practice replicating the gaze patterns of the expert. Harle and Vickers (2001) conducted research on quiet eye training on three Canadian university basketball teams. Team A was trained to replicate expert patterns of quiet eye in their pre-shot free throw routine while two other teams were used as controls. After six months of practice using quiet eye training, a posttest was conducted. Team A's quiet eye durations were significantly longer in the posttest when compared to pretest, and quiet eye duration was significantly longer on made versus missed free throws. In a similar study, Vine, Moore, and Wilson (2011) randomized 22 elite golfers with an average handicap of 2.78 into quiet eye training and control groups. During retention tests, the quiet eye trained group had significantly longer quiet eye durations than the control group. The trained group's putts were significantly closer to the hole than the control group and they holed more putts than the control group, even though the latter results were not statistically significant. Based on these findings, mimicking the gaze patterns of experts shows promise in increasing performance in lab and practice settings.

The effects of quiet eye training seem to transfer from laboratory settings to competitive performance. All three teams that participated in Harle and Vickers' (2001) quiet eye training research had their competitive free throw percentages compared over two seasons. Between the first and second season, Team A's free throw percentage improved drastically compared to the other two teams. These results indicate that the effects of quiet eye training can transfer from lab settings to competitive situations, even though other factors such as team turnover and practice differences could have played a role in the free throw shooting percentage disparity between teams. The transfer was also seen in elite golfers competitive putting. Those trained in quiet eye had significantly fewer putts per round within three months after completing quiet eye training compared to the control group that showed no significant changes in putts per round (Vine et al., 2011).

Providing athletes with knowledge of how elevated anxiety contributes to decreased performance in far aiming tasks and training them to execute expert-like visual behavior has the opportunity to reduce the negative effects of anxiety (Janelle, 2002). The effects of training to increase quiet eye were examined in 40 undergraduate students during a putting task. Participants who were trained to have longer quiet eye periods displayed longer quiet eye duration and less performance error, as measured by distance from the hole to their ball, than a technically trained group when under pressure, showing the protective effects of increased quiet eye duration on the negative effects of anxiety on performance (Moore, Vine, & Wilson, 2013). Under pressure, golfers trained in quiet eye had significantly longer quiet eye duration than a control group (Vine et al., 2011). The control group also holed significantly fewer putts and had greater error under pressure while the experimental group's performance remained the same in pressure conditions.

To better understand the underlying processes that quiet eye training contributes to performance and learning, Moore et al. (2012) conducted research using a putting task with 40 undergraduate novice participants. During retention tests, the group with quiet eye training had significantly longer quiet eye durations, holed more putts, and had a lower radial error than the technically trained group. In pressure conditions, the quiet eye trained group had little change in quiet eye duration, leading to similar performance in both the distance of their missed putts and the number of putts they made. The technically trained group had significant decrease in quiet eye durations, and when they missed, their ball ended up further from the hole compared to retention conditions. The quiet eye trained group had longer quiet eye durations and holed more puts compared to the technically trained group during pressure situations (Moore et al., 2012). These results support findings from previous studies showing that longer quiet eye durations may lead to better performance outcomes in retention and pressure situations (Moore et al., 2012; Moore et al., 2013, Vine et al., 2011). Adding to the literature, the authors found that longer quiet eye periods led to better performance kinematics, or more efficient movement, which moderated the quiet eye, performance relationship. The authors also found that longer quiet eye was related to decreased muscle tension and decelerated heartrate (Moore et al., 2012). Quiet eye training is a direct way to help athletes improve their performance effectiveness. Unfortunately, it requires athletes to have access to expensive eye tracking equipment and analysis of experts' gaze patterns. The latter becomes even more difficult considering that expert gaze patterns have only been studied in a select group of skills from a small number of sports.

External focus of visual attention has been shown to cause more efficient fixation patterns, but only if it is directed toward the right informational cues. This makes it especially necessary to study the gaze patterns of experts before quiet eye training is implemented for all skills. In a study of 72 novice putters, one group was instructed to focus their gaze on the putter, an external focal point, while the other group was instructed to focus their gaze on their hands, an internal focal point (Ziv & Lidor, 2015). The participants who were instructed to focus on external cue of the putter showed more efficient gaze patterns, which consisted of longer quiet eye duration and less fixations. However, their performance effectiveness, as measured by the average distance of their balls from the hole, did not improve (Ziv & Lidor, 2015). One reason their performance may not have improved despite more efficient visual attention may be because these participants were instructed to focus on the moving putter head. Focus on the ball is considered the optimal focus point in golf putting tasks (Vine et al., 2007; Vickers, 2007). Similar limitations were observed in a study of nine expert, nine advanced, and nine novice basketball players (Rienhoff et al., 2014). Each group was told to focus on their hand (internal focus) or on the ball (external focus) during a free throw shooting exercise. The researchers expected that external focus instructions would lead to longer quiet eye and better performance, but their findings were reversed, likely because external focus on the ball is not the optimal fixation point considering. Instead, Vickers (1996) found that quiet eye fixation on the rim or backboard was the optimal fixation point for free throw shooters. In fact, it was found that performance suffered if free throw shooters did not suppress visual information when the hand or ball came into the visual field because it was distracting. Telling the participants to focus on the ball actually distracted them from focusing on the optimal fixation point of the rim. It seems that longer quiet eye duration, which is one of the main goals of quiet eye training, fixated on external cues appears to only be helpful if the right cues are attended to. Having athletes focus their visual attention on the wrong stimuli can be detrimental to their performance, even with optimal fixation patterns.

The evidence that increasing the efficiency of gaze patterns can help improve or maintain performance in self-paced sporting tasks in lab, competitive, and anxiety inducing situations has important implications. Unfortunately, gaze tracking equipment is expensive and new, and is therefore unavailable to most athletes. It would be beneficial to find inexpensive and practical ways to help athletes improve the efficiency of their gaze without the use eye tracking technology. If anxiety is reducing the efficiency of gaze, psychological interventions used to reduce anxiety may be able to reverse the negative effects of anxiety on gaze.

Controlled Breathing

Throughout this review, evidence has been provided that efficient gaze patterns are predictive of high levels of performance effectiveness in many different types of sporting tasks, specifically far aiming targeting tasks (Vickers, 2007). Attentional control theory (Eysenck et al., 2007) hypothesizes that when anxiety is increased, task efficiency is decreased due to the increased influence of stimulus-driven attentional system. The negative effects of increased anxiety, as predicted by attentional control theory, have been seen in gaze tracking studies where increased anxiety resulted in decreased gaze pattern efficiency (Allsop & Gray, 2014; Vickers & Williams, 2007; Vine et al., 2013; Wilson, Vine, & Wood, 2009). Fortunately, the literature also supports that quiet eye training, an intervention designed to promote efficient gaze patterns, can be applied to help protect athletes from the deleterious effects of increased anxiety on gaze

(Harle & Vickers, 2001; Moore et al., 2012; Moore et al., 2013; Vine et al., 2011; Vine et al., 2014). While quiet eye training appears to be an effective way to train athletes to use more efficient gaze patterns, not all athletes have the technology or access to expert gaze patterns required for this intervention. Other possible ways of increasing gaze efficiency that are more economical and practical need to be explored.

If increased anxiety has deleterious effects on gaze efficiency (Vickers, 2007), reducing anxiety may promote efficient gaze patterns. At present, there is no published research that directly examines whether or not anxiety reducing psychological interventions affect gaze efficiency. If it was found that athletes could increase their gaze efficiency by using relaxation interventions, such interventions may be a practical substitute to quiet eye training when access to the resources required to apply quiet eye training are limited. With research data suggesting that training efficient gaze patterns can lead to increased performance effectiveness and faster learning of sport specific skills than technical training (Moore et al., 2012), reducing anxiety to increase gaze efficiency might become a primary goal of coaches and athletes.

There are numerous anxiety reduction techniques available for athletes to use (Williams & Krane, 2015). Because of the multidimensional nature of anxiety, it is suggested that different techniques should be used to manage the multidimensional symptoms of competitive anxiety (Gould & Udry, 1994; Tomas, Mellalieu, & Hanton, 2009). Due to this recommendation, often researchers who test the effects of psychological skills training on performance incorporate multimodal relaxation interventions into their research designs (Mesagno & Mullane-Grant, 2010). While this is can be a strength of the research methodology, because a combination of psychological skills are often taught to athletes in applied settings, it can also limit the findings of the research because it is difficult to determine which interventions influenced the results.

When multimodal interventions are used it is unclear if all, some, or only one of the interventions affected anxiety or performance. Therefore, the current study will isolate one anxiety reducing intervention, a single deep breath, to test its effects on anxiety, gaze efficiency, and performance.

Yoga breathing. Much of the research on the effects of controlled breathing comes from the study of yoga techniques (Telles & Naveen, 2008). Yoga originated in ancient Indian culture as a way to promote physical, mental, intellectual, and spiritual health. A common part of yoga practice is a focus on controlling the breath, which is called pranayama (Telles & Naveen, 2008). Pranayama vary in the depth of breath, rate of breath, how long the breath is held, the nostril breathed through, if a sound is made during the exhale, or if the breath is taken though the mouth (Telles & Naveen, 2008). Modern research has indicated that yoga breathing can help manage symptoms of anxiety and stress in both clinical (Brown & Gerbarg, 2005; Uebelacker & Broughton, 2016) and non-clinical populations (Monnazzi, Leri, Guizzardi, Mattioli, & Patacchioli, 2002). Pranayama also appears to increase feelings of well-being (Harinath et al., 2004). Jerath, Edry, Barnes, and Jerath (2006), theorized that low frequency controlled pranayama promotes relaxation by influencing the autonomic nervous system. They explained that slow breathing modulates the autonomic system by activating receptors in and around the lungs that respond to the lungs stretching, which inhibits neural activity. The body's response to breathing increases the dominance of the parasympathetic nervous system and decrease the dominance of the sympathetic nervous system, which promotes relaxation (Jerath et al., 2006). Increased influence of the parasympathetic nervous system can affect the eyes in many ways, most of which are beyond the scope of this study (see McDougal and Gamlin, 2015 for review). In addition, pranayama has been shown to affect the eyes by increasing the influence of the parasympathetic nervous system (Backon, Matamoros, & Ticho, 1989). Currently, no links to gaze efficiency and increased parasympathetic nervous system activity have been directly made. It may be possible that relaxation achieved by controlled breathing could affect gaze efficiency.

With research findings suggesting that pranayama practices can lower stress and anxiety, other researchers have tested if yoga breathing can reduce anxiety and increase performance simultaneously. Malathi and Damodaran (1999) tested the effects of yoga on test anxiety and test performance in 50 students with no yoga experience. Half of the participants completed one hour of yoga practice (three times a week, for three months), which involved meditation, prayer, yoga postures (ansas), and pranayama. The other half of the participants only completed school work. Students in the yoga group had significant reductions in anxiety one month before and on the day of their exam; while the control group did not have any significant changes in their mean anxiety scores. The yoga group also had significant reduction in the number of group members that failed the exam when compared to the control group, suggesting that the practice of yoga not only reduce their anxiety but also aided their performance on the test. Although findings of Malathi and Damodaran (1999) do provide some supporting evidence that yoga breathing can lower anxiety and increase cognitive performance, yoga practice was not limited to only yoga breathing. The participants completed other components of yoga (e.g., putting their body into specific yoga positions). Also, other confounding variables, such as the amount of time studied or presence of other life stressors, could have affected the outcomes.

Other studies have isolated the practice of pranayama to test its effects on anxiety and performance. Telles, Yadav, Kumar, Sharma, Visweswaraiah, and Balkrishna (2013) recruited 90 participants with high blood pressure from an Indian hospital to test the effects of alternate nostril yoga breathing (ANYB) on blood pressure, as a measure of autonomic nervous system activity, and performance. The participants randomly assigned to one of three groups: ANYB, breath awareness, and control. Participants completed the Purdue pegboard task, which tests motor coordination and attention, followed by a ten-minute intervention, then a second completion of the pegboard task. During the ten-minute intervention, the ANYB group was instructed to alternate plugging one nostril while taking a breath in and out of the other. The average duration of inhalation and exhalation for this group was 3.4 seconds and 5.6 seconds respectively. Participants in the control group read a magazine, and participants in the breath awareness group focused their attention on their breathing, but did not alter it. The researchers found that systolic blood pressure decreased for the ANYB and breath awareness group while diastolic blood pressure was reduced for only the ANYB group (Telles et al., 2013). It was speculated that the decreased blood pressure of the participants indicated that practicing ANYB increased the influence of the parasympathetic nervous system creating a relaxing effect. Participants in the ANYB also increased their performance while completing the pegboard task with their right hand and both hands, providing some evidence that ANYB helped increase motor coordination and attention, which are variables that could be beneficial to sport performance.

Other researchers have tested the effects of breathing strictly though one nostril. Telles, Raghuraj, Maharana, and Nagendra (2007) had 26 males with at least three months of yoga breathing experience participate in four different yoga breathing techniques. Researchers then tested participant performance on a letter cancellation task. The techniques included right nostril yoga breathing, left nostril yoga breathing, alternate nostril yoga breathing, and breath awareness. Each participant completed one of the four techniques for 30 minutes on four consecutive days. The participants completed the letter cancellation task once before their breathing session and once after. Participants had significant improvement in their performance on the word cancellation task after completing the alternate nostril breathing and right nostril breathing. Another study conducted by Jella and Shannahoff-Khalsa (1993) found that their undergraduate participants were able to significantly increase their scores on a spatial rotation task when practicing left nostril breathing. Participants were also able to increase their performance on a verbal analogy task after practicing right nostril breathing. The authors of these studies suggest that controlling which nostril is breathed through can have different effects on the autonomic nervous system and performance (Jella & Shannahoff-Khalsa, 1993; Telles et al., 2007). They contend that breathing through the left nostril influences the right side of the body, stimulating the parasympathetic nervous system and increasing performance on spatial tasks associated with the right hemisphere of the brain. Breathing through the right nostril is suspected to increase activity of the sympathetic nervous system and increase performance on verbal tasks associated with the left hemisphere of the brain.

The theory that forced breathing through one nostril can affect performance has been debated. Klein, Pilon, Prosser, and Shannahoff-Khalsa (1986) found that participants' performance on verbal and spatial tasks was related to what nostril was dominant, or less congested, at the time they were tested, not which nostril breath was forced through. Nostril dominance appears to be cyclical, with the dominant nostril alternating ever few hours. The researchers' findings did support that left nostril dominance was associated with higher performance on the spatial task and right nostril dominance was associated with higher performance on verbal tasks.

In sum, research on the ancient practice of yoga pranayama suggests that it is an effective way to increase performance and reduce anxiety symptoms. Based on the practice of pranayama techniques, more modern versions of controlled breathing that are standardized to provide similar effects have been created. Some of these techniques are discussed below.

Heart rate variability biofeedback. Research has shown that the controlled breathing component of yoga can affect physiological and psychological processes as well as performance (Jella & Shannahoff-Khalsa, 1993; Telles et al., 2007). However, there is large variation between yoga breathing techniques, which makes pranayama application problematic. A more modern form of standardized controlled breathing created by Lehrer, Vaschillo, and Vaschillo (2000) called heart rate variability biofeedback (HRVB) has been shown to have similar positive effects on anxiety and performance as pranayama.

The term heart rate variability refers to the variation in the length of time between heart beats (Lehrer et al., 2000). Heart rate varies due to complex reactions to physiological and psychological stimuli, with autonomic nervous system activity playing a large role (Pumprla, Howorka, Groves, Chester, & Nolan, 2002). The parasympathetic division of the autonomic nervous system slows heart rate, while the sympathetic division increases it. During HRVB, individuals are shown their heart rate data and then use controlled breathing to try to maximize their respiratory sinus arrhythmia (RSA). During inhalation, heart rate increases and during exhalation, heart rate decreases, creating a smooth oscillation in heart rate. This oscillation in heart rate caused by controlled respiration is known as RSA. Maximized RSA is characterized by high amplitude smooth oscillations in heart rate. For most healthy adults, breathing at a frequency of six breaths per minute provides the maximum oscillations in RSA (Lehrer, Vaschillo, and Vaschillo, 2010). Rhythmic high oscillations in RSA are characteristic of a balanced autonomic nervous system that can respond to the demands of the environment, while erratic low oscillation heart rate variability can indicate physical or psychological disorders (Gevirtz, 2013).Changes in heart rate variability measured at high frequencies (approximately 0.25 hz) are characteristic of parasympathetic activity; changes in heart rate variability measured at low frequencies (approximately 0.1 hz) are mediated by the baroceptor reflex and sympathetic activity (Pumprla et al., 2002).

To test how specific respiratory rates affect heart rate and heart rate variability, Song and Lehrer (2003) recruited five healthy female volunteers to breath at different frequencies while their heart rates were measured. Participants completed either 21 or 24 sessions of four breathing tasks. Each task consisted of participants breathing at a certain frequency paced by a moving bar, with a two to five minute break between each task. Breathing frequencies of 3, 4, 6, 8, 12, and 14 breaths per minute were used. The results showed no difference in participants' mean heart rate at different breathing frequencies; however, minimum heart rate was significantly lower and the low frequency amplitude of heart rate variability was greater at lower rates of breathing. The fact that there were no differences in heart rate when breathing at different frequencies suggests that participants' sympathetic activity was not increased. Increase in RSA amplitude at lower frequencies of breathing, with the peak amplitude occurring at 4 breaths/minute, suggests increased parasympathetic activity. In similar studies by Vaschillo, Vaschillo, and Lehrer (2006), it was found that participants of different ages, sex, and health status achieved maximum oscillation RSA, which is called "resonant frequency", when breathing at frequencies close to six breaths per minute. Combined, the results from these studies suggest that, while there is variance between individuals as to what breathing frequency causes homeostasis in the autonomic nervous system, most people achieve resonant frequency when breathing at a frequency of four to six breaths per minute. As such, it seems logical to teach this breathing rate to athletes to help them achieve balance in their nervous system.

In HRVB, individuals control their breathing to create rhythmic high oscillation RSA that indicates autonomic nervous system adaptability and homeostasis (Lehrer et al., 2000). Lehrer et al. (2000) stated that it is important to use biofeedback rather than simply telling people to breath at a frequency of six breaths per minute to achieve resonant frequency because of the differences between individuals. The original design of HRVB consists of 10 sessions that involve determining and individual's resonant frequency, teaching them diaphragmatic breathing, then learning to control RSA with their breath to achieve their resonant frequency (Lerher et al., 2000). Of importance to the success of HRVB is having participants correctly execute diaphragmatic breathing. Lehrer et al.'s (2000) instructions for diaphragmatic breathing included teaching individuals to draw air into their belly using their diaphragm, while having most of the movement from the breath come from the belly and not the chest or shoulders. Training also includes inhaling through the nose, exhaling through pursed lips, and having an exhale that is longer than the inhale. This type of breathing is then synchronized with a biofeedback machine that displays the oscillation in RSA.

The effect of HRVB on anxiety and stress management has been examined. In a study of 18 males in senior management positions who perceived high life stress, participants were placed into HRVB and control groups (Prinsloo, Derman, Lambert, & Rauch, 2013). The HRVB group was trained to maximize their RSA while the control group was given random wavelike feedback about their heart rate. A week later, the participants returned to complete measures of trait anxiety, state anxiety, and relaxation states and participate in a stress-inducing task. The experimental task involved a pre and post intervention modified Stroop task with a working memory component of counting squares that appeared on the computer screen during the task. The participants completed their respective interventions for 10 minutes in between the modified Stroop tasks. Statistically significant effects for time on state anxiety were found in both groups, suggesting that both groups were able to reduce their state anxiety even though they participated in a stress-inducing task. The HRVB intervention had a large effect on state anxiety while the control intervention had a medium effect size on state anxiety, suggesting that the experimental intervention was more effective at reducing state anxiety than breathing without biofeedback. Significant differences in the interaction between group and time with large effect sizes for HRVB was found on the relaxation states of mindfulness, energized and positive feelings, and basic relaxation, all of which increased for the HRVB group compared to the control group. Even though this study had a small sample size with an unrepresentative population, the anxiety reducing effects of HRVB were shown. It is also important that the anxiety reducing effects were found in individuals who had never participated in HRVB after only 10 minutes.

The relaxing effects of HRVB were also found in a study on male and female singers, and musicians (Wells, Outhred, Heathers, Quintana, & Kemp, 2012). The musicians were randomized into a HRVB, slow breathing without feedback, and control groups. The participants completed difficult musical tasks depending on their specialty. Anticipation, presence of recording equipment, and difficulty of the task were designed to increase participant stress and anxiety. Increases in state anxiety scores showed that the manipulation was successful. After completion of the first performance phase, each participant completed an intervention phase lasting 30 minutes. The HRVB group was given instructions on how to use diaphragmatic breathing to control their heart rate, the deep breath group was instructed to breath at a rate of 10 breaths per minute without biofeedback, and the control group read preferred material. After the intervention, the groups participated in a post intervention testing that was the same as the pre-intervention anticipation and performance phases. Analysis of the data revealed that both slow breathing groups were able to significantly decrease their state anxiety during the stressful task and had higher RSA amplitude than the control group, even though the intervention groups had higher trait anxiety to begin with. These results are promising as participants from both groups were able to decrease their anxiety after one session of HRVB. Also, it is important to note that deep breathing without the presence of a biofeedback machine had relaxing effects because athletes often do not have access to biofeedback machines before or during performance, and must rely on pacing their breath to reduce their anxiety.

Overall, research findings support the anxiety reducing and relaxation promoting effects of HRVB and diaphragmatic breathing at a rate of 10 breaths per minute without biofeedback. This suggests that applying this intervention to athletes may help them manage their anxiety and relax in stressful sporting situations without extensive training. It is also of note that controlled breathing at rates of 10 breaths per minute without the use of feedback managed anxiety levels in a relatively short amount of time, supporting the use of diaphragmatic breathing as a brief relaxation intervention.

The effects of HRVB on athletes have also been tested. Paul and Garg (2012) recruited 30 male and female basketball players ranging in age from 18-28 years. The participants were randomly assigned into three equal groups: An experimental group that received HRVB training, a placebo group that watched motivational video clips, and a control group with no training. The participants in the HRVB group practiced HRVB for 20 minutes on 10 consecutive days, the placebo group watched 10 minutes of motivational basketball clips for 10 consecutive days, and the control group continued their normal practice schedule. The researchers found that the HRVB group had significantly lower state and trait anxiety, which lasted for one month after the end of the training, and they were able to increase their heart rate variability. The HRVB group also significantly improved their performance of shooting, dribbling, and passing tasks compared to the other groups.

Golf performance also has shown to be affected by HRVB, which is of particular interest to the current study. Lagos et al., (2008) conducted a case study on the effects of HRVB on performance, mood, and physiology. The participant was a 14-year-old golfer who was competing in high school. His 18 hole competitive round average score was 91 strokes, which was much higher than his practice round average of 70 strokes. The participant attributed his poor competitive performances to high levels of stress and anxiety. The participant completed 10 weeks of HRVB. The participant's mood was measured using the Profile of Mood States and CSAI-2. His heart rate, breathing, and average score per round were also measured. From the start of his training to week 10, there were reductions in negative mood states and anxiety, and the participant's total heart rate variability increased. Also, his performance improved from an average of 91 strokes to an average of 76 strokes in competitive rounds. Overall, the participant was able to improve his mood, manage his anxiety, improve the balance of his autonomic nervous system, and improve his performance with no technical golf instruction by controlling his breathing.

Adding to the evidence that controlled breathing can aid golf performance, Lagos et al. (2011) conducted a case study on a 21-year-old, female, NCAA Division I golfer. The participant completed the 10-week HRVB training. A virtual reality golf task was used as a measure of performance. Resonant frequency was achieved for the participant at approximately six breaths per minute. After HRVB training, the golfer had reduced somatic and cognitive anxiety scores, reduced stress levels within and outside of sport, reduced sensation-seeking tendencies. Physiological measures indicated increased parasympathetic activity by reduced average heart rate and increased high frequency heart rate variability. Reduced sympathetic activity was also observed by the ratio of low frequency to high frequency heart rate variability shifting to lower levels. Performance was also increased as the participant decreased the number of total strokes and putts while increasing her average driving distance and longest drive. The authors concluded that HRVB can improve performance, physiological factors, and psychological factors in golfers. While the evidence is limited to two case studies (Lagos et al., 2008; Lagos et al., 2013), HRVB shows promise as a tool for aiding athletic performance and helping athletes manage their anxiety levels.

Current Study

Managing anxiety is important for athletes because elevated anxiety levels during competition can negatively affect the processing efficiency of working memory, which can lead to decreased performance (Eysenck et al, 2007). Decreased efficiency can be observed by the measurement of fixations, which can give insight into where athletes are allocating their attention (Deubel & Schneider, 1996). When anxious, athletes tend to have less efficient gaze patterns that reduce their ability to perform under pressure (Behan & Wilson, 2008; Wilson, Vine & Wood, 2009; Vickers & Williams, 2007; Vine et al., 2013; Wilson, Wood, & Vine; 2009). While the effects of increased anxiety on gaze have been tested, no research has tested the effects of anxiety reduction interventions on gaze. Controlled slow breathing has been shown to reduce anxiety and increase performance (Lagos et al., 2008; Lagos et al., 2013; Lehrer et al., Paul & Garg, 2012). The current study was the first to test if a diaphragmatic breathing intervention affected the gaze efficiency of novice golfers during competition. It is possible that reducing anxiety could lead to increased efficiency of gaze, which could aid performance.

For the current study, a diaphragmatic breath intervention modeled after Lehrer et al.'s (2000) abdominal breathing instructions was used and participants breathed at a frequency of six breaths per minute. This frequency was chosen because it is often the resonant frequency for healthy individuals (Vaschillo et al., 2006). Effective breathing uses the diaphragm. Diaphragmatic breathing is considered a muscle to mind technique of relaxation, meaning that the main objective of the intervention is to reduce muscle tension, which provides feedback to the brain that anxiety has been reduced (Williams & Krane, 2015). While the main purpose of diaphragmatic breathing is to promote somatic relaxation, there is evidence of cross over effects, where attempting to reduce one dimension of anxiety is likely to also reduce the other dimension (Tomas et al., 2009). Breathing is a physiological system that athletes are able to control. Deep diaphragmatic breaths can be an easy, quick, and common intervention used to illicit the relaxation response and reduce anxiety before or during competition (Mason, 1980). Diaphragmatic breathing has been included in studies for anxiety reduction, but as mentioned before, it has often been included as one component of a multifaceted pre-performance routine. In one of the only studies where an isolated deep breath pre-performance routine was implemented, participants in the deep breath group were able to improve their average score in an Australian football kicking task from 147 in in the low-pressure phase to 149 in the high-pressure phase of the study while participants in a control group saw their scores decline under pressure (Mesagno & Mullane-Grant, 2010). Mesagno & Mullane-Grant's (2010) study provided evidence that adding a deep breath to an athlete's pre-performance routine can have beneficial consequences. One limit of Mesagno & Mullane-Grant's (2010) study that the current study will address is that only precompetitive anxiety was measured. Without knowing the anxiety levels of the participants after taking their breaths it is unclear if the deep breaths or another factor affected anxiety and performance. The current study will measure novice golfers' anxiety during a golf-putting task, immediately after each putt, to test if anxiety is reduced by a diaphragmatic breath.

Therefore, the current study's objectives are to (1) test if taking a single diaphragmatic breath affects anxiety, (2) test if a diaphragmatic breath affects gaze efficiency, and (3) test if a diaphragmatic breath affects performance in a golf putting task.

Chapter III

Methods and Procedures

Introduction

Efficient gaze, which is characterized by less foveal fixations of longer duration and longer quiet eye fixation duration, is a predictor of successful outcomes and expert performance in several sporting tasks (Mann et al. 2007). Fixations occur when the focal point of the fovea is stabilized within 3° of a visual angle for at least 100 ms, and a quiet eye fixation is the final fixation that occurs before the initiation of a movement critical to the execution of a task (Vickers, 2007). Unfortunately, increased anxiety, which is common in competitive situations (Lazarus, 2000), tends to decrease the duration of quiet eye fixations (Behan & Wilson, 2008; Vickers & Williams, 2007; Vine et al., 2013; Wilson, Wood, & Vine, 2009), increase the frequency of fixations, and decrease the duration of fixations (Allsop & Gray, 2014; Vickers & Williams, 2007; Vine et al., 2013; Wilson, Wood, & Vine, 2009), making gaze patterns less efficient. While the effects of increased anxiety on gaze have been studied, there has been no research examining whether or not commonly used anxiety reducing interventions affect athletes' gaze efficiency. The current study tested if a common brief anxiety reducing intervention, the diaphragmatic breath, affects participants' anxiety, gaze efficiency, and performance.

Description of the Study Population

The study population consisted of 30 (13 female, 17 male) undergraduate students at a midsized university on the west coast of the United States with a mean age of 20.5 years (*SD* = 1.3). The control group consisted of male (46.7%, *n* = 7) and female (53.3%, *n* = 8) participants with a mean age of 20 years (*SD* = 1.25). The DB group consisted of male (66.7%, *n* = 10) and female (33.3%, *n* = 5) participants with a mean age of 20.93 years (*SD* = 1.28). Reported race/ethnicities of participants were White (66.7%, *n* = 20), Asian (10%, *n* = 3), Hispanic/White (6.7%, *n* = 2), both Asian and White (6.7%, *n* = 2), both Asian and Hispanic (6.7%, *n* = 2), and American Indian or Alaska native, Asian, and White (3.3%, *n* = 1). Inclusion criteria specified that all participants had to be novice golfers, undergraduate students, and at least 18 years of age. For the current study, a novice golfer was operationally defined as a person who had never taken golf lessons, never taken a physical education golf class, and never played greater than or equal to nine holes of golf in a competitive or leisure situation. Also, to be considered a novice, participants could not have practiced golf on a driving range, putted on a practice putting green, or have participated in mini-golf within the past year. Novice golfers were chosen for this study to reduce the chances of recruiting participants with already established pre-performance routines (PPR). Teaching a new routine to participants with already established PPRs would have meant that the participants would first need to break their automated routines, which may cause reduced performance under pressure conditions (Beilock & Gray, 2007).

For safety purposes, participants were excluded if they were medically reliant on a device that could be disturbed by infrared light or infrared radiation or if they had a history of epilepsy or epileptic seizures. Participants with a history of eye surgery, current eye movement or eye alignment abnormalities, and those wearing glasses were excluded because these characteristics would have interfered with the eye tracking glasses. Participants were excluded if their makeup, eyelashes, or eyelids interfered with the calibration of the eye tracking glasses.

Design of the Study

A pretest posttest randomized groups experimental study design was used to test the effects of a single diaphragmatic breath on anxiety, gaze efficiency, and performance during competitive conditions. Participants were randomly assigned to either a control or diaphragmatic breath group. The independent variables for this study were group assignment (diaphragmatic breath, control) and time (pretest, posttest). The dependent variables for this study were average fixation duration, average number of fixations per putt, average quiet eye duration, performance, cognitive anxiety, and somatic anxiety.

Data Collection Procedures

Instruments. Participants completed the golf-putting task on a synthetic putting green with a slight incline occurring before the target hole. The green had three holes, one hole in the rear center of the green and one hole on each side of the center hole, but closer to the participant. Two bunkers, narrow oblong holes that bordered the back sides of the green, bordered the back of the putting green. The same generic putter and Bridgestone e6 golf balls were used by all participants to complete the task.

Tobii Pro Glasses 2 were used to measure the participants' gaze. The Tobii Glasses 2 used in this study had a sampling rate of 50 hz, meaning the glasses captured data every 20 ms. The gaze tracking glasses work by illuminating the wearer's eyes with infrared light to detect the position of the pupil and reflection of the light on the cornea. Pupil position is used to calculate the visual axis of the wearer's eye, and the corneal reflection provides information about the location of the wearer's eye in space. These two data points are used to locate where the eye is relative to the eye tracker and stimulus, then calculate the line of sight from the central fovea to the stimulus showing where the user is looking. The data collected was used to determine the average number of fixations per putt, average fixation duration, and average quiet eye duration. The glasses were connected to a recording device that was clipped on a belt worn by the participants. The recorder was connected to a Dell Precision Tower 5810 with an Intel Xeon processor running Windows 10 that was used to control the glasses and analyze all data.

The cognitive and somatic subscales of the Mental Readiness Form-3 (MRF-3; Krane, 1994) were used to assess state anxiety during the trial (see Appendix A). The MRF-3 has been shown to be a valid and expedient measurement of competitive state anxiety, with subscales of the MRF having correlations to the corresponding subscales of the Competitive State Anxiety Inventory-2 (CSAI-2: Martens, Vealey, & Burton, 1990), a common state anxiety measure, ranging from .55 and .80, indicating moderate to strong concurrent validity (Krane, 1994). It was important that an expedient measure of state anxiety was used for the trials to quickly measure the anxiety levels of the participants during their putts. The MRF-3 (Krane, 1994) consists of 3 subscales where anxiety is measured using an 11-point Likert Scale. The bi-polar anchors for the subscales are *worried/not worried* to measure cognitive anxiety, *tense/not tense* to measure somatic anxiety, and *confident/ not confident* to measure self-confidence. Participants completed the form by circling the number that best represented their levels of state cognitive and state somatic anxiety. Only the cognitive and somatic anxiety subscales were administered in the current study because self-confidence was not a variable of interest. The MRF-3 (Krane, 1994) has been the standard scale used in eye tracking studies where a brief measure of anxiety is needed (Vickers & Williams, 2007; Vine, Lee, Moore, & Wilson, 2013; Vine, Moore, & Wilson, 2011; Wilson, Vine, & Wood, 2009; Wood, Vine, & Wilson, 2014).

Measurement techniques and procedures. The investigators underwent human research subject ethical training before any interaction with participants was initiated. A university IRB approved the study procedures before any participant recruitment or data collection commenced. A grant of $750.00 was obtained through the university so that each participant could be paid $25 for their participation if they completed all study procedures.

Participants were recruited on a university campus using fliers (see Appendix B) and in-class recruiting. In-class recruiting was initiated by sending recruitment emails (see Appendix C) to university professors requesting time to recruit in class. If professors allowed in-class recruiting, the investigator and/or the research assistant presented a scripted recruiting message during class time and provided contact information to potential participants (see Appendix D).

The primary investigator completed practice trials until all study procedures could be implemented correctly and equipment could be used properly. An undergraduate research assistant was present when available; the assistant was trained how to record performance data, fit the gaze tracking equipment, and retrieve the ball after it had been putted.

Data was collected during the daytime in a lab setting with only one participant present at a time. Upon arrival to the lab, all participants were given the informed consent form (see Appendix E) and ample time to read it. Participants were given time to ask questions, and if they wished to proceed, they signed the consent document. Participants were randomized (see Appendix F) into the control group or diaphragmatic breath (DB) group using block randomization done through an online group randomizer (GraphPad Software, 2017).

After randomization on day one, all participants completed a demographics questionnaire (see Appendix G) and inclusion/exclusion criteria were verified (see Appendix H). Two participants were excluded from the study because calibration of the gaze tracking glasses was unsuccessful. Participants were then fitted with the eye tracking equipment and given 20 warm up putts to familiarize themselves with the task. The putting task consisted of participants completing 7’ (2.1336 m) putts on a synthetic putting green. The participants were instructed to aim for the center hole throughout their participation. To verify they were sure of what hole they were aiming for the participants were asked to point to the target hole before the commencement of the first warm up block of putts. For each putt, the ball was placed on a spot on the green marked with permanent marker and the investigator or research assistant returned the ball to the starting marker after each putt. After completing the warm up block, the gaze tracker was calibrated by having participants look at the center of a target on a calibration card while the investigator clicked on the calibration icon in the Tobii Glasses Controller software. To ensure accurate calibration, participants were asked to look at the ball placed on a starting marker and the target hole while the investigator verified the calibration on the computer screen. If the calibration was accurate the trial commenced; if calibration was unsatisfactory the calibration process was repeated until calibration was satisfactory. Gaze and performance information was recorded while participants completed a pretest block of 20 putts. Performance was measured by the total number of putts made out of the block of 20 putts in the pretest and posttest phases. Participants completed the cognitive and somatic subscales of the MRF-3 (Krane, 1994) immediately after each putt in the pretest block to measure anxiety levels during the previous putt.

Participants who were randomized into the DB group were then taught how to take a diaphragmatic breath. The procedure included inhaling through their nose deeply into their lungs using their diaphragm for a count of four and exhaling through their mouth for a count of six. After completing a breath, the participants placed the putter behind the ball and executed the putt. Diaphragmatic breathing instructions were scripted (see Appendix I). The script was based off the abdominal breathing instructions outlined by Lehrer et al. (2000). The participants practiced diaphragmatic breathing until the investigator approved of the execution of the breath, which was determined when most of the movement caused by each breath was seen in the abdomen with little to no movement seen in the chest, inhalation occurred through nostrils for four seconds, and exhalation occurred through the mouth for six seconds. After approval of the participants' technique, participants were instructed to take a breath before the initiation of each putt. It was necessary to have participants execute the diaphragmatic breath before each putt so that gaze measurements after the placement of the putter were potentially influenced by the breath. Teaching of the breath, approval by the investigator, and instruction as to when a breath should be executed took approximately 15 minutes.

Participants in the control group watched a 15 minute segment of a documentary (Hogan, 2005) on the history of golf after they completed the pretest block of putts. The task for the control group was designed to be temporally equal to the diaphragmatic breath group's intervention to ensure that both groups were given a task to complete, session times would remain similar between groups, and that the control group would not think about the putting task or possibly employ relaxation techniques. It was explained to the control group participants that the investigator had to review the gaze data that was collected during the pretest block and that the golf documentary was to keep them focused on golf during this time. The use of distracting objects (e.g., electronic devices) was prohibited during the control intervention to increase the likelihood that participants paid attention to the film. Neither group received instruction on putting technique and form at any point in the study, and technique was not covered in the golf documentary.

After implementing the diaphragmatic breath intervention for the DB group and the control task for the control group, participants completed a practice phase. The practice phase consisted of three practice blocks of 20 putts each, totaling 60 practice putts. Participants in the

DB group were instructed to execute a single diaphragmatic breath before each putt during the practice blocks and to make as many putts as possible while the control group was only instructed to make as many putts as possible. Participants were allowed to take short breaks after each block of putts at their discretion. The gaze tracking glasses were worn during practice for participants to get used to putting with the equipment on, but no gaze information was recorded and analyzed from the practice blocks. Performance during the practice phase was recorded, even though performance data in the practice phase was not analyzed. It was important to the later anxiety manipulation that participants knew their performance during the practice blocks was recorded. After completion of the practice putting blocks, participants confirmed the date and time of their next session. They were asked to not share information about the study procedures and to not practice putting. They were then dismissed.

Participants returned to the lab between one and three days after completing the first session to complete a posttest phase. Upon arrival to the lab, the participants were fitted with the eye tracking gear and took 20 warm up putts (no gaze data recorded). Those in the DB group were instructed to execute a diaphragmatic breath before each putt in the warm up block per instructions given at the previous session. The control group was only asked to make as many putts as possible.

After the warm up block was completed, deception was used to manipulate the participants' anxiety levels. In an attempt to increase anxiety, all participants were told the following: 1) their scores would be posted to an online leaderboard along with their full name, 2) their performance during day 1 put them in the bottom 30% of what is expected of novice golfer based on previous research, and 3) they would need to perform better or their data would be unusable. Similar deception methods have been successfully used to increase anxiety in previous studies that have tested the effects of anxiety on gaze during tasks, including: flight simulation (Allsop & Gray, 2014), archery simulation (Behan & Wilson, 2008), biathlon rifle shooting (Vickers & Williams, 2007), golf putting (Vine, Lee, Moore, & Wilson, 2013; Vine, Moore & Wilson, 2011), basketball free throw shooting (Wilson, Vine, & Wood, 2009), and soccer penalty kicks (Wilson, Wood, & Vine, 2009). Verbal consent to continue in the study was obtained from all participants after the anxiety manipulation was given. All participants agreed to continue in the study.

Next, the gaze tracking glasses were calibrated using the same calibration procedure that was used during the pretest block of putts, then participants completed a posttest block of 20 putts where their gaze, state anxiety, and performance were recorded. Participants in the diaphragmatic breath group completed a diaphragmatic breath before each putt in the posttest block. After each putt in the posttest block, the participants' levels of anxiety were again recorded using the cognitive and somatic subscales of the MRF-3 (Krane, 1994).

After completion of the test phase, participants were immediately debriefed to the true nature of the study, given the chance to clarify any information about the study, and asked questions they had about the study procedures and purpose (see Appendix J). After being debriefed, participants were given $25 as compensation for their participation then dismissed.

Data processing. Gaze data was obtained from data imported from the glasses recording device into Tobii Pro Lab, Version 1.58.5884 (Tobii, 2017). Of the 40 total putts (20 pretest, 20 posttest) where participants' gaze was recorded, 10 putts were randomly selected from each participant's pretest and posttest blocks to be analyzed using a list randomizer (List Randomizer, 2017). Random selection of putts for analysis was completed due to time constraints, as analyzing the gaze data required extensive time for each individual putt. Once it was identified which putts would be analyzed, a custom velocity-based fixation filter was used to identify fixations. The custom fixation filter was based on the values recommended by Tobii (2012), with the exception being the minimum fixation duration being increased from 60 ms to 100 ms, because 100 ms is the minimum time it takes for information obtained visually to be processed and used to plan motor movements in normal populations (Vickers, 2007). Once fixations were identified, the start and end of each putt was marked manually and the total number of fixations per putting trial, the length of fixations per putting trial, and the duration of the quiet eye fixation were recorded. The start of each trial was marked at the first fixation that occurred during or after the putter was placed behind the golf ball. Quiet eye was defined as the final fixation which had an onset before the initiation of the backswing and offset occurring when gaze deviated off the fixation location as determined by the fixation filter (Vine et al., 2013). Initiation of the backswing occurred at the first frame where backward movement of the putter away from the ball in commencement of a full putt could be detected (Vine et al., 2013). The end of the quiet eye fixation marked the end of each putting trial.

Data Analysis

Due to low quality gaze information, one participant from the control group was excluded from analysis. The participant's gaze recordings were missing large amounts of data, which would have made for an inaccurate analysis. Information from the gaze tracking glasses was uploaded to a computer. Tobii Pro Lab software was used to analyze the information obtained from the glasses that was recorded using Tobii Pro Glasses Recorder Software. The locations of the pupil and corneal reflection are used to detect where the wearer's eyes are fixated, which is then displayed on a computer screen over the video taken by a camera on the front of the glasses. An image of the wearer's fixation point is indicated by a circle, which is displayed on the video image of the computer. The analysis of gaze data commenced at the onset of the fixation when the participant put the putter behind the ball and ended after the offset of the quiet eye fixation.

A 2 (DB, control) x 2 (pretest, posttest) x 6 (test) mixed MANOVA for the independent variables of group and time, and dependent variables of cognitive anxiety, somatic anxiety, quiet eye duration, fixation duration, number of fixations, and performance was run in SPSS to analyze for multivariate interaction effects of the independent variables on the grouped dependent variables. A MANOVA was used because there were multiple independent variables and the dependent variables had shown to be related in previous research. Post hoc testing was completed using separate mixed ANOVAs for each dependent variable to test for the effects of time and group. If the MANOVA revealed no statistically significant interaction effects, but statistically significant main effects were found, post hoc testing was planned.

Effect sizes and significance were calculated using SPSS. Findings where p = <0.05 were considered significant. If there was no significant interaction effect of the variables then the main effects were analyzed using SPSS calculation of significance and effect size. Effect sizes were determined using the partial eta squared statistic. The guidelines for interpreting partial eta squared were .01= small, .06 = medium, .138 = large. (Cohen, 1988).

Chapter IV

Results and Discussion

Introduction

The present study used the assumptions of attentional control theory (Eysenck et al., 2007) to test the effects of an anxiety reduction intervention, a single diaphragmatic breath (DB), on anxiety, gaze efficiency, and golf putting performance. Novice golfers were randomized into control and DB groups. They were tested during the pretest for baseline measures of the dependent variables, after which the DB group was instructed to take a DB before each putt they took for the rest of the study. After the intervention, all participants had a chance to practice putting. Participants returned to the lab to complete posttest trial where their anxiety was manipulated. Tobii Pro Glasses 2 were used to measure participants' average fixations per putt, average fixation duration, and average quiet eye duration. The cognitive and somatic subscales of the Mental Readiness Form-3 (MRF-3; Krane, 1994) were used to measure anxiety after each putt of the pretest and posttest putting blocks. Performance was measured as the number of putts holed.

Results

A repeated measures MANOVA was performed to investigate the multivariate interaction effects of the grouped independent variables (group, time) with the grouped dependent variables (somatic anxiety, cognitive anxiety, average fixation duration, average number of fixations per putt, average quiet eye duration, and performance). For descriptive statistics see Table 1.

The MANOVA revealed no statistically significant multivariate interaction effects, with a moderate effect size $F(5, 23) = .274$, $p = .937$; Wilk's $\Lambda = .949$; $\eta_p^2 = .051$. Given the previous results, the interaction effects for intervention and time were examined, and they were also not statistically significant with a small effect size $F(1, 27) = .021$, $p = .885$; Wilk's $\Lambda = .999$; $\eta_p^2 = .001$.

Table 1

Descriptive Statistics for Diaphragmatic Breath (DB) Group and Control Group

	DB group		Control group	
Variable	Pre *M (SD)*	Post *M (SD)*	Pre *M (SD)*	Post *M (SD)*
Somatic anxiety	2.92 (1.46)	3.26 (1.44)	4.49 (2.01)	4.5 (1.98)
Cognitive anxiety	2.78 (1.50)	3.43 (1.59)	4.32 (1.98)	4.69 (1.79)
Average fixation duration	514 (224)	430 (194)	508 (195)	565 (289)
Average number of fixations per putt	6.41 (3.50)	6.38 (4.43)	6.63 (1.98)	6.14 (2.47)
Average quiet eye duration	1033 (708)	950 (717)	902 (478)	1068 (766)
Putting performance	4.40 (2.66)	5.60 (2.56)	3.50 (2.1)	5.14 (2.14)

Note. All fixation measures are presented in milliseconds. Putting performance is the average number of putts made out of 10 putts randomly selected for analysis. Cognitive and somatic anxiety scores were measured using the cognitive and somatic subscales of the MRF-3 (Krane, 1994), which uses 11-point Likert scales to measure anxiety levels.
Note. Mean (M) and Standard Deviation (SD) data are reported for all dependent variables.

Because both multivariate interaction effects were not statistically significant, main effects were considered. The multivariate main effect for time on the dependent variables was statistically significant with a large effect size $F(1, 27) = 5.158$, $p = .031$; Wilk's $\Lambda = .84$; $\eta_p^2 = .16$. These findings suggest that time produced a large change in the interaction of the dependent variables from the pretest to posttest. The main effect for group on the grouped dependent variables was not statistically significant, with a moderate effect size $F(1,27) = 1.559$, $p = .223$;

$\eta_p^2 = .055$. While the moderate effect size of group on the grouped dependent variables explained some of the variance between groups, these findings could have been random because they were not statistically significant.

Because a significant multivariate main effect for time on the grouped dependent variables was found, post hoc testing was completed by performing six separate mixed ANOVAs for each variable to test for the effects of time (pre, post) and group (DB, control). For somatic anxiety, an interaction effect for time and group was not statistically significant with a small effect size $F(1, 27) = .377$, $p = .544$; Wilk's $\Lambda = .986$; $\eta_p^2 = .014$. The univariate main effect for time on somatic anxiety was not statistically significant with a small effect size $F(1, 27) = .410$, $p = .527$; Wilk's $\Lambda = .985$; $\eta_p^2 = .015$. The univariate main effect for group on somatic anxiety was statistically significant with a large effect size indicating a difference in the somatic anxiety between the groups; the control group reported higher levels of somatic anxiety than the DB group $F(1, 27) = 5.767$, $p = .023$; $\eta_p^2 = .176$.

For cognitive anxiety, an interaction effect for time and group was not statistically significant with a small effect size $F(1, 27) = .319$, $p = .577$; Wilk's $\Lambda = .988$; $\eta_p^2 = .012$. The univariate main effect for time on cognitive anxiety approached statistical significance with a large effect size, showing a possible increase in cognitive anxiety for both groups from pretest to posttest putting blocks $F(1, 27) = .421$, $p = .05$; Wilk's $\Lambda = .865$; $\eta_p^2 = .135$. The univariate main effect for group on cognitive anxiety was statistically significant with a large effect size, indicating a difference in the cognitive anxiety between the groups; the control group reported higher levels of cognitive anxiety than the DB group $F(1, 27) = 5.662$, $p = .025$; $\eta_p^2 = .173$.

For average fixation duration, an interaction effect was not statistically significant, but had a large effect size, indicating a possible interaction of time and group on fixation duration

$F(1, 27) = 3.143$, $p = .088$; Wilk's $\Lambda = .896$; $\eta_p^2 = .104$. Because the findings were not significant, the large effect size found could have been due to chance. During the pretest, the groups appear to have had similar average fixation durations. Trends in the data show the control group's average fixation duration increased while the DB group's average fixation duration decreased. However, the univariate main effect for time on average fixation duration was not statistically significant with a small effect size $F(1, 27) = .115$, $p = .737$; Wilk's $\Lambda = .996$; $\eta_p^2 = .004$. The univariate main effect for group on average fixation duration was not statistically significant with a small effect size $F(1, 27) = .743$, $p = .396$; $\eta_p^2 = .027$.

For the average number of fixations per putt, an interaction effect was not statistically significant with a small effect size $F(1, 27) = .206$, $p = .654$; Wilk's $\Lambda = .992$; $\eta_p^2 = .008$. The univariate main effect for time on the average number of fixations per putt was not statistically significant with a small effect size $F(1, 27) = .256$, $p = .617$; Wilk's $\Lambda = .991$; $\eta_p^2 = .009$. The univariate main effect for group on the average number of fixations per putt was also not statistically significant with a small effect size $F(1, 27) = .000$, $p = .995$; $\eta_p^2 = .000$.

For average quiet eye duration, an interaction effect was not statistically significant with a moderate effect size, indicating a possible interaction effects of the independent variables on quiet eye duration $F(1, 27) = 1.737$, $p = .199$; Wilk's $\Lambda = .940$; $\eta_p^2 = .06$. Trends in the data indicated that the DB group's average quiet eye duration decreased from pretest to posttest, while the control group's average quiet eye duration increased from pretest to posttest. These trends could be explained by chance due to the findings being not statistically significant. The univariate main effect for time on average quiet eye duration was not statistically significant with a small effect size $F(1, 27) = .189$, $p = .667$; Wilk's $\Lambda = .993$; $\eta_p^2 = .007$. The univariate main effect for group on average quiet eye duration was not statistically significant with a small effect size $F(1, 27) = .001$, $p = .979$; $\eta_p^2 = .000$.

For putting performance, an interaction effect was not statistically significant $F(1, 27) = .13$, $p = .722$; Wilk's $\Lambda = .995$; $\eta_p^2 = .005$. The univariate main effect for time on putting performance was statistically significant with a large effect size, showing that all participants significantly increased their putting performance from the pretest to posttest putting blocks $F(1, 27) = 5.345$, $p = .029$; Wilk's $\Lambda = .835$; $\eta_p^2 = .165$. The univariate main effect for group on putting performance was not statistically significant with a small effect size $F(1, 27) = 1.121$, $p = .299$; $\eta_p^2 = .040$.

Discussion

This study was novel because it was the first to test the effects of an anxiety reducing intervention, the diaphragmatic breath, on the anxiety, gaze efficiency, and performance of novice putters. A main purpose of the study was to test the effects of a diaphragmatic breath on anxiety. The results of the current study indicated that teaching a diaphragmatic breath intervention to novice populations does not quickly manage anxiety during competition, which is a common belief (Mason, 1980).

To create a pressure situation, it was important that the researchers in the current study effectively manipulated anxiety. The anxiety manipulation would have been considered effective if the control group would have had statistically significant increases in somatic and cognitive anxiety from the pretest to the posttest. The DB group's anxiety would not be expected to increase due to the possible anxiety reducing effects of the intervention. These findings would have resulted in statistically significant univariate interaction effects for the independent variables on cognitive and somatic anxiety. However, results of the study showed that both groups had increased cognitive anxiety from the pretest to the posttest putting blocks that was on the threshold of significance with a large effect size observed, while somatic anxiety was unchanged. Because the p value was at the significance threshold, effect size for time on cognitive anxiety should be considered. The trends observed in anxiety levels from pretest to posttest suggest that the anxiety manipulation could have been effective at increasing participants' cognitive, but not somatic anxiety. Eysenck et al. (2007) attributed high levels of worry to decreased processing efficiency and performance effectiveness in performance; therefore, the effects of the anxiety manipulation in the current study should have been sufficient to reduce the efficiency of the participants and possibly reduce their performance effectiveness. The control group showed positive trends in the efficiency of their gaze despite their anxiety trending upward, showing that anxiety may not have affected their efficiency. Also, both groups improved their performance despite increases in cognitive anxiety, suggesting the conditions of the study did not overload the participants' working memory enough to decrease their effectiveness.

Lazarus and Folkman's (1984) theory of cognitive appraisal may explain why the participants in the current study did not demonstrate statistically significant effects from the anxiety manipulations used in the study. It is possible that some of the participants' primary appraisals were that the task was not important to them since they were not golfers. Also, if they had secondary appraisals that the situation was benign or positive, anxiety levels may not have been elevated. Future researchers should consider using manipulations that are more likely to be appraised as important and threatening by novice participants in order to induce larger increases in anxiety.

Anecdotal evidence observed by the investigator also suggested that some participants were not affected by the anxiety manipulation. For example, some participants verbalized after completion of the study that they suspected deception was being used. A formal manipulation check after participant completion would have been useful in qualitatively understanding how the anxiety manipulation affected anxiety, and is recommended for future research.

The diaphragmatic breath is commonly thought of as a technique that is designed to reduce somatic anxiety (Mason, 1980). If the anxiety manipulation would have been more successful at increasing participant somatic anxiety, it is possible that the anxiety reducing effects of a DB on somatic anxiety may have been observed. Because somatic anxiety levels remained low throughout the study, floor effects could have been present. Future researchers who examine the effects of a somatic based relaxation technique like DB should ensure that their manipulations specifically increase somatic anxiety.

Confirming the null hypothesis, the diaphragmatic breath intervention did not produce any significant interactions between the control and DB groups' somatic or cognitive anxiety over time. Ideally, the control group's anxiety levels would have increased, confirming that the anxiety manipulation was successful, while the DB group's anxiety would have decreased or remained similar to pretest levels to support anxiety managing effects. These results would have been indicated by statistically significant univariate interaction effects for the independent variables on the dependent variables, which were not found. There are several possible explanations for this finding. First, results of the study may indicate that having novice athletes take a diaphragmatic breath before the execution of a golf putt has little to no effect on their anxiety levels. Despite evidence supporting cross over effects (Tomas et al., 2009) where anxiety reduction techniques designed to reduce anxiety in one dimension can reduce anxiety in the other (i.e., diaphragmatic breath reducing cognitive anxiety), cognitive anxiety increases approached significance and had a large effect size. The DB group's somatic anxiety trended slightly upward from the pretest to posttest blocks, but because these findings were far from statistically significant, these trends have little meaning. In the current study, participants' use of a single diaphragmatic breath before a putt did little to manage either dimension of anxiety. Past participants in studies of HRVB have had reductions in anxiety in as little as ten minutes of continuous breathing (Prinsloo et al., 2013). Breathing at a frequency of six breaths per minute, participants in Prinsloo et al.'s (2013) study would have taken approximately 60 consecutive diaphragmatic breaths to achieve reduced anxiety, which is similar to the number of breaths participants took during the practice putting blocks. Although, participants in the research by Prinsloo et al. (2013) were tested immediately after their practice while the participants in the current study came back at a later time. Therefore, participants in the current study were expected to achieve similar anxiety managing results with one single breath within one to three days after the practice session. Having participants take part in the putting task immediately after taking 60 DBs may have produced different results, but it should be considered that after taking the 100 total putts in Session 1, participants may have been fatigued during the posttest trials.

Additionally, in studies that found that performance and anxiety were significantly affected by yoga breathing, the participants were experts (Telles et al., 2007). Therefore, it may be that novices need more than one session of training before a DB is effective at reducing their anxiety. Also, findings suggest that which nostril is dominant can affect performance and autonomic activity differently (Klein et al., 1986). Based on these past findings, it is possible that participants with left nostril dominance at the time of their participation would be more effective at putting because it is a spatial task, and they would also be more relaxed. Because nostril dominance is cyclical (Klein et al., 1986), the time of day participants completed study procedures could have affected their performance, although random assignment in the current study likely helped to reduce the influence of nostril dominance on the data. In the current study, participants were scheduled at times that were convenient for them. In future research, controlling for nostril dominance by having participants come in at similar times for both sessions would reduce additional influences on the dependent variables outside of the intervention.

Another explanation for the lack of statistically significant differences in anxiety between the groups at posttest could be explained by the fact that the DB group had significantly lower state somatic and cognitive anxiety than the control group during both the pretest and posttest putting blocks. It would have been ideal for comparison of the groups if both groups were similar in anxiety levels because differences in state anxiety levels may suggest differences in trait anxiety levels. This is because individuals with higher levels of trait anxiety are predisposed to interpret situations as threatening and respond with state anxiety (Martens et al., 1990) If the current study had a larger sample, the randomization procedure might have effectively created groups with similar anxiety levels. Martens et al. (1990), found that trait anxiety can predict levels of state anxiety experienced in sport, and those findings have since been confirmed (Hanton, Mellalieu, & Hall, 2002). As such, another strategy that could have been used to ensure the groups had similar levels of anxiety would have been assigning participants to groups based on trait anxiety levels.

Another main purpose of the current study was to determine if a single diaphragmatic breath could improve participant gaze efficiency, which was tested by looking at the univariate interactions of the independent variables on measures of gaze anxiety. If the intervention was relaxing, it would have caused efficiency to increase in the DB group. While not statistically significant, the large effect size of the interaction between group and time on average fixation duration, and moderate effect size of the interaction between group and time for average quiet eye duration indicated that the gaze efficiency of participants may have been affected. Trends in the data showed that the DB group's fixation duration and quiet eye duration became shorter while the control group's fixation duration and quiet eye duration became longer from the pretest to posttest. Because these results are not statistically significant, these trends may have been due to chance; however, the trends found in the current study, when combined with the moderate and large effect sizes, suggest that introducing a diaphragmatic breathing technique to novices may reduce efficiency, not improve it. These results could be explained by past research findings, which indicate that dual tasks reduce the efficiency of anxious participants (Eysenck, 1989; Williams et al., 2002). Novices are more likely to use cognitive resources when executing a task compared to an expert, who is more likely to have fundamental skills automated (Williams & Krane, 2015). In the current study, putting and the DB instructions could have been considered a dual task for the novice participants. The instructions laid out by Lehrer et al. (2000) required the DB group participants to complete a list of technical steps to complete the DB, which could have taken up processing resources and decreased their efficiency.

Perhaps if the instruction were simpler, the participants would not have produced negative trends in efficiency measures. For example, Lam, Maxwell, and Master (2009) showed that novice participants performed better during a basketball shooting task when taught to shoot using a single analogy instruction than another group that was given a list of eight explicit instructions to follow. Lam et al. (2009) explained that the explicit instructions in the shooting task decreased the participants' processing efficiency by occupying processing resources while the single analogy instruction used less processing resources, making the participants more efficient. It is possible that if the DB group participants in the current study had one analogy for deep breathing instruction, instead of a list of technical explicit breathing instructions, their gaze would have been more efficient.

Another efficiency related result of the current study that is important to consider is that trends of the control group's gaze efficiency suggest that their gaze efficiency slightly improved, though the findings were not statistically significant. These trends, when combined with calculations of effect size, suggest that gaze efficiency may improve naturally through practice in a short amount of time without technical instruction.

Gaze efficiency is a characteristic of expert performance levels, but efficient gaze must be focused on task relevant cues for performance levels to be high (Mann et al., 2007). In the present study, participants were not instructed where to look at any point during the study procedures. While measuring where participants were looking was beyond the scope of this study, knowing where participants were looking would have provided a richer context for analysis.

No statistically significant findings were found for the effects of a DB on the average number of fixations per putt. In order for this measure to be more meaningful, the investigator would need to know how long each participant took to prepare and execute the putt, or putting time would need to be standardized. If one group took twice as long to prepare their putts, but had the same amount of fixations, they may have been considered to have more efficient gaze. Research that individuals take longer to execute skills when in pressure situations (Nieuwenhuys et al., 2008), and it is possible that execution time varied widely between and within participants.

The final purpose of the study was to test the effects of a DB on performance effectiveness. If a DB affected performance statistically significant univariate interaction effect would have been found for the grouped independent variables on performance. However, statistically significant findings were not found in the data. Golf putting performance for all participants in the current study similarly improved from pretest to posttest. Therefore, taking one deep breath before putting may not benefit novice golfers by improving their performance effectiveness when compared to practice alone. In line with Eysenck et al.'s (2007) theory, trends from the current study suggest efficiency was affected more than performance effectiveness, even though decreased efficiency is better explained by the task and not anxiety levels in the current study. Putting may not occupy enough of the processing resources of the central executive, even in novices where the putt is not automated (Williams & Krane, 2015), for efficiency to be reduced to levels that would affect performance. The suspected low demands of the task on the central executive and the effect of the anxiety manipulation being not statistically significant may have allowed for the participants to improve their effectiveness from pretest to posttest. It is possible that the non-statistically significant trends in efficiency and moderate to large effect sizes of the interaction could indicate that a DB intervention may affect novice participants' effectiveness when competing in a highly threatening situation or during a task that places large demands on the working memory system.

Limitations

There were limitations in the present study. For example, the findings of the present study could have been affected by participants engaging in other psychological skills (e.g., self-talk) during the putting task. Participants were not asked after the study about the possible use of these skills. The investigator did observe some participants using motivational self-talk during the study. Participants in the control group were observed sighing and taking deep breaths before some of their putts. Because of the observation of psychological skills being used by the participants, asking participants about what skills they may have used would have helped to determine if use of such skills added variability to the participants' data.

The level of effort given by participants to perform well and execute the diaphragmatic breath could have varied. The level of effort put forth by an individual is a key factor in determining processing efficiency (Eysenck et al., 2007). Also, previous studies have found that participants manipulate their effort levels under anxiety inducing conditions (Calvo, 1985, Calvo et al., 1996; Di Bartolo, et al., 1997; Eysenck, 1985; Hadwin et al., 2005; Smith, et al., 2001). Because participant effort was not measured, it could have been an extraneous variable that added statistical noise in the data.

The differences between the groups' levels of pretest state anxiety makes comparisons between groups difficult. Randomization was used for the purpose of limiting differences between and within groups, but the statistically significant effects of group on univariate anxiety measures showed the groups' anxiety levels were not equal, and therefore, less comparable.

Knowing how believable and effective the anxiety manipulation was would have provided useful insight into the study. A limitation of the present study is that a manipulation check was not used. Some participants verbalized after they were debriefed that they suspected manipulation was being used because they had learned about research deception in their university courses. A manipulation check after the debrief would have provided qualitative evidence for the effectiveness of the manipulation.

The external validity of the findings is limited by the setting the protocol was conducted in, participants wearing eye tracking equipment during the testing, and the population recruited.

Golf competitions are typically conduced in and outside setting with other competitors, while the current task was conducted in a lab setting where the suspected competitors were not present during the putting. These situations put different demands on individuals, and demands of the situation determine stress and contribute to anxiety (Lazarus & Folkman, 1984). The gaze tracking glasses also restricted participant movement because of the chords that connected the glasses to the computer, which are not present in real life.

Finally, a velocity based fixation filter was used to classify fixations, which is not as accurate as dispersion-based methods for defining fixations that are commonly used (Salvucci & Goldberg, 2000). Because velocity based filters are less robust than dispersion filters, it is possible that some gaze data that a dispersion based filter would have defined as a fixation was divided into multiple fixations in the current study. Also, gaze data that would have been divided into multiple fixations using a dispersion based filter may have been grouped into a single fixation in the current study if eye movements meet a certain velocity but stay fixated in a specific area. These differences could may have caused over or under estimation of average fixation duration and the number of fixations per putt.

Summary

The purpose of the current study was to determine if a commonly used intervention in the field of applied sport psychology, a DB, is effective in decreasing anxiety, increasing gaze efficiency, and improving performance. This information can be critical for sport psychology practitioners because diaphragmatic breathing is a common intervention used to manage athletes' anxiety (Williams & Krane, 2015). Findings from the current study suggest that having novice golfers take a single diaphragmatic breath before putting does not appear to improve gaze efficiency, appears to have little effect on anxiety levels during competition, and provides no extra benefit to performance effectiveness over no intervention. It may be concerning that current sport psychology practitioners often use diaphragmatic breathing interventions without knowing the short-term effects of the intervention on gaze efficiency, as there is strong evidence supporting that longer fixations and quiet eye are characteristic of expert performance (Mann et al., 2007). Therefore, instead of assisting novice athletes to manage their anxiety, sport psychology practitioners recommending the use of one DB could make athlete performance less efficient and less expert-like in their skill execution; however, more research is needed on this topic before definitive recommendations can be made.

Chapter V

Summary, Conclusions, and Recommendations

Summary

Efficient gaze patterns are characteristic of high levels of performance in sporting tasks (Vickers 2007). Increased anxiety in pressure situations has been shown to decrease the efficiency of gaze patterns (Allsop & Gray, 2014; Behan & Wilson, 2008; Vickers & Williams, 2007; Vine et al., 2011; Vine et al., 2013; Wilson, Vine, & Wood, 2009). Research indicates that controlled deep breathing can reduce athlete anxiety levels and increase performance (Lagos et al., 2008; Lagos et al., 2011; Paul & Garg, 2012). The present study examined the effects of a diaphragmatic breath intervention on novice participants' anxiety, gaze efficiency, and performance during a competitive putting task.

To test the effects of a diaphragmatic breath, 30 undergraduate students who were novice golfers were recruited. Participants were block randomized into control and DB groups. After baseline measures of dependent variables were obtained, the DB breath group was instructed to take a diaphragmatic breath before each putt they took based on the abdominal breathing instructions used in Lehrer et al. (2000) heart rate variability biofeedback manual. Anxiety was then manipulated for both groups and posttest putting was completed in a competitive situation.

Conclusions

The effects of a diaphragmatic breath intervention on cognitive anxiety, somatic anxiety, average fixation duration, average fixation per putt, average quiet eye duration, and putting performance were tested by the present study. The null hypothesis of the study was supported by findings that:

1. There were no statistically significant multivariate interactions found for the grouped independent variables on the grouped dependent variables.
2. There were no statistically significant univariate interaction effects for the independent variables on cognitive anxiety or somatic anxiety.
3. There were no statistically significant univariate interaction effects of the independent variables on putting performance.
4. There were no statistically significant univariate interaction effects of the independent variables on measures of gaze efficiency, although a moderate effect size was detected average quiet eye duration and a large effect size was detected for average fixation duration. These findings are not sufficient to reject the null hypothesis.

Although not a statistically significant difference, trends in the data suggested that the DB group's average fixation duration and average quiet eye fixation duration could have decreased from pretest to posttest. These trends suggest that implementing a single diaphragmatic breath routine for novice putting participants may have made their gaze patterns somewhat less efficient. Results from the present study support that a single diaphragmatic breath taken before the execution of a sport specific skill may not be sufficient to affect levels of anxiety and performance levels. Although, given that this is the first study to isolate a DB intervention, more research is needed before a definitive determination about the effectiveness of DB on gaze efficiency and anxiety can be made.

Recommendations

Based on the findings of the current study, several recommendations to researchers and applied sport psychology practitioners can be made. Anxiety reduction interventions are often used in situations where anxiety levels are typically elevated, making athletes less efficient.

Practitioners should consider if the intervention will use processing resources that are better allocated toward completing the task. If a psychological intervention reduces the efficiency of an athlete's working memory enough, performance effectiveness may suffer.

For novices, a single diaphragmatic breath may not be sufficient to manage anxiety and increase performance in competitive situations. Studies of the effects of HRVB have indicated immediate relaxation effects after 10 minutes of practice (Prinsloo et al., 2013), and increased performance and anxiety management in competitive sporting situations after practicing HRVB regularly for 10 weeks (Lagos et al., 2008; Lagos et al., 2013; Paul & Garg, 2012). Based on the current study as well as findings from previous research, 10 minute deep breathing sessions practiced regularly outside of competition are recommended for athletes over quickly implementing a single diaphragmatic breath as an intervention. Also, there is a need to test the effects of these longer duration deep breathing protocols on gaze efficiency; past research has already provided evidence that they can increase performance and manage anxiety, but none of these studies has monitored gaze.

Quiet eye training has been shown to be effective at helping athletes develop efficient gaze patterns, which aid their performance (Harle & Vickers, 2001; Moore et al., 2012; Vine et al., 2011). Quiet eye training provides a direct route to improving gaze efficiency. At this time, quiet eye training should be considered the preferred way to improve gaze efficiency in athletes, although more research is needed on the possible influence of mental skills on gaze efficiency.

The results of the current study cannot be applied to expert athletes, who are more likely to seek sport psychology services. Because expert athletes are more likely to have automated skills (Williams & Krane, 2015), implementing a DB intervention may affect their efficiency differently than novices who need to use cognitive resources for the same skill. Therefore, the effects of a single diaphragmatic breath should be tested on experts.

The use of a velocity based fixation filter was a limitation of the present study. Researchers in the future should use dispersion-based algorithms to classify fixations instead of the velocity based-algorithms used in the present study as dispersion-based algorithms have been found to be more accurate (Salvucci & Goldberg, 2000). This recommendation would make measures of gaze efficiency more accurate and comparable to previous research findings.

Future researchers should also increase sample sizes or match participants based on trait anxiety scores to increase the chances that control and treatment groups have similar pre-test anxiety levels. The findings of the current study were limited by effect for group assignment on somatic and cognitive anxiety, with the control group having statistically significant higher somatic and cognitive anxiety.

To continue, in the current study, participants were scheduled when convenient. Because cyclical nostril dominance can affect performance and arousal levels (Klein et al., 1986), future researchers should schedule participants for sessions during similar times of the day.

The anxiety manipulation used in the current study caused cognitive anxiety to trend upward more than somatic anxiety, though both findings were not statistically significant. To ensure elevated anxiety levels, how the population will appraise an anxiety manipulation should be considered (Lazarus & Folkman, 1984). Future researchers should find ways to manipulate somatic anxiety and see if it is affected by deep breathing, which is a somatic anxiety reduction technique.

Eysenck and Calvo (1992) hypothesized that worry, a cognitive symptom of anxiety, is the main cause of decreased efficiency. Therefore, the effects of cognitive psychological interventions on gaze efficiency, like mindfulness or cognitive reframing, should be tested because gaze efficiency seems to be critical to successful performance (Mann et al., 2007). Perhaps cognitive anxiety reduction interventions could decrease worry and improve performance more effectively than somatic techniques.

Finally, Lam et al. (2009) found that single analogy instructions used less processioning resources and made novice participants more efficient than many explicit instructions. Future research should compare analogy deep breathing instructions to explicit diaphragmatic breathing instructions to see if efficiency is less effected by the analogy instructions.

Summary

Overall, the results or the current study indicate that the single DB intervention used in the current study did little to manage anxiety, affect gaze efficiency, or affect participants' performance. Because the current study was the first to test the effects of a psychological intervention on gaze efficiency, there are numerous ways in which future researchers can add to the findings of the present study and improve the research methodology. It is important to professionals that research and apply sport psychology that they are aware of any added benefits or possible negative effects of applying commonly used psychological interventions to athletes. While the findings in the current study were mostly non-significant, they do provide insight into what may happen when a novice athlete is taught a diaphragmatic breath intervention and expected to apply it in a short amount of time.

References

Allsop, J., & Gray, R. (2014). Flying under pressure: Effects of anxiety on attention and gaze behavior in aviation. *Journal of Applied Research in Memory and Cognition*, *3*, 63-71. doi:10.1016/j.jarmac.2014.04.010

Backon, J., Matamoros, N., & Ticho, U. (1989). Changes in intraocular pressure induced by forced unilateral breathing, a technique that affects both brain hemisphericity and autonomic activity. *Graefe's Archive for Clinical and Experimental Ophthalmology*, *227*, 575-577.

Baddeley, A. D. (2001). Is working memory still working? *American Psychologist, 7*(2), 851-864. doi:10.1037/0003-066X.56.11.851

Baddeley, A. (2003). Working memory: Looking back and looking forward. *Nature Review. Neuroscience*, *4*, 829-839. doi:10.1038/nrn1201

Bard, P. (1928). A diencephalic mechanism for the expression of rage with special reference to the sympathetic nervous system. *American Journal of Physiology, 84*, 490-513.

Behan, M., & Wilson, M. (2008). State anxiety and visual attention: The role of the quiet eye period in aiming to a far target. *Journal of Sport Sciences*, *26*(2), 207-215. doi:10.1080/02640410701446919

Beilock. S. L., & Gray, R. (2007). Why do athletes choke under pressure? In G. Tenenbaum & R. C. Eklund (Eds.) *Handbook of Sport Psychology* (3rd ed., pp. 425-444). Hoboken, NJ: Wiley and Sons.

Breedlove, S. M., Watson, N. V., & Rosenzveig, M. R. (2010). *Biological Psychology*. Sunderland, MA: Sinauer Associates Incorporated Publishers.

Brown, R. P., & Gerbarg, P. L. (2005). Sudarshan kriya yogic breathing in the treatment of stress, anxiety, and depression: Part II – clinical applications and guidelines. *The Journal of Alternative and Complementary Medicine*, *11(4)*, 711-717.

Cannon, W. B. (1927). The James-Lange theory of emotions: A critical examination and an alternative theory. *The American Journal of Psychology*, *100*, 567-586. doi:10.2307/1415404

Carl J. R., & Gellman R. S. (1987). Human smooth pursuit: stimulus-dependent responses. *Journal of Neurophysiology*, *57*(5), 1446-1463.

Calvo, M. G. (1985). Effort, aversive representations, and performance in test anxiety. *Personality and Individual Differences*, *6*(5), 563-571. doi:10.1016/0191-8869(85)90005-4

Calvo, M. G., & Carreiras, M. (1993). Selective influence of test anxiety on reading processes. *British Journal of Psychology*, *84*, 375-388. doi:10.1111/j.2044-8295.1993.tb02489.x

Calvo, M., Eysenck, M. W., Ramos, P. M., & Jimenez, A. (1994). Compensatory reading strategies in test anxiety. *Anxiety, Stress, and Coping*, *7*, 99-116. doi:10.1080/10615809408249338

Calvo, M. G., Szabo, A., & Capafons, J. (1996). Anxiety and heart rate under psychological stress: The effects of exercise-training. *Anxiety, Stress, and Coping*, *9*, 321-337. doi:10.1080/10615809608249409

Cohen, J. (1988). Statistical power analysis for the behavioral sciences (2nd ed.) New York, NY: Lawrence Erlbaum.

Corbetta, M., & Shulman, G. L. (2002). Control of goal-directed and stimulus-driven attention in the brain. *Nature Reviews Neuroscience, 3*, 201-215. doi:10.1038/nrn755

Cotterill, S. T. (2011). Experiences of developing pre-performance routines with elite cricket players. *Journal of Sport Psychology in Action*, *2*, 81-91. doi:10.1080/21520704.2011.584245

Cox, R. H., Martens, M. P., & Russell, W. D. (2003). Measuring anxiety in athletics: The revised competitive state anxiety inventory-2. *Journal of Sport and Exercise Psychology*, *25*, 519-533. doi:10.1123/jsep.25.4.519

Daneman, M., & Carpenter, P. A. (1980). Individual differences in working memory and reading. *Journal of Verbal Learning and Verbal Behavior*, *19*, 450-466. doi:10.1016/S0022-5371(80)90312-6

Darke, S. (1988). Effects of anxiety on inferential reasoning task performance. *Journal of Personality and Social Psychology*, *55*(3), 499-505. doi:10.1037/0022-3514.55.3.499

Deubel, H., & Schneider, W. X. (1996). Saccade target selection and object recognition: Evidence for a common attentional mechanism. *Vision Research, 36*, 1827-1837. doi:10.1016/0042-6989(95)00294-4

Di Bartolo, P. M., Brown, T. A., & Barlow, D. H. (1997). Effects of anxiety on attentional allocation and task performance: An information processing analysis. *Behavioral Research*, *12*, 1101-1111. doi:10.1016/S0005-7967(97)80004-6

Derakshan, N. & Eysenck, M. W. (1998). Working memory capacity in high trait-anxious and repressor groups. *Cognition and Emotion, 12*, 697-713. doi:10.1080/026999398379501

Elliman, N. A., Green, M. W., Rogers, P. J., & Finch, G. M. (1997). Processing-efficiency theory and the working-memory system: impairments associated with sub-clinical anxiety. *Personality and Individual Difference*, *23,* 31-35. doi:10.1016/S0191-8869(97)00016-0

Eysenck, M. W. (1985). Anxiety and cognitive-task performance. *Personality and Individual Differences*, *6*(5), 579-586. doi:10.1016/0191-8869(85)90007-8

Eysenck, M. W. (1989). Stress, anxiety, and intelligent performance. In D. Vickers & P. L. Smith (Eds.) *Human Information Processing: Measures, Mechanisms, and Models*, 525-534. Amsterdam: North-Holland.

Eysenck, M. W., & Calvo, M. G. (1992). Anxiety and performance: the processing efficiency theory. *Cognition and Emotion*, *6*(6), 409-434. doi:10.1080/02699939208409696

Eysenck, M. W., Derakshan, N., Santos, R. & Calvo, M. G. (2007). Anxiety and cognitive performance: Attentional control theory. *Emotion 7*, 336-353. doi:10.1037/1528-3542.7.2.336

Gevirtz, R. (2013). The promise of heart rate variability biofeedback: Evidence-based applications. *Biofeedback*, *41*, 110-120. doi:10.5298/1081-5937-41.3.01

GraphPad Software [Subject randomizer quickcalc]. (2017). Retrieved from http://graphpad.com/quickcalcs/randomize1/

Hadwin, J. A., Brogan, J., & Stevenson, J. (2005). State anxiety and working memory in children: A test of processing efficiency theory. *Educational Psychology*, *25* (4), 379-393. doi:10.1080/01443410500041607

Hanin, Y. L. (1997). Emotions and athletic performance: Individual zones of optimal functioning model. *European Yearbook of Sport Psychology*, *1*, 55-73.

Hanton, S., Mellalieu, S. D., & Hall, R. (2002) Re-examining the competitive anxiety trait-state relationship. *Personality and Individual Difference, 33*, 1125-1136. doi:10.1016/S0191-8869(02)00003-X

Hanton, S., Mellalieu, S., & Williams, J. M. (2015). Understanding and managing stress in sport. In Williams, J. M. & Krane, V. (Eds.) *Applied Sport Psychology* (pp. 207-239) New York, NY: McGraw Hill

Hardy, L. (1990). A catastrophe model of anxiety and performance. In J. G. Jones & L. Hardy (Eds.), *Stress and performance in sport* (pp. 81-106). Chichester, UK: Wiley

Harinath, K., Malhotra A. S., Pal, K., Prasad, R., Kumar. R., Kain., T. C., . . .Sawhney, R. C., (2004). Effects of hatha yoga and omkar meditation on cardiorespiratory performance, psychological profile, and melatonin secretion. *The Journal of Alternative and Complimentary Medicine, 10*, 261-268.

Harle, S. K., & Vickers, J. N. (2001) Training quiet eye improves accuracy in the basketball free throw. *The Sport Psychologist*, *15*, 289-305. doi:10.1123/tsp.15.3.289

Henderson, J. M. (2003). Human gaze control during real-world scene perception. *Trends in Cognitive Sciences*, *7*, 489-504. doi:10.1016/j.tics.2003.09.006

Hogan, B. (2005). *Golf: Links in time*. United States: The History Channel

Hull, C. L. (1943), Principles of behavior. New York: Appleton- Century-Crofts.

Ikeda, M., Iwanaga, M., & Seiwa, H. (1996). Test anxiety and working memory system. *Perceptual and Motor Skills, 82*, 1223-1231.

Janelle, C. M. (2002) Anxiety, arousal and visual attention: a mechanistic account of performance variability. *Journal of Sports Sciences*, *20*(3), 237-251. doi:10.1080/026404102317284790

Jella, S. A., & Shannahoff-Khalsa D. S. (1993). The effects of unilateral forced nostril breathing on cognitive performance. *International Journal of Neuroscience 73*, 61-68. doi:10.3109/0020745987211

Jerath, R., Edry, J. W., Barnes, V. A., & Jerath, V. (2006). Physiology of long pranayamic breathing: Neural respiratory elements may provide a mechanism that explains how slow deep breathing shifts the autonomic nervous system. *Medical Hypotheses, 67*, 566-571. doi:10.4172/2157-7595.1000252

Kesner, R. P., Bolland, B. L., & Dakis, M. (1993). Memory for spatial locations, motor responses, and objects: Triple dissociation among the hippocampus, caudate nucleus, and extrastriate visual cortex. *Experimental Brain Research*, *93,* 462-470. doi:10.1007/BF00229361

Klein, R. Pilon, D., Prosser, S., & Shannahoff-Khalsa, D. (1986). Nasal asymmetries and human performance. *Biological Psychology*, *23*, 127-137.

Kolb, B., & Whishaw, I. Q. (2001). *An introduction to brain and behavior.* New York: Worth Publishers.

Krane, V. (1994). The mental readiness form as a measure of competitive state anxiety. *The Sport Psychologist*, *8*, 189-202. doi:10.1123/tsp.8.2.189

Lagos, L., Vaschillo, E., Vaschillo, B., Lehrer, P., Bates, M., & Pandina, R. (2008). Heart rate variability biofeedback as a strategy for dealing with competitive anxiety: A case study. *Biofeedback*, *36*, 109-115.

Lagos, L., Vaschillo, E., Vaschillo, B., Lehrer, P., Bates, M., & Pandina, R. (2011). Virtual reality-assisted heart rate variability biofeedback as a strategy to improve golf performance: A case study. *Biofeedback*, *39*, 15-20. doi:10.5298/1081-5937-39.1.11

Lange, C. G., & James, W. (1922). *The Emotions.* New York: Hafner Publishing Company.

Lam, W. K., Maxwell, J. P., & Masters, R. (2009). Analogy learning and performance of motor skills under pressure. *Journal of Sport and Exercise Psychology*, *31*, 337-357. doi:10.1123/jsep.31.3.337

Lazarus, R. S. (2000). How emotions influence performance in competitive sports. *The Sport Psychologist, 14*, 229-252. doi10.1123/tsp.14.3.229

Lazarus, R. S. & Folkman, S. (1984). *Stress, Appraisal, and Coping.* New York: Springer Publishing Company.

Leary, M. R., Terry, M. L., Allen, A. B., & Tate, E. B. (2009). The concept of ego threat in social and personality psychology: Is ego threat a viable scientific construct? *Personality and Social Psychology Review*, *13,* 151-164. doi:10.1177/1088868309342595

Lehrer, P. M., & Gevirtz, R. (2014). Heart rate variability biofeedback: How and why does it work? *Frontiers in Psychology, 5*, 1-9. doi:10.3389/fpsyg.2014.00756

Lehrer, P. M., Vaschillo, E., & Vaschillo, B. (2000). Resonant frequency biofeedback training to increase cardiac variability: Rational and manual for training. *Applied Psychophysiology and Biofeedback, 25(3)*, 177-191.

List Randomizer. (2017). Retrieved from https://www.random.org/lists/

MacLeod, C., & Donnellan, A. V. (1993). Individual differences in anxiety and the restriction of working memory capacity. *Personality and Individual Differences*, *15*(2), 163-173. doi:10.1016/0191-8869(93)90023-V

Malathi, A., & Damodaran, A. (1999). Stress due to exams in medical students-role of yoga. *Indian Journal of Physiology and Pharmacology, 43*, 218-224.

Mann, D. T., Williams, A. M., Ward, P., & Janelle, C. M. (2007) Perceptual-cognitive expertise in sport: A meta-analysis. *Journal of Sport and Exercise Psychology*, *29*, 457-478. doi:10.1123/jsep.29.4.457

Markham, R., & Darke, S. (1991). The effects of anxiety on verbal and spatial task performance. *Australian Journal of Psychology*, *43*, 107-111. doi:10.1080/00049539108259108

Martens, R., Vealey, R. S., & Burton, D. (1990). *Competitive anxiety in sport.* Champaign, IL: Human Kinetics

Mason, L. J. (1980). *Guide to stress reduction.* Culver City, CA: Peace Press.

McDougal, D. H. & Gamlin, P. D. (2015). Autonomic control of the eye. *Comprehensive Physiology*, *5*, 439-473. doi:10.1002/ephy.c140014

Mesagno, C., & Mullane-Grant, T. (2010). A comparison of different pre-performance routines as possible choking interventions. *Journal of Applied Sport Psychology*, *22*(3), 343-360. doi:10.1080/10413200.2010.491780

Milner, A. D., & Goodale, M. A. (1995). *Visual brain in action.* Oxford: Oxford University

Monnazzi, P., Leri, O., Guizzardi, L., Mattioli, D., & Patacchioli, F. R. (2002). Anti-stress effect of yoga type breathing: Modification of salivary cortisol, heart rate and blood pressure following a step-climbing exercise. *Stress and Health*, *18*, 195-200. doi:10.1002/smi.938

Moore, L., Vine, S. J., Cooke, A. M., Ring, C., & Wilson, M. R. (2012). Quiet eye training expedites motor learning and aids performance under heightened anxiety: The roles of response programming and external attention. *Psychophysiology*, *49*, 1005-1015. doi:10.1111/j.1469-8986.2012.01379.x

Moore, L. J., Vine, S. J., Freeman, P., & Wilson, M. R. (2013). Quiet eye training promotes challenge appraisals and aids performance under elevated anxiety. *International Journal of Sport and Exercise Psychology*, *11*(2), 169-183. doi:101080/1612197x.2013.773688

Nieuwenhuys, A., Pijpers, J. R., Oudejans, R. R., & Bakker, F. C. (2008). The influence of anxiety on visual attention in climbing. *Journal of Sport and Exercise Psychology*, *30*, 171-185. doi:10.1123/jsep.30.2.171

Oudejans, R. R., Koedijker, J. M., Bleijendaal, I., & Bakker, F. C. (2005). The education of attention in aiming at a far target: Training visual control in basketball jump shooting. *International Journal of Sport and Exercise Psychology*, *3*, 197-221. doi:10.80/161219X.9671767.

Paul, M., & Garg, K. (2012). The effect of heart rate variability biofeedback on performance psychology of basketball players. *Applied Psychophysiology Biofeedback*, *37*, 131-144. doi:10.1007/s10484-012-9185-2

Pelka, M., Kolling, S., Ferrauti, A., Meyer, T., Pheiffer, M., & Kellmann, M. (2017). Acute effects of psychological relaxation techniques between two physical tasks. *Journal of Sport Sciences*, *35*, 216-223. doi:10.1080/02640414.2016.1161208

Posner, M. I., & Raichle, M. E. (1994). *Images of mind.* New York, NY: Scientific American Library.

Prinsloo, G. E., Derman, W. E., Michael, I. L., & Rauch, H. G. L. (2013). The effect of a single episode of short duration heart rate variability biofeedback on measures of anxiety and relaxation states. *International Journal of Stress Management*, *20(4)*, 391-411. doi:10.1037/a0034777

Pumprla, J., Howorka, K., Groves, D., Chester, M., & Nolan, J. (2002). Functional assessment of heart rate variability: Physiological basis and practical applications. *International Journal of Cardiology, 84*, 1-14. doi:10.1016/S0167-5273(02)00057-8

Richards, A., French, C. C., Keogh, E., & Carter, C. (2000). Test-anxiety, inferential reasoning, and working memory load. *Anxiety, Stress, and Coping*, *13*, 87-109. doi:10.1080/10615800008248335

Rienhoff, R., Fischer, L., Strauss, B., Baker, J., & Schorer J. (2014). Focus of attention influences quiet-eye behavior: An exploratory investigation of different skill levels in female basketball players. *Sport, Exercise, and Performance Psychology*, *4*(1), 62-74. doi:10.1037/spy0000031

Salvucci, D. D., & Goldberg, J. H., (2000). Identifying fixations and saccades in eye-tracking protocols. *Tracking Research and Application Symposium,* 71-78. doi:10.1145/355017.355028

Schonpflug, W. (1992). Anxiety and effort. In D. Forgays, T. Sosnowski, & K. Wrzesniewski (Eds.), Anxiety: Recent developments in cognitive, psychophysiological and health research. (pp 51-62). Bristol, PA: Taylor and Francis

Smith, N. C., Bellamy, M., Collins, D. J., & Newell, D. (2001). A test of processing efficiency theory in a team sport context. *Journal of Sports Sciences*, *19*, 321-332. doi:10.1080/02640410152006090

Spence, J.T., & Spence, K.W. (1966). The motivational components of manifest anxiety: Drive and drive stimuli. In C.D. Spielberger (Ed.), Anxiety and behavior. New York, NY: Academic Press.

Spielberger, C. D. (1966). *Anxiety and Behavior.* New York, NY: Academic Press

Song, H. S., & Lehrer, P. M., (2003). The effects of specific respiratory rates on heart rate and heart rate variability. *Applied Psychophysiology and Biofeedback*, *28*, 13-23. doi:1090-0586/03/0300-0013/0 C

Telles, S., & Naveen, K. V. (2008). Voluntary breath regulation in yoga: Its relevance and physiological effects. *Biofeedback*, *36*, 2. 70-73.

Telles, S., Raghuraj, P., Maharana, S., & Nagendra, H. R. (2007). Immediate effect of three yoga breathing techniques on performance on a letter-cancelation task. *Perceptual and Motor Skills*, *104*, 1289-1296. doi:10.2466/PMS.104.4.1289-1296

Telles. S., Singh, N., & Balkrishna A. (2011). Heart rate variability changes during high frequency yoga breathing and breath awareness. *Biopsychosocial Medicine, 5.* Retrieved from ttp://www.bpsmedicine.com/content/5/1/4

Telles, S., Yadav, A., Kumar, N., Sharma, S., Visweswaraiah, N. K., & Balkrishna, A. (2013). Blood pressure and purdue pegboard scores in individuals with hypertension after alternate nostril breathing, breath awareness, and no intervention. *Medical Science Monitor*, *19*, 61-66. doi:10.12659/MSM.883743

Tobii (2012). Determining the Tobii I-VT fixation filter's default values: Method description and results discussion. *Tobii White Papers.* Retrieved from http://www.acuity-ets.com/downloads/Tobii%20Tobii%20IVT%20Fixation%20Filter%20Test%20Report.pdf

Tomas, O., Mellalieu, S. D., & Hanton, S. (2009). Stress management in applied sport psychology. In S. Mellalieu and S. Hanton (Eds.), *Advances in Sport Psychology* (124-161). New York, NY: Routledge

Treisman, A. (1999). Solutions to the binding problem: Progress through controversy and convergence. *Neuron*, *24*, 105-110. doi:10.1016/S0896-6273(00)80826-0

Uebelacker, L. M., & Broughton, M. K. (2016). Yoga for depression and anxiety: A review of published research and implications for healthcare providers. *Rhode Island Medical Journal*, *99*, 20-22.

Vaschillo, E. G., Vaschillo, B., & Lehrer, P. M. (2006). Characteristics of resonance in heart rate variability stimulated by biofeedback. *Applied Psychophysiology and Biofeedback*, *31*, 129-142. doi:10.1007/s10484-006-9009-3

Vickers, J. N. (1996). Visual control when aiming at a far target. *Journal of Experimental Psychology: Human Perception and Performance, 22*(2), 342-354. doi:10.1037/0096-1523.22.2.342

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

Vickers, J. N. (2016). The quiet eye: Origins, controversies, and future directions. *Kinesiology Review*, *5*, 119-128. doi:10.1123/kr.2016-0005

Vickers, J. N., & Williams, A. M. (2007). Performing under pressure: The effects of physiological arousal, cognitive anxiety, and gaze control in biathlon. *Journal of Motor Behavior*, *39*(5), 381-394. doi:10.3200/JMBR.39.5.381-394

Vine, S. J., Lee, D., Moore, L J., & Wilson, M. R. (2013). Quiet eye and choking: Online control breaks down at the point of performance failure. *Medicine and Science in Sports and Exercise*, *45*(10), 1988-1994. doi:10.1249/Mss.0b013e31829406c7

Vine, S. J., Moore, L. J., & Wilson, M. R. (2011). Quiet eye training facilitates competitive putting performance in elite golfers. *Frontiers in Psychology*, *2*, 1-9. doi:10.3389/fpsyg.2011.00008

Vine, S. J., Moore, L. J., & Wilson, M. R. (2014). Quiet eye: The acquisition, refinement, and resilient performance of targeting skills. *European Journal of Sport Science*, *14*, 235-242. doi:10.1080/17461391.2012.683815

Wells, R., Outhred, T., Heathers, J. A. J., Quintana, D. S., & Kemp, A. H. (2012). Matter over mind: A randomized-controlled trial of single-session biofeedback training on performance anxiety and heart rate variability in musicians. *Plos One*, *7(10)*, 1-11. doi:10.1371/journal.pone.0046597

Wilson, M. R., Vine, S. J., & Wood., G. (2009). The influence of anxiety on visual attentional control in basketball free throw shooting. *Journal of Sport and Exercise Psychology*, *31*, 152-168. doi:10.1123/jsep.31.2.152

Wilson, M. R., Wood, G., & Vine, S. J. (2009). Anxiety, attentional control, and performance impairment in penalty kicks. *Journal of Sport and Exercise Psychology*, *31*, 761-755. doi:10.1123/jsep.31.6.761

Williams, A. M., Singer, R. N., & Frehlich, S. G. (2002). Quiet eye duration, expertise and task complexity in near and far aiming tasks. *Journal of Motor Behavior*, *34*(2), 197-207. doi:10.1080/00222890209601941

Williams, A. M., Vickers, J., & Rodrigues, S. (2002). The effects of anxiety on visual search, movement kinematics, and performance in table tennis: A test of Eysenck and Calvo’s processing efficiency theory. *Journal of Sport and Exercise Psychology*, *24*, 438-455. doi:10.1123/jsep.24.4.438

Williams, J. M. & Krane, V. (7). (2015). *Applied Sport Psychology*. New York, NY: McGraw Hill.

Winocur, G. (1990). Anterograde and retrograde amnesia in rats with dorsal hippocampal or dorsomedial thalamic lesions. *Behavioral Brain Research*, *38,* 145-154 doi:10.1016/0166-4328(90)90012-4

Wong, W. & Bartels, M. (2015). *Tobii Pro Training Workbook.* Falls Church, VA: Tobii Pro North America.

Ziv, G. & Lidor, R. (2015). Focusing attention instructions, accuracy, and quiet eye in a self-paced task-an exploratory study. *International Journal of Sport and Exercise Psychology*, *13*(2), 104-120. doi:10.1080/1612197X.2014.946946

Appendix A

MRF-3 (Krane, 1994)

Instructions: Please answer the following statements regarding how you felt during the previous putt.

My thoughts are:

1	2	3	4	5	6	7	8	9	10	11

NOT-WORRIED WORRIED

My body feels:

1	2	3	4	5	6	7	8	9	10	11

NOT-TENSE TENSE

Appendix B

Recruitment Flier

Novice Golfers needed for sport psychology research!

If you are a person with little to zero golf experience, your assistance is requested for research that studies how visual input affects golf putting performance.

Participant Requirements:

- Must be a novice golfer (little to zero golf experience).
- Must be able to complete 2 lab sessions on separate days.
- Must be willing to participate in a putting task, wear glasses that measure where you are looking, and answer brief psychological questionnaires.
- Must not wear eyeglasses (contact lenses ok).
- Must not have a diagnosis of epilepsy, history of eye surgery, or rely on devices that could be disrupted by infrared light.
- Must not wear mascara, have very long eyelashes, or have eyelids that interfere with study equipment.

Monetary compensation of $25 for time and travel upon completion of the study.

If interested contact **Mason Nichols**
Email: nichol34@wwu.edu
Phone: (801) 722-8180

Appendix C

Recruitment Email to Professors

Hello Professor __________,

My name is Mason Nichols and I am a current Master's student at Western in sport and exercise psychology. I am starting recruitment for my Master's thesis and was wondering if I could recruit participants from your class/classes? I am looking for 30 male and female participants to take part in my golf putting study. Involvement requires participants to come to a lab on campus to participate in a putting task that takes two sessions to complete. While they are putting, participants will answer some brief questionnaires and we will measure where they are looking using eye tracking glasses. All participants must be novice golfers with little to no golf experience.

Thank you so much for your time and consideration. If you will allow me to recruit in your class, please provide me with the date, time, and location of the class where I can describe my study to your students. The recruitment should take approximately 5 minutes of your class time. If you do not have time available for in class recruiting, it would be very much appreciated if you could share the paragraph below with your class/classes via email. Also, if you are unable to accommodate this request in any capacity, please let me know via email. Please also let me know if you have any further questions. I would be more than happy to answer them for you as best as possible.

With appreciation,

Mason B. Nichols
(801) 722-8180
nichol34@wwu.edu

Hello Students,

My name is Mason Nichols and I am looking for students to participate in research for my Master's thesis. In this research, I am studying how people use their eyes while they are golf putting. During your participation in this study, you will complete a golf putting task while wearing glasses that track where you are looking. You will also answer brief questionnaires about how you are feeling. To participate in this study, you must be a novice golfer, meaning you have little to no golf experience. Also, people that have epilepsy, eye alignment issues, eye tracking issues, use a medical device that could be interfered with by infrared light, wear glasses, or have had eye surgery cannot participate because these conditions could interfere with the eye tracking glasses. Your participation would consist of completing two putting sessions over two days, taking a total of about two hours to complete. If you complete all study procedures, you will receive $25 compensation. If you are interested in participating please email me, Mason Nichols, at nichol34@wwu.edu.

Appendix D

In Class Recruiting Script

Hello, my name is ____________ and I am looking for students to participate in research for a Master's thesis. In this research, we are studying how people use their eyes while they are golf putting. During your participation in this study, you will complete a golf putting task while wearing glasses that track where you are looking. You will also answer brief questionnaires about how you are feeling. To participate in this study, you must be a novice golfer, meaning you have little to no golf experience. Also, people that have had eye surgery, eye alignment or eye tracking issues, epilepsy, use a medical device that could be interfered with by infrared light, or wear glasses cannot participate because we will be using eye tracking glasses to see where you are looking while putting, and these conditions could interfere with the glasses. Your participation would consist of completing two putting sessions over two days, taking a total of about two hours to complete. If you complete all study procedures, you will receive $25 compensation. If you would like to participate please email Mason Nichols at nichol34@wwu.edu. Does anyone have any questions? Thank you so much for your time and help completing this research.

Appendix E

Consent Form

Purpose and Benefit:

Researchers in the field of sport psychology are always looking for ways to understand what helps people perform their best. The purpose of this research study is to better understand where people are looking during a competitive putting task.

REGARDING MY PARTICIPATION IN THIS STUDY, I UNDERSTAND THAT:

1) Inclusion Criteria
    a. I must be a novice golfer to participate in this study. For this study, a novice golfer is one that has never taken golf lessons, taken a PE golf class, played 9 holes of golf in competitive or leisure situations, practiced golf on a driving range or practice green, or mini-golfed within the past year.
    b. I must be an undergraduate student at Western Washington University.
2) Exclusion Criteria
    a. Being medically reliant on any device that could be disturbed by infrared light and/or infrared radiation is exclusionary.
    b. History of epilepsy or epileptic seizures is exclusionary due to flashing infrared lights being used by the eye tracking glasses.
    c. Mascara, long eye lashes, and/or droopy eyelids that interfere with the eye tracking glasses are exclusionary.
    d. Needing to wear eye glasses is exclusionary. Contact lenses are allowed.
    e. I cannot have current eye movement or eye alignment abnormalities.
    f. Having a history of eye surgery is exclusionary.

This research study will involve completion of two sessions over the course of 2-4 days. Completion time will be approximately 2 hours total, over both days.

g. Session 1 (Day 1): After signing this consent form, completion of exclusion/inclusion criteria, and filling out a demographics questionnaire, I will be fitted with eye tracking glasses that measure where I am looking. Once the glasses are in place I will participate in a golf putting task. During some of the putts, I will be asked questions about how I was feeling. Next, I will participate in a short golf specific task taking approximately 15 minutes. Afterward, I will complete more putts while wearing the eye tracking glasses. I will be allowed brief breaks at certain points.
h. Sessions 2 (Day 3, ± 1 days): After being fitted with the eye tracking glasses, I will resume the golf putting task while being asked questions about how I felt during the putts and have where I am looking measured.

3) To protect confidentiality, my eye tracking data that is collected from the glasses will be kept on a password-protected computer. All other paperwork containing study specific information will be secured in a locked filing cabinet in a locked room.
4) If I complete all study procedures, I will receive $25 as compensation for my time and travel. My participation may further knowledge about how eyesight is used during competitive putting situations.

5) There are some risks that accompany this study. You may experience discomfort associated with competitive sport participation. The questionnaires you answer may cause minimal psychological discomfort. The gaze tracking equipment uses flashing infrared light and radiation, which occasionally causes dry irritated eyes, malfunction of certain medical devices, and induce seizures in those with epilepsy.
6) Participation is voluntary and I may choose to withdraw from participating at any time without penalty or loss of benefits. If I withdraw my consent I will not be allowed to continue in the study.
7) This research is being conducted by Mason Nichols, a Master's student at Western Washington University, under the supervision of Dr. Jessyca Arthur-Cameselle. Any questions that I have about this study or my participation may be directed to Mason at nichol34@wwu.edu.
8) A copy of this signed consent form will be provided to me, with the original copy being retained by the investigator.

The Human Subjects Review Committee (HSRC) at Western Washington University has approved this study. If you have any questions about your participation or your rights as a research participant, you can contact the Western Washington University HSRC at (360) 650-3220, or Janai Symons, the Research Compliance Officer at (360) 650-3082. If during or after participation in this study you suffer from any adverse effects as a result of participation, please notify the researcher directing the study or the WWU HSRC.

****

By signing below, I indicate that I have read the above description, I am 18 years of age or older, and I agree to participate in this study.

Participant Signature: _________________________________Date: _______________

Investigator Signature: ________________________________Date: _______________

Appendix F

Participant Randomization

Subject Number	Group A=DB, B=C	Initials
1	B	
2	A	
3	B	
4	A	
5	A	
6	A	
7	B	
8	A	
9	A	
10	B	
11	A	
12	A	
13	B	
14	A	
15	B	
16	A	
17	A	
18	B	
19	A	
20	B	
21	B	
22	A	

23	A	
24	A	
25	B	
26	B	
27	B	
28	B	
29	B	
30	B	

Appendix G

Demographics Form

Demographic Information

1. What is your age?

2. What is your gender identity?

   Male __ Female __ Transgender __ Prefer not to answer __

3. What is your ethnicity? Check all that apply.

   American Indian or Alaska Native __

   Asian (including Indian subcontinent and Philippines) __

   Black or African American (including Africa and Caribbean) __

   Hispanic or Latino (including Spain) __

   Native Hawaiian and Other Pacific Islander __

   White (including Middle Eastern) __

   Other__

Appendix H

Inclusion/Exclusion Criteria

#	Yes	No	Inclusion Criteria (If no, exclude subject)
1.	☐	☐	I must be a novice golfer to participate in this study. For this study, a novice golfer is one that has never taken golf lessons, taken a PE golf class, played 9 holes of golf in competitive or leisure situations, practiced golf on a driving range or practice green, or mini-golfed within the past year.
2.	☐	☐	I am an undergraduate student at Western Washington University.
			Exclusion Criteria (If yes, exclude subject)
1.	☐	☐	Being medically reliant on any device that could be disturbed by infrared light and/or infrared radiation.
2.	☐	☐	History of epilepsy or epileptic seizures.
3.	☐	☐	Mascara, long eye lashes, and/or droopy eyelids that interfere with the eye tracking glasses.
4.	☐	☐	Needing to wear eye classes (contact lenses are allowed).
5.	☐	☐	Current eye movement or eye alignment abnormalities.
6.	☐	☐	History of eye surgery.

Appendix I

Participant Script

Fitting of Eye Tracking Gear

- Only researcher will adjust equipment
- Glasses secured as tight as possible without discomfort
- Glasses connected to recorder, secured to clothing
- Recorder connected to the computer
- Warn participants about safety and to stay within tape box
- Have participant use restroom

Warm Up

I will now have you take 20 warm putts to familiarize yourself with the task. Please try your best to putt the ball into the center hole (What hole will you be putting to, please point at it). I will be recording a "make" if your ball goes into the center hole and a "miss" if you miss the hole or hit the ball into any of the other holes on the matt. I will keep track of if you "make" or "miss" every putt throughout the study.

When putting, make sure to look through the glasses and not under or to the side of the lens. I will place the ball on the starting marker before each putt and get the ball after you putt it. Remember to stay in the tape box and be careful not to trip over the cords or your surroundings.

Each putt will start when you place the putter behind the ball and end after you complete the putt. Do not place the putter behind the ball until you are ready to prepare and execute your putt. Once you put the putter behind the ball it is important that you try your hardest to make the putt. Remember, performing your best is more important than speeding through the study.

Pretest

Now that you are familiar with the task, you will complete 20 putts where I will track where you are looking. I will place the ball on the starting marker, then you can putt whenever you are ready. Remember, each putting trial will start when you place the putter behind the ball and end after you complete the putt. I will start measuring where you are looking after you place the putter behind the ball. Do not place the putter behind the ball until you are ready to try your hardest to prepare and execute your putt. Take your time and do not rush the process, but also do not overthink it. The goal is to make as many putts as you can.

After each putt, I will have you fill out a very brief questionnaire.

It is important that you try your hardest to putt the ball into the center hole. Remember to look through the glasses when putting. The lights the glasses use to track your gaze can dry out your eyes a bit, so it is recommended that you blink a lot between putts to keep your eyes moist.

Before we get started will need to calibrate the glasses. When I tell you to, please look at the small black dot in the center of the circle and do not stop looking at the dot until I tell you to. Any Questions?

Script for questionnaire: There are no right or wrong answers to the questionnaire, so please fill it out as honestly as possible. To fill out the questionnaire, please circle the number that represents your best and most honest answer.

Deep breath instructions

Before we move onto the next stage of putts, I am going to teach you a specific breathing technique that I am going to have you complete before each putt you take for the remainder of your participation. This special type of breath, called a diaphragmatic breath, is meant to be calming.

A diaphragmatic breath involves you taking a breath in through your nose, deep into your lungs using your diaphragm, then exhaling through your mouth. Your diaphragm is a muscle below your lungs. The diaphragm is used to draw air into the lungs. When taking a diaphragmatic breath, you will inhale air through your nose for four seconds deep into the bottom of your lungs, filling them from bottom to top. As you inhale you will breathe in relaxation. Next you will exhale through your mouth for six seconds, emptying your lungs from the top to the bottom. As you exhale you will breathe out tension and worry. You can tell that you are doing a diaphragmatic breath right if your belly inflates before your chest on the inhale and your chest deflates before your belly on the exhale.

I am going to have you practice breathing deep into your lungs using your diaphragm. Standing with your feet the same width apart as they would be when you are putting, I want you to put one of your hands on your chest and the other on your stomach. When you inhale through your nose, I want you to focus on inflating your stomach so that the hand on your belly moves before the hand on your chest. When you exhale, do so through your mouth like you are blowing out a candle and see if you can empty your lungs from the bottom down and have the hand on your chest move first. When you exhale, the air from your chest will move out of you first and your stomach will deflate last, the opposite of your inhale. Go ahead and practice inhaling though your nose and filling your lungs from the bottom up, then exhaling through your mouth like blowing out a candle and emptying your lungs from the top down. Keep your hands on your stomach while practicing so we can both tell if you are doing the breath right. Remember to breath in relaxation and breathe out any tension and worry you may have. (Give them time to practice, watch for the movement of the hands in the correct order.)

Now that you have the basics of the diaphragmatic breath down, I am going to have you practice breathing in for 4 seconds and out for 6 seconds. It is important that you focus on the timing while practicing because you will be asked to recreate this timing while breathing throughout the study. I will count for you as you practice breathing to the rhythm of inhaling for 4 seconds and exhaling for 6 seconds. Place your hands on your stomach so we can make sure you are still using the correct diaphragmatic breathing technique. Any questions? (Count for the participant while still watching their hands when possible).

Okay now that you have the technique and timing down, I am going to have you practice taking one single diaphragmatic breath before executing your putt. For the remainder of the study, I am going to have you take one deep, diaphragmatic breath before each putt. Once your breath is complete, you will place your putter behind the ball and execute your putt to the best of your ability. It is important that you place your putter behind the ball only after completing your breath. The process will be: take a diaphragmatic breath by inhaling through your nose for 4 seconds filling your lungs from the bottom to top, then exhaling through your mouth for 6 seconds like blowing out a candle while emptying your lungs from the top down, place the putter behind the ball, then execute your putt. Try to make the breath as relaxing as possible. Any questions about the order? Remember to look through the glasses at all times. Go ahead and practice until we both feel comfortable with the routine. You will be asked to complete this process for each putt you take during the remainder of the study.

Practice Blocks

Now I will have you practice putting. You will complete 3 sets of 20 putts, totaling 60 practice putts. You will be allowed a short break between each 20 blocks of putts. You will be wearing the glasses while you putt, but no gaze information will be recorded. It is important that you do your best and try to make as many putts as possible during this practice round. I will still be keeping track of your makes and misses during the practice rounds.

DB GROUP ONLY: Before each putt please execute a diaphragmatic breath exactly as I just taught you. It is important that you follow the routine we practiced as closely as possible. Remember to inhale through your nose for four seconds, then exhale through your mouth for six seconds. Once you have completed your diaphragmatic breath, place your putter behind the ball and execute the putt.

Warm Up Day 2

We will start today with 20 warm up putts while wearing the eye tracking glasses. Remember to stay in the taped box when you are wearing the glasses, to be careful of all cords and your surroundings, and to let me know if there is any discomfort so I can adjust the equipment. Like yesterday I will retrieve the ball for you and place it on the starting mark.

DB GROUP ONLY: During the warm-up putts, execute a diaphragmatic breath before each putt. The routine goes: inhale through your nose into your belly for four seconds, exhale through your mouth like you are blowing out a candle for six seconds, then place the putter behind the ball and execute your putt.

Manipulation

We decided that to make this putting task more like a real-life, for the final part of the study, you will be participating in a golf putting competition against the other participants in the study. It is important to make this competition as real as possible. To simulate real life competition, all participants will have access to an online leaderboard that will include your name and how many putts you make in this final round. Once you complete the study, you will be given the password to the website to see how you did compared to everyone else. All participants will be able to access the website until one month after collection of study data is complete. I analyzed your putting performance after day one of the study. Your performance the first day of putting put you in the bottom 30% of participant scores. It is important that you improve your performance during the competition or else your data will be unusable because we need to compare the gaze data of your makes and misses.

During this competition stage, you will be answering the same brief questionnaire that you did at your last session after each putt. Remember, there are no right or wrong answers to the questionnaire. Please answer as truthfully and accurately as possible by circling the number that best describes you during the previous putt.

Also, remember to blink between putts because the lights the glasses use can dry out your eyes. We will start with the same calibration procedure as last session. Please look at the dot in the middle of the circle and continue to look at it until I tell you calibration is finished. Once calibration is finished you may begin. Look through the glasses at all times while putting. Each trial will start when you put the putter behind the ball and end after completion of your putt.

DB GROUP ONLY: please follow diaphragmatic breath procedure for each putt that was taught to you last time. Inhale for 4 seconds, exhale for 6 seconds, then place the putter behind the ball and execute the putt. Try to make the breath as relaxing as possible.

Appendix J

Debrief Script

Thank you for participating in my study. I wanted to take some time to tell you exactly what we were studying. The main purpose of this study was to test the effects a diaphragmatic breath has on anxiety, gaze patterns, and performance. Previous studies have found that when participants have increased anxiety they become more easily distracted, causing them to look at more places for a shorter amount of time. This distracted gaze pattern that happens when people become anxious is linked to less successful performance. This study's purpose was to see if taking a deep breath can lower anxiety in a situation where anxiety typically is high, leading to less distracted gaze patterns and better performance. So, we divided all participants into two groups. The experimental group was trained to take a deep breath before each putt they took while the control group watched a video clip on the history of golf.

Sometimes in research, it is necessary to not always tell the participants everything about the study before they participate, because we don't want that information to change the way that you behave or think during the study. In this study, we wanted to increase all participants' anxiety, so it was necessary to tell everyone a few things that were not true. By telling you that your scores would be made public, that your scores in the first session placed you in the bottom 30% of participant performances, and that you must do better if your information was to be used, we hoped to increase your anxiety levels. These ways of increasing anxiety are commonly used in other research like this study. So, I want you to be aware that we did not keep a leaderboard and will not post your scores anywhere for others to see. In addition, your performance is unrelated to whether or not we can use your data.

I wanted to check in with you to see if you have any questions or comments about the procedure or the procedure that we used. Do you have any questions for me?

If you think of any questions about the study or want to see the final results, please contact me at nichol34@wwu.edu. If you have questions about your rights as a research participant in this experiment you may contact the Western Washington University HSRC at (360) 650- 3220, or Janai Symons, the Research Compliance Officer at (360) 650-3082. Sometimes after psychology studies, people feel upset or a bit of discomfort. I do not expect that you will, but if you do, please be aware that we have counseling services on campus. You can contact the Western Washington University Counseling Center at (360) 650-3164.

Now that I have explained the study to you, do you agree to allow us to use the data that we collected from your participation in this study?