Examining the Effects of Anxiety on Running Efficiency in a Cognitive-motor Dual-task

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ABSTRACT

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Dual-tasking is commonly defined as performing two tasks simultaneously and is commonplace in simple activities of daily living such as walking across the street while talking on a cell phone. When even simple motor tasks such as standing or walking are coupled with a mental task (cognitive-motor dual-task), performance of one or both tasks decreases because total available attention is limited. Dual-task performance has been shown to be affected by anxiety created by a physically threatening or disturbing environment. This can be explained by the attention-consuming effect of anxiety. Few studies have examined whether "performance anxiety" may have similar effects. This study examined the effects of performance-related anxiety on running when performed concurrently with a math task. Twenty-nine healthy university level students participated voluntarily in this study. Participants ran on a treadmill at a 20% increase from their self-selected pace while simultaneously subtracting 7 continuously from a randomly assigned 3-digit number. Each participant was subjected to the no-anxiety and anxiety conditions. Changes in stride length and stride frequency were analyzed using a Repeated Measures ANOVA with a significance level of $\alpha = 0.05$. Results were inconclusive, as analyses on anxiety showed that it was not successfully induced. Further studies should consider characteristics of the sample in order to create an experimental protocol capable of inducing population-specific anxiety.

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Table of Contents

LIST OF TABLES vii
LIST OF FIGURES viii
LIST OF APPENDICES ix
ABBREVIATIONS x
THESIS COMPOSITION xi
INTRODUCTION 1
CHAPTER I: LITERATURE REVIEW 4
Attention and information processing 4
Bottleneck theories of attention and information processing 5
Capacity-sharing theories of attention and information processing 6
Attention and performance 7
Arousal and performance 9
CHAPTER II: RATIONALE AND OBJECTIVES 16
CHAPTER III: METHODOLOGY 19
Subjects 19
Baseline measures 19
Tasks 21
Materials and apparatus 22
Variables 23
Procedure 26
Statistical analysis 27
CHAPTER IV: RESULTS 28
Baseline measures 28
Anxiety 28
Rate of perceived exertion 32
Stride length and Stride frequency 32
Stride time variability 33
Cognitive output 33
CHAPTER V: LIMITATIONS AND DISCUSSION 35
CHAPTER VI: CONCLUSION 40
REFERENCES 42

APPENDIX A..47
APPENDIX B..49
APPENDIX B..50
APPENDIX C..51
APPENDIX D..52

LIST OF TABLES

Table 1.0: Descriptive information, baseline measures, and correlation statistics……...28

Table 2.0: Analysis of stride length stride frequency…………………………………………32

Table 3.0: Analysis of normalized stride length and stride frequency……………………33

LIST OF FIGURES

Figure 1.0: Model of the central bottleneck……………………………………………………..6

Figure 2.0: Kahneman's model of attention……………………………………………………..7

Figure 3.0: Yerkes-Dodson law……………………………………………………………………10

Figure 4.0: Hanin's IZOF model…………………………………………………………………...14

Figure 5.0: The cusp catastrophe model…………………………………………………………15

Figure 6.0: Schumway-Cook and Woollacott model………………………………………………16

Figure 7.0: Biodex™ treadmill……………………………………………………………………..22

Figure 8.0: Foot switch……………………………………………………………………………..23

Figure 9.0: Rate of perceived exertion scores……………………………………………………...29

Figure 10.0: Comparison of trait anxiety of sample vs norm……………………………………...29

Figure 11.0: Comparison of state anxiety of sample vs norm……………………………………30

Figure 12.0: Group means and SD for state anxiety scores all conditions……………...30

Figure 13.0: Group means and SD for state anxiety scores for events…………………31

Figure 14.0: Results of qualitative analysis………………………………………………………32

Figure 15.0: Group means and SD for cognitive output…………………………………...34

LIST OF APPENDICES

APPENDIX A: Consent to participate in the study……………………………………………45

APPENDIX B: STAI Form Y-1 and Y-2…………………………………………………...47

APPENDIX C: SQUASH…………………………………………………………………49

APPENDIX D: BORG CR10 scale…………………………………………………………50

ABBREVIATIONS

AB:	Attentional Blink
ADLs:	Activities of Daily Living
DT:	Dual-Task/Dual-tasking
IZOF:	Independent Zones of Optimal Functioning
MAT:	Mental Arithmetic Task
PRP:	Psychological Refractory Period
RPE:	Rate of Perceived Exertion
RSVP:	Rapid Serial Visual Presentation
SET:	Social-Evaluative Threat
STAI:	State and Trait Anxiety Inventory
SQUASH:	Short Questionnaire to Assess Health-enhancing Physical Activity

THESIS COMPOSITION

INTRODUCTION: Introduction to attention, cognitive-motor dual-tasking, and the performance effects of anxiety.

CHAPTER I: Review of the literature on attention and information processing and the relationship between arousal and performance. Overview of different anxiety-based theories in sports performance.

CHAPTER II: Presentation of a detailed rationale followed by the study's objectives and hypothesis.

CHAPTER III: Presentation of the methodology including a detailed description of the experimental variables, the participants, the equipment used, and the tasks performed. Description of the statistical analysis.

CHAPTER IV: Presentation of the results for baseline measures, independent, and dependent variables. Description and detailed discussion of correlation, qualitative, and quantitative analyses.

CONCLUSION: Summary of the experimental results, conclusion and recommendations for future studies.

INTRODUCTION

Dual-tasking (DT) is commonly defined as performing two tasks simultaneously and is commonplace in simple activities of daily living (ADLs) such as walking across the street while talking on a cell phone. According to Pashler (1994), “for more than 100 years, psychologists have been interested in people’s ability (or inability) to perform two or more activities concurrently” (p. 220). Performance of simple or complex tasks is limited when multiple tasks must be performed, and many studies have been conducted throughout the years in an attempt to understand individuals’ limited ability to perform two tasks simultaneously. ‘Dual-task interference’ is a term used to define the decrease in performance observed in one or both of the concurrent tasks (Pashler, 1994), and can occur between two tasks with similar input (processing) or output (response) requirements (Shapiro, 2001). Fundamentally, dual-task (DT) interference theories are premised on attention or information processing capacities and strategies when two tasks compete for limited resources (Duncan, 1979; Pashler, 1994). In most studies constructed using a DT paradigm, a primary task is identified for which attentional needs are recorded, and a secondary task for which decreases or modifications in performance are recorded (Brisswalter and Legros, 1995). Performance on the secondary task is assumed to reflect the attentional demands of the primary task, where the magnitude of observed performance decrements are interpreted as an indication of the degree to which the primary task may be attentionally demanding. Several theoretical assumptions have been made regarding the precise mechanisms involved in DT performance, and it remains an area of research that requires further investigation if we hope to gain a fuller understanding.

In the area of fitness, motor performance, and sports psychology, DT paradigms involving cognitive tasks performed concurrently with physical, postural or paradigms involving cognitive tasks performed concurrently with physical, postural or locomotive tasks have recently come to light. Simple physical tasks such as standing and walking which were once thought to be almost entirely 'automatic' have now been shown to be attentionally demanding (Kerr et al., 1985; Lajoie et al., 1993; Yogev-Seligmann et al., 2008). When coupled with a cognitive task, individuals will distribute attention between the two tasks, but the increased effort of performing both tasks simultaneously is expected to result in changes in overall system performance (Hockey, 1997; Posner, 2012). Additionally, the emotional states resulting from physical sensations of exertion combined with the cognitive demands of a DT may further burden the system, thus affecting performance. According to Duncan (1979), "in any divided attention experiment, performance may reflect an interaction between resource limitation, single task processes, and emergent aspects of the whole situation" (p. 227).

Between 1930 and 1999, more than 200 studies were conducted to identify the effect of physical exercise on performance of a concurrent cognitive task (Brisswalter et al., 2002). In the world of athletics, an individual's interaction with the social environment, along with the goal of preserving social self-esteem has been shown to impact performance. Recent studies examining the effects of anxiety on cognitive-motor DTs involving gross motor or endurance tasks have used constructs which attempt to create anxiety through physical threat. Such threats include fear of falling, noise and other distractive stimuli and visual disturbances (Nibbeling et al., 2011; Nieuwenhuys and Oudejans, 2011). However, few studies have examined the effects of situations involving threat to the individual's social self. Situations are thought to induce social-evaluative threat (SET) when an important aspect of the self could be negatively judged by others. Such situations have been shown to provoke larger cortisol changes, a physiological response highly associated with stress (Dickerson and Kemeny, 2004; Kirschbaum et al., 1993).

As stated, previous studies have shown evidence that there is an attentional cost for walking and that consequently, a decrease in overall performance (DT interference) is expected when walking is performed simultaneously with a cognitive task (Al-Yahya et al., 2011; Dubost et al., 2006). This study is designed to examine whether anxiety induced by SET further contributes to the expected DT interference.

CHAPTER I: LITERATURE REVIEW

Attention and information processing

In everyday language, we define ‘attention’ as applying oneself to a specific task, or concentrating on one aspect of our environment despite other surrounding aspects that may have a distracting effect. From a neurocognitive point of view, ‘attention’ is defined as a measure of “how people are able to coordinate perception and action to achieve goals” (Johnson and Proctor, 2004). Simply put, an individual is faced with many different stimuli at any moment and must essentially ‘pay attention’ only to the stimuli which are relevant to the current task or goal. Granted that stimuli are essentially individual pieces of information that need to be processed by the individual, we can define attention as information processing capacity.

Different ‘types’ of attention have been proposed. Researchers have identified 3 main forms of attentional control: focused (or selective), sustained, and divided. These can briefly be defined as follows (Bruya, 2010; Johnson & Proctor, 2004; Kahneman, 1973; Yogev-Seligmann et al., 2008):

- Focused (or selective): focusing attention towards one particular stimulus or set of stimuli while avoiding or ignoring other distracting stimuli
- Sustained: focusing attention towards a stimulus or activity for an extended period of time
- Divided: attending and responding to multiple stimuli simultaneously

A thorough understanding of the information processes involved in perceiving, classifying and responding to stimuli is fundamental in understanding how attention is distributed when performing two tasks simultaneously. Recent neuroscientific research has brought about more complex theories of attention including the Bottleneck and Capacity-Sharing theories which we will discuss further. It should be noted that for the intents and purposes of this paper, we will focus primarily on capacity theories of attention, and how attentional resources and strategies are utilized for multiple task performance.

Bottleneck theories of attention and information processing

Bottleneck theories propose that information processing for multiple tasks performed simultaneously occurs in series. That is, if two or more stimuli are perceived, responses to each of the stimuli will be made in succession (Kahneman, 1973; Pashler, 1994). This theory states that parallel processing may be impossible for certain mental operations, as they require a common processing mechanism. As such, one task will be suppressed or queued as the other is processed (Fig. 1.0). Two tasks are bound by a bottleneck construct if they require operations that belong to the same set of central operations, and therefore, cannot be processed simultaneously (Shapiro, 2001). A common example of this is adding up a bill while holding a conversation.

Bottleneck models of attention involve the Psychological Refractory Period (PRP) and the Attentional Blink (AB). The PRP paradigm states that if two stimuli are presented simultaneously or in close temporal proximity, the response time to the second stimulus will be slower (Duncan, 1980; Marti et al., 2012; Shapiro, 2001). The classic model divides tasks into perception, central processing, and motor response stages, and assumes that while the perception and motor response stages can occur simultaneously, the central decision stage is rigidly serial (Marti et al., 2012) (Fig 1.0).

The AB paradigm involves a very rapid streaming of visual stimuli, referred to as rapid serial visual presentation (RSVP), in which an individual is asked to identify two specific stimuli or targets. Individuals often fail to detect the second target if it is presented in close temporal proximity to the first target, and this is called the Attentional Blink because it is comparable to missing the second target as a result of an eye blink (Raymond et al., 1992).

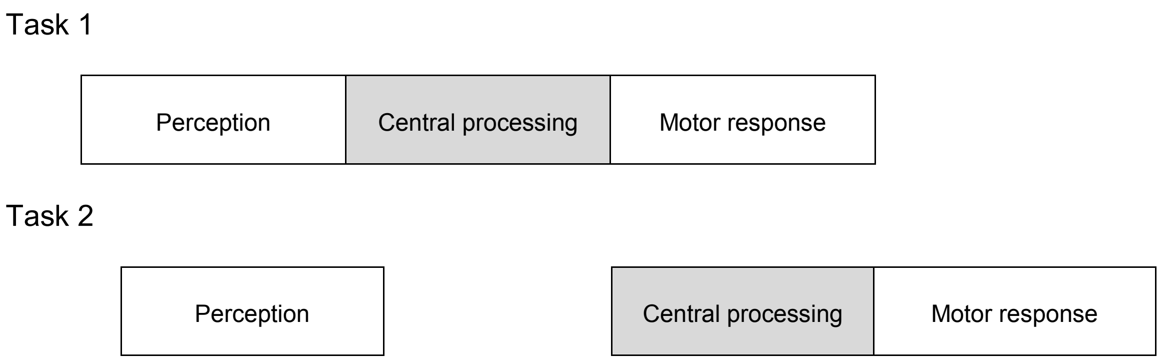

Fig. 1.0 Model of the central bottleneck accounting for the psychological refractory period Execution of one task can be divided into three stages: The perception stage entails the analysis of the stimulus, the central processing stage entails a decision about what the task-set requires, and the motor response stage is the execution of the actual response. The model assumes that the central processing stage is strictly serial and constitutes a bottleneck in the processing of two simultaneous tasks.

Capacity-sharing theories of attention and information processing

Capacity-sharing theories propose that there may be a parallel distribution of attention or information processing resources, such that two stimuli can be managed simultaneously, but with reduced accuracy. When two stimuli must be independently identified and processed, they will compete for this limited-capacity system and DT interference will be observed because attentional resources are finite and as such, the system cannot process both stimuli efficiently (Duncan, 1980; Kahneman, 1973; Pashler, 1994) (Fig. 2.0).

Allocation of resources is thought to be both a relative and strategic process. Attention will be provided to a task based on both the total capacity (resource volume) available to perform both tasks simultaneously, and from a perspective of allocation priority (resource strategy) (Sanders, 1983). In essence, these two mechanisms are not mutually exclusive. The assumption is that the sheer nature of the tasks will change how attention is selectively distributed. In studies where a physical task is performed concurrently with a cognitive task, results have shown that individuals' choice for resource allocation is based on task complexity and perceived difficulty of the task (Brisswalter and Legros, 1995; Sanders, 1983).

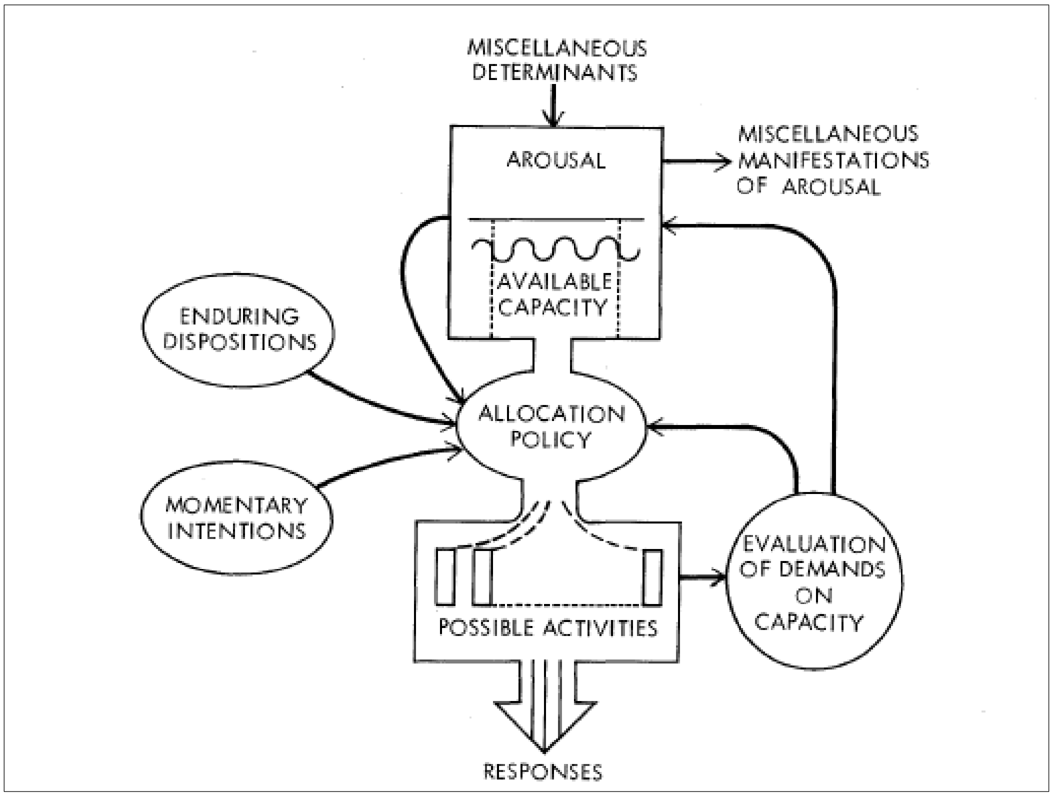

Fig 2.0 Kahneman's model of attention (Kahneman, 1973)

Attention and performance

Whether information processing occurs in series or in parallel, attention requires effort (Posner, 2012). In any dual or multi-task setting, the attention required to maintain performance is both subjectively and objectively effortful (Hockey, 1997; Kahneman, 1973), however theories rarely make a clear distinction between the two (Bruya, 2010).

In a cognitive-physical DT, the system is burdened by the effortful regulation of attention, which must be allocated between the cognitive and motor tasks. As previously stated, the nature of the tasks themselves will determine the amount of attention necessary to perform each of the tasks and how this attention will be distributed between the two. Many studies examining the effects of physical exercise on cognitive performance have found that DT interference is strongly related to the energetic constraints of the motor task. The greater the energy demand, the more attention required for performance (Audiffren et al., 2009; Brisswalter et al., 2002, Lohse and Sherwood, 2011; Tomporowski, 2003). The muscular work required to perform the task and/or maintain exercise intensity is also thought to draw upon attentional resources (Hockey, 1997; Kahneman, 1973).

Motor control, which is required for the performance of gross, fine and complex motor activities, can be defined as "the ability to regulate or direct the mechanisms essential to movement" (Shumway-Cook and Wollacott, 2001, p. 1). The performance of simple gross motor tasks such as maintaining balance in an upright stance and walking were previously assumed to be fairly 'automatic'. On the contrary, recent research has shown that they require some continued access to attentional resources. (Abernethy et al., 2002; Al Yahya et al., 2011; Dubost et al., 2006, Yogev-Seligman et al., 2008). According to Daniels (1985), "running efficiency is commonly operationalized by running economy, which is defined by the energy demand for a given velocity of submaximal running." Aside from tracking variations in physiological measures of effort such as heart rate or oxygen consumption, changes in running efficiency can be observed as changes in gait parameters such as stride frequency and stride length. Dual-task studies involving walking performed concurrently with a cognitive task have reported an increase in stride frequency and a decrease in stride length as a result of cognitive load (Al Yahya et al., 2011; Dubost et al., 2006). Such decreases in movement efficiency of endurance tasks have been further related to reductions in on-task attention (Lajoie et al., 1993; Nieuwenhuys & Oudejans, 2011).

Arousal and performance

Arousal-based theories in sports performance

In 1908, psychologists Robert M. Yerkes and John Dillingham Dodson developed the Yerkes-Dodson law, an interactional model of arousal and performance graphically illustrated by an inverted-U (Fig. 3.0). The law states that physiological arousal is associated with an arousal of the central nervous system resulting in an improvement in performance up to an optimum. Optimal arousal will result in optimal performance, while both under-arousal and over-arousal lead to decreases in performance. The law makes a distinction between the performance of simple versus complex tasks, stating that the range over which performance increases with arousal varies according to task complexity. Research to date has established that highly demanding or difficult tasks require more cognitive control, and that these higher demands require greater effort if performance is to be maintained (Bruya, 2010; Kahneman, 1973; Lajoie et al., 1993; Sanders, 1983). Many studies have shown that arousal resulting from acute bouts of low to moderate intensity exercise result in an improvement in cognitive task performance (Brisswalter and Legros, 1995; Lambourne and Tomporowski, 2010). The *drive theory* originally proposed by Hull (1943) is largely based on the inverted-U hypothesis. It states that increases in 'drive' (used synonymously with arousal or stress) are associated with increases in performance (Biddle, 1995). In sports psychology, the inverted-U theory has long been a widely accepted interpretation of the arousal-performance relationship. Research and scientific evidence based on this interpretation thus far has produced the following generalizations regarding arousal and motor performance (Suinn 1980):

- A high level of arousal is essential for the optimal performance of gross motor activities involving strength, endurance and speed
- A high level of arousal interferes with performances involving complex skills, fine muscle movements, coordination, steadiness, and general concentration
- A slightly above-average level of arousal is preferable to a normal or sub-normal arousal state for all motor tasks

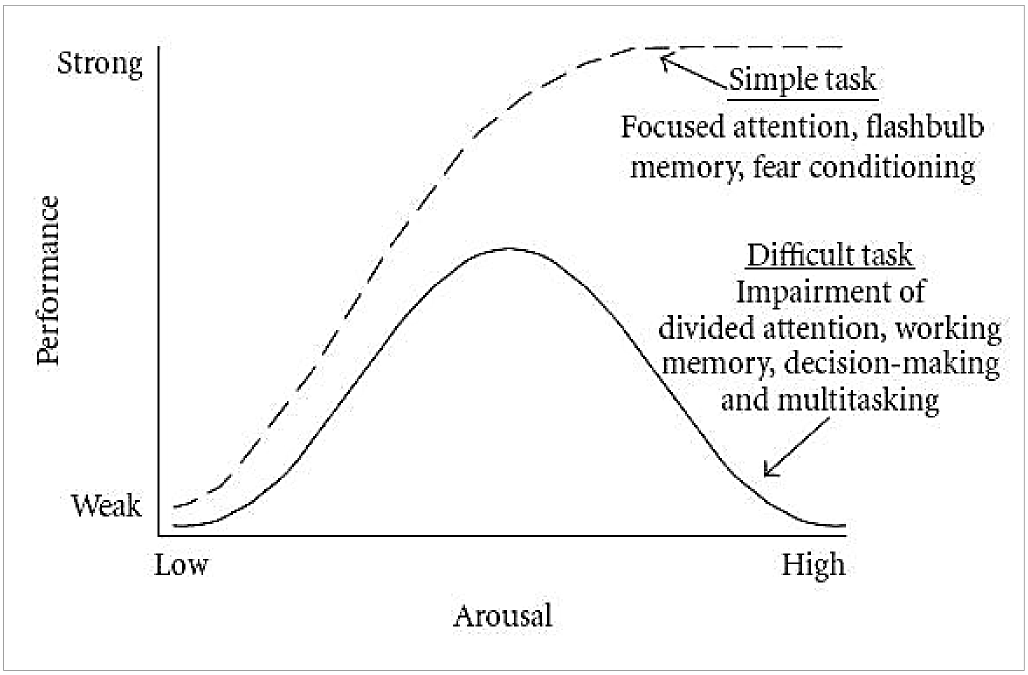

Fig. 3.0 Yerkes-Dodson law (Yerkes and Dodson, 1908)

Anxiety-based theories in sports performance

Despite the fact that the Yerkes-Dodson inverted-U has received some empirical support, the precise relationship between arousal, anxiety and performance yet remains unclear. Though effort itself is attentionally demanding, it is thought that an individual's perception of effort, particularly if it is aversive, can also consume attention and therefore affect performance (Auddifren et al., 2009; Hancock and Warm, 1989; Hockey, 1997; Lohse and Sherwood, 2011). The DT evokes physiological stress with its imposed load on the information processing system, but according to Sanders (1983) it is debatable whether the uni-dimensional inverted-U relationship is singularly sufficient in demonstrating the effects of arousal on performance because it neglects to consider the effects (perhaps detrimental) of psychological stress or ***anxiety***. There has been much criticism of the inverted-U and drive theories, namely of their failure to take into account the multidimensional aspects of arousal, which researchers suggest should not be used synonymously with the term 'anxiety' (Biddle, 1995; Jones, 1995; Sanders, 1983). Stress can be universally described as the general response of the physiological system to any physical or psychological disturbance in homeostasis, often perceived as a threat (Selye, 1956). Sanders (1983) makes a distinction between psychological and physiological stress, and identifies psychological stress as "a state of unacceptable divergences between perceived demands and capabilities to adapt likely to arise whenever the system is overloaded" (p. 62). Transactional models of stress management in psychology also use this definition, as well as defining stress as a dynamic interaction between a person and the environment (Lazarus and Folkman, 1984; Sanders, 1983). As such, a situation may become a source of stress for an individual merely by being perceived as exceeding his/her ability to cope. Anxiety involves a number of complex emotional states and occurs as a result of a situation deemed threatening by the individual (Schwenkmezger and Steffgen, 1989). It can be defined as stress emerging from emotion or thoughts, and may be manifested by negative (fear, anxiety, anger, etc.) or positive (joy, interest, etc.) emotions. Although these psychological states are different from physiological states brought about by a motor task, they manifest similar responses and contribute to overall arousal. There is also some evidence to suggest that anxiety, negative emotions and physical discomfort are likely to consume attention, and may therefore exert an influence on performance via a decrease in attentional resources (Eysenck, 1982; Hockey, 1997; Kahneman, 1973). In their review of experimental literature on anxiety and motor performance, Niuewnhuys and Oudejans (2011) observed a general consensus stating that anxiety affects motor performance through its effect on attention. In other words, anxiety consumes attention, leaving less attention available for the motor control of movements. In their study involving running on an elevated treadmill, Nibbeling et al. (2011) suggested that anxiety related to fear of falling led to decreased on-task attention and decreased running efficiency. This decrease manifested itself by a decrease in stride length and an increase in stride frequency.

Evidence suggests then, that the effects of anxiety on overall performance cannot be discounted when evaluating DT interference. Individual coping mechanisms and perception will likely affect how attention is distributed between the two tasks. Still today, it is the complex interaction between physiological and psychological arousal that remains obscure and has become an area of continuing research. Recent theories in sports psychology include the Independent Zone of Optimal Functioning (IZOF) (Fig. 4.0), multidimensional and catastrophe theories (Fig 5.0) (Weinberg 2011). These models explain how an individual's perception may mediate the beneficial or detrimental effects of emotions resulting from anxiety. The models examine the contribution of individual trait anxiety and/or task-related anxiety to performance outcomes (Robazza, 1998). Personal variables such as trait anxiety, positive or negative affect, self-confidence, neuroticism and extroversion, coping strategies, psychological skill use, achievement motivation, competitiveness, gender and skill are all examined. The models attempt to eliminate simplistic pre-existing notions that optimal arousal or anxiety facilitate performance, and/or that negative emotions are detrimental to performance (whereas positive emotions are beneficial). Instead, they seek to make individualoriented predictions between anxiety and performance. The theories provide a delineation of the cognitive components of anxiety and the somatic components of physiological arousal. They are believed to make more precise predictions about anxiety levels at which performance may be optimal (Biddle, 1995; Jones, 1995).

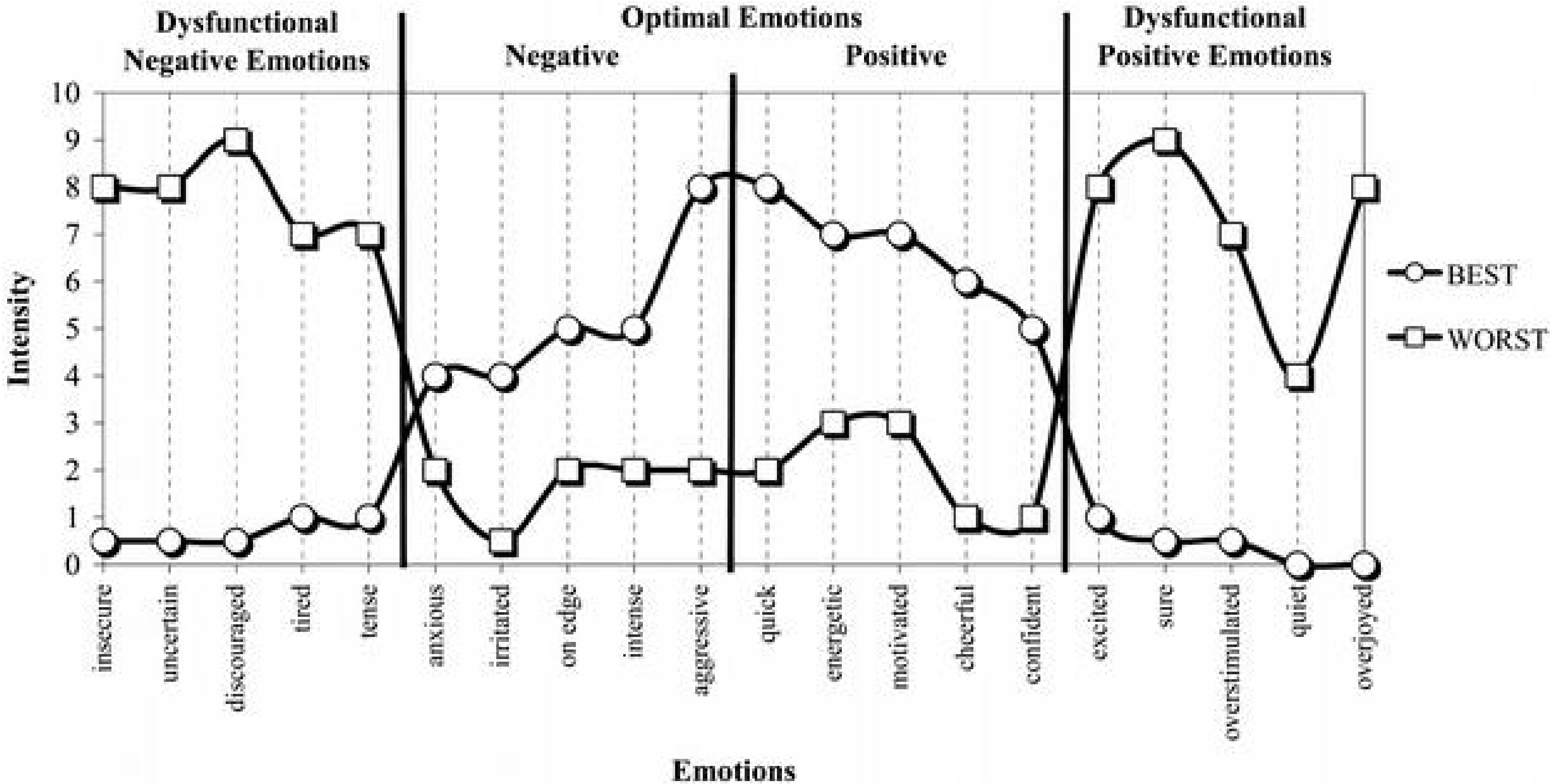

Fig.4.0 Hanin's Independent Zone of Optimal Functioning model (1980). Both dysfunctional positive and negative emotions result in worst performance, whereas optimal positive and negative emotions are linked to bets performance.

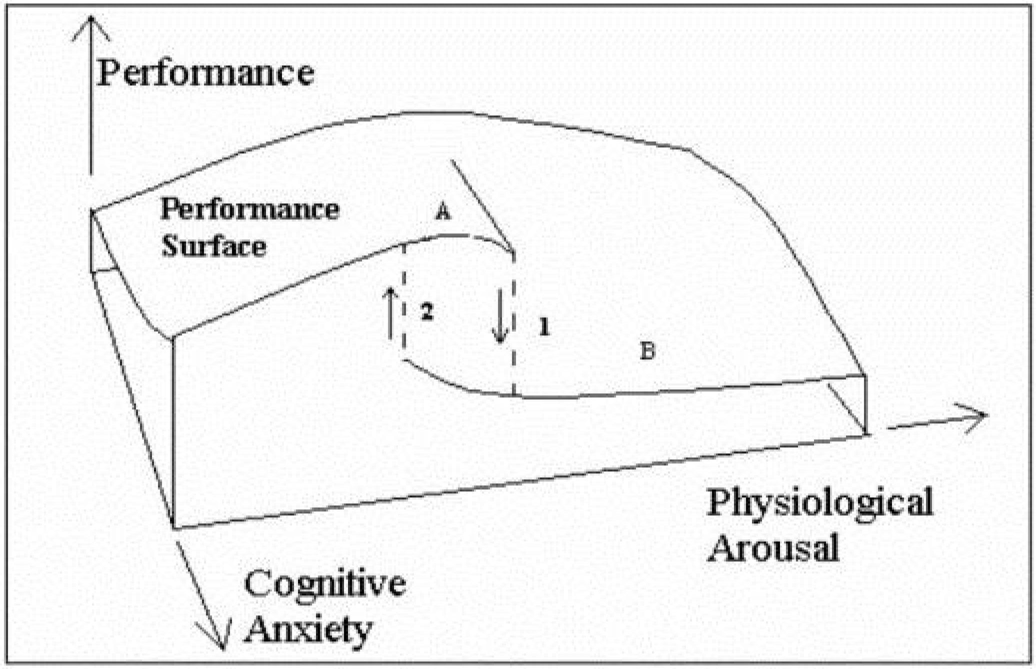

Fig. 5.0 The cusp catastrophe model of the relationship between cognitive anxiety, physiological arousal and performance (from Hardy et al. 2007). The theory predicts that physiological arousal is related to performance in an inverted-U fashion, but only when an athlete is not worried or has low cognitive state anxiety.

CHAPTER II: RATIONALE AND OBJECTIVES

Shumway-Cook and Wollacott (2001) describe movement as emerging from an interaction between the individual, the task, and the environment (Fig 6.0). Based on the review of the literature discussed thus far, we expect the following features of each of these components to affect overall performance via an increase in attentional demand and/or consumption:

- High task complexity, difficulty and/or energetic demand (intensity)
- Non-regulatory features of the environment (e.g. noise, distractions)
- High anxiety (subjectively perceived by the individual)

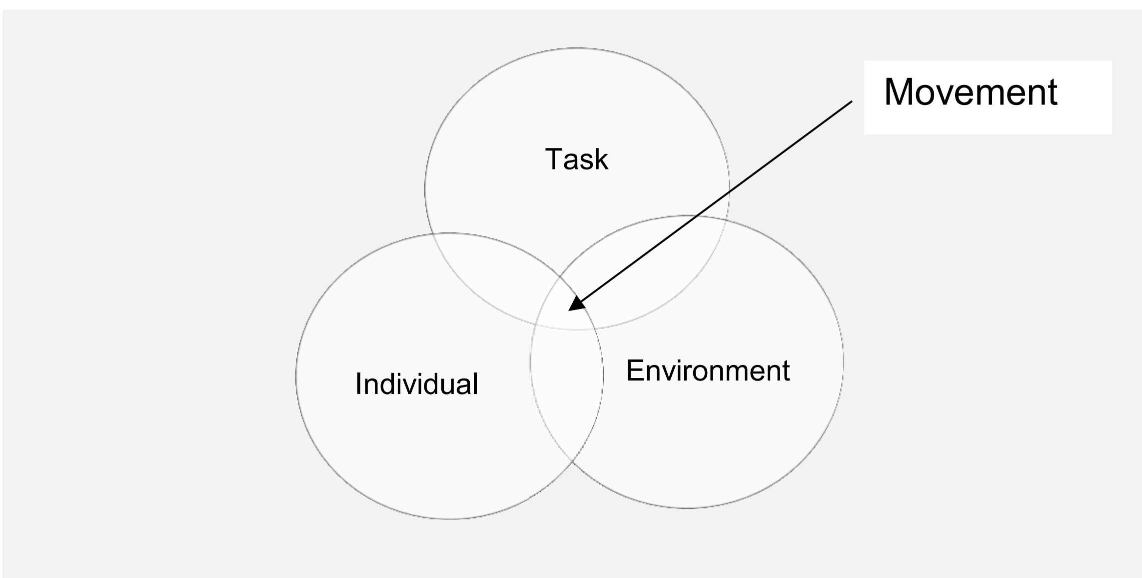

Fig. 6.0 Movement as an Interaction between the individual, the task, and the environment (Schumway-Cook & Woollacott 2001)
.

Performance has been shown to be limited by total attentional capacity, arousal, task complexity, environmental features and subjective task-related anxiety. We can conclude that the ability to regulate effort towards the two tasks is significantly impaired by a summation of effects of the cognitive, physical and emotional elements of the DT situation.

In athletics, performance is commonly subjected to the evaluation of social peers. We can logically assume that such a circumstance would add to the emotional element of DT performance. *Social-evaluative threat* (SET) is a term used to identify a circumstance in which an important aspect of the individual's self could be negatively judged by others (Dickerson and Kemeny, 2004). Experimental tasks or conditions in which performance is subject to an evaluative audience or social comparison have been shown to elicit SET (Dickerson and Kemeny, 2004; Kirschbaum et al., 1993). Dickerson and Kemeny (2004) identified the following elements of an experimental protocol capable of inducing SET:

- permanent recording of the performance
- presence of an evaluative audience during the task (at least one other person present besides the evaluator)
- presence of a negative social comparison (the real or potential out-performance by a confederate or other participant)

SET constitutes threat to the goal of preserving the social self, which according to Dickerson (2004) can manifest psychological reactions similar to those exhibited by threat to the preservation the physical self. Current studies have examined the detrimental effects of extrinsic sources of stress such as fear of falling (Nibbeling et al., 2011), balance perturbation (Brown et al., 1999) and noise (Szalma and Hancock, 2011) on performance of a DT. However, few studies have explored sources of stress pertaining to the social self. This may prove to be helpful in developing efficient strategies specific to sports psychology.

Hypothesis

The purpose of this study was to examine the effects of anxiety induced by SET on running efficiency in a DT setting. The previously cited research has established that a) there are changes in gait parameters when walking is performed concurrently with a cognitive task, that b) threat to preservation of the physical self creates anxiety and impairs motor performance in both single and dual-task conditions, and that c) the increased energetic demands or complexity of a motor task consume attention. In their meta-analysis, Dickerson and Kemeny (2004) found that characteristics such as intelligence or competence are attributes that are valued across diverse domains. As such, cognitive and verbal interaction tasks such as mental arithmetic and public speaking elicit more significant stress responses. In light of this evidence, an experimental dual-task protocol involving a cognitive mental arithmetic task (MAT) was selected for this study. The proposed hypothesis was that anxiety arising from SET would lead to decreases in running efficiency in a DT setting.

CHAPTER III: METHODOLOGY

Subjects

Twenty-nine (n=29) students participated in this study (mean age 21.97± 2.35 years). All of these participants were cleared for the exclusion criteria: acute or chronic musculoskeletal injury or inflammation, cardiovascular and/or cardiopulmonary disease, recent concussion, vestibular disorders, cancer, epilepsy, pregnancy, and diabetes. Subjects were recruited on a voluntary basis from Concordia University's Department of Exercise Science. Upon arriving at the laboratory for testing, participants were informed of any risks associated with participation in the study, and written informed consent was gathered (Appendix A).

Baseline measures

Cognitive ability

Baseline cognitive ability was measured using the Stroop test, which measures executive function (complex processing and inhibition) (Stroop, 1935). In the first part of the test (control condition), participants are presented with a sheet of paper consisting of columns of stars printed in different ink colors and asked to name the colors as quickly as possible. In the second part (interference condition), participants are presented with the words *red*, *green*, *tan* and *blue* written in incongruent colors of ink, and are asked to name the color rather than read the word. For both the control condition and the interference condition, performance values were calculated by dividing the correct number of responses by the time to completion. The Stroop interference score was obtained by subtracting the interference values from the control values.

Arithmetic ability

Mathematical ability was assessed using an arithmetic test in which participants are asked to solve a series of arithmetic problems within a specified time limit. The test begins with visual items (ex. pointing and counting out loud the number of apples on a page) and progresses to problem-solving questions of increasing complexity (ex. "Scott has 9 pens. He gives 4 to Jean. How many pens does Scott have left?" vs "If 8 machines can finish a job in 6 days, how many machines are needed to finish the job in half of a day?"). All of the items are timed, with a 30-second completion time limit. The test consists of 22 items worth 1 point each, for a total maximum score of 22 points. The arithmetic score is simply calculated as the number of items answered correctly (maximum of 22).

Trait anxiety

Baseline trait anxiety was measured using the *State and Trait Anxiety Inventory (STAI)* (Appendix B). The STAI contains two 20-item self-report scales that measure how much anxiety the participant experiences in the present circumstances (Form Y-1 for state anxiety) and how much anxiety represents a personality characteristic for this individual (Form Y-2 for trait anxiety) (Spielberger 1983). The Form Y-2 of the Self-Evaluation questionnaire was used to establish baseline levels of trait anxiety because it reflects anxiety-proneness, or "the tendency to perceive stressful situations as dangerous or threatening and to respond to such situations with elevations in the intensity of state anxiety" (Spielberger 1983). The scoring guide from the STAI for Adults Manual was used to determine the trait anxiety score.

Physical activity level

Baseline levels of physical activity were measured with use of the Short Questionnaire to Assess Health-enhancing Physical Activity (SQUASH) (Appendix C), which was completed by the participant. This questionnaire has been shown to be valid and reliable to categorize adult subjects according to their level of physical activity (Wendel-Vos et al. 2003). It was chosen because completion of the questionnaire is brief and simple.

Tasks

Motor task

The motor task selected was treadmill running. Examination of the literature indicates that there is greater variation in stride at non-preferred speeds (Abernethy et al., 2002; Beauchet et al. 2005; Dubost et al. 2006; Jordan and Newell, 2008; Jordan et al., 2007). These variations have been explained by the higher energetic and attentional demands of non-preferred speeds and are notably visible at speeds 10 to 20% higher (or lower) than preferred speed. In compliance with these protocols, participants were asked to select a comfortable jogging pace that corresponded to a 20-minute run, which was then increased by 20%.

Cognitive task

The mental arithmetic task chosen was “Serial 7’s”. For this task, participants were provided with a 3-digit number and asked to subtract 7 continuously. This well-known clinical test assesses mental function and is part of the *Mini-mental State Examination,* an examination used to screen for cognitive impairment and track changes in cognitive function (Folstein 1975).

Dual-task

Each experimental condition consisted of 4-minute bouts of treadmill running with Serial 7's performed in the last 2 minutes. Subjects were verbally encouraged to do the best they could on the cognitive task.

Control task

Each participant ran a control task, which consisted of a 4-minute bout of treadmill running at the increased speed.

Materials and apparatus

Treadmill

A Biodex™ treadmill was used for the running task (Figure 7.0). Participants were advised to grasp the treadmill side bars if they felt any discomfort or fatigue, and were given clear instructions regarding use of the emergency stop button.

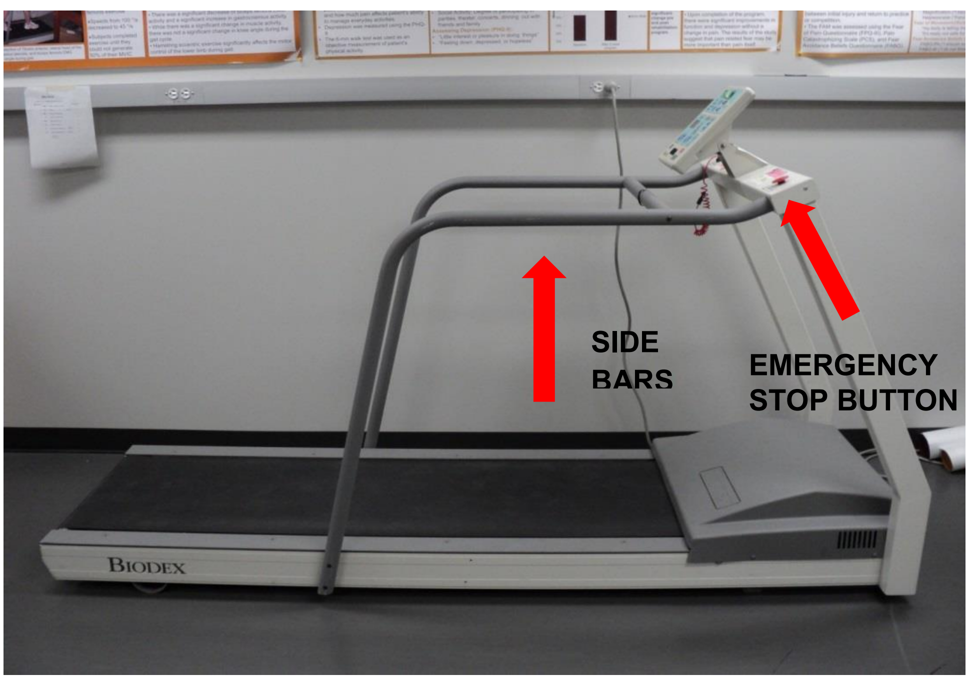

Fig. 7.0 Biodex™ treadmill

Foot switch

An appropriately sized foot switch (Figure 8.0) was inserted into the left or right shoe of each participant. Heel strike and toe-off contact signals were transmitted to a MYOPAC amplifier and receiver (DATAPAK 2K2, Run Technologies, Mission Viejo, CA), and stored in a Dell laptop computer for further analysis.

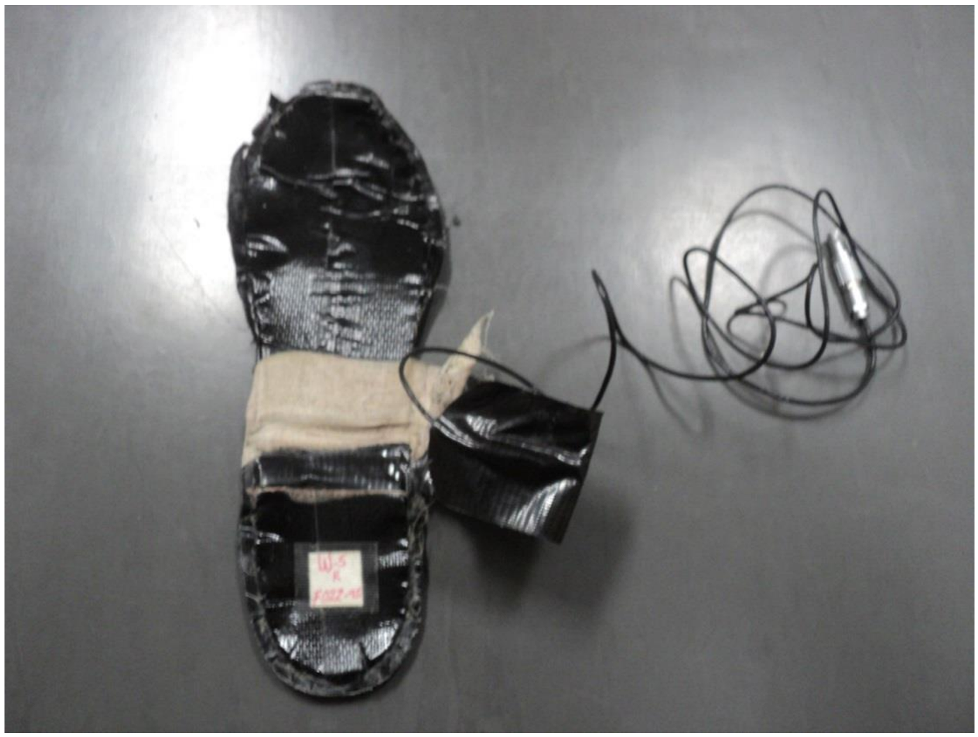

Figure 8.0. Foot switch

Variables

Independent variables

Anxiety

As previously discussed, specific elements of an experimental protocol can be utilized to induce social-evaluative threat, including permanent recording of a performance. Anxiety was manipulated through the use of a video camera to create two experimental conditions. In the **no stress** condition, participants were simply asked to perform the dual-task. In the **stress** condition, participants were informed that their performance was being recorded by a video camera to be analyzed and compared with other participants. The Form Y-1 of the Self-evaluation questionnaire was administered prior to each experimental condition to track changes in state anxiety. In this form, participants are asked to respond to the questionnaire to describe their present feelings best. Participants were asked to respond according to the task that they were about to undertake. State anxiety scores for each condition were obtained using the scoring guide from the STAI for Adults Manual (Spielberger 1983).

A qualitative analysis was also performed for 21 out of the 29 participants to gather information regarding which aspect of the dual-task was most subjectively stressful. Note that this analysis is restricted to 21 participants because it was introduced late in the protocol. At the end of the testing sessions, participants were asked to identify which part of the dual-task they were most concerned with and given the choice of the following answers:

a) not getting enough right answers on the serial 7's and therefore not seeming intelligent
b) not being able to perform both tasks simultaneously
c) not being able to complete the run at the increased speed
d) something else entirely

Dependent variables

Stride Length and Stride Frequency

Stride length and stride frequency were calculated using the foot switch heel strike signals which were collected and transmitted to the DATAPAK 2K2 software. Markers were placed at each consecutive heel strike for the right or left foot (right or left foot was selected based on quality of the footswitch signal) for minute 3 to 4 of each condition. The data were then exported to Excel which provided the stride time in milliseconds for each of the marked strides. The average stride time was calculated and converted into seconds. The treadmill speed was converted from miles per hour to centimeters per second and the stride parameters were calculated as follows:

$$\textit{Stride Length (cm)} = \frac{\textit{treadmill speed (cm/s)}}{\textit{average stride time (s)}}$$

$$\textit{Stride Frequency (strides/min)} = \textit{(1/average stride time(s))} \times \textit{60(s)}$$

Normalized stride length and stride frequency were calculated as follows:

For the NO-STRESS condition:

$$\textit{Stride Frequency/Length Normalized} = \frac{\textit{Stride Frequency/Length (NO-STRESS)}}{\textit{Stride Frequency/Length (CONTROL)}}$$

For the STRESS condition:

$$\textit{Stride Frequency/Length Normalized} = \frac{\textit{Stride Frequency/Length (STRESS)}}{\textit{Stride Frequency/Length (CONTROL)}}$$

Stride time variability

Stride time variability was measured using the standard deviation of the average stride times in each condition (time between two consecutive heel strikes).

Cognitive output

Cognitive output was calculated as the number of correct responses provided during the interval in which participants performed Serial 7's.

Rate of perceived exertion

This 10-grade scale has been shown to be a valid and reliable measure of RPE, and when compared to the original 15-grade RPE scale, is deemed more suitable for determining subjective symptoms related to exercise such as breathing difficulties, aches and pains (Borg, 1982). RPE was collected immediately after the control, stress and no-stress conditions.

Procedure

All procedures were approved by the Concordia University Human Research Ethics Committee. Participants were recruited by e-mail and asked to attend one 60-minute data collection session at the Athletic Therapy Research laboratory at the Concordia University Loyola Campus. Information about the tasks to be performed and proper preparation for the session were provided via e-mail and the consent form was signed upon arrival.

Once the baseline forms and tests were completed (SQUASH, STAI Form Y-2, Stroop test and arithmetic test), the cognitive Serial 7 task was explained and participants performed a 30-second practice bout. Participants were then fitted with the footswitch and asked to run on the treadmill to choose a self-selected jogging pace. As a control condition, all participants began with a 4-minute run at a 20% increase from their selected pace. Each subject was then exposed to the no-stress and stress conditions in counter-balanced order. Participants who began with the no-stress condition were simply asked to perform both tasks simultaneously and do they best they could on the Serial 7's task. Prior to the stress condition, the video camera was set up. Participants were asked to repeat the same task and informed that this time their performance would be recorded by the video camera and evaluated by the laboratory assistant for comparison with other participants. For participants having begun with the stress condition, the primary concern was to ensure that they no longer felt anxious about their performance in the ensuing no-stress condition. The video camera was removed and put away, and they were informed that this next task was simply to collect extra footswitch data but that their performance was not being evaluated, however, they should still try to do the best they could on Serial 7's.

Participants were asked to complete the Y-1 Form prior to each condition based on the task they were about to perform. The Borg scale was completed immediately following each condition.

Statistical analysis

The statistical analysis was performed using PASWStatistics 18.0 (SPSS Inc. Chicago, IL) and Microsoft Excel 2010.

A Repeated Measures ANOVA with a significance level of $\alpha = 0.05$ was performed on stride length and frequency, state anxiety scores, and stride time variability across conditions.

Using a paired t-test with a significance level of $\alpha = 0.05$, an analysis between the no-stress and stress conditions was performed for normalized stride length and stride frequency, RPE, state anxiety scores (events), and cognitive output.

Pearson correlation coefficients were calculated or cognitive ability and mathematical ability vs average stride parameters in all experimental conditions. Average stride length/stride frequency in the no-stress and stress conditions (further referred to as 'dual-task stride length' and 'dual-task stride frequency') were calculated for use in the correlation analyses. Average trait and state anxiety of the sample were calculated for comparison with the normative sample. Percentages were calculated for the qualitative analysis.

CHAPTER IV: RESULTS

Baseline measures

Pearson correlation coefficients were calculated to verify if there were any relationships between baseline cognitive and mathematical abilities and stride parameters if and where applicable. The average stride parameters of both dual-task conditions were used for this calculation. There were no significant correlations between these baseline measures and average dual-task stride length or average dual-task stride frequency (Table 1.0).

	Age (yrs)	**Stroop interference (items/s)**	**Arithmetic score (correct answers)**	**Trait anxiety**
Group means	21.97	0.68	13.7	33.5
SD	2.35	0.23	2.99	8.39
Pearson correlation coefficient (str. length/str. freq.)	N/A	-0.08/0.04	0.15/0.01	N/A

Table 1.0 Descriptive information, baseline measures and correlation statistics

Anxiety

Results of the Y-2 Self-Evaluation questionnaire show that the average level of trait anxiety was lower in our sample when compared with the normative sample provided in Spielberger's STAI Manual (1983) (Figure 10.0).

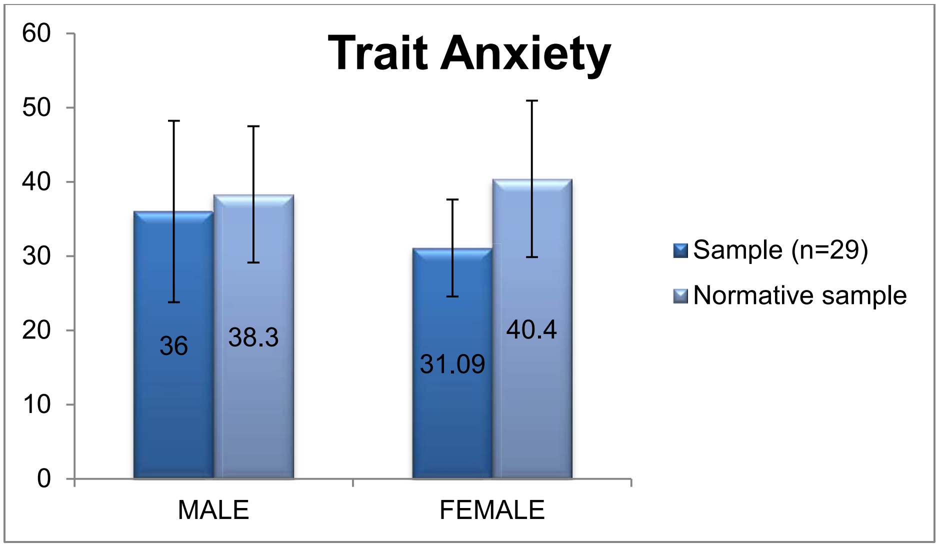

Figure 10.0. Comparison of trait anxiety of sample vs norm

Similarly, average state anxiety scores were consistently lower across conditions when compared to a normative sample (Figure 11.0).

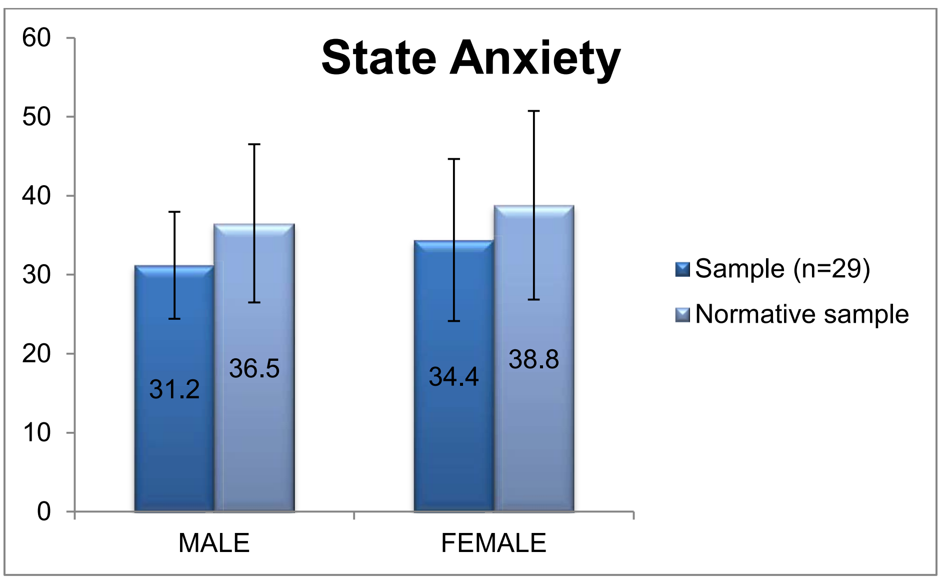

Figure 11.0. Comparison of average state anxiety of sample vs norm

Higher trait anxiety was positively correlated with higher average state anxiety across conditions (r = 0.55, ρ < 0.01) and higher fluctuations in state anxiety (r = 0.44, ρ

< 0.05). However, there were no significant differences in state anxiety scores across conditions ($F_{(2, 84)}$ = 0.93, ρ = 0.39) (Fig. 12.0).

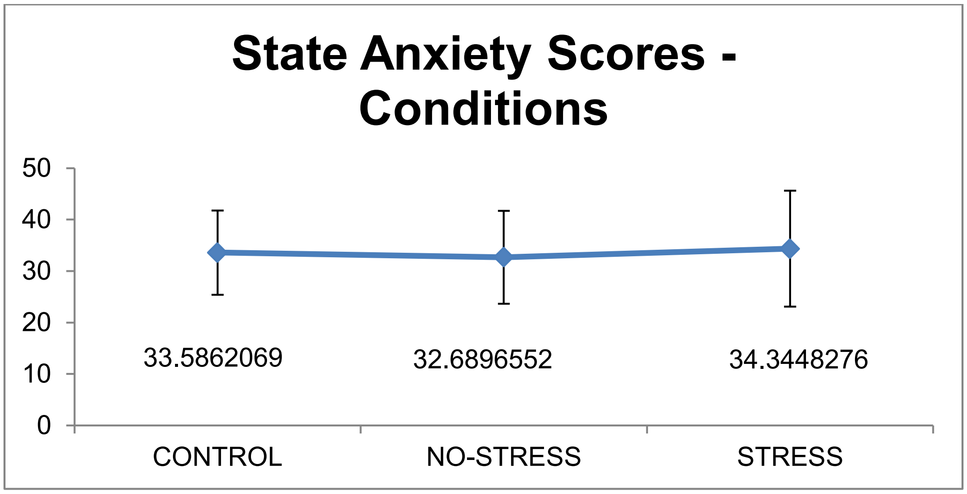

Figure 12.0. Group means and standard deviations for state anxiety scores all conditions

To verify that a learning effect did not occur between conditions we analyzed the state anxiety scores with respect to the order of events (DT 1 vs DT 2). The assumption was that participants might have been more anxious in performing the DT the first time, with decreased anxiety when performing it the second time. However, there was no significant difference between anxiety in the first versus the second event ($t_{(28)}$=0.32, ρ=0.75) (Fig. 13.0).

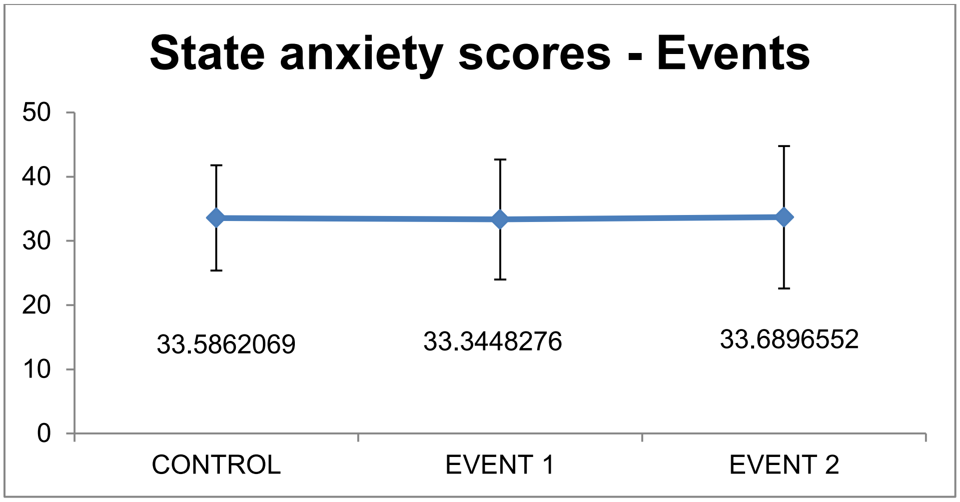

Figure 13.0. Group means and standard deviations for state anxiety scores for events

A qualitative analysis was performed to gather subjective information from the participants regarding which aspect of the DT they were most concerned about. Of the 21 participants included in this analysis, 61.9% answered (a), indicating that they were most concerned with not appearing intelligent. Of the 19% of participants who answered (d), half expressed a concern related to the arithmetic task such as getting too many wrong answers or having difficulty at specific intervals of the Serial 7s (Fig. 14.0).

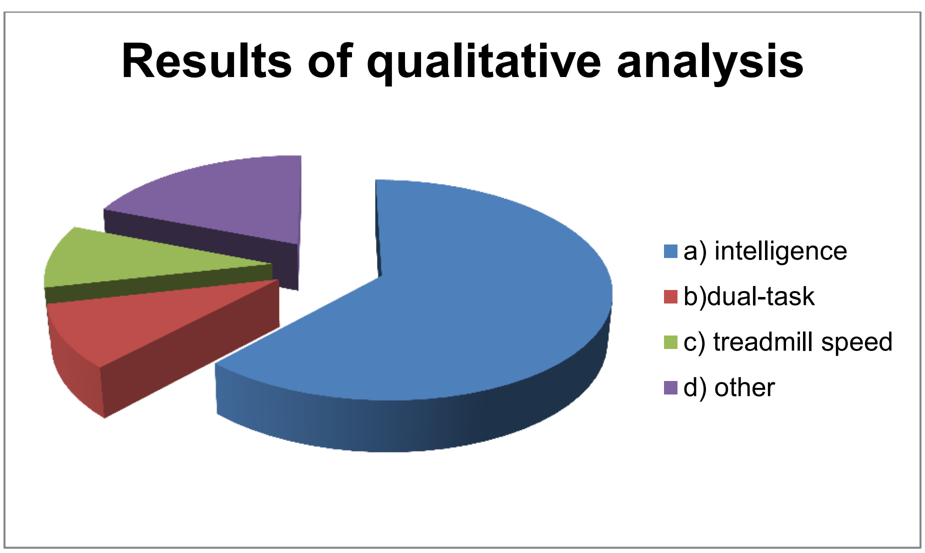

Figure 14.0 Results of qualitative performance-preoccupation analysis

Rate of perceived exertion

Rate of perceived exertion was slightly higher in the DT conditions than in the control (single-task) condition. However, average RPE was not significantly different across conditions ($t_{(28)}$ = 0.60, ρ = 0.55) (Figure 9.0).

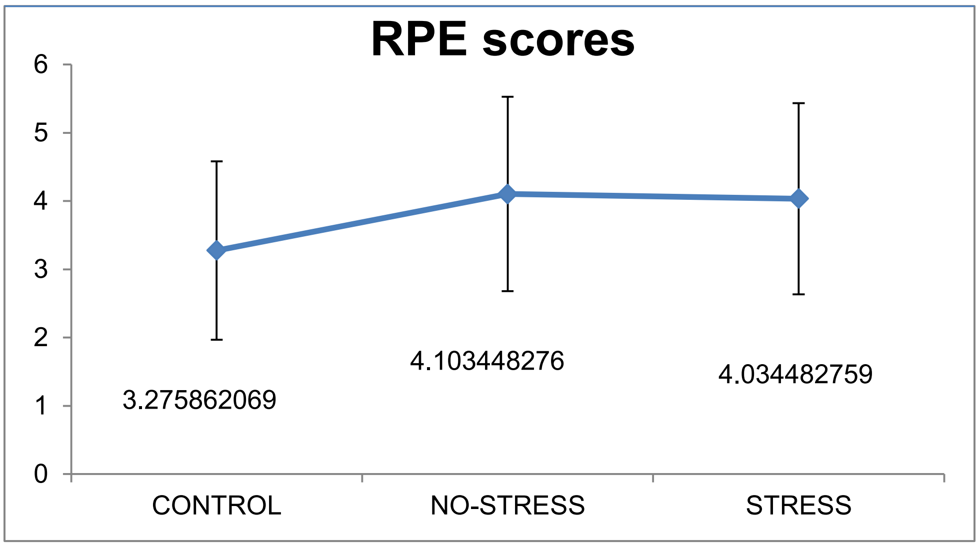

Figure 9.0. Group means and standard deviations for rate of perceived exertion.

Stride length and Stride frequency

There were no significant differences in stride length and stride frequency (Table 2.0), and results of the paired t-test on the normalized data showed no within-subject effects between the stride parameters in the no-stress and stress conditions (Table 3.0).

	Control	No-Stress	Stress	Repeated measures ANOVA for stride length and frequency
Stride length (cm)	M = 182.7 SD = 36.3	M = 182.9 SD = 36.4	M = 183.1 SD = 36.9	$F_{(2,84)} = 0.19$ ($\rho = 0.85$)
Stride frequency (str/min)	M = 83.6 SD = 4.2	M = 83.6 SD = 4.7	M = 83.5 SD = 4.6	$F_{(2,84)} = 0.04$ ($\rho = 0.96$)

Table 2.0 Analysis of stride length and stride frequency

	No-Stress	Stress	Paired t-test for normalized stride length and frequency (no-stress vs stress)
Stride length (normalized)	*M* = 1.0013 *SD* = 0.024	*M* = 1.0015 *SD* = 0.021	$T_{(28)} = 0.09$ ($\rho = 0.93$)
Stride frequency (normalized)	*M* = 1.014 *SD* = 0.249	*M* = 1.034 *SD* = 0.277	$T_{(28)} = 0.14$ ($\rho = 0.89$)

Table 3.0 Analysis of normalized stride length and stride frequency

Stride time variability

Although some studies have shown dual-task effects on stride time variability, which is indicative of fluctuations in gait (Beauchet et al., 2005; Dubost et al., 2006), there was no significant difference in stride time variability between conditions ($F_{(2,84)}$ = 0.10, ρ = 0.90).

Cognitive output

There was no significant difference in cognitive output in the no-stress condition when compared to the stress condition ($t_{(28)}$ = 1.89, ρ = 0.07) (Figure 15.0).

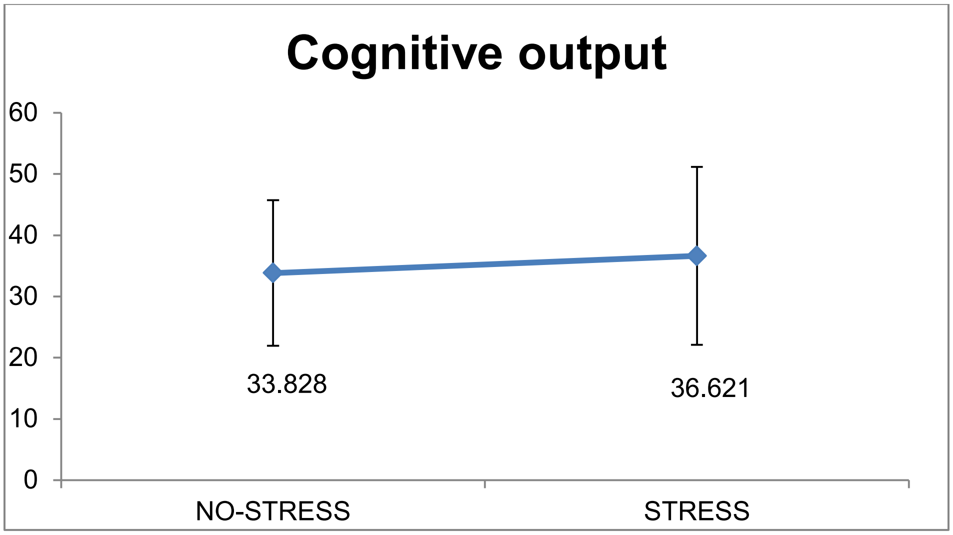

Figure 15.0 Group means and standard deviations for cognitive output measured as number of correct responses.

CHAPTER V: LIMITATIONS AND DISCUSSION

The objective of the study was to create anxiety within a challenging dual-task paradigm in order to determine whether it contributes to dual-task interference. Results are inconclusive, as manipulation of the independent variable was not effective in inducing anxiety. This portion of the thesis will address the limitations of the study.

Cognitive task prioritization

In any dual-task situation, resource allocation is partly based on individual strategies. An individual will prioritize attention towards the task for which he/she possesses fewer resources (Brisswalter and Legros, 1995; Sanders, 1983). However, instructed prioritization towards a specific task has been shown to have compensatory effects (Yogev-Seligmann, 2010). In our pilot study of 2009 (same dual-task protocol), we observed a trade-off between the cognitive and motor tasks. Participants who struggled with running at the increased speed subsequently stopped providing responses to the Serial 7's. In this particular study, we wanted to avoid such a trade-off. Participants were explicitly instructed to perform as best they could on the cognitive task. However, there was some concern that cognitive and/or arithmetic ability might influence participants' motor performance. That is, participants with poorer cognitive or mathematical skills might show changes in stride parameters as a result of the increased attentional demand of the Serial 7's and not of anxiety. Results of the correlation statistics between the baseline measures and average dual-task stride parameters show no significant relationships. Furthermore, participants' cognitive performance was comparable in both experimental conditions, indicating that such a trade-off did not occur.

Anxiety

Running on a treadmill requires that individuals make the necessary adjustments to maintain speed so as not to run off the front or the back of the treadmill. Participants were required to do this, and instructed to direct attention towards performance of the Serial 7's task. We can speculate that any effects in stride parameters could have been attributed to the effects of anxiety. However, the principal limitation of this study remains that the filming manipulation was not effective in inducing anxiety in the stress condition. When attempting to induce anxiety, we must consider that there is a large inter-individual variability in some aspects of the stress response. The review of the literature surrounding stress management demonstrates that anxiety occurs when an individual perceives an imbalance between the demands of the task and his/her capabilities to adapt. As demonstrated by Selye's General Adaptation Syndrome (1976), any extrinsic sources of stress such as those previously discussed (fear of falling, balance perturbations, and noise) present a threat to the physical self that will elicit a similar stress response in all individuals. However, individuals having undergone repeated exposure to a stressor may develop adaptation mechanisms allowing them to cope with these threats more effectively. For example, a trapeze artist would certainly feel less threatened by fear of falling than the average individual. In any situation then, what one individual perceives as threatening may not appear threatening at all to another.

A meta-analysis of psychological stress protocols suggests that the Trier Social Stress Test (TSST) is the most useful protocol for inducing stress in a laboratory setting (Dickerson and Kemeny, 2004). Elements of the TSST protocol include social-evaluative threat and challenging arithmetic, all elements which were included in our testing protocol. Results of our qualitative analysis show that a majority of participants (61.9%) were subjectively concerned with not appearing intelligent if they did not provide enough correct answers on the serial sevens. Furthermore, of the 19% of participants who answered *(d) something else entirely,* half expressed a concern related to some element of performance of the Serial 7's. Based on what we know, this finding would seem to be indicative of Social-evaluative threat. However, the state anxiety scores clearly reflect that our participants were neither threatened by the arithmetic task nor, presumably, by the social evaluative component intended by use of the video camera. Perhaps our sample, comprised of first and second-year University students, was accustomed to the stress of an evaluative audience due to the prevalence of practical examinations and oral presentations in the academic setting. As such, they would have possessed the required resources and adaptation capabilities to cope with our intended stressor.

Although the participants who showed higher trait anxiety also showed higher state anxiety across conditions, the average trait anxiety of the sample was lower than the normative sample. Trait anxiety reflects anxiety-proneness such that people with higher trait anxiety exhibit elevations in state anxiety more frequently than people with lower trait anxiety (Spielberger, 1983). Conceivably, our inability to induce social-evaluative threat may have been due to participants' lower disposition to perceive stressful situations as threatening.

Rate of perceived exertion

We know that some degree of attention is consumed by the physical discomfort and somatic signals of pain and fatigue associated with a cognitive-motor dual-task (Hockey, 1997; Lohse & Sherwood, 2011). However, previous findings have also shown that mental arithmetic and other psychologically challenging tasks elicit heart rates substantially greater than what would be expected based on energy expenditure alone (Carroll et al 1986). Following each experimental condition, participants were asked to complete a Borg scale. RPE values have been shown to correlate closely with heart rate (Borg, 1982). Indeed, RPE scores were somewhat higher in the dual-task conditions than in the control task (Figure 9.0). However, these differences were not significant, and there was no evidence of additional increases in heart rate in the stress condition that might have suggested an anxiety effect.

Physical workload and arousal

There was no significant change in stride parameters across conditions, presumably because anxiety was not generated. Participants were asked to select a preferred treadmill speed equivalent to the speed at which they would run for 20 minutes. Because greater variations in stride have been demonstrated at non-preferred speeds, self-selected speed was increased by 20% (Abernethy et al., 2002; Beauchet et al. 2005; Dubost et al. 2006; Jordan and Newell, 2008; Jordan et al., 2007). In the event that participants under-estimated their initial selection, a 20% increase may have been insufficient to establish a speed that could be considered non-preferred. The increased speed may not have been different enough from preferred speed to elicit potential adjustments in stride. Even under dual-task conditions, stride variability is lower at preferred speeds. Indeed, stride time variability was not significantly different across conditions.

Yerkes-Dodson's law on the relationship between arousal and performance states that optimal arousal results in optimal cognitive performance (Yerkes and Dodson, 1908). Similarly, low to moderate levels of physical activity (such as running at preferred speeds) has been shown to create optimal levels of arousal resulting in improvements in cognitive task performance (Brisswalter and Legros, 1995; Lambourne and Tomporowski, 2010). Hypothetically, participants may have been optimally aroused thus facilitating performance of the dual-task. Had they been aroused beyond optimal levels, cognitive performance might have suffered, and performance of the dual-task might have been perceived as a greater challenge. Perhaps then, the video recording of their performance would have elicited social-evaluative threat.

CHAPTER VI: CONCLUSION

Because we were not successful in inducing anxiety, it is not possible to draw conclusions on its effect. The purpose of this study was to determine whether anxiety arising from social-evaluative threat would affect running efficiency in a dual-task setting. Review of the current literature suggests that anxiety, the energetic demands of the motor task and the cognitive demands of the mental arithmetic task all compete for attention. The goals of our protocol were to create a challenging cognitive-motor dual-task paradigm, instruct prioritization towards the cognitive task to avoid a trade-off effect, and induce social-evaluative threat in order to observe whether additional dual-task costs could be attributed to anxiety.

In a pilot study performed in 2009 using the same dual-task protocol, participants expressed high anxiety related to the mental arithmetic task and at times, an inability to perform both the running and arithmetic task simultaneously. Although merely speculative, these observations line up with the current literature, which has demonstrated clear effects of anxiety. Unfortunately, it was not a variable included in the 2009 study. We do not know whether trait or state anxiety of the sample was different than that of our current sample, but it is possible that the filming manipulation is more effective in individuals with higher trait anxiety. Future analyses might compare the results of this study with results in sample with higher baseline trait anxiety.

The TSST identifies uncontrollability as a factor that can amplify the stress response in situations of social-evaluative threat. In the discussion, we identified specific sample characteristics such as familiarity with test-tasking, practical and oral examinations as a bias that may have contributed to the absence of a condition difference. We suggest that future studies should consider characteristics of the sample in order to ensure a successful anxiety manipulation.

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APPENDIX A
Consent to participate in the study

CONSENT TO PARTICIPATE IN
EXAMINING THE EFFECTS OF A MENTAL TASK ON RUNNING EFFICIENCY IN A COGNITIVE MOTOR DUAL-TASK

I understand that I have been asked to participate in a program of research being conducted by Mai-Linh Dovan of the Department of Exercise Science of Concordia University (**Contact info:** *514-867-6110, mai_linh10@hotmail.com*) under the supervision of Dr. Richard DeMont (***contact info*:** **(**514)848-2424 ext 3329, *richard.demont@concordia.ca*).

A. PURPOSE

I have been informed that the purpose of the research is to examine a mental task will affect my running techinique when they are performed at the same time.

B. PROCEDURES

- I understand that I am volunteering to participate in this study, which will be carried out in the Athletic Therapy Lab of the Concordia University Loyola Campus.
- I understand that I will participate in one session lasting approximately 1.5 to 2 hours and that all procedures will be explained in detail.
- I understand that I will be completing tests and questionnaires for which I will have to provide verbal and/or written answers that will be used to assess my ability in math, my general mental ability, my anxiety and my physical condition.
- I understand that I will be performing a physical task (running on a treadmill) and that there may be some temporary physical discomfort associated with this.
- I understand that portions of testing session will be filmed and that this video will be evaluated by researchers, students and professors involved in this study.

C. RISKS AND BENEFITS

- I understand that all procedures are completely non-invasive.
- I understand that there is a possibility that I may experience some muscle soreness and/or discomfort from the physical task. I understand that these are temporary side effects with no known long term risk.
- I understand that I must inform the experimenter if I feel any discomfort.

D. CONDITIONS OF PARTICIPATION

- I understand that I am free to withdraw my consent and discontinue my participation at any time without negative consequences.

- I understand that I am free to request that my video not be viewed at any time following the filmed portions of the testing session.

- I understand that my participation in this study is CONFIDENTIAL, i.e., all researchers involved in this project will know but will not disclose my identity.

- I understand that the data from this study may be published.

I HAVE CAREFULLY STUDIED THE ABOVE AND UNDERSTAND THIS AGREEMENT. I FREELY CONSENT AND VOLUNTARILY AGREE TO PARTICIPATE IN THIS STUDY.

NAME (please print) ____

SIGNATURE ____

If at any time you have questions about the proposed research, please contact the study's Principal Investigator, Dr. Richard DeMont, Department of Exercise Science, at (514) 848-2424x3329 or by email at richard.demont@concordia.ca.

If at any time you have questions about your rights as a research participant, please contact the Research Ethics and Compliance Advisor, Concordia University, 514.848.2424 ex. 7481 ethics@alcor.concordia.ca

APPENDIX B
STAI Form Y-1- Self-evaluation questionnaire for State Anxiety

For use by Mai-Linh Dovan only. Received from Mind Garden, Inc. on October 23, 2012

SELF-EVALUATION QUESTIONNAIRE **STAI Form Y-1**

Please provide the following information:

Name_______________________________________Date_____________S_____

Age__________________ Gender (*Circle*) **M** **F** T_____

DIRECTIONS:

A number of statements which people have used to describe themselves are given below. Read each statement and then circle the appropriate number to the right of the statement to indicate how you feel *right* now, that is, *at this moment*. There are no right or wrong answers. Do not spend too much time on any one statement but give the answer which seems to describe your present feelings best.

	NOT AT ALL	SOMEWHAT	MODERATELY SO	VERY MUCH SO
1. I feel calm	1	2	3	4
2. I feel secure	1	2	3	4
3. I am tense	1	2	3	4
4. I feel strained	1	2	3	4
5. I feel at ease	1	2	3	4
6. I feel upset	1	2	3	4
7. I am presently worrying over possible misfortunes	1	2	3	4
8. I feel satisfied	1	2	3	4
9. I feel frightened	1	2	3	4
10. I feel comfortable	1	2	3	4
11. I feel self-confident	1	2	3	4
12. I feel nervous	1	2	3	4
13. I am jittery	1	2	3	4
14. I feel indecisive	1	2	3	4
15. I am relaxed	1	2	3	4
16. I feel content	1	2	3	4
17. I am worried	1	2	3	4
18. I feel confused	1	2	3	4
19. I feel steady	1	2	3	4
20. I feel pleasant	1	2	3	4

APPENDIX B
STAI Form Y-2- Self-evaluation questionnaire for Trait Anxiety

SELF-EVALUATION QUESTIONNAIRE

STAI Form Y-2

Name____Date__________

DIRECTIONS

A number of statements which people have used to describe themselves are given below. Read each statement and then circle the appropriate number to the right of the statement to indicate how you *generally* feel.

	ALMOST NEVER	SOMETIMES	OFTEN	ALMOST ALWAYS
21. I feel pleasant	1	2	3	4
22. I feel nervous and restless	1	2	3	4
23. I feel satisfied with myself	1	2	3	4
24. I wish I could be as happy as others seem to be	1	2	3	4
25. I feel like a failure	1	2	3	4
26. I feel rested	1	2	3	4
27. I am "calm, cool, and collected"	1	2	3	4
28. I feel that difficulties are piling up so that I cannot overcome them	1	2	3	4
29. I worry too much over something that really doesn't matter	1	2	3	4
30. I am happy	1	2	3	4
31. I have disturbing thoughts	1	2	3	4
32. I lack self-confidence	1	2	3	4
33. I feel secure	1	2	3	4
34. I make decisions easily	1	2	3	4
35. I feel inadequate	1	2	3	4
36. I am content	1	2	3	4
37. Some unimportant thought runs through my mind and bothers me	1	2	3	4
38. I take disappointments so keenly that I can't put them out of my mind	1	2	3	4
39. I am a steady person	1	2	3	4
40. I get in a state of tension or turmoil as I think over my recent concerns and interests	1	2	3	4

APPENDIX C
SQUASH – Short Questionnaire to Assess Health-enhancing Physical Activity

Short Questionnaire to Assess Health-enhancing Physical Activity (SQUASH)

Think about an average week in the past few months. Please indicate **how many days per week** you performed the following activities, how much time **on average** you were engaged in them, and (if applicable) how strenuous this activity was for you.

COMMUTING ACTIVITIES (round trip)	**Days per week**	**Average time per day**		**Effort (circle please)**
Walking to/from work/school	. . . . days	. . . . hours	. . . . minutes	slow/moderate/fast
Bicycling to/from work/school	. . . . days	. . . . hours	. . . . minutes	slow/moderate/fast

Not applicable

LEISURE-TIME ACTIVITIES	**Days per week**	**Average time per day**		**Effort (circle please)**
Walking	. . . . days	. . . . hours	. . . . minutes	slow/moderate/fast
Bicycling	. . . . days	. . . . hours	. . . . minutes	slow/moderate/fast
Gardening	. . . . days	. . . . hours	. . . . minutes	light/moderate/intense
Odd jobs	. . . . days	. . . . hours	. . . . minutes	light/moderate/intense
Sports (please write down yourself) *eg, tennis, fitness, skating, swimming, dancing*				
1.	. . . . days	. . . . hours	. . . . minutes	light/moderate/intense
2.	. . . . days	. . . . hours	. . . . minutes	light/moderate/intense
3.	. . . . days	. . . . hours	. . . . minutes	light/moderate/intense
4.	. . . . days	. . . . hours	. . . . minutes	light/moderate/intense

Not applicable

HOUSEHOLD ACTIVITIES	**Days per week**	**Average time per day**
Light household work (cooking, washing dishes, ironing, child care)	. . . . days	. . . hours . . . . minutes
Intense household work (scrubbing floors, carrying heavy shopping bags)	. . . . days	. . . . hours . . . . minutes

Not applicable

ACTIVITY AT WORK AND SCHOOL	**Average time per week**
Light work (sitting/standing with some walking, eg, a desk job)	. . . . hours . . . . minutes
Intense work (regularly lifting heavy objects at work)	. . . . hours . . . . minutes

Not applicable

APPENDIX D
BORG CR10 – Rate of perceived exertion scale

BORG CATEGORY-RATIO SCALE (BORG CR10)

rating	description
0	NOTHING AT ALL
0.5	VERY, VERY LIGHT
1	VERY LIGHT
2	FAIRLY LIGHT
3	MODERATE
4	SOMEWHAT HARD
5	HARD
6	
7	VERY HARD
8	
9	
10	VERY VERY HARD (MAXIMAL)