The SPEED Study: Self Paced Exercise and Endpoint Definition

Dissertation

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By

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Abstract

The amount of effort people place into exercise sessions, as well as their attention, affect and perceptions are influenced by a range of psychophysiological factors that can influence subsequent participation and performance. Awareness of the duration or distance of an exercise session, attentional focus and the perception of time can contribute to pacing strategy, and perhaps play a role in the maintenance of an exercise or sport program; however, little is known about the relationship among these factors and no research has been conducted to examine the relationship between psychophysiological responses, time perception and pacing, especially when the duration of an event is unknown and subjects are allowed to self-pace.

The primary purpose of the SPEED (Self-Paced Exercise and Endpoint Definition) study was to determine the effect of running with and without an unknown endpoint on psychophysiological variables, and to investigate the perception of time in runners. Subjects in the study consisted of 22 runners (11 men, 11 women) that consistently logged at least 10 miles per week of running in the previous six months. They were apparently healthy and “low risk” according to American College of Sports Medicine risk stratification guidelines. Subjects were asked to participate in two conditions: 1) a run with an unknown endpoint that was relative to each subject, calculated based on their running history; and 2) a run to the same distance with the
knowledge of the endpoint. In both conditions the subjects were blind to speed, distance and elapsed time. At varying time points, rating of perceived exertion (RPE), affect, heart rate, attentional focus and time perception were assessed.

Results showed that subjects ran significantly faster when the endpoint was known ($p < .01$) but no differences were seen in psychophysiological variables between conditions ($p > .05$). A significant curvilinear increase in RPE was seen in both conditions ($p < .001$). For all subjects there was a feeling of time “slowing down” when they progressed through each run, while women consistently underestimated prospective time intervals compared to men. Additionally, cardiorespiratory fitness level was a significant predictor of attentional focus near the end of the run with a known endpoint.

The results from this study support the concept of teleoanticipation; metabolic resources were conserved during exercise when the endpoint was unknown. Despite running faster when the endpoint was known, no differences were seen in psychophysiological variables. Subjects with high levels of cardiorespiratory fitness used associative cognitive strategies during exercise when the endpoint was known. Additionally, significant differences in time estimations were seen between men and women; women in this study perceived time as moving by relatively slowly compared to the men. This contributes to what is known about sex differences in time perception.
Dedication

To my very patient wife, Erica
Acknowledgments

I would not be where I am right now without a strong support crew by my side, encouraging me and pushing me to succeed. I would first like to thank my advisor, Janet Buckworth, for all of your help over the last three years. You have allowed me to fully explore my interests and I appreciate that you have always been more than willing to make time for me. I couldn’t be happier that our paths crossed and I was able to work with you.

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Erica, my crew leader - I cannot thank you enough for all that you have done for me. I hope you understand how much I appreciate you.
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Selected Publications


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Fields of Study

Major Field: Education and Human Ecology

Specialization: Kinesiology
Table of Contents

Abstract ......................................................................................................................... ii
Dedication .................................................................................................................... iv
Acknowledgments ........................................................................................................ v
Vita ............................................................................................................................. vi
List of Tables ................................................................................................................. x
List of Figures .............................................................................................................. xi
Chapter 1: Introduction ............................................................................................... 1
Chapter 2: Review of Literature .................................................................................. 17
Chapter 3: Methods ..................................................................................................... 63
Chapter 4: Results ....................................................................................................... 79
Chapter 5: Discussion .................................................................................................. 99
References .................................................................................................................. 124
Appendix A: SPEED Study recruitment flyers .......................................................... 136
Appendix B: ACSM risk stratification guidelines ..................................................... 139
Appendix C: Scales: Rating of Perceived Exertion (RPE) and Feeling Scale (FS) .... 143
Appendix E: IRB Application – Research Protocol .................................................. 165
Appendix F: Informed Consent .................................................................................. 178
Appendix G: Medical Health and Running History ..................................................188
Appendix H: Subjects’ Running History ...................................................................195
Appendix I: Approval Letter from the Institutional Review Board............................197
List of Tables

Table 3.1: Assessments during the SPEED study ..........................................................78
Table 4.1: Demographics, listed as $M (SD)$ .................................................................80
Table 4.2: Summary of VO$_2$max testing ......................................................................81
Table H.1: Subjects’ running history ............................................................................196
List of Figures

Figure 2.1: An interpretation of the simple feedback control versus an integrative control system (Lambert, St Clair Gibson, & Noakes, 2005) ..................20

Figure 2.2: Interpretation of the A.V. Hill model of fatigue (Noakes, 2012b).............32

Figure 2.3: End spurts shown for different distance races (Noakes, 2012b).............33

Figure 2.4: Central Governor Model of Exercise Regulation (Noakes, 2012a). ........34

Figure 2.5: The original Rating of Perceived Exertion (RPE) scale (Borg, 1982)... ...36

Figure 2.6: CR-10 scale (Borg, 1982)..................................................................36

Figure 2.7: Effect of task length expectancy on levels of fatigue (Walster & Aronson, 1967) ........................................................................................................38

Figure 2.8: Electromyography activity in arm muscles, showing the effect of task length expectancy on muscle activity (Vidacek & Wishner, 1971)........40

Figure 4.1: Changes in RPE over absolute time ......................................................82

Figure 4.2: Changes in RPE over percent time completed......................................84

Figure 4.3: Changes in heart rate over absolute time.............................................86

Figure 4.4: Changes in affect over absolute time ...................................................88

Figure 4.5: Changes in time estimations across time.............................................89

Figure 4.6: Sex differences in time estimations across endpoint conditions ..........90
Figure 4.7: Sex differences in time estimations during the unknown endpoint condition .................................................................91

Figure 4.8: Sex differences in time estimations during the known endpoint condition ..................................................................................................................92

Figure A.1: SPEED Study flyer .................................................................................................................................137

Figure A.2: SPEED Study flyer with tear-offs .................................................................................................................138

Figure B.1: ACSM risk stratification guidelines (Thompson, Gordon, & Pescatello, 2009) .................................................................141

Figure C.1: Rating of Perceived Exertion (RPE) Scale .................................................................144

Figure C.2: Instructions for RPE Scale ......................................................................................................................145

Figure C.3: Feeling Scale (FS) with instructions .................................................................................................146
Engaging in regular exercise and sport involves participation in repeated bouts of physical activity that varies in both intensity and duration. How long and how much effort people put into exercise sessions, as well as their attention, affect, and perceptions are influenced by a range of factors that can consequently influence subsequent participation and performance. Awareness of the duration or distance of an exercise session, attentional focus, and perception of time passing can contribute to the efficiency of pacing, but may also play a role in sustaining an exercise or sport program. However, little is known about the relationships among these factors.

*Teleoanticipation and the knowledge of an endpoint*

Both competitive and recreational athletic events generally have a beginning and an endpoint. In some events this endpoint is based on distance, in other events it is based exclusively on time. In most athletic events, the distance is set and the goal is to reach the finish line in the shortest amount of time possible. However, in other events such as a 12 hour or 24 hour timed run the goal is to complete as much distance as possible in the given time. In all athletic events, however, the pacing is chosen by the athlete and can vary widely depending on a multitude of factors.

Teleoanticipation, from the Greek “teles” for “to bring to a close, to finish or end,” is the concept that humans pace themselves according to the amount of time left in
an athletic event (Garrison; Ulmer, 1996). The goal is to regulate metabolic reserves and prevent system failure, while simultaneously attempting to reach the endpoint as quickly as possible (or cover the most amount of distance in a timed event). Athletes are constantly comparing how fatigued they are at any given point in an event to how fatigued they expected to feel at that point; this perception is then compared to the preset “template” that they subconsciously create beforehand (Joseph et al., 2008). They then are forced to make a decision as to whether or not they should increase or decrease the pace, based on how much physiological disturbance they are willing to accept. Hans Ulmer (1996) first coined the term “teleoanticipation,” based on work that he performed on athletes who were asked to run and maintain certain ratings of perceived exertion (RPE) levels, allowing them to adjust their pacing accordingly (Borg, 1982). Ulmer concluded that there is likely a “regulation center” in the brain that performs precise calculations about metabolic reserves, as well as time and effort needed to finish exercise bouts at a given intensity.

Ulmer’s study on athletes corroborated results from a previous experiment by Vidacek and Wishner on the effect of task length on muscle activity (Vidacek & Wishner, 1971). They asked subjects to hold a weighted pulley attached to their wrist with their elbow flexed at 90 degrees for two conditions: a short task, in which they were asked to hold the weight for 30 seconds and a long task, where they were asked to hold the weight as long as possible. Electromyography was used to show the activity of the muscles; results showed that there was significantly more muscle activity in the short task compared to the long task. This implied that when the length of a task is
unknown, the energy sources are conserved, and feelings of fatigue are suppressed until the subject is sure that he or she will be able to complete the task in full.

Tasks with unknown endpoints have also been investigated in the sports science literature, and can provide researchers with useful insight into the sources of fatigue. Baden et al. (2005) examined well-trained recreation runners as subjects. In one condition, they were asked to run for 20 minutes and were stopped at 20 minutes. In another condition they were asked to run for 10 minutes but at the end the researchers asked them to run another 10 minutes. In a third condition, subjects were unaware of the time they would have to run, and were stopped at 20 minutes. The treadmill speed was fixed, but was relative to each subject and the same speed was used for all three trials. In the end, all trials lasted a total of 20 minutes; however, the subjects were unaware of this at the beginning of the study. The subjects overall had lower oxygen consumption in the unknown endpoint condition but similar RPE levels as in the known endpoint conditions, showing that they were actually running more economically when the endpoint was unknown. Since level of enjoyment, or affect has been shown to influence RPE during exercise (e.g., Rejeski & Ribisl, 1980), Baden et al. (2005) also assessed affect (via the Feeling Scale) throughout each of the three conditions; they found that at the 11 minute point in the condition where the subjects were asked to continue running after 10 minutes, the reported affect was significantly less positive than the other two conditions.

Perceived exertion has also been shown to be affected by focus of attention, that is, cognitive strategies of association or dissociation. Associative thoughts are those in
which the focus is placed on cues received from the body, whereas dissociative thoughts are those in which a person does not tune in to bodily cues, and engages in thoughts such as daydreaming. There is good evidence that at greater levels of intensity physiological cues dominate attentional focus (Tenenbaum, 2001). The expected task duration may also affect the direction of attentional focus (Baden, Warwick-Evans, & Lakomy, 2004), which may in turn affect the reported level of perceived exertion and the person’s pacing strategy.

**Self-pacing**

The majority of studies using a laboratory treadmill have implemented fixed pacing, usually to a speed that is relative to the subject’s capability. The ability to constantly adjust pace is highly beneficial to athletes but is not often utilized in sport science research. Garcin et al. (2008) studied the effect of self-pacing versus fixed pacing on ratings of perceived exertion (RPE) in 10 male trained endurance runners. The first run was a fixed paced run until exhaustion at 90% of the velocity reached at VO₂max (also called 90% vVO₂max) and the second run was a self-paced run to the same distance that they covered in the first run. They were asked to complete the distance in the second run as fast as they could. The results showed that the subjects were able to maintain a significantly faster velocity in the self-paced run compared to the fixed pace run, while there were no differences in perceived exertion or oxygen uptake.

When the distance of an event is known and subjects are able to self-pace, they choose an optimal speed to complete the event at the highest level of efficiency (de Paula
Viveiros, Amorim, Alves, Passos, & Meyer, 2011). World records in running events from 1500 meters up to the marathon have shown a variation in running speed of 1 to 5 percent, showing that elite runners constantly adjust their pace during a race to optimize performance (Billat, Slawinski, Danel, & Koralsztein, 2001). In 2006, Billat and colleagues showed that a “freely” or self-paced run elicited significantly higher VO₂ values, heart rate and blood lactate concentration compared to a fixed pace run over 10,000 meters (Billat, Wesfreid, Kapfer, Koralsztein, & Meyer, 2006).

A novel self-paced, fixed time VO₂max protocol was recently introduced by Mauger and Sculthorpe (2012). When compared to a standard incremental VO₂max protocol (fixed speed and incline) where subjects did not know the endpoint and were asked to run to volitional exhaustion, the 10-minute self-paced protocol resulted in both higher VO₂max values and power outputs. Other studies have shown that knowledge of endpoint can affect perception. Coquart et al. (2008) asked subjects to run at a certain pace with an unknown endpoint until exhaustion. They were asked to run at that same pace two more times, the same distance that was reached and for the same amount of time. For the last two trials the subjects were aware of the endpoint, which was a set distance in trial two and a set time in trial three. Subjects’ RPE was higher and their heart rate was slightly lower when the endpoint was known even though they were running at the same speed, again showing that perceived exertion is affected by knowledge of an endpoint.
There is evidence that perception of how much time is passing is influenced by attentional focus and can differ among people and situations. In prospective time estimation studies, level of attention has shown to greatly affect time judgments (Brown, 1985, 2008; Glicksohn, 2001; Zakay & Block, 1996) and cause one to feel as though time is moving faster or slower than at rest. Level of attention has also been shown to affect perceptions during exercise. Studies have shown that associative, compared to dissociative, strategies lead to higher reported RPE values (Johnson & Siegel, 1992) and that dissociating as a consequence of increased levels of external stimuli leads to faster finishing times during self-paced running but no significant differences in RPE (Pennebaker & Lightner, 1980). Characteristics of an exercise bout can also affect attentional focus. For example, as the level of exercise intensity rises, the amount of attention and focus allocated to that activity also rises (Masters & Lambert, 1989; Masters & Ogles, 1998; Silva & Appelbaum, 1989). Given these relationships, it is possible that pacing, perceived exertion, attentional focus, and affect are related to the perception of time during athletic events.

Sex and cardiovascular fitness are other factors that may moderate the relationships among pacing, attentional focus, and time perception. Several studies have found differences in perception of time between men and women (Block, Hancock, & Zakay, 2000; Espinosa-Fernández, Miró, Cano, & Buela-Casal, 2003; Rammsayer & Lustnauer, 1989; Rammsayer & Rammstedt, 2000) and sex differences have been
observed in the pacing strategies of long distance runners (March, Vanderburgh, Titlebaum, & Hoops, 2011; Speechly, Taylor, & Rogers, 1996).

The problem

Self-pacing is important to study because many people choose to run outdoors where their pace is not fixed, and most races occur in situations where athletes are able to constantly adjust their pace as they deem necessary. To the author’s knowledge, no studies to date have investigated the effect of running with an unknown endpoint during self-paced exercise; current studies utilizing self-pacing are tests that end in volitional fatigue (time to exhaustion) or those with a defined endpoint. Knowledge of an endpoint or duration during exercise can play a vital role in regulation of resources. In addition, perception of time, personality, attentional focus, and affect, which have been related to exercise adoption and maintenance (Courneya & Hellsten, 1998; Dishman, Sallis, & Orenstein, 1985; Harte & Eifert, 1995; Williams, 2008), have not been studied under these conditions.

If a participant did not know the endpoint of an event, psychophysiological variables such as perceived exertion and affect, as well as pacing strategies, could potentially be affected. No defined endpoint could also have implications for perception of time, level of perceived exertion and enjoyment, as well as level of anxiety. Additionally, perceived lack of time is one of the most common reasons people report for not exercising (Bartlett et al., 2011; Dishman et al., 1985). Further knowledge of the perception of time before, during and after exercise could help to
illuminate how time perception is related to psychophysiological responses to exercise, which in turn have been shown to influence exercise adherence (Buckworth & Dishman, 2002; Dishman, 1994; Ekkekakis & Lind, 2005). For example, a sense that time is passing more slowly during exercise could be associated with low levels of enjoyment and a reduced likelihood that exercise would be repeated.

**Statement of Purpose**

The purpose of this study was to examine the effect of running with an unknown endpoint versus a known endpoint on psychophysiological variables such as heart rate, rating of perceived exertion, attentional focus and affect. Another purpose was to investigate the perception of time before, during and after exercise, as well as moderating effects of sex and cardiovascular fitness in those time judgments.

**Hypotheses and Research Questions**

The **primary aim** was to investigate the effects of a bout of exercise with and without a known endpoint on perceived exertion and psychophysiological variables.

A **secondary aim** was to investigate the perception of time before, during and after exercise with and without a known endpoint.

A **tertiary aim** was to determine if sex or cardiorespiratory fitness moderates the relationship between any of the variables tested.
The research questions were as follows:

1. **Ratings of Perceived Exertion** –
   
   What is the effect of running with an unknown or known endpoint on average and final ratings of perceived exertion?

2. **Heart rate** –
   
   a. What is the effect of running with an unknown or known endpoint on average and final heart rate?
   
   b. Are there differences in heart rate response between men and women?

3. **Feeling Scale (affect rated +5 [very good] to -5 [very bad])** –

   What is the effect of running with an unknown or known endpoint on average and final Feeling Scale rating?

4. **Time Perception** –

   a. Are there differences in time perception between men and women during exercise or at rest?
   
   b. When the endpoint of exercise is unknown, will cardiorespiratory fitness level affect time perception when the subject has completed 90% of the distance?
   
   c. When the endpoint of exercise is known, will cardiorespiratory fitness level affect time perception when the subject has completed 90% of the distance?
d. Does age affect time perception at rest or during exercise?

e. Are there differences in time estimation as exercise progresses?

f. Are there differences in time estimation before and after a bout of exercise?

g. Does attentional focus affect time perception during exercise?

h. Does reported weekly mileage affect time perception during exercise?

5. Association/Dissociation –

a. Is attentional focus related to endpoint condition? Are there differences in attentional focus between the unknown and known endpoint conditions?

b. In the unknown endpoint condition, will cardiorespiratory fitness level influence attentional focus?

c. In the known endpoint condition, will cardiorespiratory fitness level influence attentional focus?

d. Will attentional focus be related to RPE levels during both conditions? Specifically, as the percentage of dissociative thoughts decreases will the reported RPE levels increase?

6. Pacing –

Will the subjects run faster overall when the endpoint of the exercise bout is known?
Limitations

The subjects used in this study were runners ranging from recreational to highly competitive and experienced. As a consequence of using this sample, most results from this study can only be generalized to runners and not to the general public or even other athletes. All testing was performed on a laboratory treadmill; most runners prefer to run outdoors and tend to avoid running on treadmills unless the weather prohibits them from outdoor activities.

With this specific study design, we were not able to randomly sample subjects for testing. Random sampling is assumed in the use of inferential statistics, which refer to the fact that various conclusions are drawn regarding the relationships in the data based upon inferring knowledge from the sampling distribution. Inferential statistics assess estimates made using random samples, and if sampling is not random the particular statistics involving sampling error are not relevant. However, some authors, such as Michael Oakes, note that the use of inferential statistics may be warranted for nonprobability samples if the sample seems to represent the population. This is a limitation to the design of this study (Oakes, 1986).

Definitions and Terms

**Affect** – This is the experience or feeling of emotion, and is often assessed during exercise. It is separated into positive (pleasant) and negative (unpleasant)
dimensions, with positive affect supporting future exercise behavior by the promotion of positive memories of an exercise experience.

**Operational Definition** – The Feeling Scale (FS) was used to assess positive and negative affect. This is an 11 point scale ranging from +5 to -5; the subjects were asked multiple times to report their affect on this scale during all tests.

**Attentional focus** – This is the cognitive process of selecting one aspect of the environment while ignoring other aspects. It is the allocation of attentional resources.

**Operational Definition** – In both endpoint conditions the subjects were asked to report their level of attentional focus at random time points. Specifically, they were asked to report the percentage that they were dissociating. The differences between association and dissociation were clearly described prior to testing.

**Cardiorespiratory Fitness** – This is the ability of the circulatory and respiratory systems to supply oxygen to working skeletal muscles during exercise. \( \text{VO}_2\text{max} \) is the maximum amount of oxygen that can be provided to and used by working skeletal muscle.

**Operational Definition** – Cardiorespiratory fitness level was assessed with an initial \( \text{VO}_2\text{max} \) test. This is an incremental test where the workload is progressively increased and the subjects are asked to run until volitional fatigue, or where they decide that they cannot continue exercise.
Closed loop – This is an exercise bout in which the endpoint is known by the subjects; they are asked to run or cycle for a set time or distance.

**Operational Definition** - In the “known endpoint” condition the subjects were aware of the distance that they were going to run. This was the same distance that was calculated for the “unknown endpoint” condition and was determined based on their weekly running mileage and their longest run over the last six months.

Fixed pace – Exercise in which the speed is predetermined or “clamped”; during this manner of testing the subject is not able to adjust speed at all.

**Operational Definition** - During the VO2max test, a speed was chosen that was slightly faster than their normal training speed. This speed was not adjusted during the VO2max test and was fixed throughout.

Open loop - An exercise bout in which the endpoint is not known by the subjects; they are asked to run or cycle until exhaustion.

**Operational Definition** - In the “unknown endpoint” condition the subjects were unaware of the distance that they were going to run. This distance was determined based on their weekly running mileage and their longest run over the last six months.
**Ratings of Perceived Exertion** – This is the subjective report of the amount of overall effort a subject is experiencing. It is based on physical sensations that are experienced by a person such as heart rate, ventilation, sweating and muscle fatigue.

**Operational Definition** – The Rating of Perceived Exertion (RPE) scale was used in this study to assess perceived exertion. This is a 6-20 scale; the subjects were asked multiple times to report their RPE on this scale during all tests.

**Self-paced** – Exercise in which a subject is able to constantly adjust speed as he or she wishes.

**Operational Definition** - In both endpoint conditions the subjects were allowed to adjust their pace throughout. The speed was not displayed to the subjects; they were blind to both speed and elapsed time. The “speed up” and “speed down” buttons were available to the subjects and they were encouraged to adjust as they felt needed.

**Speed decreases/increases** – These are the increases and decreases in speed during testing sessions with known/unknown endpoints.

**Operational Definition** – The subjects were asked to run on a laboratory treadmill and were able to adjust speed throughout the testing. The speed was increased or decreased as they wished by pressing a “+” button or a “-” button during the run. The number of speed increases and decreases was determined for each subject.
**Time estimation** – Used to measure the perception of time in subjects; they are asked to either estimate how long they believe a previous event lasted or to estimate a certain amount of time from start to finish. Time is separated into subjective and objective aspects; subjective time is the length of time experienced by a subject, and objective time is the interval that the subject is attempting to estimate. A prospective time estimation (subjective time) that is less than the objective time indicates that the subject is experiencing time to be passing slowly. Conversely, prospective time estimations (subjective time) greater than the objective time indicate that the subject feels as though time is passing by quickly.

**Operational Definition** – The subjects were asked to prospectively estimate a 60 second period of time before, three times during, and after a bout of exercise. This time judgment, in seconds, was divided by 60 to provide a ratio (subjective time divided by objective time).

**Significance**

There is considerable research on the effects of psychophysiological responses to acute exercise and subsequent exercise adoption and adherence, and studies have shown that affect during and after exercise can predict adherence 6 and 12 months after the exercise session. However, no research has been conducted to examine the relationship between pacing and psychophysiological responses and time perception, especially when the duration of the event is unknown to the subject.
The results from this experiment could be useful in determining whether or not experienced runners have a different perception of time before, during and after running compared to inexperienced runners. There may also be sex differences in time perception during exercise, which might help to explain pacing strategies of men and women. A sense that time is passing slowly during exercise could be related to low enjoyment levels, negative affect and a reduced likelihood of continuing exercise. Alternatively, the sense that time has passed quickly during exercise could counteract the perception of not having adequate time for exercise (the most often cited barrier to regular exercise). The examination of attentional focus in this study could show a modifiable influence of time perception during exercise and provide information to include in exercise interventions.
Chapter 2: Review of Literature

The purpose of this literature review is to provide a comprehensive background to the areas of research that are involved with the current study. The backbone of the study is the concept of teleoancipation, which is the notion that the regulation of metabolic reserves is highly dependent on the remaining time or distance left to complete in an event, whether athletic or otherwise. A key factor in teleoancipation is the desire to keep fatigue levels as low as possible, and to not reach complete fatigue before the end of the event. The perception of time is also likely related to teleoanticipation, because how we perceive the passage of time greatly affects many areas of life. If the passage of time is different between two individuals, then strategies of pacing could be different as well. Lastly, prospective time estimation is highly related to level of attention. During exercise, cognitive strategies are both temporally and environmentally dependent. Which cognitive strategy is used at any given time is likely to be related to time perception, and thus related to teleoanticipation and pacing strategies as well. Therefore, this review of literature has been separated into four areas of research that are implicit to the current study: 1) teleoanticipation, 2) fatigue, 3) perception of time, and 4) cognitive strategies. A summary of the review of literature is also provided for the reader.
1. Teleoanticipation

Every athletic event has both a start and a finish. Sometimes the finish point is a set time, but more often it is a set distance that the athlete must cover. When people take part in an athletic event, especially an endurance event such as a marathon, their perception of the approximate amount of time remaining in the event can greatly affect psychophysiological functioning, specifically their perceived exertion. In the marathon, for example, the goal of most runners is to complete the 26.2 mile distance as quickly as possible. The simple solution would be to run as hard as possible, in hopes of completing the distance in a short time. There is a caveat, however. If they run too quickly, they will likely fatigue early and may not even finish the race at all. This could potentially waste months of rigorous training. Alternatively, if they run too slowly, they are more likely to complete the race but will not reach their goal time. The athlete must constantly arrange his/her energy consumption per unit of time depending on approximately how much time is left in the course of the event (Ulmer, 1996).

Hans Ulmer was one of the first individuals to study this concept in depth, and originally coined the term “teleoanticipation,” based on work that he performed on various types of athletes and non-athletes (Ulmer, 1996). In his studies he used the Rating of Perceived Exertion (RPE) scale as an index of overall effort or exertion (Borg, 1982). He asked his subjects to maintain certain RPE levels, and allowed them to adjust their pace accordingly. He concluded that there is likely a “regulation center” in the brain that performs very precise calculations about metabolic reserves and rates, as well as the time and effort needed to finish the bout of exercise at a given intensity. He also
postulated that there must be some sort of feedback control system with a programmer that takes into account the end, or finishing point. Just as migrating birds must regulate their metabolic reserves very carefully to arrive at their destination safely, humans regulate their reserves in an attempt to complete a task without failure.

Ulmer used various psychophysiological experiments to show the concept of teleoanticipation and utilized RPE (Borg 6-20 scale). In all sub-studies he asked subjects to exercise at certain RPE levels and informed them that they could adjust their pace as necessary to maintain the RPE. Various experiments were performed but in the end there were six main conclusions.

1. Efferent motor signals to the muscle include information about not only the biomechanics of motion but also about the intensity of metabolics.
2. There is the ability to feed back the intensity of metabolic rate to the motor control system.
3. There is likely the existence of an extracellular closed-loop regulation of metabolic rate during high-intensity exercise.
4. Motor learning also includes the adjustment of exertion and performance (not only somatosensory).
5. Teleoanticipation exists for the optimal arrangement of exertion, so that subjects can avoid early exhaustion.
6. The “regulation center” of the system has to perform very complex calculations about metabolic reserves and rate, as well as the time needed to finish the exercise bout.
1.1 - Teleoanticipation and Pacing

Proper pacing is often what wins races; it is important to know when to push the pace and when to back off. Carl Foster was one of the first scientists to investigate pacing in sport and exercise in depth. In a seminal *Sports Medicine* journal review (Foster, Schrager, Snyder, & Thompson, 1994), Foster and colleagues showed that some sort of pacing is necessary even in athletic events lasting only a few seconds. Athletes can become very “in tune” with their bodies and learn how to sense very low pH levels and attempt to reach critically low levels only at the very end of a race. Proper pacing, then, is highly dependent on the knowledge of an endpoint.
St Clair Gibson et al. (2006) suggested that humans have an “internal clock” with scalar time scales used by the brain to cover a certain distance without catastrophic failure (death). The person is thereby able to adjust power output and the rate of metabolic processes as needed throughout the exercise or race. St Clair Gibson et al. mention that knowledge of an endpoint in athletic events is crucial, and various different pacing strategies are often used, ranging from all-out, slow start, and even or variable pacing. Pacing strategies of athletes depends on physiological capacity, duration or distance of the event, exercise mode, level of competition, environment, motivation and experience of the athlete (Faulkner, Parfitt, & Eston, 2008).

1.2 - Teleoanticipation and deception

Deception is used in exercise science studies in an attempt to change the length of time or distance that subjects believes they will be exercising. Rejeski and Ribisl (1980) led an early study investigating the effect of deception on ratings of perceived exertion. Their subjects were 15 moderately fit men (mean VO₂max of 48.03 ml/kg/min). They asked their subjects to run at a fixed pace eliciting approximately 85% of their VO₂max. In the first trial, the subjects were told they would be running for 20 minutes and they were stopped at 20 minutes. In the second trial, they were told that they would be running for 30 minutes but were stopped early at 20 minutes. The trials were counterbalanced in an attempt to avoid any order effect. The absence of any differences between trials on physiological variables (heart rate, ventilation, etc.) showed that there was an intentional suppression of fatigue during the condition with a longer endpoint.
Another study investigated the energy expenditure and perceptions of effort during exercise with an unknown endpoint as well as deception about the time they would be running (Baden et al., 2005). Sixteen recreational runners (8 men, 8 women) were asked to run for 20 minutes in one condition. In a second condition, they were asked to run for 10 minutes but at the 10 minute point they were asked to run another 10 minutes for a total of 20 minutes. In the third condition, they were not told the amount of time they would run, but were stopped at 20 minutes. In the end, all three experimental conditions consisted of a 20 minute run. The treadmill speed was relative to each subject and the same fixed pace was used for all three trials. The subjects overall had lower oxygen consumption in the unknown endpoint condition. This showed that although the subjects were experiencing similar levels of exertion and running at the same speed, they were actually running more economically when the endpoint was unknown. Baden and colleagues also assessed the level of affect experienced by their subjects, since affect is a psychological factor that contributes to RPE levels (Buckworth & Dishman, 2002). To assess affect they used the Feeling Scale (Hardy & Rejeski, 1989), which spans from +5 (very good) to -5 (very bad). They found that affect at the 11 minute mark of the condition in which the subjects were asked to continue running was significantly less positive than the other two conditions. The corresponding RPE value at the 11 minute point was significantly higher than the other two conditions, and affect was less positive. However, VO2, heart rate, and the other variables were not different, showing that perceived exertion is indeed closely related to affect. Furthermore, Baden and colleagues suggested that psychological
variables may have more of an influence on RPE than physiological variables (Baden et al., 2005).

Eston and colleagues performed a similar study (Eston, Stansfield, Westoby, & Parfitt, 2012). They tested runners and cyclists (all men) in conditions that were the same as used in the Baden et al. (2005) study, and included a 20 minute condition, a 10 minute condition in which the subject was asked to run/bike and additional 10 minutes, and a condition in which the endpoint was not known but subjects were stopped at 20 minutes. The outcome variables of interest were oxygen uptake (VO$_2$), heart rate, affect (as measured by the Feeling Scale) and RPE. Ratings of perceived exertion were lower in the unknown endpoint condition compared to the other two conditions in the runners but not in the cyclists, showing a possible effect of exercise modality. Both groups of athletes showed a sharp decrease in affect after the 10 minute point in which they were asked to run/bike another 10 minutes. No significant differences between the three conditions were seen, however, and the authors pose that it was likely due to relatively low fixed exercise intensity (70% of VO$_2$max for running and 65% for cycling). The lower heart rate found in the unknown condition does suggest that there was an attempt to conserve metabolic resources when the time of an exercise task was not known.

Albertus et al. (2005) used deception to investigate teleoanticipation in trained cyclists (all men). The subjects performed four 20 kilometer time trials. In one condition they were told their correct 1km splits. In the other three conditions they were given 1km splits but in actuality the splits were too short, too long or random. There were no significant differences in RPE between any of the conditions. Since every condition was
the same overall distance, this suggests that RPE is set according to the distance before
the activity even begins and does not vary significantly over the duration of the exercise
bout even when subjects were deceived about their progress.

1.3 - Teleoanticipation with an unknown endpoint

A useful method of investigating the effect of teleoanticipation in a laboratory
setting is to perform open-loop exercise. Open-loop exercise is one where the endpoint is
literally unknown to the subject. This normally involves runs that are “to exhaustion,”
where the athlete simply rides or runs at a fixed pace to the point where they physically
and mentally feel they cannot go any farther. This is in stark contrast to closed-loop
exercise, where the distance or time is clearly stated and known to the subject. During
closed-loop exercise it is more common to allow subjects to self-pace.

In a review of studies related to fatigue during exercise, it was mentioned that
athletes who were unaware of exercise time actually ran with greater mechanical
efficiency (Lambert et al., 2005). In a linear model of fatigue, subjects would simply
exercise until their muscles were completely depleted of substrate; this is not the case,
however. Vissing’s experiments with cats has shown that liver glucose production is
independent of exercise intensity and there is an integrative regulation of homeostasis and
the motor centers of the brain use feed forward activation of glucose (2000). Lambert
and colleagues reported that lactate and muscle glycogen levels seem to act as peripheral
signaling agents rather than the actual cause of fatigue failure, and proposed that lactic
acid may even protect against muscle fatigue during high-intensity exercise (Lambert et
al., 2005).
Mauger et al. (2012) recently compared two different types of VO₂max tests: a traditional open-loop graded test to exhaustion and a novel closed loop test where the subject was aware of the endpoint. During the closed-loop test the subjects were instructed to ride at certain RPE intensities for two minutes segments – 11, 13, 15, 17 and 20. The last two minutes of the closed-loop VO₂max test were meant to be all-out and very intense. The researchers found that the subjects achieved a significantly higher VO₂max during the closed-loop tests compared to the open-loop tests even though the max heart rate was not different. This suggests that the subjects can endure a higher level of discomfort, or perceived exertion, when the endpoint of the exercise is known.

Coquart and Garcin (2008) implemented a scale that they created called the Estimated Time Limit (ETL) scale. This is a 0 to 20 ratio scale that includes verbal anchors (1 = more than 16 hours, 19 = 2 minutes) and the subject is asked the question "how long would you be able to perform an exercise at this intensity to exhaustion?" The authors state that the RPE scale gives an estimation of the intensity of the exercise whereas the ETL scale is a subjective prediction of how long exercise can be maintained at a certain level. The subjects in their study consisted of 14 police academy trainees (men) with an average age of 24.8 years. The main dependent variables were the RPE and ETL scales, as well as heart rate. Each subject performed four trials of outdoor running. A bicycle pacer was used to keep pace throughout all trials. The first session consisted of an incremental test to exhaustion, the purpose of which was to determine their VO₂max and then estimate their 90% maximal aerobic velocity (MAV). The second test consisted of a run to exhaustion at the estimated 90% MAV; the subjects
were instructed to run as long as they could, and were not given an endpoint for termination of exercise. During the third and fourth trials, the subjects were told to run at their 90% MAV for the same amount of time that was reached in the second trial and the amount of distance that was covered in the second trial. The subjects were counterbalanced, so every other subject completed the known time and the known distance conditions in opposite orders. No significant differences were found for the heart rate or the ETL data. However, the RPE data did show some differences between trials. The unknown endpoint condition elicited significantly lower RPE values throughout the testing compared to the known distance and known time trials. This showed that the trial with the unknown endpoint felt “easier” for the subjects even though they went just as far in the known distance and just as long in the known time conditions as they did in the unknown endpoint condition. Since they were also running at the same speed for each condition, this again shows the influence of psychological variables on the perception of exertion.

1.4 - Teleoanticipation – multiple trials and self pacing

Another way to investigate teleoanticipation is by comparing perceived exertion in the same subjects but using distance or time as an independent variable. As described earlier, Baden et al. (2004) took 40 healthy college students (20 men, 20 women) and had them run on a treadmill at a self-selected pace. In the first trial they were instructed to run at that pace for 10 minutes. In the first trial they were instructed to run for 20 minutes at the same pace, but the test was stopped abruptly at 10 minutes. In both tests they reported their RPE at various time points, and the researchers found that the
subjects’ perceived exertion was significantly higher in the first trial where they knew
they were running a total of 10 minutes. This supports the effect that teleoanticipation
has on the perception of exertion.

Wittekind et al. (2011) had nine healthy subjects (all men) cycle as hard as they
could for differing amounts of time – anywhere from 5 to 45 seconds. They found that as
the time increased, RPE and power output clearly decreased; the subjects were
conserving energy for the longer duration bouts, even though they were told to cycle as
hard as they could for every trial.

Swart and colleagues (2009) found that when eight elite cyclists were asked to
perform multiple time trials of the same distance, there was a linear increase in RPE until
the last trial where there was a clear decrease. The performance of the subjects was
negatively correlated with the RPE as well, so as RPE increased the performance of the
cyclists decreased (Swart et al., 2009). Often times when subjects are asked to perform
intervals, the second-to-last interval is usually reported as the most difficult and elicits the
highest RPE values. In the same study by Swart et al, they showed that when they asked
the subjects to cycle progressively longer distances (5k, 10k, 40k and 100k) the RPE and
power output decreased as distance increased. The same research group used
methylphenidate (Ritalin), a CNS stimulant, to see if cyclist would be able to perform
better and stave off fatigue (Swart et al., 2009). With Ritalin, the subjects had a slower
decline in RPE and a higher heart rate over the trial and cycled significantly longer than
the control (placebo) condition. Both conditions showed similar blood glucose and
lactate levels, as well as similar EMG activity. This showed that there was a change in
CNS regulation, not just peripheral fatigue. This supports Ulmer’s theory of a central command center that uses information in a feed-forward manner to constantly regulate reserves.

Faulkner et al. (2008) registered 9 healthy subjects (5 men, 4 women) in two separate races, a 7 mile road race and a ½ marathon (13.1 mile) road race. The researchers fitted each subject with an armband and marker so that each mile they could record their perceived exertion using the RPE 6-20 scale. They normalized the RPE to percent of race time completed, and did not find any significant differences between the two races. During the ½ marathon at mile 2, the subjects were at essentially the same RPE that was reported at mile 1 of the 7 mile race. This was an interesting way again show teleoanticipation and how it affects exertion levels.

Summary

Teleoanticipation is the concept that humans regulate their energy reserves based on the remaining time or distance in an event. Collectively, these studies help to show the importance of knowledge of an endpoint on perceived exertion and determination of a pacing strategy. The use of deception with subjects can provide useful information on the RPE template and how this must be altered when the endpoint of exercise is changed. When the endpoint is unknown to a subject, metabolic reserves used at a slower rate and ratings of perceived exertion are minimized by the brain in an attempt to finish the event before fatiguing. Lastly, studies that utilize self-pacing are limited and those that do allow the subjects to self-pace either do not have an unknown endpoint or are to
volitional exhaustion. Since self-pacing is utilized regularly by subjects it is important to study teleoanticipation under these conditions.

2. Fatigue

Fatigue in humans is often difficult to measure or even describe in detail. In medicine, fatigue is often the result of disease and impacts quality of life. In exercise physiology, fatigue results in a steep decline in human performance. In neurophysiology, fatigue is defined by a decline in efferent motor signals to active muscles (St Clair Gibson et al., 2003). Because of the multiple interpretations in different fields, some researchers have proposed that fatigue is actually an emotion or a feeling rather than a physiological process, while others differentiate specifically between physical and mental fatigue (Nozaki et al., 2009).

When discussing the performance characteristics of endurances athletes, one of the major factors that determines the winner of a race is which athlete has the least amount of fatigue. A high VO$_2$max, lactate threshold and running economy are extremely important to have success in endurance sports, but staving off fatigue is just as critical as these other factors. In exercise physiology, fatigue is generally defined by a significant decrease in the production of force by the skeletal musculature (Hagberg, 1981; Hawley & Reilly, 1997) or the loss of the ability to create the same amount of force when the perceived effort is increased (Bigland-Ritchie, 1981; Enoka & Stuart, 1992).
Essentially, fatigue is an impairment of performance during exercise that includes increases in the amounts of effort involved at a certain workload (Davis & Bailey, 1997).

Fatigue can have multiple causes, and can either have “peripheral” or “central” origins. Peripheral fatigue is a decrease in the force production of skeletal muscle due to the failure of an action potential, excitation-contraction coupling or cross-bridge cycle, when neural drive is either maintained or increased. Central fatigue is defined as a decline or reduction in neural drive or motor impulses to the skeletal muscle, which results in a decline in force production (St Clair Gibson, Lambert, & Noakes, 2001).

2.1 – Early examinations of fatigue

The study of fatigue is not new to the field of physiology. Angelo Mosso, a Professor of Physiology at the University of Turin authored a book that was published posthumously in 1915 (Mosso, 1915) with some early profound observations regarding fatigue:

“On an examination of what takes place in fatigue, two series of phenomena demand our attention. The first is the diminution of the muscular force. The second is fatigue as a sensation (p. 154)... In raising a weight we must take account of two factors, both susceptible to fatigue. The first is of central origin and purely nervous in character - namely, the will; the second is peripheral, and is the chemical force which is transformed into mechanical work.” (pp. 152-153)
Mosso also stated in his book that fatigue, which:

"at first sight might appear an imperfection of our body, is on the contrary one of its most marvelous perfections. The fatigue increasing more rapidly than the amount of work done saves us from the injury which lesser sensibility would involve for the organism." (p. 156)

Mosso and other physiologists realized early on that fatigue is a protective device that is characterized by changes in the function of brain and muscle during exercise (Noakes, 2012b).

Through a series of studies in the early 1900s by Archibald Vivian (A.V.) Hill, it was concluded that lactic acid is produced only under the condition of muscle anaerobiosis and muscle fatigue is caused by increased concentration of lactate in the muscle (Noakes, 2012b). Additionally, multiple studies showed that with inhalation of oxygen during exercise, performance was improved. These studies led to the conclusion that oxygen supply is the most important factor in the limitations to performance. Therefore, since circulating blood supplies the needed oxygen to working muscle, it was determined that the capacity of the heart to pump blood to the active skeletal muscle was the limiting factor in human performance. Interestingly, Hill’s original model of the “cardiovascular/anaerobic/catastrophic model of human exercise performance” (below) originally included a “governor” that acted to protect the brain from damage. This was removed in later versions of this diagram, perhaps due to evidence that the heart receives
sufficient blood flow even during maximal exercise (Noakes, 2012b; Raskoff, Goldman, & Cohn, 1976).

Figure 2.2 – Interpretation of the A.V. Hill model of fatigue (Noakes, 2012b, p.48)

The problem with the A.V. Hill model of fatigue is that there is no room for psychological factors, such as motivation, to influence fatigue. If exercise performance is only limited by failure of the heart to supply oxygen to the working skeletal muscles, then motivation and other psychological variables cannot play a role (Noakes, 2012b).

However, pacing and the “end spurt” show that this cannot be the case. Pacing strategies are modified based on the distance of the race; results from world records (Figure 2.3) show that as the distance increases, the starting pace decreases. The “end spurt” is the
phenomenon that regardless of level of fatigue, an increase in speed during the last percentage of a race regularly occurs. Other reasons that the original model cannot be correct are that muscle does not always become anaerobic during exercise and the fact that there is not always a plateau in oxygen consumption during tests to peak values.

Figure 2.3 – End spurts shown for different distance races (Noakes, 2012b, p. 50).
* Significantly slower than the first lap ($p < .005$). Φ Significantly faster than previous intervals.
2.2 - Central Governor Model

The Central Governor Model of Exercise Regulation, proposed by Noakes (2012a), accounts for the many different factors that are involved in the regulation of exercise and fatigue. The brain continuously regulates performance by modifying the number of motor units utilized. There are both conscious and unconscious factors at play before, during and after exercise. The important aspects of this model that particularly apply to the present study are those under the title “Anticipation (Teleoanticipation)” and include the fact that exercise begins at different intensities depending on length, and the idea that rate of increase in RPE predicts exercise duration.

Figure 2.4 – Central Governor Model of Exercise Regulation (Noakes, 2012a, p. 5).
2.3 - Measurement of perceived exertion

Electromyography can be used to measure the activity of specific muscles and monitor changes in fatigue. Researchers recognized need to quantify perceived exertion or provide a subjective measure of how people feel during exercise because fatigue may be a perception, rather than (or in addition to) a physiological process. Subjective measures, then, may indicate impending levels of fatigue.

Gunner Borg was the first to design a scale to measure perceived exertion called the Rating of Perceived Exertion, or RPE, scale (Borg, 1970, 1982). There are two versions of the scale, the first roughly corresponds to heart rates and included 15 points ranging from 6 to 20. The category ratio 10-item (CR-10) scale ranges from 0 to 10+ and includes category and ratio properties. The CR-10 includes a 0.5 value between 0 and 1 as well as a rating of 10+ that indicates a true maximum value. They both include numbers as well as verbal anchors. The 6-20 scale uses verbal anchors such as “very light,” “somewhat hard” and “very hard.” The 0 to 10+ scale implements verbal cues such as “just noticeable,” “light,” and “heavy.” Values that approach a level of 20 (on the 6-20 scale) or a 10+ (on the CR-10 scale) indicate maximal exercise and intensities at a level that cannot be sustained for long. Both RPE scales are still used extensively in research today and allow a psychophysiological frame of reference for the researcher.
Table 1. The 15-grade scale for ratings of perceived exertion, the RPE Scale. (3)

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>6</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Very, very light</td>
</tr>
<tr>
<td>8</td>
<td>Very light</td>
</tr>
<tr>
<td>9</td>
<td>Fairly light</td>
</tr>
<tr>
<td>10</td>
<td>Somewhat hard</td>
</tr>
<tr>
<td>11</td>
<td>Hard</td>
</tr>
<tr>
<td>12</td>
<td>Very hard</td>
</tr>
<tr>
<td>13</td>
<td>Very, very hard</td>
</tr>
</tbody>
</table>

Figure 2.5 – The original Rating of Perceived Exertion (RPE) scale (Borg, 1982, p. 378)

Table 2. The new rating scale constructed as a category scale with ratio properties. (5)

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Nothing at all</td>
</tr>
<tr>
<td>0.5</td>
<td>Very, very weak (just noticeable)</td>
</tr>
<tr>
<td>1</td>
<td>Very weak</td>
</tr>
<tr>
<td>2</td>
<td>Weak (light)</td>
</tr>
<tr>
<td>3</td>
<td>Moderate</td>
</tr>
<tr>
<td>4</td>
<td>Somewhat strong (heavy)</td>
</tr>
<tr>
<td>5</td>
<td>Strong</td>
</tr>
<tr>
<td>6</td>
<td>Very strong</td>
</tr>
<tr>
<td>7</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Very, very strong (almost max)</td>
</tr>
<tr>
<td></td>
<td>Maximal</td>
</tr>
</tbody>
</table>

Figure 2.6 – CR-10 scale (Borg, 1982, p. 380)

Borg suggested in the concluding remarks of his original manuscript that for most purposes the 6-20 scale is appropriate, and the 0-10+ scale could be useful for
determining other subjective symptoms such as breathing difficulties (1982). Thus, RPE provides researchers with a quantitative value for the effort that is perceived by the subject, and can give insight into the amount of fatigue the subject is experiencing (Takaishi, Yasuda, & Moritani, 1994).

The individual perception of fatigue is personal and is affected by both psychological as well as physical factors. A psychological factor that can influence feelings of fatigue is the expectation regarding the amount of work left. If someone feels extremely fatigued during a task and if it is very important that they finish that task in a given period of time, they can either quit or finish. If they choose to finish, they can either attempt to ignore the fatigue, or underestimate it in their own mind. The goal, then, is to ignore fatigue until the task is nearly finished. When the task is nearly finished, and the person is fairly certain that fatigue will not interfere with finishing, there is evidence for a rise in the perceived exertion (Walster & Aronson, 1967).

2.4 - Studies on task expectancy and fatigue

In 1967, Walster and Aronson had subjects perform a fatiguing task. Half of the subjects were told that there would be three trials, and the other half was told there would be five trials. However, there were really only three trials for every subject. Their rationale was that if people feel that they need to complete \( N \) fatiguing trials, they will feel a greater increase in fatigue on the \( N \)th trial compared to someone else who has performed the same number of trials but believes that they have more trials left to complete. Their hypothesis was confirmed; they found that on the third trial the subjects
who believed they had two more trials to go reported significantly lower fatigue than the subjects who believed it was the last trial (Walster & Aronson, 1967).

**EXPECTANCY AND FATIGUE**

![Graph showing the effect of task length expectancy on levels of fatigue.](image)

**Figure 1.** Fatigue over trials as a function of expectancy of task duration.

Figure 2.7 – Effect of task length expectancy on levels of fatigue (Walster & Aronson, 1967, p. 45)

Mental fatigue is thus involved in performance and perceptions when there is no set endpoint (either time or distance) and participants are asked to continue with a task until they reach exhaustion. St Clair Gibson et al. (2001) proposed that higher mental functions such as motivation and concentration carry a considerable metabolic cost. When exercise is open ended and participants do not have an indication of the length of
the bout, they must pace themselves more conservatively because of the physical and the mental demands on energy.

In 1971, Vidacek and Wishner devised a study to examine muscular fatigue during a task with an unknown endpoint using 10 young/old men (students and instructors). They attached a 19 pound load to a pulley, and had their subjects hold the weight off of the floor while their elbow was flexed at a 90 degree angle. For the “short task” the subjects were asked to hold the weight for 30 seconds, and for the “long task” they were asked to hold the weight for as long as they possibly could without letting it hit the floor. They used electromyography (EMG) to assess the muscle activity in the arms of the subjects. The arm muscles examined included the Biceps brachii, Brachialis, Brachioradialis and Flexor carpi ulnaris. They found that during the short task there was significantly more muscle activity present than in the long task (Figure 2.8). Both of these relatively simple studies (Vidacek & Wishner, 1971; Walster & Aronson, 1967) help to show that when the duration of a task is not known, humans subconsciously conserve their energy resources so that they can complete the task in full.
The above two studies provided valuable insight into how humans regulate their energy reserves, and how the regulation is associated with the required length of the task. As the length of the task increases, humans pace themselves so they can be sure to reach the endpoint comfortably. These concepts are utilized subconsciously by endurance athletes during events in which pacing is extremely important, such as the marathon.
Summary

Fatigue is often difficult to describe and its specific meaning may be different based upon field of research, and can have peripheral or central origins. Early studies led researchers to believe that it was the capacity of the heart to deliver oxygen that was the limiting factor in human performance. Now, studies have been performed that support the idea of a central governor in the brain that truly limits the upper levels of performance by regulating efferent motor output. Rating of perceived exertion is a useful subjective tool used to measure how subjects feel during exercise and has been used extensively in exercise science research. Lastly, a key study was discussed that utilized electromyography to show that even during a simple task subjects truly regulate muscle activity when the endpoint is not known.

3. Time Perception

It is possible that pacing, perceived exertion and affect are all related to time perception during athletic events. It was Peter Hancock, a time perception researcher, who stated that “perhaps the greatest of all challenges in psychological research is to find ways to render personal, private experience open to mutual, public inspection” (Hancock, 2010, p. 1). The study of time is difficult in many ways but is paramount to many fields of study, such as Philosophy, Physics, Biology and Astronomy (Eson & Kafka, 1952; Gilliland, Hofeld, & Eckstrand, 1946). It is also important in a more practical manner to workers whose wages are paid hourly, pilots who must precisely maneuver airplanes, and athletes competing in various events (Gilliland et al., 1946). It is very likely that many
years ago, the ability of humans to perceive time was a useful tool for survival (Block, Zakay, & Hancock, 1998; Gibbon, Church, & Meck, 1984; Pouthas, 1999; Terman, Gibbon, Fairhurst, & Waring, 1984).

Time estimations are constantly being used by everybody. For example, we estimate how long we have to wait at the bus stop and the time for a web page to load on the computer. Estimates of time can affect whether or not a person will continue to wait or if they will quit and move on to something different. It is therefore important to learn more about time estimations, especially short ones less than a few minutes, and to understand more about the underlying processes involved (Block et al., 2000).

The perception of time is a part of the human experience and is essential in everyday behavior (Wittmann, 2009), yet the neural basis of time perception is still largely unknown. The temporal experience of humans is also part of the individual’s specific relationship to his or her own environment. The experience of time is an integration of parallel chains of events, both external and internal, and depends on a highly functioning nervous system capable of this integration (Eson & Kafka, 1952). Simple decisions that we all make on a daily basis such as waiting for elevators or taking stairs, are based on an individual’s perception of time passage (Wittmann, 2009).

One could argue that it is obvious that we have some sense of time passage but unlike other sensory organs such as eyes and ears, there is not a single sensory organ in humans used for time passage. However, areas such as the cerebellum (Ivry & Spencer, 2004), posterior parietal cortex (Buetti, Bahrami, & Walsh, 2008), the right prefrontal
cortex (Lewis & Miall, 2006; Rubia & Smith, 2004) and the fronto-striatal circuits (Harrington et al., 2004; Hinton & Meck, 2004) have been shown to be potential areas of the brain where some form of timekeeping may occur. Evidence from fMRI studies have shown that certain regions of the basal ganglia may have time-keeping properties and aid in the perception of time (Harrington, Haaland, & Hermanowitz, 1998). Since the perception of time is so personal and individualized, one can postulate that perceived time can represent in some ways the mental status of the beholder (Wittmann, 2009).

The perception of time is an area of psychology that has received a fair amount of research interest over the last century. Researchers are often either interested in retrospective or prospective time perception. The distinction between the two types was originally made by William James (1890). These are now commonly described by psychology researchers as the retrospective paradigm and the prospective paradigm. The retrospective paradigm involves having a subject estimate the amount of time that they believe has passed. In the prospective paradigm of time, subjects know that they will be asked to judge the duration of a time period. Research has shown that estimation of time retrospectively and prospectively uses different neural processes. Retrospective time estimation uses primarily stored memory processes and prospective estimation utilizes attentional control and allocation (Zakay, 1993).

In a relatively early article, three methods of time perception measurement were proposed: (1) verbal estimation: where the experimenter presents the subject with an interval and the subject is asked to verbally estimate the duration of that interval; (2) production: where the subject is instructed to delimit an interval of a given duration stated
verbally beforehand by the experimenter; and (3) reproduction: where the experimenter presents the subject with a given interval and the subject is asked to reproduce an interval of the same duration (Bindra & Waksberg, 1956).

According to Zakay (1990) there are four distinct methods to the study of time interval estimation: (1) verbal estimation: where the subject is asked to report the elapsed time after an interval is complete; (2) interval production: where an interval of a specific duration is produced by the subject; (3) interval reproduction: an interval of a specific duration is perceived, then the subject is asked to reproduce the same duration interval; and (4) interval comparison: two time intervals are compared by the subject and they are asked to determine which was longer or shorter. Zakay argues that interval reproduction and interval comparison are distinctly different from each other, whereas Bindra and Waksberg state that the two are very similar and for all intents and purposes can be combined when describing methods of time interval estimation. The interval comparison method is simply a variation of the interval reproduction method. It has been established in the literature that verbal estimation and interval production produce inverse results. Someone who experiences time as passing slowly would overestimate duration via the verbal estimation method and would underestimate the same duration via the interval production method.

Eson and Kafka (1952) stated that disturbances in the experience of time generally come from (1) distorted external events, (2) physiological disturbances, such as varying heart and respiration rates, and (3) a defective or malfunctioning mechanism that is involved with the integration of the above two factors. Additionally, studies involving
both animals and humans have shown that dopaminergic agonists and antagonists can influence the perception of time. Dopaminergic agonists, such as methamphetamines, tend to increase internal “clock speed” and antagonists act to decreases the internal speed (Buhusi & Meck, 2002; Çevik, 2003; Mohs, Tinklenberg, Roth, & Kopell, 1980). Individuals who are addicted to cocaine or methamphetamine show changes in overall brain metabolism and even changes in structure, leading to impaired performance on time estimation tasks (Wittmann, Leland, Churan, & Paulus, 2007). Patients with Parkinson’s disease have decreased or impaired dopaminergic functioning in the basal ganglia of the brain and have been found to have poor performance in time interval reproductions (Harrington et al., 1998; Hellström, Lang, Portin, & Rinne, 1997). Further studies with Parkinson’s patients has shown that with subthalamic deep brain stimulation (DBS), performance on time reproduction tasks becomes more similar to control subjects compared to without DBS (Koch et al., 2004).

Studies have shown that a host of factors can affect the perception of time. Cognitive functions such as attention, memory (both long and short-term), drive states, mood, emotion, anxiety and personality have all been shown to affect time perception in some way. Other studies have shown that age, sex, and metabolism are also factors that can in some way influence how people perceive the passage of time. Lastly, some areas of research on time perception that have seen less work is on athletes and on sleep deprivation. Studies in all of these areas will be discussed and the research will be dissected.
3.1 - Anxiety and fear

High levels of both state and trait anxiety have been shown to affect attention-related cognitive functioning (M. W. Eysenck, 1992). Individuals who score high on these scales generally have decreased performance on cognitive-related tasks, especially when high levels of attention are required (Bishop, 2008). Early research also found a relationship between anxiety and perception of time. In a study by Siegman (1962) high levels of general anxiety was positively correlated with estimates of time duration by undergraduate students.

The effect of anxiety on the perception of time has been studied more recently by researchers in Israel who examined the effect of anxiety on perception of time, and used exposure to threat as a source of anxiety (Bar-Haim, Kerem, Lamy, & Zakay, 2010). Fifty-eight undergraduate students were separated into high and low trait anxiety groups based on their calculated score on the Spielberger State-Trait Anxiety Inventory (Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983). The groups were split evenly; there were 29 subjects in the high-anxiety group (24 women, 5 men) and 29 subjects in the low-anxiety group (21 women, 8 men). They differed significantly on trait anxiety scores ($p < .001$). The subjects were shown people with various facial expressions (either a fearful or a calm expression) on a computer screen and later asked to reproduce the time duration that each face was shown on the screen. They found that when presented with fearful facial expressions for 2 seconds, the high-anxiety subjects experienced time as moving more slowly compared to the low-anxiety subjects. However, when the duration
was increased from 2 seconds to 4 and 8 seconds, the group differences were no longer present.

Distortions in the perception of time can also occur during very stressful periods of time such as life-threatening events, road accidents or when witnessing violence (Hancock & Weaver, 2005). This is sometimes displayed on television or in movies; often the scene slows down dramatically in order to show how the character is perceiving time to be passing by. In a recent study, this was investigated through the use of novice skydivers as subjects (Campbell & Bryant, 2007). The 76 subjects (37 women, 39 men) with a mean age of 28 years were all partaking in their first skydive. They were first asked about their level of fear and level of excitement for the impending jump. Each subject was taken to 14,000 feet and completed a tandem jump. Subjects were not told that they would be asked at the end how long they thought the jump took. Soon after the subjects landed on the ground they were asked about their level of fear and excitement during the jump, as well as how long (in minutes) that they thought the jump took in total. The results showed that high levels of fear prior to and during the jump was significantly positively correlated with how long the subjects thought the jump took in total. Excitement prior to the jump was negatively correlated with how long the subjects thought the jump took. Though not technically a traumatic experience for the subjects, this study did show that increased levels of fear led to a feeling that time was slowing down.
3.2 - Mood and emotions

Our mood at any given time can greatly affect how we perceive the passage of time. When situations present themselves that are extremely unpleasant or boring, such as waiting anxiously for something to happen or waiting for something, time seems to slow down and subjects tend to overestimate their duration retrospectively. Alternatively, when we are being entertained and are participating in a rewarding activity time somehow seems to pass very quickly and in retrospect time is generally underestimated (Wittmann, 2009). It is thought that emotions act to affect the amount of attention that is given to a particular task, and higher physiological levels of arousal lead to an increase in the internal clock and a feeling that time is moving fast.

Perception of time has been studied extensively in the area of consumerism and impulsivity research. It has been found that the passage of time depends on our subjective well-being, and that drive, moods and emotions help to influence our decisions so that we generally prefer immediate satisfaction rather than delayed gratification. Emotional distress is a main factor that changes the way in which people make decisions, and overestimation of time (prospectively) occurs as a result of heightened arousal states and is indicative of time moving rapidly. However, in impulsive individuals there is more often a slowing down of time, as shown by underproduced prospective time intervals, especially when they are unable to act upon their urges (Wittmann & Paulus, 2008).
3.3 - Personality

The influence of personality on the perception of time has been investigated since the 1960’s, yet the specific association between the two has yet to be determined. The personality dimensions of extraversion and neuroticism have been thought to be most likely to be associated with deficits in time estimation. However, their effects on time estimation have been inconsistent in previous studies.

In 1960, Claridge used the time reproduction method to study perception in introverts and extroverts. The degree or amount of error was calculated by subtracting the actual time from the time estimated by each subject. Time intervals ranging from 10 to 90 seconds were used. Results from the 10s and 60s conditions showed significant correlation between extraversion scores and the amount of error in time estimation; extraverts overestimated the time (felt as though time passed quickly) compared to introverts. The 90s condition did not show any significant differences. The results were similar to a 1959 study in which subjects scoring high in both extraversion and neuroticism overestimated 5 and 10 second time intervals compared to subjects scoring high in introversion and neuroticism (H. J. Eysenck, 1959). Longer intervals of 20 and 30 seconds did not show any significant differences between groups of subjects. One of the reasons that extroversion was considered to be a personality dimension that could affect time estimation is from Eysenck’s inhibition theory of extraversion (Claridge, 1960; H. J. Eysenck, 1959) which states that extraverts are able to generate and dissipate reactive inhibition more rapidly than introverts. So with any given stimulus, extraverted subjects perceive the duration as relatively shorter compared to introverts.
Studies on the effect of high levels of neuroticism on time perception are not as numerous as those on extraversion. One study showed that subjects with low levels of neuroticism tended to overestimate time intervals of 20s to 180s compared to subjects with higher levels of neuroticism (Davidson & House, 1982). Additionally, Kirkcaldy showed a negative correlation between neuroticism and time estimations. This was not a significant difference, but did show that subjects with high levels of neuroticism tend to overestimate time.

Thomas Rammseyer (1997) performed a study on 34 undergraduate students (men, aged between 19 and 28 years). They were given the short version of the German adaptation of the Eysenck Personality Questionnaire (revised), which determines personality in four dimensions: extraversion, neuroticism, psychoticism and lie or social desirability. Time reproduction was used as the method to assess time perception, and the duration intervals were 5s, 15s and 40s. Results showed that neuroticism was significantly negatively correlated with extraversion ($r = -0.34, p < .05$) and psychoticism ($r = -.039, p < .05$). No significant correlations were seen between the other personality dimensions. Time reproduction ratio scores were significantly positively correlated with psychoticism. These results show that subjects scoring high in the personality dimension of neuroticism are more likely to overestimate time during a reproduction task.

3.4 - Metabolism

Studies have also shown that body temperature can affect how individuals perceive the passage of time. Early studies showed a consistent relationship between
body temperature and metabolism to perception of time (Gilliland et al., 1946; Hoagland, 1933; Stern, 1959; Thor, 1962). When body temperature or metabolism is high, subjects tend to perceive time as moving slower than normal as shown by lower reported time estimations. In a 1993 study, Hancock used a radiant heating helmet on 12 subjects (all men) to increase the temperature of their brains. There was a “mild heat” condition in which the temperature was raised about 0.75 degrees Celsius, and a “more severe heating” in which 1.50 degrees Celsius increase was achieved. The subjects were asked to prospectively estimate periods of 1s, 11s and 41s multiple times with no helmet, and in the two heated helmet conditions. The 1s period and the 11s period did not show dramatic changes between helmet heating and control conditions, likely due to the short amount of time involved. However, in the 41s condition the mean time estimate between the control condition and the “more severe heating” condition was 45.032s ($SD = 10.766$) compared to 40.044s ($SD = 10.493$), respectively. The subjects were also asked to retrospectively estimate the amount of time for the entire testing period with all trials, and no significant difference was seen. The mean elapsed time was 49.6 minutes and the mean estimate of time from the subjects was 49.2 minutes.

3.5 - Sleep deprivation

Sleep deprivation is common for many people, such as night-shift workers, truck drivers, pilots, soldiers and doctors. Miro and colleagues (2003) studied the effect of extreme sleep deprivation on the estimation of time. They asked their 30 subjects (15 men, 15 women; average age of 20.06 years) to completely refrain from any sleeping for 60 hours straight. The researchers used the Beck Depression Inventory (BDI), the State-
Trait Anxiety Inventory: Trait Scale (STAI) and the Eysenck Personality Questionnaire (EPQ-A) as a basis for exclusion from the study, as well as the Horne and Ostberg Morningness-Eveningness Scale. They did not wish to include subjects who were depressed, had large shifts in mood or personality, and those subjects who were clearly “morning types” or “evening types.” Before the sleep deprivation, the subjects were asked to complete a baseline test of time estimation production. They were asked to press a button on a computer screen when they thought ten seconds had passed since the introduction of a sound. The results showed that throughout the 60 hours of sleep deprivation their estimation of time increased linearly, meaning that they felt as though time was moving slower as they became more tired. The authors state the importance of time perception in workers, long-distance runners, musicians and drivers (Miró et al., 2003). Since deprivation of sleep led to an experience of time moving slowly, this could affect performance in these individuals.

3.6 - Sex differences in time perception

Generally, time perception studies use the term “sex” as opposed to “gender” due to the fact that sex is used to differentiate individuals physiologically whereas the term “gender” is usually used in terms of social role of the person. Researchers that find differences in perception of time primarily due to social factors tend to use the term “gender” to describe men and women. Alternatively, when researchers believe that time perception differences are innate and physiological in nature the term “sex” is used to differentiate between men and women (Hancock, 1993).
Differences in time estimation between men and women have shown varying results (Rammsayer & Lustnauer, 1989). In the early part of the 20th century, most researchers believed that women made larger and more variable estimations of time compared to men (MacDougall, 1904; Seashore, 1899; Yerkes & Urban, 1906). Not all researchers came to this conclusion, however, and very few explanations were given. By the middle part of the century, differences between men and women in time estimations were not often mentioned and rarely were significant differences discovered or reported. By the later part of the century, in the mid 1980’s and 1990’s, researchers were again finding sex differences in time estimation. To date, the differences between men and women are unclear.

In a very early 1904 study, it was found that when students (both men and women) were asked to prospectively estimate a one minute period of time using whatever method they found most useful that the men tended to slightly underestimate the 60 seconds \( M = 56.5 \text{s} \) and the women tended to overestimate \( M = 84 \text{s} \) (MacDougall, 1904). When the students were instructed to be as idle as possible and not count the time passing in their head the results were overestimation for both sexes (men: \( M = 82 \text{s} \), women: \( M = 140 \text{s} \)). When the instructor read aloud to the class a work that they were unfamiliar with and the students were asked to estimate the 60 second period of time, the results was again an overestimation from both sexes (men: \( M = 89 \text{s} \), women: \( M = 126 \text{s} \)). The students were asked to estimate other periods of time ranging from 15 seconds to 90 seconds. The result was that the men had an average error in judgment of around 45 percent, compared to the 111 percent shown by the women. The author stated that the
sex differences were not the primary research question in mind but were indeed interesting and mentioned that other researchers should examine data for sex differences.

Espinosa-Fernandez et al. (2003) found that women subjects showed a greater underestimation of time, but only in a 5 minute condition. The 10 second and 60 second time estimations in their study did not show any significant main effect of sex, though a trend was seen in the 60 second condition. They did find a significant difference on 10 second time estimation between their subjects who were between 61 and 70 years of age, specifically that the older women in that group overestimated the time period compared to similar aged men. The authors suggested that hormonal changes or reaction time differences could be to blame for this difference. Other studies have shown that women subjects tend to underestimate time intervals (Block et al., 2000; Hancock, Arthur, Chrysler, & Lee, 1994; Kirkcaldy, 1984).

3.7 - Effect of age on the perception of time

In a meta-analytic review, Block et al. (2000) showed that sex effects are nearly absent during young adulthood (8.0 – 12.9 years) and adolescence (13.0 – 17.9 years) but are present during young age (18.0 – 29.9 years) and older age (over 60 years). They showed that interval productions were shorter for boys than girls, but the opposite was true for older men and women (Block et al., 2000).

Espinosa-Fernandez et al (2003) studied a wide range of ages, from 8 to 70 years of age. The research group was also interested in the effect of age on time estimation, and used the same number of men and women as subjects (140 total subjects; 70 men and
70 women). They tested time productions of 10 seconds, 1 minute, and 5 minutes. The 10 second estimation did not yield any significant main effects of age or sex, but the longer estimates of one and five minutes elicited significant age differences. The five minutes time estimation also showed a significant main effect of gender. Linear multiple regression results from these data showed that as their subjects increased in age, their one minute and five minute time estimations decreased. This showed that in their sample, as subjects aged they perceived time to pass by faster.

Previous studies have shown similar findings. One group used a sample of 60 subjects with an average age of 76 and found that subjects underestimated a one minute time interval (Antequera Jurado, 1994). Another study found much greater underproduction of time intervals by a group of elderly individuals over 60 years compared to a group of young adults 18-29.9 years (Block et al., 1998). One group found that in a 10 second time reproduction method, intervals reported by elderly men with an average age of 79.1 were shorter than those from a group of young men (average age of 26.2 years) (Carrasco, Bernal, & Redolat, 2001).

3.8 - Time perception in athletes

Pacing strategy, perceived exertion, affect and attentional focus are likely related to the perception of time. However, research on time perception in athletes has received surprisingly little attention. One recent study (Tobin & Grondin, 2012) used elite swimmers to investigate the impact of previous knowledge about the duration of a specific task on time estimation. In their first experiment, 28 swimmers (18 men, 10
women) with a range of experience levels were tested. After a full warm-up, the subjects were asked to complete four 100 meter swims; before each they were asked to estimate the amount of time it would take to complete the swim. Two of the swims utilized the subjects’ best stroke (from butterfly, backstroke, breaststroke and freestyle) and two used their worst stroke. In one condition of each type of stroke, they were also asked to find words that rhyme with a certain word while they were swimming, inducing an attentional task during the swim. The swimmers were accurate in their estimations of the amount of time needed to make a full lap in the pool. This was surprising, because even though swim timing durations while in competition are relatively consistent, in training the time per lap is much more variable. For all of the swimmers, they were able to predict their time much better during their best stroke compared to their worst stroke. The additional attentional demand from the rhyming task was not enough to produce a significant difference; the researchers hypothesize that the task may not have demanded enough attention to distract the swimmers. In the second experiment, the two parameters of speed and distance were altered. Rather than have the swimmers complete a full lap of the pool for each condition, they were either tethered to the side of the pool in order to swim in place or attached to a parachute to slow them down. They were specifically asked to swim six times, each time for what they thought was 36 seconds. Two times were normal full pool laps, two times were while tethered to the side of the pool and two were with a parachute. An ANOVA showed that the effect of condition was significant and in the parachute and tethered conditions, the subjects overestimated the amount of time that passed. The last experiment used visualization to examine the effect of
environmental cues on time perception. The subjects were asked to lie on a yoga mat and either visualize swimming in the university pool (something they knew very well) or climbing Mount Everest (something they had never done). They were then asked to estimate a 36 second period of time, while their eyes were closed and they were visualizing the movement. Results showed that the swimmers were much more erratic in their estimation of time while visualizing climbing compared to swimming. The difference was not significant, however, because in the climbing condition many of the swimmers over-estimated and many also under-estimated, resulting in a mean that was very similar to the swimming condition.

Summary

The perception of time is an area of research that can be useful to many fields of study, and it is something that is crucial to everyday behavior. Still, much is not known about time perception. There are many ways to assess time perception, but essentially there are two methods: retrospective and prospective time estimations. Research has shown that perception of time can be affected by anxiety, fear, emotions, mood, personality, metabolism, sleep deprivation, sex and age. Time perception in athletes is an area of psychology that has received very little attention but warrants further research.
4. Cognitive strategies - Attentional focus

The perception of time in athletes has been shown to be influenced by many factors, but mostly by the level of attention of the person. This can have major implications in the field of exercise science; multiple studies have shown that as the level of exercise intensity rises, the amount of attention and focus allocated to that activity also rises. Therefore, the perception of time during an athletic event may change based on the level of attention involved.

Generally speaking, there are either associative or dissociative thoughts (or strategies) that are used during exercise. During associative strategies, subjects are very “in tune” with their body and they are very focused on the task at hand. They pay attention to the cues they receive from their body and they constantly are aware of their body and the physical factors that are important to performance (Masters & Ogles, 1998; Morgan, 1978). Conversely, with dissociative strategies, subjects tend to be daydreaming or mentally very far away from the task at hand. They purposely remove themselves from the feedback that they get from their body.

Masters and Lambert (1989) found that when marathoners were questioned about their focus, they reported that roughly 75% of their thoughts were associative throughout the marathon. The same subjects reported a high level of dissociative thoughts throughout their training runs, or a mix of the two strategies depending on the run. Results from the marathon race showed that as fatigue and intensity increased the subjects moved to an associative strategy, perhaps in an attempt to monitor such factors
as pain, pacing, running form, etc. This study provided results that were similar to previous studies that showed most runners use dissociative strategies during training runs and move to associative strategies when racing, or when the run is more competitive (Okwumabua, 1985; Summers, Sargent, Levey, & Murray, 1982).

Other studies have demonstrated that increased levels of external stimuli lead to no significant differences in RPE but did lead to faster finishes during self-paced running. In 1980, Pennebaker & Lightner tested subjects on two running courses. Their subjects were 24 introductory psychology students, and only one considered himself a “runner.” They were asked to run 1800 meters as fast as they desired. Half of the subjects began on an 1800 meter cross-country course and the other half began on the 200 meter lap course (consisting of 9 laps around the course in the same direction). Thirteen subjects (8 men, 5 women) completed both conditions multiple times. The researchers consistently found that the subjects ran faster on the cross-country course compared to the lap course (mean times of 9.17 min and 10.08 min, respectively) without any significant differences in the physiological measures of heart rate and blood pressure. Although they did not measure association or disassociation, the researchers speculated that when the subjects were running the cross-country course they were focused more on external cues (trees, scenery, sounds, etc.) and were dissociating more, which allowed them to run faster (Pennebaker & Lightner, 1980).

However, all but one of the subjects in the Pennebaker and Lightner (1980) study were not familiar with running. Morgan and Pollock (Morgan & Pollock, 1977) found that elite distance runners primarily use associative strategies, whereas recreational
runners use primarily dissociative strategies while running. Ungerlieder et al. (1989) found similar results with masters track and field athletes; the more experienced the runners were the more they were likely to use associative strategies while running. In 1986, Schomer found that regardless of experience level, marathoners in their study all used primarily associative strategies. However, they used them in different fashions. While the novice marathoners tried to “relax” during the race, the more experienced runners would focus on the relaxation of a specific area of their body. This suggested that as experience level increased, runners learned ways to better control their thoughts and were able to make the associative thoughts more specific (Schomer, 1986; Tammen, 1996).

One study with experienced runners showed that association was preferred by runners who were very invested in running and competed regularly. The study also showed that runners who were slower and less competitive tended to use dissociative thoughts when running (Masters & Ogles, 1998). The authors suggested that the cognitive strategy used by the runners (associative versus dissociative) was highly dependent on both motivational and physiological factors. Finally, in a study involving runners who were participating in the Olympic Marathon Trials, top finishers were found to use a mix of associative and dissociative strategies throughout the race. Lower finishers, conversely, showed the implementation of a dissociative cognitive strategy during the marathon (Silva & Appelbaum, 1989). This showed that elite marathoners used “adaptive flexible” strategies during the race and shifted between cognitive
strategies depending on the demands of the race, and the particular cognitive strategies employed are related to skill and performance level.

Summary

Cognitive strategies used by athletes are generally described in a bipolar nature as either “associative” or “dissociative.” Associative strategies are those in which athletes are focused and “in tune” with their body. Alternatively, dissociative strategies are when athletes lose focus and are lost in thinking about something different than the task at hand. Research has shown that environment, skill level and amount of experience can affect the cognitive strategy that is chosen by the athlete.

5. Summary

Fatigue and perceived exertion are related to teleoanticipation, and all three factors are vitally linked to the knowledge of the endpoint of any task. Fatigue is an important factor to consider when determining performance during endurance related activities. Some studies reviewed suggest that fatigue is a brain-derived emotion and is not necessarily linked to physiological symptoms. Physiological fatigue (i.e., failure of motor neurons to activate muscles, depletion of fuel) can be experienced regardless of emotion or motivation in extreme situations, but fatigue can also be experienced when there is no physiological reason for a decrement in performance. Perception of time is likely related to athletic performance as well, and may have a reciprocal relationship with
fatigue and perceived exertion. Time perception in athletes has received very little attention, but may provide valuable insight into why certain individuals excel in endurance events. Finally, cognitive strategies have been studied in athletes but have not shown to have a link to the perception of time or perceived exertion.
Chapter 3: Methods

The primary purpose of the SPEED (Self-Paced Exercise and Endpoint) study was to determine the effect of running with and without an unknown endpoint on psychophysiological variables, and to investigate the perception of time in runners. This chapter outlines the inclusion criteria for the subject sample, measures that were used, and a specific methodology for each day of testing.

Subjects:

The subjects in this study consisted of runners (both men and women) of varying abilities. The majority of the participants were students of the university, but some did not have any affiliation with The Ohio State University (OSU). Subjects were recruited with a variety of methods including word of mouth, social networking websites, flyers posted on campus and an announcement to the OSU Running club and the OSU Exercise Science club. To be eligible for participation, volunteers were required to be at least 18 years of age and must have been running an average of at least 10 miles per week for the last year. They were also required to be stratified by the American College of Sports Medicine (ACSM) guidelines (Armstrong, 2006; Thompson et al., 2009) as “low risk,” meaning an upper age limit of 45 for men and 55 for women. For this study the upper limit for women was set at 50 years of age to be closer to the age criterion for men.

Please see Appendix B for a description of the ACSM guidelines. Subjects were excluded
from the study if they reported any injuries in the previous year that kept them from running more than 6 weeks. All subjects were asked to complete a running history questionnaire as well as a brief overview of their medical and family history of cardiovascular disease (Appendix G). Results of the subjects’ running history are described in Appendix H.

**Research Design**

This study used primarily paired samples t-tests to determine differences in group overall and final means between conditions. Simple regression was used for prediction of different dependent variables using cardiorespiratory fitness levels and age as independent variables. The study also employed a 2-factor within-subjects design with 2 conditions (unknown and known endpoint) X 5 time points (pre, 33%, 66%, 90% of distance and post) or 3 time points (33%, 66% and 90% of distance) with sex (men, women) as a between-subjects factor. The Institutional Review Board of The Ohio State University originally approved the study in December of 2012 and testing was performed in January and February of 2013.

**Statistical Analyses**

Since perception of time has not been investigated in this population, the required sample size was initially calculated using the predicted change in RPE of the subjects. The sample size was estimated through the use of G*Power Software (Faul, Erdfelder, Buchner, & Lang, 2009). Using an alpha value of $p < .05$ and a power of 80%, we estimated a meaningful difference in maximum RPE of approximately one point with a
standard deviation of 1.6 points based on published research (Baden et al., 2004; Coquart & Garcin, 2008) and pilot work. This yielded a sample size of 20 subjects. A 20% attrition rate was assumed, and therefore 25 subjects were targeted for recruitment.

Descriptive statistics were calculated and presented for all subjects; VO_{2\text{max}} data, height and weight were calculated separately for men and women. Data were presented in graphical form when deemed appropriate. The significance level for all analyses was set \textit{a priori} at \( p < .05 \) and effect size using partial Eta-squared was reported for repeated measures ANOVA analyses. Cohen’s \( d \) was provided as an effect size for paired samples t-tests, Rho was given for correlational analyses and \( R^2 \) was given as an effect size for simple regressions. The effect sizes were given in addition to \( p \) values in order to provide information about the differences between groups and any practical significance.

Analysis included screening data for potential errors or missing data, and inspecting the variables to the assumptions related with repeated measures ANOVA and simple regression. The assumptions for repeated measures ANOVA include: 1) the dependent variable is measured at the interval or ratio level, 2) the independent variables consist of related groups, 3) there are no significant outliers in the differences between the two related groups, 4) the distribution of the differences in the dependent variable are normally distributed, and 5) the data do not violate the assumption of sphericity. The assumptions for simple regression include: 1) independent variables are measured without error, 2) the means of errors for each observation of the dependent variable is zero over repeated testing, 3) errors associated with one observation are independent of errors from other observations, 4) observations are independent, 5) homoscedasticity: the
variance of the errors in the dependent variable over all values of the independent variable are constant, and 6) errors are normally distributed.

**Primary Aim.**

The main aim was to investigate the effects of a run on a treadmill with and without an unknown endpoint on perceived exertion and psychophysiological variables. For the outcome variables of rating of perceived exertion (RPE), affect during the exercise bouts (feeling scale; FS) and heart rate (HR), the mean and final values were averaged and compared between conditions using paired samples t-tests. RPE values were also normalized to percent time complete, and a 2 (endpoint condition) X 10 (percent time complete ranging from 10 to 100) repeated measures ANOVA was used to analyze the effect of endpoint condition and time.

**Secondary Aim.**

The secondary aim of this study was to investigate the perception of time before, during and after exercise with and without a known endpoint. Each time judgment of the passage of one minute in seconds was divided by 60 to provide a ratio to the actual amount of time. A two-factor repeated measures ANOVA with two conditions (unknown and known endpoint) and either five time points (PRE, 33%, 66%, 90% of the distance complete, and POST) or three time points during exercise (33%, 66% and 90% of distance complete) as within-group factors was used to examine the outcome variable, which was the time estimation ratios.
Tertiary Aim.

Another aim of this study was to determine if sex or cardiorespiratory fitness acts to moderate the relationship of the variables tested. To examine the effect of these suspected moderators on the outcome variables, they were used in simple regression analyses as independent variables in the prediction of dependent variables.

Measures

Rating of Perceived Exertion (RPE).

RPE is a 15 point scale used to assess perceived exertion, and ranges from 6 to 20 with verbal anchors such as “very light,” “somewhat hard” and “very hard” and has been shown to have high levels of validity ($r = 0.80 – 0.90$) with physiological variables (Borg, 1982). The scale ranges from 6 to 20 is because it is meant to denote heart rates in the range of 60 to 200 beats per minute. For example, a heart rate of approximately 150 should correspond to an RPE of 15. The scale is widely used in research and has been translated into many languages including French, German, Japanese, Hebrew and Russian. Intraclass correlation coefficients (ICCs) for the test-retest reliability of RPE range from 0.71 to 0.90 (Skinner, Hutsler, Bergsteinova, & Buskirk, 1973; Stamford, 1976; Wenos, Wallace, Surburg, & Morris, 1996). In the current study, the calculated ICC for RPE was 0.92.
**Feeling Scale (FS).**

This scale was developed to assess fluctuations in mood across time and determine when and if exercise is pleasurable or unpleasant to individuals (Hardy & Rejeski, 1989). The Feeling Scale is a single-item measure with responses being given along an 11-point scale ranging from +5 (very good) to -5 (very bad) with zero as a neutral midpoint.

The Feeling Scale was designed to assess how people feel during exercise. Since RPE represents a host of sensations related to the physical strain of exercise, it may not have the power to assess the actual feeling that a person has during exercise. For example, a person may have an RPE value of 17 and report feeling “very good” but under different conditions could report feeling “very bad.” Therefore, in light of this reason and the findings that emotions play a very important role in exercise and sport, the need of an additional scale to be used in accordance with RPE was warranted (Hardy & Rejeski, 1989; Vallerand, Straub, & Williams, 1984). The Feeling Scale has high levels of both construct and content (0.95) validity (Hardy & Rejeski, 1989; Kenney, Rejeski, & Messier, 1987; Rejeski, Best, Griffith, & Kenney, 1987) and an ICC of 0.87 (Robbins, Pis, Pender, & Kazanis, 2004). In the current study, the test-retest ICC was calculated as 0.93.

The following verbiage was used to describe the Feeling Scale to subjects:

*While participating in exercise it is quite common to experience changes in mood. Some individuals find exercise pleasurable, whereas others find it to be unpleasurable. Additionally, feeling may fluctuate across time.*
That is, one might feel good and bad a number of times during exercise. Scientists have developed a scale to measure such responses. [At this point subjects were presented with a copy of the FS. The scale is presented in an 11-point bipolar good/bad format, ranging from +5 to -5. Verbal anchors are provided at the 0 point, and at all odd integers +5 = very good, +3 = good, +1 = fairly good, 0 = neutral, - 1 = fairly bad, - 3 = bad, and -5 = very bad.] (Hardy & Rejeski, 1989)

**Association/Dissociation.**

The level of attentional focus, as measured by the reported percentage of dissociative thoughts, was assessed. The method used was similar to that used by Baden (2004), through use of a bipolar line with “associative” at one end and “dissociative” at the other where subjects are asked to mark an “X” on the line corresponding with their level of association (thoughts directed at bodily symptoms) or dissociation (external thoughts that are distracting from exercise) (Baden et al., 2004; Lima-Silva et al., 2012). However, rather than asking subjects to mark an “X” while they are running they were asked to verbally state their current percentage of dissociative thoughts. This scale has been shown to correlate with more traditional Likert scale measures and allows for immediate assessment of perception without interfering with testing protocol (Krane, 1994; Murphy, Greenspan, Jowdy, & Tammen, 1989).

The following verbiage was used to describe the Association/Dissociation Scale to subjects:
At regular intervals I will ask you to put a cross on the line below that represents the approximate ratio of associative thoughts to dissociative thoughts over the last segment of the run. But please don’t think that you have to be aware of exactly what you are thinking all the time, an approximate proportion is fine. Also, quite often dissociative-type thoughts are like daydreams and quickly forgotten. So although you may start off by thinking that your feet hurt, you may then go on to speculate whether to get new trainers and then may find you are in a daydream you may not remember. In this case, just the original thought counts as an associative thought and the rest is dissociative (Baden et al., 2004).

**Time Estimation.**

Subjects were asked to estimate time duration by verbally expressing a “start” and “end” when they believed that a 60 second period of time had elapsed. The method used to assess perception of time was similar to that used by Espinosa-Fernandez and colleagues (2003) except the researcher was in control of the stopwatch rather than the subject. Using a stopwatch, the actual time passed was recorded and compared to the estimated time. Subjects were never told what their estimated time was, as the feedback could have affected performance on this task (Fraisse, 1971). They performed five 60 second time estimations during visits 1 and 2: before testing, three times during the run and once after testing. There were no clocks in the room, and the subjects were not allowed to wear a watch at any point during data collection.
The following verbiage was used to describe the time estimations to subjects:

*I would like you to estimate a 60 second period of time. To begin, you must verbally express that you are ready by saying the word “start” aloud, and I will begin the time collection. When you think that 60 seconds has passed, you must say “stop.” This is the point in which I will end time collection.*

We tested the following null hypotheses:

1. **Ratings of Perceived Exertion** –
   - a. Average and final ratings of perceived exertion will not be significantly different between known and unknown endpoint conditions.
   - b. When RPE is normalized to the percentage of time complete, there will be no differences between the unknown and known endpoint conditions.

2. **Heart rate** –
   - a. The overall mean and the mean of the final heart rate assessment during the exercise bouts will not be different between the known endpoint compared and unknown endpoint conditions.
   - b. There will not be differences in heart rate response between men and women.
3. Feeling Scale (affect rated +5 [very good] to -5 [very bad]) –

a. FS scores will not be different between endpoint conditions.

b. During both endpoint conditions, heart rate will be independent of FS scores.

4. Time Perception –

a. Time perception across endpoint and time conditions will not be different between men and women.

b. Cardiorespiratory fitness level will not be a significant predictor of time estimations taken at 90% of the completed distance in the unknown endpoint condition.

c. Cardiorespiratory fitness level will not be a significant predictor of time estimations taken at 90% of the completed distance in the known endpoint condition.

d. Age will not be a significant predictor of time estimations taken at rest (before exercise) and during exercise at 90% of the completed distance.

e. During exercise, the time estimation assessed at 90% of the distance covered will not be different than the assessments at 33% and 66% of the distance.

f. There will not be a difference between time estimations before and after exercise.
g. The final assessment of attentional focus will be independent of the final time perception assessment taken during exercise.

h. Reported weekly mileage will not be a significant predictor of time estimations taken at 90% of the completed distance.

5. Association/Dissociation –

a. There will be no differences in level of attentional focus between the unknown and known endpoint conditions.

b. In the unknown endpoint condition, there will be no relationship between dissociative thoughts and cardiorespiratory fitness level.

c. In the known endpoint condition, there will be no relationship between dissociative thoughts and cardiorespiratory fitness level.

d. Attentional focus will be independent of RPE levels during both conditions.

6. Pacing –

Time to complete the required distance will not differ between the known endpoint and the unknown endpoint conditions.

Procedures

All testing was performed on the ground floor of the Physical Activity and Educational Services (PAES) building at OSU. If subjects were interested in
volunteering for the study they were instructed to email the lead investigator. The subjects were sent the running and medical history questionnaire and asked to complete the form and return it back either via email or campus mail. Once it was determined that the subjects were eligible for testing, they were sent the consent form to read and their first visit was scheduled.

*Laboratory Visit #1*

Approximately one full hour was allowed for the first visit. The consent form was reviewed and any questions were addressed before securing the subjects written consent. The subjects then reported to the exercise testing lab for a VO$_2$max test to assess their cardiorespiratory fitness level. The 15-point RPE scale was described in detail before testing and the subject was asked to report RPE during the last 30 seconds of each 2 minute stage (Borg, 1982). A modified Astrand-Saltin protocol using incremental increases in speed and grade was used (Hawkins, Raven, Snell, Stray-Gundersen, & Levine, 2007).

The metabolic cart (True One 2400, ParvoMedics, Sandy, Utah) was warmed up a minimum of 30 minutes prior to each test, and was calibrated directly before the test with both a gas calibration and a flowmeter calibration via a 3.000 liter Hans Rudolf 5530 series syringe. The flowmeter calibration involves a five-stroke calibration with varying flow rates during each stroke. Subjects were fitted with a Polar heart rate chest strap and monitor (Polar Electro Oy, Kempele, Finland) and asked to warm up at a light to moderate intensity on the laboratory treadmill for five minutes before beginning the test.
The subjects were then fitted with the appropriate headgear and mouthpiece, and began the VO2max test by running for two minutes at a pace that was slightly faster than his or her normal training pace and 0% grade. Every two minutes thereafter the speed was kept constant and the grade increased by 2% until they reached volitional exhaustion. They were instructed to run as long as they possibly could, and were told to put their hands on the treadmill handrails and lift themselves off of the belt when they were finished. It was made clear that the test would not be stopped until this occurred. The two highest consecutive relative VO2max values, in ml/kg/min, were averaged to obtain the appropriate VO2max value. Sampling frequency of the metabolic cart was 0.067 Hz.

Tests were considered “true” maximal tests if two of the following three criteria were obtained: (1) RPE: equal to or greater than 18; (2) HR: within 10 beats per minute of the subject’s age predicted maximal heart rate (calculated with the following formula: 220 – age = HRmax); (3) VO2 plateau: the difference between the peak relative VO2 value and the value in the immediately preceding 15s of 2.0 ml/kg/min or less.

Laboratory Visit #2

During the second laboratory visit the subject was first asked to perform a 60 second time estimation while seated. Subjects were then fitted with a Polar heart rate monitor (chest strap) and were asked to warm up by running on the laboratory treadmill at a constant self-selected speed for five minutes. After this initial warm up they were stopped briefly so that the treadmill distance could be zeroed.
The subjects were then asked to run for an unspecified distance, which was calculated after the first laboratory visit based on their running history and average weekly or daily mileage and was not longer than the subjects’ longest run in the previous six months. For example, if a subject reported running 5 miles per day for 4 days a week for the last six months with a long run of 12 miles, their run for this condition would be 75% or their normal daily run or $5 \times 0.75 = 3.75$ miles. If the subject reported running a range, such as 5 to 7 miles per day for 3-5 days per week, the average of the range was taken; this subject would run $(5+7)/2 \times 0.75 = 4.5$ miles. Rating of Perceived Exertion, Feeling Scale, and level of association/dissociation were all assessed at varying time points during the testing ranging from 1 to 4 minutes apart (Table 3.1). The subjects were told that they would be asked to report their level exertion, feeling and percent dissociation at random time points, in order to make them aware that they would not be able to count the number of assessments and estimate the time they had been running.

Subjects were asked to estimate a 60 second time period when 33%, 66% and 90% of the distance had been covered. At no point during the testing was the subject told either the cumulative distance or time. When they reached the predetermined but undisclosed endpoint they were told that they had completed the trial. After walking on the treadmill to cool down for a full 5 minutes, subjects were asked to perform one final time estimation while seated.

Laboratory Visit #3

Randomization to treatment order was not possible because it was necessary to have the subject be unaware of the distance that they would complete in the first
experimental trial (visit #2). Therefore, the third laboratory visit was identical to the second visit, with the exception that the subjects were aware of the distance that they were asked to run. They were still, however, blind to the elapsed speed and distance during the course of the run. They were asked to complete the same distance as in visit #2 and were instructed to warm up for 5 minutes at the same self-selected speed as in visit #2. Laboratory visits #2 and #3 were scheduled for approximately 1.5-2.0 hours.
Table 3.1  
Assessments during the SPEED study

<table>
<thead>
<tr>
<th>Measure</th>
<th>Assessment point</th>
</tr>
</thead>
<tbody>
<tr>
<td>RPE, FS, HR</td>
<td>3,6,8,10,13,16,17,19,23,25, 28,29,31,34,36,39,41,43,46, 48,50,53,55,58 minutes</td>
</tr>
<tr>
<td>% Dissociative</td>
<td>5,12,18,26,32,39,45,53 minutes</td>
</tr>
<tr>
<td>Time estimations</td>
<td>Before warm-up/after cool-down and at 33%, 66%, 90% of calculated distance</td>
</tr>
</tbody>
</table>
Chapter 4: Results

This chapter includes results of various statistical analyses of the SPEED study data. The characteristics of the subjects are presented, with key differences in demographics between men and women subjects reported. Each of the hypotheses is presented with statistical data and tests; graphs for visualization of the data are presented as well.

Characteristics of the Subjects:

A total of 22 subjects were recruited for this study, 11 male and 11 female recreational runners. They were all apparently healthy at the time of testing and had no previous lower limb injuries. The subjects reported running 29.02 miles per week on average ($SD = 16.87$). The men reported more weekly mileage than the women ($M = 36.91, SD = 18.76$ versus $M = 21.14, SD = 10.43$ respectively), $t(20) = -2.437, p = .024, d = .823$. The distance that the subjects were asked to run was based on their weekly mileage over that last six months, and was never longer than their longest run during that same time period. As a result of the higher reported weekly mileage, the men were required to run significantly farther than the women ($M = 4.84, SD = 1.21$ versus $M = 3.46, SD = 0.62$ miles), $t(20) = -3.343, p = .003, d = 1.388$.

$VO_2_{\text{max}}$ scores were calculated by taking the average of the highest two consecutive measurements. Overall, the $VO_2_{\text{max}}$ scores were not significantly correlated...
to weekly running mileage \((r = .341, p = .120)\). However, when the subjects were separated by sex, the women showed a significant positive correlation between \(\text{VO}_2\text{max}\) scores and weekly mileage (women: \(r = .817, p = .002\); men: \(r = -.202, p = .552\)). A description of the subjects and the results of the \(\text{VO}_2\text{max}\) testing are listed in tables 4.1 and 4.2 below.

Table 4.1

*Demographics, listed as \(M (SD)\)*

<table>
<thead>
<tr>
<th>Sex</th>
<th>Age</th>
<th>Height (cm)</th>
<th>Mass (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Men (n=11)</strong></td>
<td>28.6 (6.4)</td>
<td>177.34 (9.42)</td>
<td>73.60 (13.84)</td>
</tr>
<tr>
<td><strong>Women (n=11)</strong></td>
<td>24.5 (5.5)</td>
<td>164.41 (6.33)</td>
<td>57.19 (7.18)</td>
</tr>
<tr>
<td><strong>Sig.</strong></td>
<td>(p = .116)</td>
<td>(p = .001)</td>
<td>(p = .002)</td>
</tr>
</tbody>
</table>
Table 4.2

Summary of $VO_2^{max}$ testing

<table>
<thead>
<tr>
<th>Variable</th>
<th>$M$</th>
<th>$SD$</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>VO$_2^{max}$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Men (n=11)</td>
<td>57.85</td>
<td>7.78</td>
<td>45.70 - 68.10</td>
</tr>
<tr>
<td>Women (n=11)</td>
<td>48.85</td>
<td>3.46</td>
<td>38.40 - 60.50</td>
</tr>
<tr>
<td>HR$_{max}$</td>
<td>189.9</td>
<td>10.0</td>
<td>169 - 208</td>
</tr>
<tr>
<td>RER (N=22)</td>
<td>1.15</td>
<td>0.05</td>
<td>1.06 - 1.26</td>
</tr>
</tbody>
</table>

Note. *Significantly different ($p = .006$)

Multiple hypotheses were tested in this study. Results from the statistical analyses of each are described below:

1. Ratings of Perceived Exertion –

a. Average and final ratings of perceived exertion will not be significantly different between known and unknown endpoint conditions.

The final reported RPE for each condition was averaged and compared. A paired samples t-test showed that the difference in final RPE between the unknown endpoint ($M = 14.9, SD = 1.8$) and the known endpoint ($M = 15.5, SD = 2.0$) was not significant, $t(21) = -1.914, p = .069$. The mean RPE for each subject was also calculated and a paired...
samples t-test showed that the average RPE for the unknown endpoint condition was 13.5 (SD = 1.4) and for the known endpoint condition was 13.8 (SD = 1.8); this difference was also not significant, $t(21) = -1.130, p = .271$. Reported RPEs over absolute time between conditions are shown in Figure 4.1. The null hypothesis was not rejected.

Figure 4.1 – Changes in RPE over absolute time. Subject numbers decrease as time increases; all subjects ($N=22$) through 19 minutes, and $n=3$ at 39 minutes.
b. When RPE is normalized to the percentage of time complete, there will be no differences between the unknown and known endpoint conditions.

Since there was variation in the amount of time the subjects ran, there was also variation in the number of data points for each subject. Therefore, the ratings of perceived exertion were normalized to the percentage of time complete. There were 10 percent increments and the range was from 10 to 100 percent of the time complete. A 2 (endpoint condition) X 10 (time) repeated measures ANOVA was used to specifically test this hypothesis. The results showed that there was not a significant main effect of condition ($F(1,20) = .069, p = .796, \eta^2_p = .003$) or an interaction between time and condition, $F(7,14) = 1.000, p = .471, \eta^2_p = .333$. There was an effect of time and this effect was significant at both the linear ($F(1,20) = 104.655, p < .001, \eta^2_p = .840$) and the quadratic levels ($F(1,20) = 33.426, p < .001, \eta^2_p = .626$). The assumption of sphericity was not met, so the Greenhouse-Geisser adjustment was made for the quadratic effect of time, $F(2.640, 12) = 52.110, p = < .001, \eta^2_p = .723$. All other assumptions of repeated-measures ANOVA were met. Reported RPEs over the percentage of time complete are shown in Figure 4.2. The null hypothesis was not rejected.
Figure 4.2 - Changes in RPE over percent time completed.
2. Heart rate –

a. The overall mean and the mean of the final heart rate assessment during the exercise bouts will not be different between the known endpoint compared and unknown endpoint conditions.

The mean heart rate over the entire run with an unknown endpoint was 166.8 (SD = 14.7) beats per minute (bpm). The mean heart rate during the known endpoint run was 169.7 (SD = 14.7) bpm. These were not significantly different, \( t(21) = -1.451, p = .161 \). When the final heart rate measurement for each condition was averaged there was also not a difference between the unknown endpoint condition (\( M = 173.5, SD = 13.9 \)) and the known endpoint condition (\( M = 176.0, SD = 14.7 \)) using a paired samples t-test, \( t(21) = -1.552, p = .136 \). The null hypothesis was not rejected. The changes in HR over absolute time are shown in Figure 4.3.
b. There will not be differences in heart rate response between men and women.

During the unknown endpoint condition, the average heart rate for the women was 174.7 ($SD = 12.6$) and for the men was 158.9 ($SD = 12.6$) beats per minute. An independent samples t-test showed that this difference was significant, $t(20) = 2.949, p = .008, d = 1.254$. The differences in average heart rate during the known endpoint condition were also significant, $t(20) = 3.198, p = .005, d = 1.369$. The men had an average heart rate of 161.3 ($SD = 15.4$) and the women had an average of 178.1 ($SD =
8.0) beats per minute. The null hypothesis was rejected; there was a sex difference in average heart rate during both endpoint condition runs.

3. Feeling Scale (affect rated +5 [very good] to -5 [very bad]) –

a. FS scores will not be different between endpoint conditions.

The average FS values over the course of each run were 2.164 (SD = 1.602) for the unknown endpoint condition and 2.124 (SD = 1.595) for the known endpoint condition. This difference was not significant, \( t(21) = .143, p = .887 \). To specifically test this hypothesis, the last reported FS scores were evaluated. The reported feelings declined over the course of each run, regardless of endpoint condition. The average last reported FS scores were .64 (SD = 2.38) for the unknown endpoint condition and .73 (SD = 2.43) for the known endpoint condition. Due to the large standard deviations in both conditions, this difference was not significant, \( t(21) = -.245, p = .809 \). The null hypothesis was not rejected. Reported FS scores are shown in Figure 4.4.

b. During both endpoint conditions, heart rate will be independent of FS scores.

Reported FS scores were moderately correlated with heart rate in the unknown endpoint condition \( (r(22) = -.281) \) and in the known endpoint condition \( (r(22) = -.085) \) but neither of these comparisons were significant \( (p = .205 \) and \( p = .706, \) respectively). The null hypothesis was not rejected.
Figure 4.4 – Changes in reported affect over absolute time. Subject numbers decrease as time increases; all subjects (N=22) through 19 minutes, and n=3 at 39 minutes.

4. Time Perception –

a. Time perception across endpoint and time conditions will not be different between men and women.

A 2 (endpoint condition) X 5 (time point) repeated measures ANOVA with sex as a between-subjects factor was used to test this hypothesis. Across the five time points and both conditions in which the time estimations were assessed, the men showed an average time estimation ratio (time judgment in seconds divided by 60) of 1.067 (SD =
.170) and the females an average ratio of .918 (SD = .179). This main effect of sex was statistically significant, $F(1,20) = 5.856, p = .025, \eta^2_p = .226$. Additionally, the main effect of condition ($F(1,20) = 2.490, p = .130, \eta^2_p = .111$) and all interactions (condition*time, condition*sex, time*sex) were not significant ($p > .05$). An examination of the results showed that no significant outliers were discovered; the data were normally distributed, and met the assumption of sphericity for repeated measures ANOVA. The men consistently overestimated time intervals, and these differences were present before, during and after exercise. The null hypothesis was rejected. Changes in time estimations between conditions are shown in Figure 4.5. Sex differences in time estimations are shown in Figures 4.6, 4.7 and 4.8.

![Figure 4.5 – Changes in time estimations over time. Time estimations were converted to ratio format by dividing each one minute estimation by 60.](image-url)
Figure 4.6 – Sex differences in time estimations across endpoint conditions. A significant main effect of sex was seen, and each individual time point was also significantly different between the two groups ($p < 0.05$).
Figure 4.7 - Sex differences in time estimations during the unknown endpoint condition.
b. Cardiorespiratory fitness level will not be a significant predictor of time estimations taken at 90% of the completed distance in the unknown endpoint condition.

A simple linear regression was used to test this hypothesis, with the time estimation taken at 90% of the distance covered as the dependent variable and VO$_2$max as a continuous independent variable. Results showed that VO$_2$max was not able to significantly predict the time estimation in the unknown endpoint condition, $t = 1.196$, $p = .246$. The null hypothesis was not rejected; cardi/respiratory fitness level (VO$_2$max) was not a significant predictor of time estimation in the unknown endpoint condition.
c. Cardiorespiratory fitness level will not be a significant predictor of time estimations taken at 90% of the completed distance in the known endpoint condition.

The same simple linear regression analysis that was used in the previous hypothesis test was used for this test. VO₂max was a significant predictor of the time estimation taken at 90% of the completed distance in the known endpoint condition and explained 18.6% of the variance in time estimations, $t = 2.141, p = .045, R^2 = .186$. In the known endpoint condition, as VO₂max levels increased, time estimations also increased. The null hypothesis was rejected. For both analyses (b and c) an examination of collinearity statistics revealed no problems with collinearity and upon examination of the residuals, there were no violations of the assumptions of linear regression.

d. Age will not be a significant predictor of time estimations taken at rest (before exercise) and during exercise at 90% of the completed distance.

Simple linear regression was used to test this hypothesis. In both endpoint conditions, age was not a significant predictor of time estimations at rest (unknown endpoint: $t = -.762, p = .455$; known endpoint: $t = .398, p = .695$). Age was also not a significant predictor of time estimations during exercise, at the 90% distance point (unknown endpoint: $t = .495, p = .626$; known endpoint condition: $t = .616, p = .545$). Age was not a significant predictor of time estimation, either before exercise or at the 90% distance covered points. The null hypothesis was not rejected. Further examination of collinearity statistics revealed no problems with collinearity and upon examination of the residuals, there were no violations of the assumptions of linear regression.
During exercise, the time estimation assessed at 90% of the distance covered will not be different than the assessments at 33% and 66% of the distance.

A paired samples t-test showed that the time estimations assessed at 90% of the distance completed were nearly identical between conditions and the difference was not significant (unknown: $M = .951, SD = .173$; known: $M = .949, SD = .163$), $t(21) = .075, p = .941$. A 2 (endpoint condition) X 3 (time point – 33%, 66%, 90% of covered distance) repeated measures ANOVA was used to address this specific hypothesis. There was not a significant main effect of condition ($F(1,21) = 1.325, p = .263, \eta^2_p = .059$) and no interaction effects ($F(1,21) = 1.649, p = .217, \eta^2_p = .142$). There was, however, a significant main effect of time during exercise ($F(2,21) = 4.107, p = .023, \eta^2_p = .164$). Using a Bonferroni adjustment for multiple comparisons, there were no significant differences between time points ($p > .05$). The null hypothesis was rejected. An examination of the results showed that no significant outliers were discovered; the data were normally distributed, and met the assumption of sphericity for repeated measures ANOVA.

There will not be a difference between time estimations before and after exercise.

A 2 (endpoint) X 2 (time point – pre/post) repeated measures ANOVA was used to test this hypothesis. In both endpoint conditions there was a trend toward lower time estimations after compared to before exercise. In the unknown endpoint condition the average estimation was 1.06 ($SD = .22$) before the run and 1.02 ($SD = .17$) after. In the known endpoint condition the average was 1.02 ($SD = .19$) before and .97 ($SD = .20$).
after the run. There was not a significant main effect of condition \( (F(1,21) = 2.803, p = .109, \eta^2_p = .118) \) or interaction effects \( (F(1,21) = .196, p = .662, \eta^2_p = .009) \). However there was a significant main effect of time point \( (F(1,21) = 4.785, p = .040, \eta^2_p = .186) \). Therefore, the null hypothesis was not rejected. An examination of the results showed that no significant outliers were discovered and the data were normally distributed. There were only two repeated measures in this analysis, so there was not a need to assess whether or not the data met the assumption of sphericity for repeated measures ANOVA.

**g.** The final assessment of attentional focus will independent of the final time perception assessment taken during exercise.

The correlation between the final assessment of attentional focus and time perception was not significant in the unknown endpoint condition \( (r(21) = .201; p = .382) \) or in the known endpoint condition \( (r(21) = -.004; p = .985) \). Using these assessments, there was not a significant relationship; therefore, the null hypothesis was not rejected.

**h.** Reported weekly mileage will not be a significant predictor of time estimations taken at 90% of the completed distance.

A simple regression was used for this analysis. Time estimation at 90% of the distance complete was used as the continuous dependent variable and weekly mileage as the independent variable. In the unknown endpoint condition, miles run was not a significant predictor of time estimation \( (t = .779, p = .445) \). Miles run per week was also not a significant predictor of time estimation in the known endpoint condition \( (t = .449, p = .659) \). The null hypothesis was not rejected. Additionally, an examination of
collinearity statistics revealed no problems with collinearity and upon examination of the residuals, there were no violations of the assumptions of linear regression.

5. Association/Dissociation –

a. There will be no differences in level of attentional focus between the unknown and known endpoint conditions.

The last assessment of attentional focus for each subject was averaged for each endpoint condition. The mean final value for the unknown endpoint was 56.0 (SD = 18.1) percent and was 45.2 (SD = 21.0) percent for the known endpoint condition. A paired samples t-test showed that the difference between these two means was significant, t(20) = 2.275, p = .034, d = .499. Subjects dissociated more in the unknown endpoint condition than in the known endpoint condition; the null hypothesis was rejected.

b. In the unknown endpoint condition, there will be no relationship between dissociative thoughts and cardiorespiratory fitness level.

A simple linear regression was used to test this hypothesis, with the final attentional focus assessment as the dependent variable and VO₂max as a continuous independent variable. Results showed that VO₂max was not able to significantly predict the last attentional focus assessment in the unknown endpoint condition (t = - .684, p = .502). When the average attentional focus over the entire run was used as the dependent
variable, VO2max was also not a significant predictor ($t = -1.335, p = .198$). The null hypothesis was not rejected.

c. In the known endpoint condition, there will be no relationship between dissociative thoughts and cardiorespiratory fitness level.

The same simple linear regression analysis that was used in the previous hypothesis test was used for this test. VO2max was a significant predictor of the final attentional focus assessment in the known endpoint condition and explained 31.7 percent of the variance in attentional focus ($t = -2.972, p = .008$, $R^2 = .317$). VO2max was also a significant predictor of the average attentional focus over the entire run ($t = -2.439, p = .025$, $R^2 = .239$). In the known endpoint condition, as VO2max levels increased, reported associative thoughts increased. The null hypothesis was rejected. For both of these analyses (b and c) further examination of collinearity statistics revealed no problems with collinearity and upon examination of the residuals, there were no violations of the assumptions of linear regression.

d. Attentional focus will be independent of RPE levels during both conditions.

The last assessment of attentional focus (percent dissociative thoughts) was significantly negatively correlated to RPE levels at both 90% ($r = -.668, p = .005$, $\rho = .667$) and 100% ($r = -.572, p = .021$, $\rho = .572$) of the completed time in the known endpoint condition. In the unknown endpoint condition, attentional focus was not correlated with RPE at either the 90% ($r = -.324, p = .221$) or 100% ($r = -.286, p = .283$) of the completed time. During the known endpoint condition, increases in RPE were
significantly related to decreases in dissociative thoughts (or an increase in association).

This negative correlation was present in the known endpoint condition, but was not significant. The null hypothesis was rejected in the unknown endpoint condition, and not rejected in the known endpoint condition.

6. Pacing –

a. Time to complete the required distance will not differ between the known endpoint and the unknown endpoint conditions.

The mean time to complete the required distance in the unknown endpoint condition was 32:49.0 (SD = 8:01.3) minutes and in the known endpoint condition was 31:20.1 (SD = 8:02.5) minutes. This difference was statistically significant, \( t(20) = 3.915, p = .001, d = .865 \). The null hypothesis was rejected.
Chapter 5: Discussion

The main objective of this study was to investigate how the knowledge of an endpoint affects different psychophysiological variables. The second objective was to investigate the perception of time before, during and after exercise in runners, both men and women, with a range of experience and cardiovascular fitness levels. To the author’s knowledge, this is the first study to investigate the effect of an unknown endpoint on psychophysiological variables while using self-pacing, which is constantly variable, rather than fixed pacing. All other studies utilizing self-pacing protocols have been protocols in which subjects cycle or run at a very high intensity, during a race (or simulated race), or “to exhaustion,” when they decide that they cannot go any farther.

One important finding from this study was that ratings of perceived exertion were higher on average in the known endpoint condition, but overall and final RPE were not significantly different between endpoint conditions despite a significantly faster completion time in the known endpoint condition. Even when RPE values were normalized to the percentage of time completed, there was not a significant difference between the endpoint conditions.

Another important finding in this study was the difference in perception of time between men and women participants. For all subjects in the study, there was a feeling of time “slowing down” when they were (unknowingly) 90% of the way through each run
when compared to time estimations taken before and after the run. This was shown through a relative decrease in prospective time estimations. There was also a clear difference between men and women on their perception of time before, during and after each run. Overall, the women had a time estimation ratio (prospective time estimation in seconds divided by 60) of .918 ($SD = .179$) and the men had an average ratio of 1.067 ($SD = .170$). This showed that the women in this study, compared to men, experienced time as moving by more slowly. These differences were present before, during and after each run.

**Effect of an unknown endpoint on perceived exertion**

There was no difference in RPE between the conditions. The average final reported RPE was 14.9 ($SD = 1.8$) when the endpoint was not known, and 15.5 ($SD = 2.0$) when the endpoint was known, and the difference between these averages was not significant. The average RPE over the course of each run was also not significant, and was 13.5 ($SD = 1.4$) when the endpoint was not known and 13.8 ($SD = 1.8$) when it was known.

Coquart and Garcin (2008) asked their 14 subjects (all men) to run in three different conditions. The first consisted of a run with an unknown endpoint, in which the subjects were instructed to run to exhaustion. The second run was performed to the same distance reached in the first run. Lastly, during the third run the subjects were told to run to the same distance that was reached on the first run. The conditions, then, were
“unknown endpoint,” “known duration” and “known distance.” The researchers assessed RPE throughout the trials and discovered that RPE was significantly lower in the unknown endpoint condition compared to the other two conditions in which the distance or duration was known ($p = .023$). For all conditions, the subjects were not able to self-pace; they were asked to run at a fixed pace coinciding with 90% of their maximal aerobic velocity (MAV). They found significant differences in RPE at the 40%, 60% and 80% time points but not at the 20% time point. When using paired samples t-tests to compare the 20%, 40%, 60% and 80% relative time points between known and unknown endpoint conditions in our subjects, it was found that there were no differences between any of the time points. In the current study, there were also no significant differences in average or maximum RPE values between unknown and known endpoint conditions. However, our subjects were able to adjust their pace throughout the trials and as a result ran faster in the known endpoint condition. The ability to self-pace may have enabled our subjects to manage the effort they expended consistently regardless of knowledge of remaining distance.

In 2008, Faulkner et al. investigated RPE differences between two very different long-distance races. The first was a simulated 7-mile road race with prize money offered to increase motivation. The second was the Great West Run, a half-marathon (13.1 miles) road race. Their subjects consisted of five men (mean VO$_2$max of 58.6 ml/kg/min) and four women (mean VO$_2$max of 48.8 ml/kg/min). Every mile of each race, the subjects were asked to record their RPE on a record sheet attached to their wrist. For both races, the subjects were allowed to self-pace and complete the trials as quickly as
they could. Considering the difference in race distance, there was a significant difference in time to complete the races (51.5 minutes in the 7 mile race versus 108.2 minutes in the half-marathon). The rate of rise in RPE over time was calculated for both races by regressing RPE against time for each subject and obtaining an average slope. They found that RPE rose significantly faster in the 7 mile race compared to the half-marathon ($p < .001$). However, when the rate of rise in RPE was normalized to the percent of time completed, by regressing RPE against percentage of time complete, the difference was not significant between races ($p = .388$). In their study, the graph of RPE versus time (or percentage of time) visually appears to be linear. In the current study, however, the graph of RPE versus time or percentage of time appears to be curvilinear (See Figure 4.3). This was confirmed through significant linear and quadratic effects as shown by a 2 (endpoint condition) X 10 (time point) repeated measures ANOVA.

To compare our results to the Faulkner et al. (2008) study, RPE data in the current study were regressed against time and percentage of time for each subject and the slope was averaged across all subjects. We found that the rate of rise in RPE was significantly greater when the endpoint of the run was known. This occurred even though the subjects were allowed to constantly adjust their pace throughout each trial. For the RPE values versus actual time, the average slope was .141 ($SD = .089$) in the unknown endpoint condition and .188 ($SD = .083$) when the endpoint was known. This difference was significant ($p = .007$). When the RPE was normalized and regressed against the percentage of the time complete, the rate of rise was .046 ($SD = .022$) when the endpoint was unknown and was slightly higher ($M = .051$, $SD = .019$) when the endpoint was
known. The difference between these means was also significant ($p = .042$). These differences between studies may be due to the fact that the endpoint of each race in the Faulkner et al. study was well-known to each subject. Conversely, in our study the endpoint was not disclosed to the subjects prior to testing. As the authors mention, the known distances may have led the subjects to create an “RPE template” pre-race which contributed to their rate of rise in RPE values. Feedback may in part explain some differences between the Faulkner et al. study and the current investigation as well. During each road race in their study, the subjects constantly had feedback as to how many miles they had completed and consequently, how many miles they had left to complete before they reached the finish line. Since a key concept of teleoanticipation is based on how much time or distance there is left to complete, feedback is an important determinant in how metabolic sources are used during exercise. In the present study, even in the “known endpoint” condition there was no feedback given to the subjects. They were blind to all feedback and were not told how fast they were running, how much time had elapsed or how far they had gone. They simply knew the distance in which they would be told they could stop running. Consequently, they had an RPE template, though less precise, for the known endpoint that was based on the quality of their recall of the previous exercise bout. This RPE template was also likely to be influenced by level of experience; the subjects with greater running and racing history may have been more mindful of their pace and effort level required to complete the distance most efficiently.

Another more recent study by Faulkner et al. (2011) used either inaccurate, accurate or no distance feedback during four self-paced 6 kilometer treadmill runs. The
“inaccurate” feedback was further split into either premature or delayed feedback, so each subject completed the 6 kilometer run a total of four times. Their subjects consisted of 13 healthy, physically active young men. They asked their subjects to complete the trials as quickly as they could. They found that completion times were significantly ($p < .001$) slower when the subjects were given no feedback about the distance that they had covered. Performance was unaffected by inaccurate feedback, which was also shown by another study of 15 male cyclists (Albertus et al., 2005). Faulkner et al. also found that RPE was similar between all conditions, further supporting the idea that an RPE template is created prior to the trial based upon distance. Additionally, only in the three conditions in which feedback was given (either accurate or inaccurate) was the “end spurt” phenomenon clearly observed.

Expected task duration is one of the factors that determines the perception of exertion during exercise. The subjects in this study were unaware of the distance that they would be running, but they did know that the absolute maximum time they would be running would be 90 minutes. This was more than some subjects had ever run, and the length of a normal weekend long run for other subjects. Subjects were not formally asked the amount of time thought they would be asked to run but many stated post-testing that they suspected they would be required to run the entire allotted time.
Effect of endpoint condition on heart rate response

Heart rate was essentially the only physiological variable in this experiment, so its interpretation is important to this study. It was found that the average heart rate over the entire run was 166.8 ($SD = 14.7$) beats per minute (bpm) in the unknown endpoint condition and 169.7 ($SD = 14.7$) bpm in the known endpoint condition. Despite the fact that the subjects ran at an overall faster pace in the known endpoint condition, the difference between these two means was not significant ($p = .161$). Additionally, there were differences between the final recorded heart rates in the unknown ($M = 173.5$, $SD = 13.9$) and known ($176.0$, $SD = 14.7$) endpoint conditions but significance was not achieved ($p = .136$).

During self-paced running, there are often no differences in heart rate between conditions. In the Faulkner et al. (2008) study, they did not find any differences in absolute average heart rate between the two races (7 mile simulated race and a 13.1 mile half-marathon). They also did not find any differences between the final recorded heart rate during the 7 mile race ($M = 186.7$, $SD = 9.7$) and the half-marathon ($M = 185.8$, $SD = 6.8$). When the recorded heart rate data was normalized to percentage of the subjects’ maximum heart rate, there were still no differences between conditions. This is despite the subjects running nearly twice as long in the half-marathon and running at a significantly faster pace in the 7 mile race compared to the first 7 miles of the half-marathon. In the current study, when the heart rate was normalized to the percentage of each subject’s maximum heart rate obtained from the VO$_2$-max test, the mean of the unknown endpoint condition was 87.7% ($SD = 5.2\%$) and for the known endpoint was
89.2% ($SD = 5.7\%$). The higher heart rate in the known endpoint condition could be explained by the faster overall time to complete the distance compared to the unknown endpoint condition. However, the difference between the means was not significant.

**Effect of sex on heart rate response**

Another finding from the current study was the difference in heart rate response between men and women. It was discovered that the women in the study had significantly higher heart rates compared to the men in both the unknown (women: $M = 174.7$, $SD = 12.6$ versus men: $M = 158.9$, $SD = 12.6$) and known endpoint (women: $M = 178.1$, $SD = 8.0$ versus men: $M = 161.3$, $SD = 15.4$) conditions. Further analysis showed that the heart rate percentages were also significantly different between men and women in both the unknown (women: $M = 90.1\%$, $SD = 4.5\%$ versus men: $M = 85.3\%$, $SD = 4.8\%$) and known (women: $M = 91.9\%$, $SD = 3.3\%$ versus men: $M = 89.5\%$, $SD = 6.4\%$) endpoint conditions ($p = .025$ and $p = .022$, respectively).

As most other studies investigating teleoanticipation have either only involved men (Albertus et al., 2005; Coquart & Garcin, 2008; Eston et al., 2012; Wittekind, Micklewright, & Beneke, 2011) or did not report sex differences in heart rate data (Baden et al., 2005; Baden et al., 2004; Mauger & Sculthorpe, 2012), these results can only be compared to a limited number of relatable studies.

The Faulkner et al. (2008) study used men and women as subjects and they did not discover any sex differences or interactions in heart rate response in either condition.
(7 mile run or half-marathon). A recent study was performed that asked men and women to walk at a self-selected pace on a laboratory treadmill (Dasilva et al., 2011). It was found that there were no significant sex differences in walking speed, RPE, heart rate or percentage of heart rate, even though the men were consuming significantly more oxygen than the women \((p < .05)\).

The higher heart rate response seen in the women could be explained by substrate utilization during higher intensity exercise. Research has shown that there are clear differences in substrate utilization between men and women. At the same relative intensity, women tend to oxidize more fat for fuel compared to men (Carter, Rennie, & Tarnopolsky, 2001). Studies have shown that women reach maximal fat oxidation (MFO) levels at a relatively higher heart rate than men (Venables, Achten, & Jeukendrup, 2005). The average heart rate across endpoint conditions (87.4\% for men, 91.0\% for women) was much higher in the current study than has been seen at MFO (45\% for men, 52\% for women). Subjects in the current study were likely at or above their lactate threshold for some of the test. Baden et al. (2005) showed that there were differences in oxygen consumption during endpoint conditions, and therefore likely different substrate utilization. However, without collecting expired gasses in the current study during the trials we cannot be sure if there were differences in substrate utilization.
**Effect of an unknown endpoint on reported affect**

It was hypothesized that the subjects would have significantly more negative affect during the known endpoint condition, based on the assumption that they would be running at an overall faster pace that could be unpleasant and result in reports of less positive affect. It was discovered that there were no significant differences in average Feeling Scale (FS) scores between the unknown ($M = 2.164, SD = 1.602$) and known ($M = 2.124, SD = 1.595$) endpoint conditions. After investigating the last reported FS score, there were still no differences between endpoint conditions. The mean final FS score in the unknown endpoint condition was .64 ($SD = 2.38$) and in the known endpoint condition was .73 ($SD = 2.43$). In both endpoint conditions, there were very large standard deviations in the final reported FS score. This shows that across endpoint condition, the subjects showed a large amount of variation in their affect. Further analysis of these data showed that the range of final FS scores in the unknown endpoint condition was from -4 to +4, and in the known endpoint condition was -5 to +5. Additionally, the median final FS score in the unknown endpoint condition was 0, and was +1 in the known endpoint condition. These descriptive statistics help to illustrate the fact that while some subjects felt more negative toward the end of exercise, others felt surprisingly good. One explanation for the FS variability could be differences in personality because links have been found between personality and exercise behavior (Courneya & Hellsten, 1998; Ekkekakis, Hall, & Petruzzello, 2005). Personality could be a moderating factor on affect during running under known and unknown endpoint conditions and warrants further investigation.
Reported FS scores were moderately correlated with heart rates in both endpoint conditions (unknown: $r = -.281$, known: $r = -.085$) but neither of these were significantly different ($p = .205$ and $p = .706$ respectively). The original manuscript on the validation of the Feeling Scale by Hardy and Rejeski (1989) showed a much stronger negative significant correlation between FS scores and heart rate across all tested workloads ($r = -.70$, $p < .05$) than was seen in the present study. This relationship could be due to the fact that their subjects were college students enrolled in a health and fitness class who might not have been regular exercisers, whereas our subjects were experienced runners.

As previously described, Baden et al. (2005) had subjects (both men and women) complete three conditions. In one condition, they were asked to run for 20 minutes, in another they were asked to run for 10 minutes but the time was extended to 20 minutes. In a last condition, the subjects were not told the endpoint but it was actually 20 minutes in length. They measured affect with the FS and the results showed that positive affect decreased throughout the course of each run. Additionally, they found that the trial with an unknown endpoint elicited lower reported affect compared to the other two conditions in which the endpoint was known. The subjects were not allowed to adjust pace at all, which may explain the difference between their results and those of the current study. It is likely that in an attempt to keep affect at a tolerable level, the subjects in our study decreased (or increased) their pace as needed. Eston et al. (2012) also looked at affect through assessment of FS scores using the same treadmill conditions as Baden et al. (2008). From visual inspection of the affect vs. time graph, the affect was consistently
higher in the unknown endpoint condition compared to the two known endpoint conditions, but these differences were not statistically significant.

**Sex differences in time perception**

The method commonly used to investigate prospective time estimation differences (Block et al., 1998; Espinosa-Fernández et al., 2003) is to divide the estimated time (subjective time determined by the subject) by the actual time (objective time, 60 seconds in this study). Based on previous evidence for gender differences in time perception, it was hypothesized that across all time points (pre, during and post) and endpoint conditions there would be significant differences in time estimations between men and women in the current study. It was discovered that the women consistently underestimated time intervals, as shown by relatively lower time estimation ratios ($M = .918, SD = .179$) compared to the men in the study ($M = 1.067, SD = .170$). This shows that the women in this study perceived time to be passing by more slowly than the men, regardless of time point or condition.

Espinosa-Fernandez et al. (2003) also asked men and women to prospectively estimate a 60 second period of time. They did not find a main effect of sex in their study, and the interaction between sex and age was also nonsignificant. There were sex differences between age groups, however. Men 11 through 40 years of age had higher time estimation ratios than women in the same age range. For subjects aged 41 through 70 years, the opposite was true; women increased time interval ratios and men decreased
to the point that the ratios given by the women were much higher than the men. In the current study, the age range for the men was 19 to 40 and for the women was 19 to 35. This age range is very similar to the range reported by Espinosa-Fernandez et al. (2003) that resulted in higher time estimation ratios by the men compared to the women. We have shown that in our sample, this sex differences in time perception is observed at rest and during exercise.

These results are also in line with those of a meta-analytic review of sex difference in time estimation (Block et al., 2000). When looking specifically at the prospective time estimation studies in the meta-analysis, they discovered 74 relevant articles to review, none of which compared time estimates between men and women during exercise. There were sex differences in estimations; specifically, women tended to make shorter productions of time compared to men. However, the researchers note that sex differences in prospective time estimations are often moderated by three main variables: the number of trials the subjects experience, the method used to judge time duration, and the age of the subjects. The results of the meta-analysis, along with those of the present study, support the notion that women focus their attention more on time than men and accumulate “temporal units” at a faster rate.

Effect of age on the perception of time

There is evidence for an effect of age on time perception in both men and women (Coelho et al., 2004; Espinosa-Fernández et al., 2003). Studies seem to suggest that as
one ages there is a sense of time moving by increasingly faster, as shown by increased prospective time estimations. In a review of the topic in which 16 studies were used for analysis, Block et al. (1998) showed that as age increased, time estimations (prospectively) consistently increased. Coelho et al. (Coelho et al., 2004) tested a sample of subjects within a very wide age range, from 15 to 90 years. Their prospective time estimation task was 58 seconds long, and they grouped their subjects into 10-year age ranges. They found a significant negative correlation between time estimations and age ($r = -.273, p < .01$). This suggests that the older the subjects were, the faster their “internal clock” was and the more time felt as though it was moving by quickly.

It was hypothesized in the current study that the average time estimation taken at rest and at the point in which subjects had covered 90% of the distance would be significantly related to age. Simple regression analyses showed that age was not a significant predictor of time estimations in either the unknown ($t = -.762, p = .455$) or the known ($t = .398, p = .695$) endpoint conditions at rest or during exercise (unknown endpoint: $t = .495, p = .626$; known endpoint condition: $t = .616, p = .545$). As most studies suggest that age-related changes in the perception of time do not occur until approximately 50 years of age (Espinosa-Fernández et al., 2003), the subjects in the current study (age range of 19-40 years) were likely not old enough to show a significant effect of age on time perception.
Effect of metabolism on time perception

Research has been performed to show that body temperature and metabolism can affect the perception of time, and a fairly consistent relationship has been determined (Gilliland et al., 1946; Hoagland, 1933; Stern, 1959; Thor, 1962). Hancock (1993) showed that when brain temperature was increased artificially with a heated helmet, 41-second prospective time estimations were significantly lower. The increased brain temperature essentially acted to “slow down” the perceived time in those individuals.

When exercising at a relatively high intensity, core temperature in both men and women is known to increase. Regardless of environmental temperature, when people exercise, cutaneous vasoconstriction occurs initially. This acute reduction in skin blood flow is elicited by increased vasoconstrictor system activity; as exercise continues however, the vasodilator system is activated in an attempt to keep core temperatures low by redirecting blood flow to the cooler periphery (Gonzalez-Alonso, Crandall, & Johnson, 2008). During exercise, it is the goal of the body to maintain a proper core temperature, but fatigue and dehydration can lead to a decreased stroke volume and an increase in core temperature.

Since increases in body temperature have been shown to affect the perception of time, it was hypothesized that as exercise progressed (regardless of endpoint condition) there would be a sense of time “slowing down” in our subjects that would be shown by decreases in average time estimation ratios. In our subjects there was a sense of time slowing down, as shown by a significant main effect of time during exercise ($F(2,21) =$
4.107, $p = .023, \eta_p^2 = .164$). Regardless of endpoint condition or sex, time estimations decreased as exercise progressed. Since the subjects overall were running at a relatively high percentage of their maximum heart rates (men: 87.4%, women: 91.0%) this effect on perception of time could be partially due to increased core temperature during exercise. We unfortunately have no further data to support this notion.

**Effect of cardiorespiratory fitness and experience on time perception**

The effect of fitness level on the perception of time has not been investigated in depth. However, we hypothesized that differences in fitness level would account for a portion of the variance in time estimations taken when 90% of the distance was complete. This time estimation was chosen because it was the final assessment of time perception and was likely a point at which the subjects were beginning to fatigue and show the most differences in prospective estimations of time. In the unknown endpoint condition, VO$_2$max was unable to significantly predict time estimations at the point in which subjects had reached 90% of the total distance. In the known endpoint condition, though, VO$_2$max was a significant predictor at the same relative distance (90%) and was able to explain 18.6% of the variance in the time estimations. Given the evidence for effects of body temperature on prospective estimates of time, perhaps those subjects who had higher levels of cardiorespiratory fitness were able to push themselves harder (and increase their core temperature) when the endpoint of exercise was made known.
A recent study on time perception during exercise (previously described) used various levels of experienced university swimmers (18 men, 10 women) as subjects (Tobin & Grondin, 2012). Specific values are not given for the cardiorespiratory fitness levels of the subjects, but it is assumed that since they were university-level swimmers they had at least moderate to high levels of fitness. The researchers found that when they asked their subjects to swim for 36 seconds while tethered to the side of the pool, their time estimations were much greater than when they were able to swim laps in the pool. An added secondary task (counting backwards from a large number) added to the swimming conditions decreased the time estimations in the tethered condition but not in the normal condition. This study provides further support regarding the importance of feedback (whether time or distance) on performance. Feedback not only led to more accurate estimations of time, but when a secondary task was added it affected time estimations much more when the subjects were not able to receive feedback as to the distance that they had covered. Perhaps the results of the current study would be different if the subjects would have been allowed to also run on an indoor track where they would have more feedback on distance covered and more external stimuli. External feedback could act to increase the overall pace of the subjects when the endpoint of exercise was known, and the corresponding increase in intensity could elicit further differences in time estimations.

We were also interested in determining the effect of experience on the perception of time. In this case, experience was defined as the average weekly miles reported by the subjects over the last six months. The range of reported mileage was between 10 and 70
miles per week. This was not a significant predictor of time estimation assessed at 90% of the completed distance in either endpoint condition. In this subject sample, time spent running over the last six months does not seem to have any effect on the perception of time during exercise.

**Effect of exercise on pre/post time perception**

It was hypothesized that a bout of exercise, whether utilizing a known or unknown endpoint, would not affect the perception of time in our subjects. Across subjects, the average time estimation ratios in the unknown endpoint condition were 1.06 ($SD = .22$) before the run and 1.02 ($SD = .17$) after. In the known endpoint condition the ratios were slightly lower, and were 1.02 ($SD = .19$) before and .97 ($SD = .20$) after the run. There was a main effect of time ($F(1,21) = 4.785$, $p = .040$, $\eta^2_p = .186$), and after exercise the time estimations across endpoint conditions were significantly shorter. So, this means that the subjects in our study felt as though time was moving by more slowly after exercise than before.

These results can potentially be explained by the relationship between mood and emotions to the perception of time. When placed in a situation that is unpleasant or boring, such as waiting for something to occur, time can seem to slow down and take longer than usual. Alternatively, in situations in which there are high levels of physiological arousal and enjoyment, time seems to speed up. Wittmann & Paulus (2008) showed that impulsive individuals who are unable to act upon their urges tend to
underproduce prospective time intervals, that is, for them time is perceived as moving by slowly. Studies have shown that there is an acute decrease in stress levels and an increase in positive mood after a single bout of exercise (Yeung, 1996). Since the subjects in the present study were recreational runners, it is assumed that they enjoy running and experience positive mood changes after running. Perhaps before exercise the subjects were excited to run and were anxious about starting the test, as compared to after exercise when they were more relaxed. A more positive mood after exercise could account for the decrease in time estimation ratios.

**Relationship between attentional focus and time perception**

There was a significant difference in the percentage of dissociative thoughts between the unknown (\(M = 56.0\%, SD = 18.1\%\)) and known (\(M = 45.2\%, SD = 21.0\%\)) endpoint conditions, meaning that the subjects used dissociative strategies to a greater degree when the endpoint was not known. The results of this comparison could be explained by some previous research in the area of cognitive strategies. When Baden et al. (2005) asked their subjects run with an unknown endpoint there was no difference in percentage of associative thoughts compared to two conditions in which the endpoint was known. However, in their study the pace was fixed and the time was equal between conditions. Consequently, there was no difference in either time or distance between conditions. In an earlier study by the same author, it was found that subjects reported more associative thoughts during a self-paced outdoor 8 mile run than in a 10 mile run.
with the same conditions (Baden et al., 2004). In another study within the same manuscript, they also found that subjects reported a greater amount of associative thoughts during a 10 minute run compared to a run in which subjects believed they would run 20 minutes but in actuality only ran 10 minutes. These two runs were performed on a laboratory treadmill with a fixed pace. The results from the current study coincide with the Baden et al. (2004) study; our subjects reported a higher percentage of associative thoughts during the known endpoint run which was significantly shorter in time than the unknown endpoint condition. This suggests that the amount of time subjects are planning to run is a major contributor to the cognitive strategy that they will use.

Studies have shown that attentional focus is highly related to exercise intensity (Okwumabua, 1985) and level of attention is related to prospective time estimations (Zakay, 1993). It was therefore hypothesized that the last evaluation of attentional focus would be related to the final time perception assessment during exercise. A positive correlation between the two variables was expected, so as the percentage of dissociative thoughts decreased (and associative thoughts increased) there would be a corresponding decrease in time estimations. However, there was no significant relationship between these variables, which could be explained by either sex difference in time perception, or multiple psychosocial factors affecting choice of cognitive strategies by the subjects.
Effect of cardiorespiratory fitness on attentional focus

It was hypothesized that during each endpoint condition, level of cardiorespiratory fitness would be able to explain variance in attentional focus. Specifically, in the unknown endpoint condition it was expected that greater fitness levels would correspond with decreases in associative thoughts. The opposite was expected of the known endpoint condition, greater fitness would be associated with increased associative thoughts. These hypotheses were made based upon the assumption that pacing, and therefore choice of cognitive strategy, would be different based upon knowledge of an endpoint. Fitness was not a significant predictor of attentional focus in the unknown endpoint condition ($t = -.684$, $p = .502$). However, in the known endpoint condition greater fitness levels did correspond with higher levels of reported associative thoughts ($t = -2.972$, $p = .008$, $R^2 = .317$).

Multiple studies have shown that as runners become more experienced they tend to use more associative compared to dissociative strategies. Masters and Lambert (1989) found that marathoners reported that roughly 75% of their thoughts during a marathon race were associative. Only the extremely fit are able to qualify for the Olympic Trials Marathon. In a study investigating these runners, it was discovered that top finishers used a greater percentage of associative thoughts compared to slower finishers (Silva & Appelbaum, 1989). Additional studies have shown that as competition increases, there is also a corresponding move toward more associative thoughts (Okwumabua, 1985; Summers et al., 1982). During the known endpoint run, the subjects in the current study
may have been competing with their unknown endpoint run, especially those that had relatively higher fitness levels or high levels of racing experience.

**Relationship of attentional focus to ratings of perceived exertion**

In the current study, the final assessment of attentional focus was significantly negatively correlated to ratings of perceived exertion only during the known endpoint condition. When the endpoint was unknown, there was a similar negative correlation but significance was not reached. This means that during the known endpoint condition only, increases in RPE were related to decreases in dissociative (or increases in associative) thoughts. Baden et al. 2004 also found a significant positive correlation between associative thoughts and RPE in their subjects. This correlation was seen at the end of both an 8 mile and 10 mile outdoor, self-paced run. A significant positive correlation was also seen between two 10 minute conditions (one with deception about the time) on a treadmill with a fixed pace. In the current study, these findings regarding the relationship between attentional focus and RPE can be explained by the pacing strategies chosen for each condition. When the endpoint was unknown to the subjects, their pacing was significantly slower overall despite showing no difference in the number of total speed increases and decreases (unknown: $M = 3.00, SD = 2.87$; known: $M = 3.39, SD = 2.66$; $p = .435$). During the known endpoint condition, the significantly faster pace likely led to an increase in overall RPE that was sufficient enough to decrease the amount of dissociative thoughts (and increase associative thoughts).
Effect of an unknown endpoint on pacing strategy

It was hypothesized that the subjects would run significantly faster when they were aware of the endpoint compared to during the unknown endpoint condition. The average time required to complete the distance was 32:49.0 (\(SD = 8:01.3\)) minutes in the unknown endpoint condition and 31:20.1 (\(SD = 8:02.5\)) minutes during the known endpoint condition. These two means were significantly different (\(p = .001\)). The fact that this difference was seen even though the subjects received no feedback during either condition is interesting. The differences may have been even greater if the subjects received feedback about their time and distance. When the subjects were not aware of the distance that they would be running, they ran more slowly than when they did when they were aware of the distance. Based on the concept of teleoanticipation, the subjects conserved their metabolic resources when the endpoint was unknown, because they did not want to fatigue before they reached the end of the trial.

Recommendations

The “end spurt” has been seen in the analyses of multiple world records in long distance running events, and is indicative of an ideal pacing strategy where the athlete balances the desire to run as fast as possible and also reach the finish without critically low levels of metabolic reserves. In the current study, the “end spurt” was not seen in the runners in the known condition, but would not be expected in the unknown condition. Future research in this area should be done with an added condition in which distance
feedback is provided to the subjects. This could elicit a faster overall pace, an “end spurt” during the final stages of exercise, and further evidence that feedback affects pacing strategies.

In the current study, subjects may not have utilized the ability to change speed as much as they would have if increasing or decreasing simply meant speeding up or slowing down at a subconscious level, perhaps without even realized they were doing so. The actual pressing of a button may not have been performed by subjects because they wanted to stay at a certain pace for as long as they could. Even slight variations in pace occur when running outdoors at a target pace. To create a more realistic self-pacing condition, future testing should be performed in a situation where subjects are not required to press a button to increase or decrease speed, such as an indoor track or a self-pacing treadmill. This would increase variability in pace, which is regularly seen in outdoor running.

Conclusions

The following conclusions are warranted from the results of the present study:

1. A self-paced run with an unknown endpoint did not elicit significantly different ratings of perceived exertion, heart rate or affect compared to a run with a known endpoint.

2. Subjects in this study had a sense of time “slowing down” during exercise regardless of endpoint condition, as shown by decreasing prospective time estimations.
3. Multiple differences were discovered between men and women in this study.

   a. Regardless of endpoint condition and time, men perceived time to pass by more quickly compared to women.

   b. Women in the study ran at a significantly higher percentage of their maximum heart rate compared to the men.

4. The use of teleoanticipation was seen in three forms:

   a. When the endpoint was not known to the subjects, they ran at a significantly slower pace overall. This shows a greater conservation of metabolic resources when they are unsure how long they would be running.

   b. Normalized RPE was not different between endpoint conditions even with a significant difference in pacing strategy.

   c. No “end spurt” was seen in either endpoint condition. Feedback is an important aspect of teleoanticipation; since the subjects did not receive any feedback as to the distance that they covered they were unable to fully utilize this strategy.


126


James, W. (1890). The principles of psychology, Vol I.


130


Noakes, T.D. (2012a). Fatigue is a brain-derived emotion that regulates the exercise behavior to ensure the protection of whole body homeostasis. *Frontiers in Physiology, 3*.


Appendix A

SPEED Study recruitment flyers
To be eligible you must be:

> A runner between the ages of 18-50
> Logging at least 10 miles per week for the last year
> In good health

Participate in research investigating the effects of running on attentional focus, perceived exertion and perception of time.

Participation involves 3 lab sessions. The first will include a VO₂ max test and will last approximately 1 hour. The final two sessions will last approximately 2 hours each.

For more info, contact Nick Hanson:

hanson.235@osu.edu

Figure A.1 – SPEED Study flyer
Figure A.2 – SPEED Study flyer with tear-offs
Appendix B

ACSM risk stratification guidelines
ACSM Risk Stratification

The three major components of the ACSM guidelines for risk stratification include (1) stratification categories, (2) risk factors and signs/symptoms, and (3) recommendations for the need of a physician’s presence during exercise testing. The ACSM guidelines stratify individuals as “low risk,” “moderate risk,” or “high risk” based on these three components. Positive and negative risk factors are listed in the table below:
Figure B.1 – ACSM risk stratification guidelines (Thompson et al., 2009)

Individuals are classified as “low risk” if they are men under the age of 45 or women under the age of 55 who are asymptomatic and have no more than one positive risk factor. Those classified as “moderate risk” are those individuals who are men over the age of 45 and women over the age of 55 or who have two or more positive risk factors.
factors. “High risk” individuals are those who report one or more signs and symptoms listed or those who have a known cardiovascular, pulmonary or metabolic disease.

The recommendations provided by the ACSM guidelines are used to prescribe exercise and were not used in this study. However, they state that for “low risk” individuals a maximal treadmill test is not necessary before beginning an exercise program. For “moderate risk” individuals they recommend a maximal treadmill test before starting a vigorous exercise training program. “High risk” individuals are suggested to receive a maximal treadmill test before beginning either a moderate or vigorous exercise program.
Appendix C

Scales: Rating of Perceived Exertion (RPE) and Feeling Scale (FS)
Figure C.1 – Rating of Perceived Exertion (RPE) Scale (Borg, 1982)

6 No exertion at all
7 Extremely light
8 Very light
9 Light
10 Somewhat hard
11 Hard  (heavy)
12 Very hard
13 Maximal exertion

14
15
16
17
18
19
20

Instructions to the Borg-RPE-Scale®

During the work we want you to rate your perception of exertion, i.e. how heavy and strenuous the exercise feels to you and how tired you are. The perception of exertion is mainly felt as strain and fatigue in your muscles and as breathlessness or aches in the chest.

Use this scale from 6 to 20, where 6 means “No exertion at all” and 20 means “Maximal exertion.”

9 Very light. As for a healthy person taking a short walk at his or her own pace.
13 Somewhat hard. It still feels OK to continue.
15 It is hard and tiring, but continuing is not terribly difficult.
17 Very hard. It is very strenuous. You can still go on, but you really have to push yourself and you are very tired.
19 An extremely strenuous level. For most people this is the most strenuous exercise they have ever experienced.

Try to appraise your feeling of exertion and fatigue as spontaneously and as honestly as possible, without thinking about what the actual physical load is. Try not to underestimate, nor to overestimate. It is your own feeling of effort and exertion that is important, not how it compares to other people’s. Look at the scale and the expressions and then give a number. You can equally well use even as odd numbers.

Any questions?

Figure C.2 – Instructions for RPE Scale
Feeling Scale (FS)  
(Hardy & Rejeski, 1989)

While participating in exercise, it is common to experience changes in mood. Some individuals find exercise pleasurable, whereas others find it to be unpleasant. Additionally, feeling may fluctuate across time. That is, one might feel good and bad a number of times during exercise. Scientists have developed this scale to measure such responses.

+5 Very good
+4
+3 Good
+2
+1 Fairly good
0 Neutral
-1 Fairly bad
-2
-3 Bad
-4
-5 Very bad

Figure C.3 – Feeling Scale (FS) with instructions
Appendix D

Institutional Review Board Application:

Initial Review of Human Subjects Research
INITIAL REVIEW OF HUMAN SUBJECTS RESEARCH
The Ohio State University Institutional Review Board

Office of Responsible Research Practices (ORRP)
300 Research Administration Building, 1980 Kenny Road, Columbus, OH 43210
Phone: (614) 688-8457    Fax: (614) 688-0366    www.orrp.osu.edu

<table>
<thead>
<tr>
<th>ITEM</th>
<th>DATE RECEIVED</th>
<th>DATE VERIFIED COMPLETE</th>
<th>OSU PROTOCOL NUMBER</th>
</tr>
</thead>
</table>

1. PROJECT TITLE
The effects of self-paced exercise with and without a known endpoint on task anticipation and psychophysiological variables

2. INSTITUTIONAL REVIEW BOARD
Select the Board to review this research:

Final Board assignment is determined by ORRP.

☐ Behavioral and Social Sciences
☐ Biomedical Sciences
☐ Cancer

3. PRINCIPAL INVESTIGATOR (or Advisor) - see Qualifications for service as a PI
Name (Last, First, MI):
Backworth, Jason

University Academic Title:
Associate Professor

Department Name (TTU):
EHE (Education & Human Ecology)

Degree(s):
Ph.D., Exercise Psychology

College (TTU):
OSU ID Number:
95070524

Campus Mailing Address:
A44 PAES Building
395 W 17th Ave
Columbus, OH 43210

E-mail:
backworth.1@osu.edu

Fax:
614.322.0757

Phone:
614.322.0757

Emergency phone:

4. CO-INVESTIGATOR(S)
Are there any OSU Co-Investigators on this protocol? ☑ Yes ➔ Complete Appendix A1

Signatures of Co-Investigator(s) are required on Appendix A1.

5. KEY PERSONNEL
Are there any OSU key personnel on this protocol? ☑ Yes ➔ Complete Appendix A1

Key personnel are defined as individuals who participate in the design, conduct, or reporting of human subjects research. At a minimum, include individuals who recruit participants, obtain consent, or who collect study data.
6. EXTERNAL CO-INVESTIGATOR(S) & KEY PERSONNEL

Are any external (non-OSU) investigators or key personnel engaged in the OSU research? □ Yes □ No → Go to Question #7

“Engaged” individuals are those who intervene or interact with participants in the context of the research or who will obtain individually identifiable private information for research funded, supervised, or coordinated by OSU. See OHRP Engagement Guidance or contact OHRP for more information.

If Yes → Who will provide approval for these external personnel? □ OSU IRB → Complete Appendix A2 □ Non-OSU IRB → Provide a copy of the approval(s)

7. ADDITIONAL CONTACT(S)

If further information about this application is needed, specify the contact person(s) if other than the PI (e.g., study or regulatory coordinator, research assistant, etc.) □ N/A

Name (Last, First, MI): Harrison, Nicholas J
Phone: 614.292.0458
E-mail: khmmn.23@osu.edu
Fax: 614.688.2422

Name (Last, First, MI): Phone:
E-mail:
Fax:

All OSU individuals listed on this protocol will have access to information about IRB actions and the completion status of each individual’s administrative and training requirements (CITI, COI disclosure). Personal financial information provided in COI disclosures is not included.

8. EDUCATION

Educational requirements (initial and continuing) must be satisfied prior to submitting the application for IRB review. See CITI Training or contact OHRP for more information.

Have all OSU investigators and key personnel completed the required web-based course (CITI) in the protection of human research subjects? □ Yes □ No

9. FINANCIAL CONFLICT OF INTEREST

All OSU investigators and key personnel must have a current COI disclosure (updated as necessary for the proposed research) before IRB review. Examples of financial interests that must be disclosed include (but are not limited to) consulting fees or honoraria; stocks, stock options or other ownership interests; and patents, copyrights and royalties from such rights. For more information, see Office of Research Compliance COI Overview and eCOI.

a. Have all OSU investigators and key personnel completed the required COI disclosure? □ Yes □ No

b. Does any OSU investigator (including principal or co-investigator), key personnel, or their immediate family members have a financial interest (including salary or other payments for services, equity interests, or intellectual property rights) that would reasonably appear to be affected by the research, or a financial interest in any entity whose financial interest would reasonably appear to be affected by the research? □ Yes □ No

10. FUNDING OR OTHER SUPPORT

If the research is federally funded and involves a subcontract to or from another entity, an IRB Authorization Agreement may be required. Contact OHRP for more information.

a. Is the research funded or has funding been requested? □ Yes □ No
11. OTHER INSTITUTIONAL APPROVALS

Check all that apply and provide applicable documentation. See websites listed below for information on obtaining approvals. IRB review cannot be conducted until required institutional approvals or exemptions are obtained, except as noted.

- None
- Clinical Research Center (CRC) Scientific Advisory Committee (SAC) – Approval required for research sponsored by the CRC. Final IRB approval will be held pending receipt of SAC approval.
- Institutional Biosafety Committee (IBC) – Approval required for research involving biohazards (recombinant DNA, infectious or select agents, toxins), gene transfer, or xenotransplantation.
- Comprehensive Cancer Center (CCC) Clinical Scientific Review Committee (CSRC) – Approval or exemption required for cancer-related research.
- Maternal-Fetal Welfare Committee – Approval required for some research involving pregnant women and fetuses.
- Human Subject Radiation Committee (HSRC) – Approval required for research involving radiologic procedures for research purposes (e.g., non-clinical care X-rays, DEXA or CT scans, nuclear medicine procedures, etc.).

12. LOCATION OF THE RESEARCH

Research to be conducted at locations other than approved performance sites will minimally require a letter of support and may require another IRB’s approval if personnel are engaged. See OHRP Engagement Guidance or contact ORRP for more information.

<table>
<thead>
<tr>
<th>Location Name (or description)</th>
<th>Address (street, city and state or country)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PAES Building</td>
<td>305 West 17th Ave, Columbus, Ohio</td>
</tr>
</tbody>
</table>

b. Are all the sites named above on the OSU list of approved research performance sites?

- Yes
- No

If No → Domestic sites → Provide a letter of support, as applicable

International sites → Complete Appendix U

c. Is the OSU PI the lead investigator or is OSU the lead site for collaborative research?

- Yes
- No → Go to Question #13

Not collaborative research → Go to Question #13

d. Describe the communication between sites that might be relevant to the protection of participants, such as unanticipated problems, interim results, and protocol modifications.
12. Describe IRB oversight arrangements for each collaborative site (i.e., who will provide IRB review and approval). Provide copies of the non-OSU approvals, as applicable. Contact OEBR if requesting that OSU serve as the IRB of record.

13. EXPEDITED REVIEW
Are you requesting Expedited Review?  ☒ Yes → Complete Appendix E
☐ No

14. SUMMARY OF THE RESEARCH

Summarize the proposed research using non-technical language that can be readily understood by someone outside the discipline. Explain briefly the research design, procedures to be used, risks and anticipated benefits, and the importance of the knowledge that may reasonably be expected to result. Use complete sentences (limit 500 words).

Both competitive and recreational athletic events generally have a beginning and endpoint, whether it is based on distance or on time. Teleoanticipation is the concept that humans pace themselves according to the amount of time left in an athletic event, in an attempt to regulate their metabolic reserves and prevent failure. Not knowing the endpoint in an event could have a significant affect on pacing. No defined endpoint could also have implications for perception of time, level of perceived exertion, anxiety, and enjoyment, and may be influenced by personality. Additionally, perceived lack of time is one of the most common reasons for not exercising. Further knowledge of the perception of time (before, during and after exercise) could help to illuminate how human perception is related to psychophysiological responses to exercise, which have been shown to influence exercise adherence.

We plan to investigate the concept of teleoanticipation by having subjects run on a laboratory treadmill for an unspecified distance. The distance will be relative to each subject and will be calculated based upon the level of training and average weekly mileage run over the last year, and will not be more than 12 miles in length. After completing the run with the unknown endpoint, the subjects will return to the lab for a second visit. They will run the same distance as the unknown endpoint and will be told how far they are to run, but they will be blind to the elapsed time and distance covered during the known endpoint run.

Previous research has shown differences in time perception and pacing among various age groups and genders (6, 10, 12). Therefore, the sample will include both men and women and a range of ages and running backgrounds.

15. SCIENTIFIC BACKGROUND & LITERATURE REVIEW

Summarize existing knowledge and previous work that support the expectation of obtaining useful results without undue risk to human subjects. Use complete sentences (limit 500 words). –

Hans Ulmer coined the term “teleoanticipation”, based on work that he performed on athletes (14) who were asked to run and maintain certain Rating of Perceived Exertion (RPE) levels, allowing them to adjust their pacing accordingly (4). Ulmer concluded that there is likely a “regulation center” in the brain that performs precise calculations about metabolic reserves, as well as time and effort needed to finish exercise bouts at a given intensity.

Boden et al. (6) examined teleoanticipation in runners. Subjects ran for 10 minutes in one condition and 20 minutes in another. In the third condition, subjects were unaware of the time they would have to run, and were stopped at 20 minutes. The treadmill speed was relative to each subject and was used for all three trials. The subjects had lower oxygen consumption in the unknown endpoint condition but similar RPE levels as in the know endpoint condition, showing that they were actually running more economically when the endpoint was unknown.
Coquart et al. asked subjects to run at a certain pace with an unknown endpoint (until exhaustion) (5). They were asked to run at that same pace two more times, the same distance that was reached and for the same amount of time. Subjects' RPE was higher when the endpoint was known even though they were running at the same speed and their heart rate was slightly lower, showing that perceived exertion is affected by knowledge of an endpoint.

Self-pacing is important to study because many people choose to run outdoors and constantly adjust their pace. No studies to date have investigated the effect of running with an unknown endpoint during self-paced exercise. In addition, time perception, personality, associated/disassociated, and affect, which have been related to exercise adoption and maintenance, have not been studied under these conditions.

16. RESEARCH OBJECTIVES

List the specific scientific or scholarly aims of the research study.

The specific aim of this study is to investigate the effect of an unknown endpoint on pacing, perceived exertion, affect and time perception before, during and after a self-paced bout of treadmill running, and to examine the relationships among personality and psychophysiological responses.

We will test the following hypotheses:

1. Rating of Perceived Exertion – The ratings of perceived exertion will be significantly lower in the unknown endpoint condition compared to the known endpoint condition. We hypothesize that heart rate data will show the same trend, and will be lower in the unknown endpoint condition.

2. Feeling Scale (affect rated -6 [very good] to -6 [very bad]) – In the known endpoint condition the reported feelings will decrease as a function of the remaining time/distance, moving from positive to negative feelings. In the unknown endpoint condition, the reported feelings will decrease relatively slower.

3. Time Perception – There will be differences in time perception between experienced runners and novice runners, and also between males and females.

4. Associative/Disassociative thoughts – The experienced runners (defined by number of years running regularly) will have more disassociative thoughts during the unknown endpoint condition compared to the less experienced runners. In the known endpoint condition, the experienced runners will have more associative thoughts compared to the less experienced runners.

5. Personality – Personality will affect the relationship between variables; we hypothesize that high scores on certain dimensions of personality will affect how runners with varying experience levels report RPE or affect. Specifically, higher scores in the dimension of Neuroticism will be associated with higher reported RPE, whereas higher scores in Openness will be associated with lower reported RPE levels.

17. RESEARCH METHODS & ACTIVITIES

a. Identify and describe all interventions and interactions that are to be performed solely for the research study. Distinguish research (i.e., experiments) activities from non-research activities. Provide description (e.g., spreadsheet or form) of data being collected. Do not include case report forms for multi-site industry-sponsored or cooperative group studies.

This research is proposed to be done with healthy adult men and women (18-50 years old).

Inclusion criteria will be:

- 18 to 50 years of age
- Run ≥10 miles per week for at least 1 year
- Stated by the American College of Sports Medicine as “low risk”

Exclusion criteria will be:

- Under 18 to over 50 years of age
- Run less than 10 miles per week for the last 1 year, or have run less than one year total
• Stratified by the American College of Sports Medicine as “moderate risk” or “high risk”
• Women who are pregnant
• Participants with language barriers

All criteria will be based solely on an eligibility questionnaire filled out by the potential subjects. The three laboratory visits will be a minimum of 48 hours apart, to allow for proper test and recovery from the prior visit.

Laboratory Visit #1

Consents: Upon arrival to the Behavior Laboratory, the researchers will review the consent form and answer any questions. Upon agreeing to participate in the research, the researcher and volunteer will sign two copies of the consent form, one to be retained by the researchers.

Personality test: Subjects will be asked to complete a personality test called the Big Five Inventory (BFI-90). This will be administered on the computer located in the Behavior Laboratory and will take approximately 5-10 minutes.

VO₂_{max} test: Subjects will report to the exercise testing lab for a VO₂_{max} test to assess their cardiovascular fitness level. The 15-point RPE scale (6) will be described in detail before testing and will be asked of the subject during the last 10 seconds of each 2 minute stage. A modified Astrand-Ryhming protocol using incremental increases in speed and grade will be used (8). Subjects will begin by running for two minutes at their normal training pace and 0% treadmill incline. Every two minutes thereafter the speed will stay the same and the incline will increase by 2% until the subject reaches volitional exhaustion.

Subjects will be allowed to stop if they feel comfortable running during the test. Expired gases will also be collected and analyzed to quantify the maximal oxygen uptake during the test. Subjects will be monitored by exercise physiologists who are familiar with normal and abnormal responses to exercise at all times during the test. Following test termination, subjects will walk for no less than 5 minutes at 1.7 mph and 0% grade as a cool down, or until heart rate has dropped to a safe level to terminate walking.

Laboratory Visit #2

During the second laboratory visit, subjects will first be asked to complete the Subjective Exercise Experience Scale (SEES) (13). This is a 12-item questionnaire that assesses three distinct categories of responses to exercise: positive well-being, psychological distress, and fatigue. For each of the 12 items, subjects will be asked how strongly they are experiencing that particular state on a 7-point Likert scale ranging from 1 (not at all) to 7 (very much so). This will be performed via pen and paper. Subjects will then be asked to estimate a 60 second period of time by verbally expressing a “start” and “end” when they believe that a 60 second period of time has elapsed. Subjects will not be allowed to wear a wristwatch during any of the testing sessions, and there will be no clocks in the room visible to them.

After subjects are fitted with a Polar heart rate monitor (chest strap) they will then warm up by running on a treadmill at a self-selected speed for five minutes. After this initial warm up they will stop briefly so that the treadmill distance can be reset. They will then be asked to run until they are told the session is over. The distance will be unknown to them, but will be calculated after the first laboratory visit based on their running history and average weekly mileage and pace known to the investigators. RPE, Feeling Scale (7), level of association/dissociation (3, 11) will all be assessed at random time points during the testing ranging from 1 to 4 minutes. The SEES will be administered when approximately 75% of the distance has been covered by the subject. Additionally, the subject will be asked to estimate a 60 second time period when 33%, 66% and 90% of the distance has been covered. At no point during the testing will they be told the cumulative distance that they have covered. When they reach the endpoint they will then be told that they have completed the trial and how far they ran.

Laboratory Visit #3

The third laboratory visit will be identical to the second visit, with the exception that subjects will be told the distance that they will run at the beginning of the session. Subjects will still, however, be blind to the speed and distance during the run. They will run the same distance as in visit #2 and will warm up for 5 minutes at the same self-selected speed as in visit #2.
b. Check all research activities that apply:

- Anesthesia (general or local) or sedation
- Audio, video, digital, or image recordings
- Biologics (e.g., sDNA, infectious agents, select agents, toxins)
- Biological sampling (other than blood)
- Blood drawing
- Coordinating Center
- Data: not publicly available
- Data: publicly available
- Data repositories → Complete Appendix C
  (future unspecified use, including research databases)
- Deception → Complete Appendix D & Appendix M1
- Devices → Complete Appendix F
- Diet, exercise, or sleep modifications
- Drugs or biologics → Complete Appendix F
- Emergency research
- Focus groups
- Food supplements
- Geno transfer
- Genetic testing → Complete Appendix C
- Internet or e-mail data collection
- Magnetic Resonance Imaging (MRI)
- Materials that may be considered sensitive, offensive, threatening, or degrading
- Non-invasive medical procedures (e.g., EKG, Doppler)
- Observation of participants (including field notes)
- Oral history (does not include medical history)
- Placebo
- Pregnancy testing
- Program Protocol (Umbrella Protocol)
- Radiation (e.g., CT or DEXA scans, X-rays, nuclear medicine procedures) → Complete Appendix V
- Randomization
- Record review (which may include PHI)
- Specimen research
- Stem cell research
- Storage of biological materials → Complete Appendix H
  (future unspecified use, including repositories)
- Surgical procedures (including biopsies)
- Surveys, questionnaires, or interviews (one-on-one)
- Surveys, questionnaires, or interviews (group)
- Other
  Specify:

18. DURATION

Estimate the time required from each participant, including individual interactions, total time commitment, and long-term follow-up, if any.

- VO2-max test → approximately 1.0 hour
- First testing visit → approximately 2.0 hours
- Second testing visit → approximately 2.0 hours
- Total time commitment for participation in the study → three visits totaling approximately 3 hours

19. NUMBER OF PARTICIPANTS

The number of participants is defined as the number of individuals who agree to participate (i.e., those who provide consent or whose records are accessed, etc.) even if all do not prove eligible or complete the study. The total number of research participants may be increased only with prior IRB approval.

a. Provide the total number of participants (or number of participant records, specimen, etc.) for whom you are seeking OSUIRB approval. 25

b. Explain how this number was derived (e.g., statistical rationale, attrition rate, etc.).
Using an alpha value of $p < 0.05$ and a power of 80%, for the primary aim, we estimate a meaningful difference in RPE of approximately one point with a standard deviation of 1.6 points based on published research and pilot work. This yields a sample size of 30 subjects. Assuming a 20% attrition rate, 35 subjects will be enrolled.

c. Is this a multi-site study?  
   ☐ Yes  ☐ No  
   Indicate the total number of participants to be enrolled across all sites:  
   ____________________

39. PARTICIPANT POPULATION

a. Specify the age(s) of the individuals who may participate in the research:
   Age(s): 18-50

b. Specify the participant population(s). Check all that apply:
   ☐ Adults  ☐ Pregnant women/ferusus → Complete Appendix A
   ☐ Children (< 18 years) → Complete Appendix J
   ☐ Adults with decisional impairment → Complete Appendix W
   ☐ Non-English speaking → Complete Appendix L
   ☐ Student research pools (e.g., psychology, linguistics) → Complete Appendix J
   ☒ Unknown (e.g., secondary use of data/specimen, non-targeted surveys, program protocols)
   Specify: ____________________

c. Describe the characteristics of the proposed participants, and explain how the nature of the research requires/justifies their inclusion.

Subjects included in this study are healthy individuals who currently run recreationally and do not have multiple risk factors. This study involves maximal exercise. In order to test subjects without a physician present, and to reduce the potential for adverse events, subjects must fall under the cardiovascular risk stratification category of "low risk" as set forth by the American College of Sports Medicine. To be categorized as "low risk", subjects must be men <45 years of age (or women under 55 years of age), symptom free of cardiovascular, pulmonary or metabolic disease, and have no more than one risk factor for cardiovascular disease (1). However, all males subjects in this particular study must be under the age of 45 and all females must be under the age of 50. A self-administered questionnaire that includes all necessary questions (i.e., the current History and Physical History questionnaires) is a sufficient step for initial risk stratification and as an alert for those with an elevated risk. Despite subjects' low risk classification, complications can occur. CPR (Cardio Pulmonary Resuscitation) and AED (Automated External Defibrillator) certified personnel are on hand, as well as an AED and phone for dialing 911.

d. Will any participants be excluded based on age, gender, race/ethnicity, pregnancy status, language, education, or financial status?  
   ☐ Yes  ☐ No
   
   If Yes → Explain the criteria and reason(s) for each exclusion. Consider the study’s scientific or scholarly aims and risks.
   - Under 18 or over 60 years of age: The lower age limit was set because the study will be focused on adult subjects, and not children. The upper limit was set to keep the ACSM risk stratification to “low risk”.
   - Run less than 10 miles per week for the last year, or have run less than one year total. We want to include only subjects that have run consistently for the last year, and those that have run at least 10 miles per week consistently. The study population is “novice” and if they do not meet these relatively minimal requirements then they do not fit the particular population of subjects.
   - Stratified by the American College of Sports Medicine as “moderate risk” or “high risk”. A physician will not be present to monitor the testing, so we will only be testing subjects that are classified as “low risk”.
   - Women who are pregnant: Maximal exercise is fairly unsafe for pregnant women, and it is for this reason that we would like to exclude them from this study.
   - Participants with language barriers: A translator will not be available for this study, so if these are any potential subjects
that cannot speak English they will be excluded from the study.

21. PARTICIPANT IDENTIFICATION, RECRUITMENT, & SELECTION

a. Provide evidence that you will be able to recruit the necessary number of participants to complete the study.

Due to the relatively low number of needed subjects and the close relationship our department, Health and Exercise Science, shares with the local fitness community, we believe flyers distributed to facilities that train aerobic athletes and stores that cater to runners, social media, and word of mouth will provide an ample subject population from which to draw from.

b. Describe how potential participants will be identified (e.g., advertising, individuals known to investigator, record review, etc.). Explain how investigator(s) will gain access to this population, as applicable.

Advertising through social media, posting of flyers on campus and in the community, word of mouth, and recruitment at running-related events and races.

c. List the name(s) of investigator(s) and/or key personnel who will recruit participants.

Recruitment will be via printed advertising distributed by co-investigators and key personnel. Subject questionnaires will be screened for eligibility by one of the co-investigators (Nicholas Hansen or Janet Buckworth).

d. Describe the process that will be used to determine participant eligibility.

The eligibility of the participants will be determined by the completion of the questionnaire that will be filled out by potential subjects. If potential subjects do not meet the inclusion criteria listed they will be told as such.

e. Describe the recruitment process, including the setting in which recruitment will take place. Provide copies of proposed recruitment materials (e.g., ads, flyers, website postings, recruitment letters, and oral/written script).

Summary in as follows:
- Advertisements are placed or posted
- Potential subjects respond by phone or email
- Potential subjects are contacted by the same method of contact used by the potential subject to ask for information (phone or email); possible subjects will be sent a consent form in PDF format + a questionnaire, the contact will be done by the co-investigator (Nicholas Hansen or Janet Buckworth)
- If still interested, potential subjects will send back the completed questionnaire and the answers are evaluated
157

The Ohio State University Institutional Review Board - INITIAL REVIEW OF HUMAN SUBJECTS RESEARCH

- Some potential subjects are ruled ineligible and notified by the co-investigators (Nicholas Hanson or Janet Backworth).
- Others are ruled eligible, and are given some time to examine the research site (Nicholas Hanson or Janet Backworth).

Potential subjects will respond to the advertisement by phone to a voice mail number or by email. They will then be contacted back by the same mechanism which they used to make contact. The email addresses will be that of the co-investigators (Nicholas Hanson and Janet Backworth). Potential subjects will be sent a consent form and questionnaire. If the first contact is by email, these documents will be sent with the initial return email. If the initial contact is by phone, then the form will be sent by either email or postal mail (subject preference). After that, it is up to the subject to resume communication with study personnel to make a commitment, and then report to the research site to sign the consent form and commence participation.

f. Explain how the process respects potential participants’ privacy.

The privacy of each subject, whether they meet the inclusion criteria or not, is important. The potential subjects are only screened by two individuals, and contact will be made in direct telephone conversation or through email. If the questionnaire is not returned, no further contact will be made. For each subject, as well as for subjects ruled ineligible, all email correspondence will be deleted.

22. INCENTIVES TO PARTICIPATE

Will participants receive compensation or other incentives (e.g., free services, cash payments, gift certificates, parking, classroom credit, travel reimbursement) to participate in the research study? Compensation plans should be pro-rated (not contingent upon study completion) and should consider participant withdrawals, as applicable.

If Yes - Describe the incentive, including the amount and timing of all payments.

Paying funding, subjects will be given cash incentives of increasing amounts ($10, $20, $34) at the completion of each of the three testing sessions to total $64.

23. ALTERNATIVES TO STUDY PARTICIPATION

Other than choosing not to participate, list any specific alternatives, including available procedures or treatments that may be advantageous to the subject.

Subjects can abstain from participating in our study and make a decision based on current literature on whether or not to continue their current training program.

24. INFORMED CONSENT PROCESS

Indicate the consent process(es) and document(s) to be used in the study. Check all that apply. Provide copies of documents and/or complete relevant appendices, as needed. See Consent for Research for templates, OSU HRPP policies Informed Consent Process and the Elements of Informed Consent, Documentation of the Informed Consent Process, and Assent and Parental Permission or Consent OHRPP for more information.

- Parental Permission – Form
- Informed Consent – Form
- Informed Consent – Verbal Script
- Waiver of Alteration of Consent Process

b. List the names of investigator(s) and/or key personnel who will obtain consent from participants or their legally authorized representatives.
The Ohio State University Institutional Review Board - INITIAL REVIEW OF HUMAN SUBJECTS RESEARCH

Janet Buckworth (key personnel)
Nicholas Hanson (key personnel)

c. Who will provide consent or permission (i.e. participant, legally authorized representative, parent and/or guardian)? □ N/A

The participant will provide consent.

d. Describe the consent process. Explain when and where consent will be obtained and how subjects and/or their legally authorized representatives will be provided sufficient opportunity (e.g., waiting period, if any) to consider participation. □ N/A

A consent form will be sent to potential subject before they would decide whether they want to participate in the study. These people will be given an email and phone number where they can ask questions. Subjects that are ruled eligible and decide to participate will come to the research site to sign the consent form and to initiate participation. The co-investigators or key personnel will answer any questions about the study and their participation. After this additional chance to ask questions in person, the subject will sign a consent form at the research site before any testing is initiated.

e. Explain how the possibility of coercion or undue influence will be minimized in the consent process. □ N/A

Potential subjects initiate contact in response to an advertisement. After that, they are sent a consent form and an eligibility questionnaire. They will not be contacted further if they express a disinterest or do not return the questionnaire. If a potential subject does return the eligibility questionnaire, and is ruled eligible, they will be contacted with times to come to the research site. If messages about those times are given to the potential subject by email or left on answering machine/voice mail, and no response is given back, one follow up will be done. If again, no response is given, no further contact will be initiated with the potential subject.

f. Will any other tools (e.g., quizzes, visual aids, information sheets) be used during the consent process to assist participant comprehension? □ Yes → Provide copies of these tools

 ☒ No

g. Will any other consent forms be used (e.g., for clinical procedures such as MRI, surgery, etc. and/or consent forms from other institutions)? □ Yes → Provide copies of these forms

 ☒ No

25. PRIVACY OF PARTICIPANTS

a. Describe the provisions to protect the privacy interests of the participants. Consider the circumstances and nature of information to be obtained, along with factors (e.g., age, gender, ethnicity, education level, etc.) that may influence participants' expectations of privacy.

Names, ages and general information gathered from eligibility questionnaires, as well as data gathered in the study, will not be released to anyone who is not working on the study including other participants. Any communications made by email will be to an individual person or by blind carbon copy (BCC). Also, for anyone who is ruled ineligible, or who never initiates participation after an initial inquiry, records of names, correspondence information, and eligibility questionnaires will be destroyed at the time the person is dropped from further study consideration. Questionnaires for participants will be kept in a locked closet or file cabinet until 5 years after the study is completed, after which they will be destroyed. Data from the study will be published without subject names and only as treatment group means and statistics.

b. Does the research require access to personally identifiable private information? □ Yes

 ☒ No
26. CONFIDENTIALITY OF DATA

a. Explain how information is handled, including storage, security measures (as necessary), and who will have access to the information. Include both electronic and hard copy records.

Electronic data will be stored on a password protected university computer. Questionnaires for participants will be kept in a locked closet or file cabinet until 5 years after the study is completed. Data will be gathered by subject number. A key linking subject number to name will be kept by the PI on an OSU password accessed computer. These files will be deleted at study completion. Data from the study will be published without subject names and only as group means and deviations.

b. Explain if any personal or sensitive information that could be potentially damaging to participants (e.g., relating to illegal behavior, alcohol or drug use, sexual attitudes, mental health, etc.) will be collected. □ N/A

c. Will you be obtaining an NIH Certificate of Confidentiality? □ Yes □ Provide a copy before you begin the research □ No

See OSU HRP policy Privacy and Confidentiality for more information.

d. Explain any circumstances (ethical or legal) where it would be necessary to break confidentiality. □ N/A

e. Indicate what will happen to identifiable data at the end of the study. Research-related records should be retained for a period of at least three years after the research has been discontinued (i.e., no further data collection, long term follow-up, re-conact or analysis of identifiable/coded data.) □ Identifiers permanently removed from the data and destroyed (de-identified)

□ Identifiers/coded (linked) data are retained

□ Identifiable data not collected

27. HIPAA RESEARCH AUTHORIZATION

Will individually identifiable Protected Health Information (PHI) subject to the HIPAA Privacy Rule requirements be accessed, used, or disclosed in the research study?

□ No

□ Yes → Check all that apply:

□ Written Authorization → Provide a copy of the Authorization Form

□ Partial Waiver (recruitment purposes only) → Complete Appendix N

□ Full Waiver (entire research study) → Complete Appendix N

□ Alteration (written documentation) → Complete Appendix N

28. REASONABLY ANTICIPATED BENEFITS

a. List the potential benefits that participants may expect as a result of this research study. State if there are no direct benefits to individual participants. Compensation is not to be considered a benefit.
All subjects will receive a VO2max test as part of the study protocol. This is a beneficial test to the subject because it allows them to quantify their cardiorespiratory fitness.

b. List the potential benefits that society and/or others may expect as a result of this research study.

Self-pacing is important to study because many people choose to run outdoors and constantly adjust their pace. Information about the psychophysiological responses to an unknown endpoint can be useful to runners and coaches. No defined endpoint could also have implications for perception of time, level of perceived exertion and enjoyment. Perceived lack of time is one of the most common reasons for not exercising. Further knowledge of the perception of time (before, during and after exercise) could help to illuminate how time perception is related to psychophysiological responses to exercise, which have been shown to influence exercise adherence. For example, a sense that time is passing more slowly during exercise could be associated with lower levels of enjoyment and a reduced likelihood that exercise would be repeated and could contribute to a belief that exercise takes too much time.

29. RISKS, HAZARDS, & DISCOMFORTS

a. Describe all reasonably expected risks, harms, and/or discomforts that may apply to the research. Discuss severity and likelihood of occurrence. As applicable, include potential risks to an embryo or fetus if a woman is or may become pregnant. Consider the range of risks, including physical, psychological, social, legal, and economic.

Risk of breach of confidentiality: No major confidential information is requested.
Risk of accidental discovery: No risk since none of the project measures have direct diagnostic or predictive value for any specific disease.
Risk of exercise testing: Muscle soreness, muscle strains and tears, accidental injury, and a possible cardiovascular injury event (unlikely for subject age and health status). Most of the exercise risks are already occurring in the subjects since they are exercising apart from the research participation. Risks associated with maximal exercise are minimal in a population of low-risk subjects. The American College of Sports Medicine suggests that it is not necessary for persons stratified as Low Risk to receive medical clearance for exercise or it is necessary for a physician to be present in this type of testing. Low risk individuals have a 1 in 10,000 chance of abnormal heart beats or heart attack as well as a 1 in 10,000 chance of sudden cardiac death. Risk stratification can be done satisfactorily using the Self-Report Health and Running History questionnaire as it follows the guidelines set forth by ACSM.

b. Describe how risks, harms, and/or discomforts will be minimized. If testing will be performed to identify individuals who may be at increased risk (e.g., pregnant women, individuals with HIV/AIDS, depressive disorders, etc.), address timing and method of testing; include how positive test results will be handled.

There is a slight risk of injury during exercise testing, but this will be minimized from having healthy participants as subjects, through proper explanation of the test beforehand, and trained personnel administering the test. Exercise does not provoke cardiac events in individuals with normal cardiovascular systems, only in those with pre-existing heart disease (1). Low risk stratification of subjects greatly decreases the likelihood that they have pre-existing heart disease and allows maximal testing without a physician or further medical clearance. The test will be monitored by at least one laboratory personnel, who is familiar with the emergency procedures and is CPR (cardiopulmonary resuscitation) and AED (automated external defibrillator) certified. Should subjects suffer from a cardiac related event an AED will be available if needed. A phone will be on hand for dialing 911 in case of any emergency.

30. MONITORING

Does the research involve greater than minimal risk (i.e., are the harm or discomforts described in Question 29 beyond what is ordinarily encountered in daily life or during the performance of non-invasive physical or psychological tests)?

☐ Yes
☐ No

If Yes → Describe the plan to oversee and monitor data collected to ensure participant safety and data integrity. Include the following:

- The information that will be evaluated (e.g., incidence and severity of actual harm compared to that expected);
• Who will perform the monitoring (e.g., investigator, sponsor, or independent monitoring committee);
• Timing of monitoring (e.g., at specific points in time, after a specific number of participants have been enrolled), and
• Decisions to be made as a result of the monitoring process (e.g., provisions to stop the study early for unanticipated problems).

31. ASSESSMENT OF RISKS & BENEFITS
Discuss how risks to participants are reasonable when compared to the anticipated benefits to participants (if any) and the importance of the knowledge that may reasonably be expected to result.

The risks are very minimal. In these athletic populations, subjects routinely perform exercise at or above levels we employ without any trained medical supervision. So, in addition to the benefit of free exercise testing, which will aid in their training programs, they will receive supervision not normally present in testing, which parallels the training they participate in daily. The knowledge gained regarding cardiorespiratory fitness from a VO2max test is substantial and will greatly aid the subjects in planning their running programs.

32. PARTICIPANT COSTS/REIMBURSEMENTS
a. List any potential costs participants (or their insurers) will incur as a result of study participation (e.g., parking, study drugs, diagnostic tests, etc.).

Most subjects will likely be OSU students, faculty, or staff who will walk to the research site. However, if they are not part of the OSU community, they may incur a small cost to park in an OSU garage for the duration of each test.

b. List any costs to participants that will be covered by the research study.

None.
33. APPLICATION CONTENTS

Indicate the documents being submitted for this research project. Check all appropriate boxes.

☒ Initial Review of Human Subjects Research Application
☒ Appendix A1: OSU Co-Investigators & Key Personnel (questions 4 & 5)
☐ Appendix A2: External (non-OSU) Co-Investigators & Key Personnel (question 6)
☒ Appendix B: Expedited Review – Initial Review (question 13)
☐ Appendix C: Data Repositories (question 17b)
☐ Appendix D: Deception (question 17b)
☐ Appendix E: Devices (question 17b)
☐ Appendix F: Drugs or Biologics (question 17b)
☐ Appendix G: Genetic Testing (question 17b)
☐ Appendix H: Storage of Biological Materials (question 17b)
☐ Appendix I: Children (question 20b)
☐ Appendix J: Non-English Speaking Participants (questions 20b and 24a)
☐ Appendix K: Pregnant Women/Infants/Neonates (question 20b)
☐ Appendix L: Prisoners (question 20b)
☐ Appendix M1: Waiver or Alteration of Consent Process (questions 17b & 24a)
☐ Appendix M2: Waiver of Consent Documentation (question 24a)
☐ Appendix N: Waiver or Alteration of HIPAA Research Authorization (question 27)
☐ Appendix U: Research in International Settings (question 12)
☐ Appendix V: Radiation (question 17b)
☐ Appendix W: Adults with Decisional Impairment (question 20b)
☒ Consent Form(s), Assent Form(s), Permission Form(s), and Verbal Spino(s), including translated documents (question 24a)
☒ HIPAA Research Authorization Form(s) (question 27)
☒ Data Collection Form(s) (question 17a)
☒ Data Collection Form(s) involving protected health information (Appendix N)
☒ Recruitment Materials (e.g., ads, flyers, telephone or other oral script, radio/TV scripts, internet solicitations) (question 21d)
☐ Script(s) or Information Sheet(s), including Debriefing Materials (question 24)
☒ Instruments (e.g., questionnaires or surveys to be completed by participants) (question 17b)
☐ Other Committee Approvals/Letters of Support (questions 11 & 12)
☒ Research Protocol
☒ Complete Grant Application or Funding Proposal
☒ Drug Manufacturer’s Approved Labeling/Investigator’s Drug Brochure (Appendix F)
☒ Device Manufacturer’s Approved Labelling (Appendix E)
☐ Other supporting documentation and/or materials
For Multi-Site Clinical Trials supported by DHHS, the submission will also include:
☐ DHHS-approved Sample Informed Consent Document (if one exists)
☐ DHHS-approved Protocol (if one exists)
The Ohio State University Institutional Review Board - INITIAL REVIEW OF HUMAN SUBJECTS RESEARCH

PRINCIPAL INVESTIGATOR (or Advisor)

I agree to follow all applicable policies and procedures of The Ohio State University and federal, state, and local laws and guidance regarding the protection of human subjects in research, as well as professional practice standards and generally accepted good research practice guidelines for investigators, including, but not limited to, the following:

- Perform the research as approved by the IRB under the direction of the Principal Investigator (or Advisor) by appropriately trained and qualified personnel with adequate resources;
- Initiate the research after written notification of IRB approval has been received;
- Obtain and document (unless waived) informed consent and HIPAA research authorization from human subjects (or their legally authorized representative) prior to their involvement in the research using the currently IRB-approved consent form(s) and process;
- Promptly report to the IRB events that may represent unanticipated problems involving risks to subjects or others;
- Provide significant new findings that may relate to the subjects willingness to continue to participate;
- Inform the IRB of any proposed changes in the research or informed consent process before changes are implemented, and agree that no changes will be made until approved by the OSU IRB except where necessary to eliminate apparent immediate hazards to participants;
- Complete and submit a Continuing Review of Human Subjects Research application before the deadline for review at intervals determined by the IRB to be appropriate to the degree of risk (but not less than once per year) to avoid expiration of IRB approval and cessation of all research activities;
- Maintain research-related records (and source documents) in a manner that documents the validity of the research and integrity of the data collected, while protecting the confidentiality of the data and privacy of participants;
- Retain research-related records for audit for a period of at least three years after the research has ended (or longer, according to sponsor or publication requirements) even if I leave the University;
- Contact the Office of Responsible Research Practices for assistance in amending (to request a change in Principal Investigator) or terminating the research if I leave the University or am unavailable to conduct or supervise the research personally (e.g., sabbatical or extended leave);
- Provide a final study report to the IRB when all research activities have ended (including data analysis with individually identifiable or coded private information); and
- Inform all Co-Investigators, research staff, employees, and students assisting in the conduct of the research of their obligations in meeting the above commitments.

I certify that the information provided in the Initial Review of Human Subjects Research application is accurate and complete.

Signature of Principal Investigator (or Advisor)  Date

Printed name of Principal Investigator (or Advisor)

DEPARTMENT CHAIR (or Signatory Official)

As Department Chair (or Signatory Official) for the Principal Investigator, I acknowledge that this research is in keeping with the standards set by our unit and that it has met all Departmental/College requirements for review.

If the PI or any Co-Investigator is also the Department Chair, the signature of the Dean or other appropriate Signatory Official, such as the Associate Dean for Research, must be obtained.

Signature of Department Chair  Date

Printed name of Department Chair
References

Appendix E

Institutional Review Board Application:

Research Protocol
Research Protocol
The effects of self-paced exercise with and without a known endpoint on teleoanticipation and psychophysiological variables

Objectives

Both competitive and recreational athletic events generally have a beginning and endpoint, whether it is based on distance or on time. Teleoanticipation is the concept that humans pace themselves according to the amount of time left in an athletic event, in an attempt to regulate their metabolic reserves and prevent system failure. If a participant did not know the endpoint in an event, pacing could be greatly affected. No defined endpoint could also have implications for perception of time, level of perceived exertion and enjoyment, as well as attentional focus, and responses may be different as a function of personality. Additionally, perceived lack of time is one of the most common reasons people give for not exercising. Further knowledge of the perception of time (before, during and after exercise) could help to illuminate how time perception is related to psychophysiological responses to exercise, which have been shown to influence exercise adherence (Buckworth & Dishman, 2002; Dishman, 1994; Ekkekakis & Lind, 2005). For example, a sense that time is passing more slowly during exercise could be associated with low levels of enjoyment and a reduced likelihood that exercise would be repeated, but also that exercise takes too much time.

The primary aim of this study is to investigate the effects of a bout of exercise with and without a known endpoint on perceived exertion and psychophysiological variables. A secondary aim is to investigate the perception of time before, during and after exercise with and without a known endpoint. A tertiary aim is to determine if personality affects the relationship between the variables tested.

Background and Rationale

Hans Ulmer originally coined the term “teleoanticipation”, based on work that he performed on various types of athletes (Ulmer, 1996). In his studies he used the Rating
of Perceived Exertion (RPE) scale as an index of overall effort or exertion (Borg, 1982). He asked his subjects to maintain certain RPE levels, and allowed them to adjust their pace accordingly. He concluded that there is likely a “regulation center” in the brain that performs very precise calculations about metabolic reserves and rates, as well as the time and effort needed to finish the bout of exercise at a given intensity. Baden et al. studied energy expended and perceptions of effort during exercise with an unknown endpoint (Baden et al., 2005). Their subjects were asked to run for 10 minutes in one condition and 20 minutes in another. In the third condition, they were not told the amount of time they would run, and were stopped at 20 minutes. The treadmill speed was relative to each subject and that same speed was used for all three trials. The subjects overall had lower oxygen consumption in the unknown endpoint condition. This showed that although the subjects were experiencing similar levels of exertion and running at the same speed, they were actually running more economically when the endpoint was unknown.

Coquart et al. asked subjects to run at 90% of their maximal aerobic velocity with an unknown endpoint (until exhaustion) (Coquart & Garcin, 2008). They were then asked to run at that same pace for two more sessions, the same distance that was reached and for the same amount of time. They found that the subjects’ RPE was higher when the endpoint was known even though they were running at the same speed and their heart rate overall was slightly lower, showing that perceived exertion is affected by knowledge of an endpoint.

No studies to date have investigated the effect of running with an unknown endpoint when the pacing is variable. Self-pacing is important to study because many people choose to run outdoors and constantly adjust their pace. In addition, we plan to assess additional variables such as perception of time, personality, affect, association/disassociation, and heart rate response that have not been investigated together under these conditions. Differences in perception of time have been related to psychological and situational variables, but these relationships have not been studied in respect to exercise, especially during a session in which the endpoint is unknown to the participant.
Procedures

Research Design

To test our research hypotheses we are using a cross-sectional experimental design, using both physiological (metabolic cart, heart rate monitoring, pacing) and psychological (surveys and single-item scales) testing equipment to assess study variables.

Sample

Based on power calculations using differences in RPE of 1.6 SD reported in studies with known and unknown endpoints and assuming a 20% drop out, 25 male and female runners will be recruited. To be eligible, volunteers must be at least 18 and no older than 50 years, have been running at least 10 miles per week for the last year, and stratified by the American College of Sports Medicine guidelines as “low risk”.

Measurement / Instrumentation

Big Five Inventory (BFI): This is a 44-item questionnaire used to measure personality in five dimensions (extroversion, neuroticism, openness, agreeableness and conscientiousness) (John, Robins, & Pervin, 2008). Subjects respond to statements about themselves using a five point Likert scale ranging from 1 “strongly disagree” to 5 “strongly disagree”.

Subjective Exercise Experience Scale (SEES): This is a 12-item questionnaire that assesses three distinct categories of responses to exercise: positive well-being, psychological distress and fatigue (McAuley & Courneya, 1994). Subjects will be asked to rate how strongly they are experiencing that particular state on a 7 point Likert scale ranging from 1 (not at all) to 7 (very much so).

Feeling Scale (FS): This scale was developed to assess fluctuations in mood across time and determine when and if exercise is pleasurable or unpleasant to individuals (Hardy & Rejeski, 1989). The FS is a single-item measure with responses being given along an eleven point scale ranging from +5 (very good) to -5 (very bad) with zero as a neutral midpoint.

Attentional Focus (Associative/Dissociative Thoughts): This is a bipolar line with “associative” at one end and “dissociative” at the other. Subjects are asked to mark an “X” on the line corresponding with their level of association (thoughts directed at bodily
symptoms) or dissociation (external thoughts that are distracting from exercise) (Baden et al., 2004; Lima-Silva et al., 2012).

**Rating of Perceived Exertion (RPE):** This is a 15 point scale used to assess perceived exertion, and ranges from 6 to 20 with verbal anchors such as “very light,” “somewhat hard” and “very hard” (Borg, 1982).

**Time Estimation:** Subjects will be asked to estimate time duration by verbally expressing a “start” and “end” when they believe that a 60 second period of time has elapsed. The actual time passed will be recorded and compared to the estimated time.

**Detailed study procedures**

**Laboratory Visit #1**
After completing the BFI on a desktop computer, the subject will report to the exercise testing lab for a VO2max test to assess their cardiorespiratory fitness level. The 15-point RPE scale will be described in detail before testing and the subject will report RPE during the last 30 seconds of each 2 minutes stage (Borg, 1982). A modified Astrand-Saltin protocol using incremental increases in speed and grade will be used (Hawkins et al., 2007). The subject will begin by running for two minutes at his or her normal training pace and 0% grade. Every two minutes thereafter the speed will stay the same and the grade will increase by 2% until they reach volitional exhaustion.

**Laboratory Visit #2**
During the second laboratory visit the subject will first be asked to complete the SEES and perform a time estimation. After the subject is fitted with a Polar heart rate monitor (chest strap) they will then warm up by running on a treadmill at a self-selected speed for five minutes. After this initial warm up they will stop briefly so that the treadmill distance can be zeroed. The subject will then be asked to run for an unspecified distance, which will be calculated after the first laboratory visit based on their running history and the average distance that they run daily. RPE, FS, level of association/dissociation will all be assessed at random time points during the testing ranging from 1 to 4 minutes apart. The subject will be asked at some point in the testing to verbally complete the SEES. Additionally, the subject will be asked to estimate a 60 second time period when 33%, 66% and 90% of the distance has been covered. At no point during the testing will the subject be told the cumulative distance. When they reach the endpoint they will be then be told that they have completed the trial. After walking on the treadmill to cool down, the subject will be asked to perform a final time estimation and SEES.

**Laboratory Visit #3**
Randomization to treatment order is not possible because the subject must be unaware of the distance that they will complete in the first experimental trial (visit #2). Therefore, the third laboratory visit will be identical to the second visit, with the exception that the subject will be aware of the distance that they will be asked to run. They will still,
however, be blind to the elapsed speed and distance during the course of the run. They will be asked to complete the same distance as in visit #2 and will warm up for 5 minutes at the same self-selected speed as in visit #2. The three laboratory visits will be a minimum of 48 hours apart, to allow for proper rest and recovery from the prior visit. After the third visit, the subject will be verbally given their physical times and told how they score on the five dimensions of personality.

**Internal Validity**

With this study, it is not possible to randomize the order that the subjects receive treatment. They must be unaware of the distance that they will be running in the first visit and will be aware (but still blind to) distance in the second visit. There will be no control group in this study, and all of the subjects will be runners but with varying levels of experience. Appropriate steps will be taken to ensure that experimenter bias is limited. In this study, however, a double blind study protocol is not possible.

**Data Analysis**

All quantitative data that is interval or ratio level will be presented as means (M) and standard deviations (SD). All categorical variables will be presented as frequencies and percentages. **Primary/Secondary aims:** Repeated measures ANOVA will be used to determine differences between conditions and post-hoc comparisons will be used to compare the “unknown endpoint” condition to the “known endpoint” condition on SEES, RPE, FS, attentional focus and time estimation. **Tertiary aim:** Multiple regression will be the primary statistical analysis technique that will be used to answer this specific aim. This will permit the running experience and fitness levels of subjects to be continuous, rather than categorical, variables. It will also allow us to investigate the effects of certain variables while controlling for the effects of others.


James, W. (1890). The principles of psychology, Vol I.


Noakes, T.D. (2012a). Fatigue is a brain-derived emotion that regulates the exercise behavior to ensure the protection of whole body homeostasis. *Frontiers in Physiology, 3*.


Appendix F

Informed Consent
The Ohio State University Consent to Participate in Research

Study Title:
The effects of self-paced exercise with and without a known endpoint on teleoanticipation and psychophysiological variables

Principal Investigator:
Janet Buckworth, Ph.D.

Sponsor:

- This is a consent form for research participation. It contains important information about this study and what to expect if you decide to participate. Please consider the information carefully. Feel free to discuss the study with your friends and family and to ask questions before making your decision whether or not to participate.

- Your participation is voluntary. You may refuse to participate in this study. If you decide to take part in the study, you may leave the study at any time. No matter what decision you make, there will be no penalty to you and you will not lose any of your usual benefits. Your decision will not affect your future relationship with The Ohio State University. If you are a student or employee at Ohio State, your decision will not affect your grades or employment status.

- You may or may not benefit as a result of participating in this study. Also, as explained below, your participation may result in unintended or harmful effects for you that may be minor or may be serious depending on the nature of the research.

- You will be provided with any new information that develops during the study that may affect your decision whether or not to continue to participate. If you decide to participate, you will be asked to sign this form and will receive a copy of the form. You are being asked to consider participating in this study for the reasons explained below.
1. Why is this study being done?

The purpose of this study is to learn more about psychological and physical responses to self-paced running when you do and when you don’t know ahead of time exactly how far you will run. Healthy adult runners often run outside and set their own pace, and understanding more about responses before, during, and after self-paced bouts of known and unknown distances can help with coaching and designing training programs to increase enjoyment and maintenance of regular running.

You are an apparently healthy adult within the ages of 18-50 who runs regularly (at least 10 miles per week for the last year). You are at low risk for cardiovascular events during maximal exercise.

2. How many people will take part in this study?

If you decide to participate you will be one of 25 subjects needed to study an effect.

3. What will happen if I take part in this study?

If you decide to participate in this study you will complete a questionnaire about your endurance/running background and a questionnaire about your current and past health status. This should take 15 minutes and will be done before any testing occurs. The questions associated with your medical history are considered important factors for cardiovascular risk by the American College of Sports Medicine. Once completed, this questionnaire will provide us with all the required information necessary to assess your risk for cardiovascular problems during exercise. This questionnaire acts to assess your ability to participate in maximal exercise testing without having a physician present. Should it be determined that you are low risk according to your answers on the questionnaire, you may participate in maximal exercise without a physician and you are at minimal risk for cardiovascular events during exercise. These questionnaires further help us to determine if you qualify for this study.

Assuming you meet the criteria to participate, you will be contacted by phone or email to schedule the first testing session. You will be tested on three separate occasions (one maximal exercise test and two experimental runs), allowing 2-7 days between the first and second session and 2-7 days between the second and third session. All measurements and testing will occur in the W. Michael Sherman Laboratory of The Ohio State University Physical Activity and Educational Services (PAES) building. During all three sessions, before any testing occurs, you will be informed about the individual test protocols to clarify questions. The total required time over the three sessions is about 5
hours. No heavy exercise should be engaged in 24 hours prior to all sessions. Your normal training routine should be in place for any day not accounted for. You will receive pre-test instructions before each testing session that outlines the steps you will need to follow prior to arriving.

Visit #1

You will first be asked to complete a personality test on the laboratory computer which will take approximately 15 minutes. You will then be given 5 minutes to warm-up on the treadmill at a self-selected speed. Upon completion of the warm-up you will be allowed to stretch and will be fitted for a heart rate monitor and breathing valve. During the maximal exercise test you will breathe through a two-way breathing valve via a mouthpiece held between your lips and teeth. A clip will be placed over your nose. You will be running at various inclines on the treadmill during the test. The maximal exercise test protocol will start at a pace that you normally train at and 0% grade. The treadmill incline will increase 2% every two minutes. The test will continue until you reach fatigue. You will indicate your desire to stop the test by grabbing hold of the handle bar of the treadmill and stepping to the sides of the belt. The test will then be terminated. This procedure is standard during maximal testing and you will be reminded of it before any testing begins. Note: you may stop the test at any time you feel uncomfortable or concerned. You will be monitored at all times. Your heart rate will be monitored at all times. If we feel we need to stop the test for your safety, we may stop the test. The total time for the first visit is about 1 hour.

Visit #2

Upon arrival for the second visit you will be asked to estimate a 60 second period of time and complete a short survey. You will then be allowed to warm up for five minutes on a laboratory treadmill at a self-selected pace. After the warm-up you will be asked to run on the laboratory treadmill for an unspecified distance, but one that we will have calculated based on your training history and will not be longer than 90 minutes in duration. The unspecified distance will not be greater than the longest single day run that you reported in your Health and Running History questionnaire. At random time points throughout the testing you will be asked how you are feeling on two different scales, one that measures perceived exertion and another that measures positive feelings. At various time points you will also be asked about the types of thoughts you are experiencing and will be asked to estimate multiple 60 second periods of time. Throughout the test you will not be able to see the speed that the treadmill is set at, or the distance that you have travelled. You will, however, be allowed to increase or decrease the speed as you like.
When you have reached the endpoint that is determined prior to the test you will be notified and will be allowed to step off of the treadmill or slow to a walk.

Visit #3

The third visit will be identical to the second visit with the exception that you will be told before you begin the distance you will be asked to run. You will not be able to see the current distance you have covered or the speed at which you are running.

4. **How long will I be in the study?**

If you decide to participate in this study you will come to the testing lab in the PAES building for 3 nonconsecutive days of testing. The first session will take ~1 hour to complete. You will return in 2-7 days for the second day of testing. The second session will take ~2 hours to complete. You will return in 2-7 days for the third day of testing. The third session will take ~2 hours to complete. All together you will spend approximately 5 hours testing over 5-15 days. In the unlikely event of technical difficulty with instrumentation or collection of data or illness, retesting may be necessary. If you choose to retest, your total time commitment will increase. You may leave the study at any time. If you decide to stop participating in the study, there will be no penalty to you, and you will not lose any benefits to which you are otherwise entitled. Your decision will not affect your future relationship with The Ohio State University.

5. **Can I stop being in the study?**

You may leave the study at any time. If you decide to stop participating in the study, there will be no penalty to you, and you will not lose any benefits to which you are otherwise entitled. Your decision will not affect your future relationship with The Ohio State University.

6. **What risks, side effects or discomforts can I expect from being in the study?**

   *If you are pregnant or you have any doubt as to whether or not you are pregnant during the course of the study, you must tell the investigator and you cannot participate in the study.* There are major risks if you are pregnant. Engaging in maximal exercise can potentially pull blood from the fetus.

   If you are not pregnant the risks associated with this study are similar to those encountered during high intensity running events in the heat. Light headedness, dizziness, chest pain and difficulty breathing are possible side effects during tests of this nature.
Your level of comfort will be continuously monitored and the test may be terminated by the researcher or by you at any point should an issue arise. There is also a small risk for abnormal heart beats and heart attack (1 in 1,666) and a very small risk of sudden cardiac death (1 in 18,000). These risks are higher during a VO2max test than during typical exercise because the intensity is high. If you qualify as a subject for this study then you have already been stratified as low risk for the aforementioned cardiovascular events using guidelines set forth by the American College of Sports Medicine. This was done through the use of the Medical Health and Running history questionnaire. During the first testing session in the VO2max test, there is also a slight risk of discomfort related to using the breathing apparatus and nose clips.

You may experience muscle stiffness and soreness after the exercise trials. Following the test, you may experience respiratory uneasiness, muscle cramping, light-headedness, and general fatigue, but you should not experience pain. Standard emergency procedures are in place in the Exercise Science laboratory. The test will be monitored by at least one laboratory personnel, who is familiar with the emergency procedures and is CPR (cardiopulmonary resuscitation) and AED (automated external defibrillator) certified. In case of a cardiac related event, an AED is available for use. A phone will be on hand for dialing 911 in case of any emergency.

7. **What benefits can I expect from being in the study?**

   By participating in this study, you will obtain information about your physical fitness: maximal oxygen consumption (maximal amount of oxygen that your muscles can consume, which is a good indicator of fitness level), maximal heart rate, and anaerobic threshold to assist in your personal training program. Additionally, you will gather some information on how you score on the five dimensions of personality (Openness, Conscientiousness, Agreeableness, Extraversion and Neuroticism).

8. **What other choices do I have if I do not take part in the study?**

    You may choose not to participate without penalty or loss of benefits to which you are otherwise entitled.

9. **Will my study-related information be kept confidential?**

    Efforts will be made to keep your study-related information confidential. However, there may be circumstances where this information must be released. For example, personal information regarding your participation in this study may be disclosed if required by state law.
Also, your records may be reviewed by the following groups (as applicable to the research):

- Office for Human Research Protections or other federal, state, or international regulatory agencies;
- U.S. Food and Drug Administration;
- The Ohio State University Institutional Review Board or Office of Responsible Research Practices;
- The sponsor supporting the study, their agents or study monitors; and
- Your insurance company (if charges are billed to insurance).

If this study is related to your medical care, your study-related information may be placed in your permanent hospital, clinic, or physician’s office records. Authorized Ohio State University staff not involved in the study may be aware that you are participating in a research study and have access to your information.

A description of this clinical trial will be available on http://www.ClinicalTrials.gov, as required by U.S. law. This website will not include information that can identify you. At most, the website will include a summary of the results. You can search the website at any time.

You may also be asked to sign a separate Health Insurance Portability and Accountability Act (HIPAA) research authorization form if the study involves the use of your protected health information.

10. What are the costs of taking part in this study?

You may incur a charge due to parking in one of The Ohio State University parking garages if you are not affiliated with The Ohio State University and do not have a parking pass. This charge is $1.50 per hour, or $5 for a weekday or weekend flat fee.

11. Will I be paid for taking part in this study?

You will not be paid to participate in this study.

12. What happens if I am injured because I took part in this study?

If you suffer an injury from participating in this study, you should notify the researcher or study doctor immediately, who will determine if you should obtain medical treatment at The Ohio State University Medical Center.

The cost for this treatment will be billed to you or your medical or hospital insurance. The Ohio State University has no funds set aside for the payment of health care expenses for this study.
13. What are my rights if I take part in this study?

If you choose to participate in the study, you may discontinue participation at any time without penalty or loss of benefits. By signing this form, you do not give up any personal legal rights you may have as a participant in this study.

You will be provided with any new information that develops during the course of the research that may affect your decision whether or not to continue participation in the study.

You may refuse to participate in this study without penalty or loss of benefits to which you are otherwise entitled.

An Institutional Review Board responsible for human subjects research at The Ohio State University reviewed this research project and found it to be acceptable, according to applicable state and federal regulations and University policies designed to protect the rights and welfare of participants in research.

14. Who can answer my questions about the study?

For questions, concerns, or complaints about the study you may contact Nicholas Hanson at 614.292.0458 or hanson.235@osu.edu or Janet Buckworth at 614.292.0757 or buckworth.1@osu.edu.

For questions about your rights as a participant in this study or to discuss other study-related concerns or complaints with someone who is not part of the research team, you may contact Ms. Sandra Meadows in the Office of Responsible Research Practices at 1-800-678-6251.

If you are injured as a result of participating in this study or for questions about a study-related injury, you may contact Janet Buckworth at 614.292.0757 or buckworth.1@osu.edu.
Signing the consent form

I have read (or someone has read to me) this form and I am aware that I am being asked to participate in a research study. I have had the opportunity to ask questions and have had them answered to my satisfaction. I voluntarily agree to participate in this study.

I am not giving up any legal rights by signing this form. I will be given a copy of this form.

Printed name of subject__________________________________________Signature of subject_____________________________________________

AM/PM

Date and time

Printed name of person authorized to consent for subject (when applicable)________________________________________Signature of person authorized to consent for subject (when applicable)____________________________________

AM/PM

Relationship to the subject________________________________________Date and time_____________________________________________
**Investigator/Research Staff**

I have explained the research to the participant or his/her representative before requesting the signature(s) above. There are no blanks in this document. A copy of this form has been given to the participant or his/her representative.

<table>
<thead>
<tr>
<th>Printed name of person obtaining consent</th>
<th>Signature of person obtaining consent</th>
</tr>
</thead>
<tbody>
<tr>
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</table>

**AM/PM**

**Date and time**

**Witness(es) - May be left blank if not required by the IRB**

<table>
<thead>
<tr>
<th>Printed name of witness</th>
<th>Signature of witness</th>
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<tbody>
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</table>

**AM/PM**

**Date and time**

<table>
<thead>
<tr>
<th>Printed name of witness</th>
<th>Signature of witness</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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</tbody>
</table>

**AM/PM**

**Date and time**
Medical Health and Running History

All information given is personal and confidential. All information will be destroyed if you choose not to participate or become ineligible. If you choose to participate, any identifiers will be removed and a code number will be used in their place. This information will enable us to better understand you and your health and fitness habits. Please answer each question to the best of your ability. Should you need clarification on any of the questions below, please contact the Co-Investigator, Nicholas Hanson, at hanson.235@osu.edu or the Principal Investigator, Janet Buckworth, at buckworth.1@osu.edu. Also, we will contact you if we need clarification on any items below.

Name________________________________________________

Date____________________

Email_____________________________

Phone ____________________________

Date of Birth____/____/_____         Sex________      Height_______ inches

Weight_______  lbs

I. Signs and Symptoms

Have you ever experienced any of the following? (Please circle Yes or No)

Yes   No   1. Pain, discomfort, tightness or numbness in the chest, neck, jaw or arms.

Yes   No   2. Shortness of breath at rest or with mild exertion.

Yes   No   3. Dizziness or fainting.

Yes   No   4. Difficult, labored, or painful breathing during the day or at night.

Yes   No   5. Ankle swelling.

Yes   No   6. Rapid pulse or heart rate.

Yes   No   7. Intermittent cramping.

Yes   No   8. Known heart murmur.

Yes   No   9. Unusual shortness of breath or fatigue with usual activities.
If you answered Yes to any of the above:
How often do you experience the symptom?
_________________________________________________________________
Have you ever discussed the symptom with a doctor?_______________
Explain the symptom in more
detail:____________________________________________________________
__________________________________________________________________
************************************************************************
II. Major Risk Factors
************************************************************************
<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>2.</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>3.</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>4.</td>
<td></td>
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<tr>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>5.</td>
<td></td>
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<tr>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>6.</td>
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<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>7.</td>
<td></td>
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<tr>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>8.</td>
<td></td>
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</tbody>
</table>

************************************************************************
III. Medical Diagnoses
************************************************************************
Has your doctor ever said that you have any of the following? Circle all that apply:

- Cardiac disease
- Peripheral vascular disease
- Cerebrovascular disease
- COPD
- Asthma
- Interstitial lung disease
- Cystic fibrosis
- Diabetes Mellitus Type 1
- Diabetes Mellitus Type 2
- Thyroid disorder
- Renal disease
- Liver disease

Any special problems not listed above: ________________________________________

If any of the above are circled, please give details and explain: ______________________

______________________________________________________________________________

Medications

Yes  No  Do you take any medications? If Yes, please provide information below:

______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________

Females Only

Yes  No  1. Are you pregnant?

Yes  No  2. Is there any possibility that you might be pregnant?
Running History

1. How many years have you been involved with endurance-type exercise? ________
2. How many years have you been running? ________________________________
3. What is your approximate weekly running mileage? ______________________
4. What would you say is your normal daily “go-to” running distance? ________
5. How many days per week (on average) do you spend running? ______________
6. How many hours per week (on average) do you run? _______________________
7. How long have you been running your present mileage? __________________
8. What is your estimated running pace during training? _____________________
9. What is the longest run you have completed in the last 8 weeks? ____________
10. How many years have you been racing? _________________________________
11. Frequency of Racing:

<table>
<thead>
<tr>
<th>Distance</th>
<th># in the Past Year</th>
<th># in the Past 3 Years</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 k</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 mile</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10 k</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Half-marathon</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Marathon</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

12. What is the longest race that you have completed in the last year?
   Name __________________________ Finish Time _________________

13. Have you suffered any injuries in the past six months that prevented you from
    running/training/racing?  Yes  No
    If yes, please explain: ____________________________________________
    __________________________________________________________________
14. Have you ever participated in a maximal graded exercise (VO$_{2\text{max}}$) test before?
   Yes   No

***********************************************************************

My signature certifies that all of the above is true, to the best of my knowledge.

Signature: ___________________________________________ Date: ____________

***********************************************************************
Comments:______________________________________________________________
Stratification:  Low Risk           Moderate Risk           High Risk
Date:_____________________________  Initials:____________________________

*****************************************************************
STAFF USE ONLY
*****************************************************************


Appendix H

Subjects’ Running History
<table>
<thead>
<tr>
<th>Variable</th>
<th>$M$</th>
<th>$SD$</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Years involved with endurance exercise</td>
<td>9.76</td>
<td>5.96</td>
<td>3-23</td>
</tr>
<tr>
<td>Years running</td>
<td>9.29</td>
<td>5.04</td>
<td>3.5-23</td>
</tr>
<tr>
<td>Approximate weekly running mileage</td>
<td>29.02</td>
<td>16.87</td>
<td>10-70</td>
</tr>
<tr>
<td>Normal daily “go-to” running distance</td>
<td>5.24</td>
<td>1.74</td>
<td>3-10</td>
</tr>
<tr>
<td>Days spent running per week</td>
<td>5.03</td>
<td>1.27</td>
<td>3-7</td>
</tr>
<tr>
<td>Hours spent running per week</td>
<td>4.51</td>
<td>2.24</td>
<td>1.5-8.0</td>
</tr>
<tr>
<td>Years running present mileage</td>
<td>3.01</td>
<td>2.48</td>
<td>.33-8.00</td>
</tr>
<tr>
<td>Estimated average running pace (min/mile)</td>
<td>8:03</td>
<td>1:12</td>
<td>6:30-11:00</td>
</tr>
<tr>
<td>Longest run in prior 8 weeks (miles)</td>
<td>11.49</td>
<td>7.62</td>
<td>4-31.1</td>
</tr>
<tr>
<td>Racing experience (years)</td>
<td>7.08</td>
<td>5.37</td>
<td>0-20</td>
</tr>
<tr>
<td>Number of races in last year</td>
<td>3.83</td>
<td>2.94</td>
<td>0-10</td>
</tr>
<tr>
<td>Number of races in last 3 years</td>
<td>10.78</td>
<td>11.25</td>
<td>0-44</td>
</tr>
<tr>
<td>Longest race in last year (miles)</td>
<td>17.26</td>
<td>11.23</td>
<td>0-31.1</td>
</tr>
</tbody>
</table>
Appendix I

Approval Letter from the Institutional Review Board
Biomedical Science Institutional Review Board

December 21, 2012

Protocol Number: 2012H0341
Protocol Title: THE EFFECTS OF SELF-PACED EXERCISE WITH AND WITHOUT A KNOWN ENDPOINT ON TELEOANTICIPATION AND PSYCHOPHYSIOLOGICAL VARIABLES, Janet Buckworth, Nicholas Hanson, Education/Human Ecology Development

Type of Review: Initial Review
IRB Staff Contact: Tish Denlinger
(614) 688-3330
Denlinger.33@osu.edu

Dear Dr. Buckworth,

The Biomedical Science IRB APPROVED the above referenced research.

Date of IRB Approval: December 21, 2012
Date of IRB Approval Expiration: December 21, 2013

If applicable, informed consent (and HIPAA research authorization) must be obtained from subjects or their legally authorized representative and documented prior to research involvement. The IRB-approved consent form and process must be used. Changes to the research (e.g., recruitment procedures, advertisement, enrollment numbers, etc.) or informed consent process must be approved by the IRB before they are implemented (except where necessary to eliminate apparent immediate hazards to subjects).

This approval is valid for one year from the date of IRB review when approval is granted or modifications are required. The approval will no longer be in effect on the date listed above as the IRB expiration date. A Continuing Review application must be approved within this interval to avoid suspension of IRB approval and cessation of all research activities. A final report must be provided to the IRB and all records relating to the research (including signed consent forms) must be retained and available for audit for at least 3 years after the research has ended.

It is the responsibility of all investigators and research staff to promptly report to the IRB any serious, unexpected and related adverse events and potential unanticipated problems involving risks to subjects or others.

This approval is issued under The Ohio State University’s OHRP Federally Assumed #00006578. All forms and procedures can be found on the ORSP website - www.orsp.osu.edu. Please feel free to contact the IRB staff contact listed above with any questions or concerns.

[Signature]

Katala Zadock, OD, PhD, Chair
Biomedical Science Institutional Review Board