RELATIONSHIPS AMONG EMOTION, MOTIVATION, AND EXERCISE BEHAVIOR: REGULAR EXERCISERS' AND SEDENTARY INDIVDUALS' SUBJECTIVE AND CORTICAL RESPONSE TO EXERCISE STIMULI

By

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This thesis is dedicated to my family who has helped, supported, and loved me throughout the years, and taught me the meaning of family.

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Greater than 60% of adults in the United States fail to participate in amounts of physical activity necessary for fitness gains. Despite attempts by numerous intervention studies to increase exercise adherence rates, physical inactivity trends remain constant among adults and continue to increase in youth. The experimenters presented exercise-related stimuli visually and auditorily during an fMRI scan to determine differences between regular exercisers' (RE) and sedentary individuals' (SI) responses to physical activity stimuli. Based upon Lang's biphasic theory of emotion, the researchers hypothesized that exercise stimuli elicit positive responses from regular exercisers. Conversely, exercise stimuli were expected to evoke either a negative or neutral reaction from sedentary individuals. Results provided support for differential brain activation of the ventrolateral prefrontal cortex and the cerebellum in response to exercise-related stimuli.

CHAPTER 1
INTRODUCTION

People with obesity and people who are overweight have an increased risk of developing heart disease, high blood pressure, diabetes, and some cancers (Center for Disease Control & Prevention (CDC), 2003e). Heart disease is the leading cause of death in the United States, and cancer accounted for 23% of all fatalities in 1999. Together, these two diseases annually account for more than 50% of American deaths (CDC, 2003d). Furthermore, over 132 billion dollars are spent in association (directly and indirectly) with diabetes annually. Including expenses incurred related to these and other preventable diseases, researchers estimate that the direct medical cost of physical inactivity was $76.6 billion in 2000 (CDC, 2003d). In addition, approximately 59 million adults in the United States are obese and nearly nine million (15%) young people are overweight (CDC, 2003e).

Despite the discouraging portrayal provided by these astounding figures, each can be significantly decreased by participation in regular physical activity. Physical activity is associated with numerous health-related benefits, such as decreasing the risk of developing heart disease, diabetes, colon cancer, obesity, and hypertension (CDC, Morbidity and Mortality Weekly Report, 2003c) . The Surgeon General's 1996 Report on Physical Activity and Health defined physical activity as "bodily movement that is produced by the contraction of skeletal muscle and that substantially increases energy expenditure" (United States Department of Health & Human Services (USDHHS), 1996, p. 21). Exercise, according to the report, is defined as "planned, structured, and repetitive bodily movement done to improve or maintain one or more components of physical fitness (USDHHS, 1996, p.21). Considering the health gains associated with regular physical activity, the National Center for Chronic Disease Prevention and Health Promotion recommends 30 minutes of moderate-intensity physical activity on five or more days per week (CDC, 2003a). The American College of Sports Medicine also suggests that engaging in 30 minutes of aerobic activity five days per week will promote weight loss. The benefits of engaging in regular physical activity are well-known. However, in the United States, less than 40% of the adult population engages in adequate levels of physical activity and greater than 25% fail to engage in any leisure-time physical activity (CDC, 2003b).

Given the physical inactivity epidemic, the Surgeon General of the United States, Dr. Audrey Manley, stressed the value of research, promotion, and engagement in physical activity:

> We must get serious about improving the health of the nation by affirming our commitment to healthy physical activity on all levels…Because physical activity is so directly related to preventing disease and premature death and to maintaining a high quality of life, we must accord it the same level of attention that we give other important public health practices that affect the entire nation…More work will need to be done so that we can determine the most effective ways to **motivate** [bold added] all Americans to participate in a level of physical activity that can benefit their health and well-being. (USDHHS, 1996, pp. v-vi)

The increasing rates of preventable diseases, health care costs, and sedentariness, coupled with the rising rate of childhood obesity, necessitate research regarding exercise initiation and adherence. What differentiates the subset of the population that engages in regular physical activity from those who fail to exercise? The Surgeon General suggests that increasing levels of exercise motivation will result in exercise behavior change. Dr. Manley's recommendations beg the following questions: Does motivation differentiate exercisers from sedentary individuals? What motivates individuals to exercise? What variables or circumstances are responsible for changes in levels of motivation? Does emotional perception of exercise (e.g., negative, positive, or neutral) affect motivation and behavior?

Several models and theories have been proposed to describe, explain, and predict human behavior, several with relevance to the motivation to exercise (Ajzen, 1991; Bandura, 1986; Deci & Ryan, 1985; Janz & Becker, 1984; Lang, 1985; Prochaska, DiClemente, & Norcross, 1992). Though widely applied to understanding motivated behavior in various contexts, Lang's biphasic theory of emotion has rarely been applied to understanding exercise behavior, but may hold promise in answering the questions posed above. According to the biphasic theory of emotion (Lang 1985, 2000), two motivational systems, the appetitive and aversive, coordinate organismic responses. When the appetitive motivational system is activated, then the organism approaches a behavior. Conversely, activation of the aversive motivational system results in avoidance behavior. Because emotion influences motivated attention, these organismic responses reflect the emotional experience of the organism. Lang's (1995) conceptualization of emotions as "action dispositions" enables researchers to measure emotion via three output systems: (1) emotional language, (2) behavior sequelae, and (3) physiological changes.

If emotion affects motivated attention, then differences in behavior should reflect differences in both emotion and motivation. According to Lang (1985), overt behavior (e.g., duration, intensity, and frequency of exercise) is one measure of emotion. Thus, discrepancies (between the groups) in emotion and motivated attention should correspond with distinct behavioral output. If regular exercisers and sedentary individuals vary in motivation levels, then comparing and contrasting the responses of the two groups should provide information regarding motivated behavior. If researchers establish that differences in both overt and covert indices of emotion are associated with disparities in exercise behavior, then determining the variables that cause changes in emotions associated with exercise (as measured by language, behavior, and psychophysiological responses) should facilitate exercise behavior change.

Previous Research

The increasing rates of preventable diseases and the recognition that physical activity can reduce these rates has prompted a tremendous amount of research involving exercise initiation and adherence. Recently, an entire journal issue was dedicated to research on physical activity and exercise behavior (American Journal of Preventive Medicine, SI, 2002), and the Center for Disease Control and Prevention released their inaugural issue of Preventing Chronic Disease in December of 2003. These new developments indicate the growing significance of physical activity in the United States. Researchers have adapted or conceptualized several theories and models to explain exercise behavior. Within these theories, investigators have examined the influence of factors such as attitude, perceived behavior control, subjective norm, intention, readiness to change, self-efficacy, intrinsic and extrinsic motivation, and decisional balance on physical activity behavior. Several meta-analyses have been conducted to examine the efficacy of theories of exercise behavior and the effectiveness of physical activity interventions (Hausenblas, Carron, & Mack, 1997; Marshall & Biddle, 2001).

Currently, Ajzen's (1991) Theory of Planned Behavior (TPB) and Prochaska, DiClemente, and Norcross' (1992) Transtheoretical Model have received the most attention in the exercise psychology domain. The TPB maintains that attitude, perceived behavioral control, and subjective norm affect intention to engage in behavior. Both intention and perceived behavioral control can influence behavior directly within this theory. Prochaska et al. (1992) developed the TTM to explain and predict smoking cessation. According to the TTM, stages of change, decisional balance, processes of change, self-efficacy, and temptation combine to impact human behavior. Other theories that have been implemented within exercise psychology include the Health Belief Model (Janz & Becker, 1984), Social Cognitive Theory (SCT) (Bandura, 1986), Theory of Reasoned Action (TRA) (Ajzen & Fishbein, 1980; Fishbein & Ajzen, 1975), Self-Determination Theory (SDT) (Deci & Ryan, 1985, 2000), and Ecological Model (Moos, 1980; Sallis & Owen, 1997).

Limitations

Although these theories and models provide solid frameworks from which to investigate cognitive variables associated with exercise behavior, each has its own set of unique and common limitations. First, and most important, they do not consider basic and core causal variables that influence motivation and behavior. The lack of causal mechanisms of exercise behavior change identified by these theories indicates the need for additional research within other, more easily tested, and more multifaceted research paradigms. Furthermore, the National Institutes of Health recently recognized several shortcomings of research guided by these theories.

On June 23rd, 2003, the National Institutes of Health (NIH) released a request for [grant] applications (RFA) emphasizing the need to augment knowledge concerning the development of efficacious physical activity interventions, to understand psychosocial, environmental, and physiological factors responsible for physical activity behavior change, and to determine the "causal pathways" responsible for exercise behavior change. The NIH cited numerous limitations of previous research, current models, and theories in the field of exercise psychology that necessitate additional research including the absence of: (1) an understanding of mechanisms of change, (2) a multidisciplinary perspective of the process of exercise behavior change, and (3) a comprehensive grasp of causal pathways involved in increasing physical activity participation. (National Institutes of Health (NIH), 2003). Discrepant findings within the field of exercise psychology further indicate the need for future studies. Theory-based interventions fail to identify true mechanisms of change for several reasons, namely: (1) constructs have been randomly, not systematically, selected for evaluations, (2) a priori explanations of causal pathways have not been stated, (3) multiple components of various theories have been implemented, and (4) all aspects of a theory have not been tested.

Current Study

To address the aforementioned shortcomings, the purpose of this study was to measure emotions related to exercise within Lang's theory of biphasic emotion and bio-informational theory of emotional imagery (Lang, 1985, 2000; Lang, 1979). Participants' (1) heart rate activity, (2) skin conductance response, (3) brain activity, and (4) verbal report were measured in response to 20 pictures selected from the International Affective Picture System (IAPS), 20 pictures related to running, and 12 imagery scripts to examine differences between regular exercisers and sedentary individuals with respect to exercise emotion and motivation. Participants rated the emotionality (valence, arousal, and dominance) of pictures and imagery scripts using the Self-Assessment Manikin (SAM, Lang, 1980).

Regular exercisers, in this study, are defined as individuals who (1) meet the ACSM criteria for recommended levels of exercise by running, on average, five days per week, for a minimum of 30 minutes, (2) meet the criteria for either action, maintenance, or termination stages within the TTM's stages of change, and (3) report enjoyment from running. Conversely, sedentary individuals are defined as people who (1) do not engage in any type of exercise or physical activity (2) and report a strong dislike of running.

Previous research has indicated that regular exercisers engage in exercise imagery for various reasons in multiple contexts (Hausenblas, Hall, Rodgers, & Munroe, 1999; Giacobbi, Hausenblas, Fallon, & Hall., 2003). Because mental imagery involves mental processes, it provides another medium through which to measure brain response, heart rate, and electrodermal activity associated with exercise. During an fMRI scan, participants heard the following six types of imagery scripts: erotica, pleasant, neutral, attack, contamination, and running. All participants were expected to display brain activation consistent with mental imagery during the imagery scripts. However, the researchers predict that differential brain activity should appear between groups if the scripts are associated with different emotions, in this case, as related to exercise imagery.

Statement of Problem

While theories and models of exercise behavior, such as the Theory of Planned Behavior, Transtheoretical Model, Social Cognitive Theory, and Self-Determination Theory, provide valuable insight into cognitive and environmental explanations of exercise behavior, their descriptive tenets are founded largely on self-report data. Self-report measurements are susceptible to various biases, such as the self-presentation effect and demand characteristics. Measuring motivation solely through self-report forces researchers to rely on purely subjective data, which are often biased and superficial. As such, these theoretical frameworks are limited by, among others, a failure to take into account important psychophysiological principles of emotion and motivation. Multiple methods for assessment of the mechanisms that underlie motivation, emotion, and behavior are essential for the accurate assessment of these constructs.

Another major limitation of existing exercise behavior theories and models is the long-term ineffectiveness of interventions based upon these theories. Results from studies that involved or investigated the efficacy of extant theory-based interventions provide some evidence for short-term effects and relatively little for long-term effects of the treatment/intervention (Pinto et al., 2002; Marcus et al., 1998; Dunn, Andersen, & Jakicic, 1998). Identifying the variables that elicit exercise change is necessary to change exercise behavior. The first step in examining the influence of motivation on exercise behavior is establishing that differences in motivation levels exist between regular exercisers and sedentary individuals. Subsequent steps include examining the role the emotional value of exercise on motivational levels and determining which variables affect the emotional value of exercise.

Statement of Purpose

The purpose of this study was to examine the influence of perceptions of physical activity on self-report and psychophysiological responses to exercise stimuli in a laboratory setting. Psychophysiological responses can involve measurement of both the central and peripheral nervous systems. Heart rate activity and skin conductance response were used to assess peripheral nervous system response, while the central nervous system was examined through assessment of cortical activity. If perceptions of physical activity were to have a motivational influence on exercise behavior (i.e., positive reinforcement or punishment), then changing the associated value of the reinforcer should necessitate exercise behavior change. Researchers can confirm the self-reported value of exercise by determining which motivational system (appetitive or aversive), an indication of the nature of emotion, is activated in response to exercise stimuli.

Hypotheses

Generally, we hypothesize that a motivational difference exists between regular exercisers and sedentary individuals that will be reflected in emotional responses to exercise stimuli. This motivational difference is assumed to affect an individual's decision to exercise, which, in turn, affects exercise behavior. Regular exercisers are hypothesized to have experienced positive reinforcement from running. Conversely, running is expected to have been perceived as punishing or to have lacked positive reinforcement for sedentary individuals.

Functional magnetic resonance imaging (fMRI) is used to compare the brain responses of regular exercisers and sedentary individuals. Regular exercisers are thought to perceive exercise as more rewarding, arousing, and pleasant than non-exercisers, thereby resulting in activation of the appetitive motivational system. Activation of the appetitive motivational system should theoretically motivate these individuals to seek physical activity. Exercise, or the consequences of it, may act as positive reinforcement for some individuals. Thus, the positive reinforcement of exercise may perpetuate exercise behavior.

Sedentary individuals, on the other hand, may not perceive physical activity as rewarding, arousing, or pleasant. Physical activity, or the thought of physical activity, may either activate the aversive motivational system or fail to activate either motivational system. Lacking strong positive reinforcement or experiencing punishment when engaging in or thinking of physical activity may result in the avoidance of exercise.

Within Lang's (1985) biphasic theory of emotion, hypothesized is that the exercise stimuli activate the appetitive motivational system for regular exercisers and the aversive (or fails to activate the appetitive) motivational system among non-exercisers. The neural circuits that are functionally activated, as evaluated by fMRI, are used as indicators of the motivation or lack of motivation that an individual experiences.

Areas of the brain associated with reward and punishment (e.g., orbitofrontal cortex, amygdala, and the anterior cingulate cortex) should display activation in response to exercise stimuli if the stimuli are associated with either reward or punishment (Rolls, 2000; Zald & Kim, 2000). Peripheral nervous system (PNS) responses, such as heart rate and skin conductance, should reflect the valence and arousal, respectively, of the stimuli presented. Both central and peripheral nervous system reactions should correlate with self-reported picture ratings and responses to open-ended questions. For example, if a participant rates a picture as pleasant and highly arousing, then the corresponding heart rate pattern should display a greater increase in the second peak and the associated level of electrodermal activity should increase.

Multiple explanations could account for non-significant findings between or within terminators and precontemplators. First, a failure to find differences could imply that no difference exists between regular exercisers and sedentary individuals at a psychophysiological level. Instead, the incongruity must exist exclusively at a subjective level.

An alternate explanation (and possible limitation) involves the relative strength or perceived arousal of the exercise stimuli. In previous studies, psychophysiological responses to highly arousing IAPS pictures have been significantly different for noxious stimuli, such as mutilation, threat, disgust, etc., when compared to neutral (e.g., household objects) and positive stimuli (e.g., erotica) whereas low arousing stimuli do not elicit such effects. Will participants, from either the RE or SI groups, perceive exercise stimuli as arousing as contamination, threat, or erotica? While exercise stimuli are not anticipated to be as arousing as pictures of contamination, threat, or erotica, the experimenters expect all psychophysiological responses, including brain activity, heart rate patterns, and skin conductance responses, to reflect the perceived valence of the stimuli. Within Lang's framework, a priori hypotheses concerning the expected differences follow.

Self-Reports (SAM ratings)

1. Mean SAM ratings (on valence, arousal, and dominance dimensions) for stimuli that are **not related to running** (e.g,, pictures of household objects, mutilation, threat, and erotica; positive, negative, and neutral scripts) will not differ significantly between regular exercisers (RE) and sedentary individuals (SI). For example, valence ratings of pictures of threat should not vary significantly between groups. Subjective ratings of pictures for both groups should resemble normative data collected by Lang and colleagues (Lang, Bradley, & Cuthbert, 1999).

2. Mean ratings of **running-related pictures** will differ significantly between regular exercisers and sedentary individuals on, at the very least, the valence dimension. Participants in the RE group should rate running-related pictures more positively than sedentary individuals. Pictures of elite and recreational runners should elicit more positive ratings from regular exercisers compared to sedentary individuals if they are perceived more positively on a conscious level. However, running stimuli could be equally arousing for both groups, so differences are not expected on the arousal dimension. Also, there are no directional hypotheses regarding the dominance dimension.

3. On the valence dimension of the SAM, regular exercisers should rate the **running script** significantly different than the sedentary individuals. If sedentary individuals perceive overt negative affect in response to the running-related imagery script, then they should rate the running script more negatively than regular exercisers. Moreover, SAM ratings of the running script should resemble the SAM ratings for the negative scripts within the SI group if both scripts are experienced negatively. In contrast, regular exercisers should experience positive

affect during the running-related imagery script. Thus, the RE group's mean rating of the running script should mirror the pleasant imagery script.

Psychophysiological Responses

Heart rate

1. Heart rate activity should not differ significantly between the two groups for the stimuli which are unrelated to running (IAPS pictures). For example, pictures of household objects should evoke similar heart rate patterns for both regular exercisers and sedentary individuals.

2. Heart rate patterns should differ significantly between the RE and SI groups in response to running-related stimuli:

    a. Participants in the RE group should display activation, in response to **pictures** of elite and recreational runners, that reflects positive affect. In contrast, running pictures will elicit heart rate activity in sedentary individuals that is indicative of negative affect. Lang and colleagues have demonstrated that prolonged deceleration in the initial phase of the triphasic heart rate pattern is correlated with ratings of unpleasantness (Bradley & Lang, 2000; Lang, Bradley, & Cuthbert, 1990). Thus, the magnitude of the initial deceleration in heart rate activity should be greater for sedentary individuals when viewing pictures of elite and recreational runners.

    b. Unlike picture stimuli, the initial deceleration in heart rate activity corresponds to rating of **pleasantness** with **imagery** stimuli (Bradley & Lang, 2000; Lang, Bradley, & Cuthbert, 1990). The initial deceleration (in heart rate activity) should be greater for regular exercisers when **imaging** the running-related script.

Skin conductance

3. Skin conductance responses are hypothesized to not differ significantly between the two groups for the IAPS stimuli (Bradley & Lang, 2000). For example, the positive imagery script should result in comparable electrodermal activity for both regular exercisers and sedentary individuals.

4. Patterns of electrodermal activity should be consistent with individuals' self-reported arousal ratings of both the pictures of elite and recreational runners and the imagery script involving running (Bradley & Lang, 2000). Running-related stimuli could evoke similar levels of arousal, but contrasting valence ratings, for both regular exercisers and sedentary individuals. Therefore, skin conductance responses could be similar between groups if the stimuli are perceived similarly.

Brain activation (fMRI)

5. Areas of the brain associated with processing visual stimuli, such as the visual cortex and occipital lobe, should be active when participants view pictures. More specifically, the experimenters anticipate greater activity in the **right** hemisphere and in the occipital lobe during processing of **all pictures**. Greater activation is also expected during the processing of **emotional** stimuli, compared to neutral, in the right hemisphere and occipital lobe, as well (Lang et al., 1998).

6. Consistent with previous research (Bradley et al., 2003), the researchers predict that participants' rating of picture arousal will positively correlate with brain activity. Bradley et al. (2003) report that "the most affectively arousing pictures generally prompted more cortical activity than other picture contents" (p. 376). Morever, pictures associated with the primary motive system (erotica, threat, and contamination) should elicit the most intense brain activation. Pictures related to running are not expected to demonstrate the same amount of brain activity as more arousing stimuli.

7. The **right fusiform gyrus**, right inferior and superior parietal lobules, orbital gyrus, and portions of Brodmann's Area 19 are expected to display greater activation during **both** pleasant and unpleasant (emotional) compared to neutral (Lang et al., 1998).

8. Greater brain activation is expected to occur in the **right fusiform gyrus**, portions of Brodmann's Area 18 (on the right side), and in a **right** hemisphere cluster (located centrally and in the anterior) for **unpleasant** compared to pleasant pictures. For example, if sedentary individuals perceive pictures of elite and recreational runners negatively, then they should show greater activation in these areas of the brain than regular exercisers during running-related pictures (Lang et al., 1998).

9. Conversely, the researchers hypothesize that **pleasant** pictures will elicit more activation in the **left fusiform gyrus**, **right lingual gyrus,** and portions of **Brodmann's Area 19** in the right hemisphere than unpleasant pictures (Lang et al., 1998).

10. Areas of the brain corresponding to mental imagery (e.g., primary visual cortex) should display activity when the regular exercisers and sedentary individuals image the various scenes (Klein et al., 2000).

11. Pictures of elite and recreational runners are hypothesized to provoke activation in the **orbitofrontal cortex** (OFC) for regular exercisers. Rolls (2000) maintains that the OFC is involved in representing rewarding stimuli and continually updating the reward value of the stimulus.

12. The running-related imagery script and pictures of elite and recreational runners should elicit activation in the **nucleus accumbens** for regular exercisers compared to sedentary individuals. The nucleus accumbens, an area in the ventral striatum,

has been implicated in aspects of reward, reinforcement, and behavior required for reinforcement (Zald & Kim, 2001).

13. Activation is expected to occur in the **amygdala** during the presentation of **emotional** (especially **negative**) visual stimuli (Zald & Kim, 2001). Sedentary individuals and regular exercisers should display greater activation in the amygdala when viewing pictures of runners compared to pictures of household objects.

14. If dopaminergic neurons fire in response to running-related stimuli for regular exercisers, then the **anterior cingulate cortex** (ACC) should show activation. The ACC receives dopaminergic input that may be related to reward (Allman et al., 2001).

Significance

There are numerous benefits associated with conducting the current experiment within the controlled environment of a laboratory. First, the experimenters control the content and duration of the picture and imagery presentations via computer programs. Therefore, all participants will be exposed to the same stimuli for the same amount of time. Although controlling participants' eye movements and thoughts remains impossible, their responses to the stimuli still reflect their reactions. In other words, if a participant averts his or her eyes from the screen during picture viewing, this behavior of averting the eyes still represents a reaction. Second, the advanced technological equipment provides accurate and precise measurements of physiological responses. Third, the accurate measurement and controlled environment afforded by a laboratory study allow for comparison of the current results to previous findings involving the IAPS.

This multidisciplinary (e.g., self-report and psychophysiological) approach should provide a more comprehensive understanding of the factors associated with exercise behavior change. Measuring the "emotional" value of exercise through the three output systems outlined by Lang should facilitate future research concerning exercise behavior modification. If exercise is perceived as a punishment for sedentary individuals and a reward for regular exercisers, then future studies could test the effects of and best methods for changing the value of the stimulus, physical activity.

Successfully implementing this paradigm would provide a framework from which to compare other groups of individuals with differing levels of motivated attention and behavior in the future. For example, do differences exist, beyond self-report, at psychophysiological levels, between individuals who enjoy engaging in required exercise and those who abhor participation in required exercise? Examples of these populations, in which autonomy is limited, include children in required physical education classes and men and women in the armed forces. If differences do exist, then changing the value of the association of exercise (from negative to positive) may change their enjoyment of and performance in the activity. Increased enjoyment and improved performances could affect future exercise behavior.

Models and theories of physical activity could predict physical activity behavior better potentially by considering the emotional association (positive, neutral, negative) of exercise for each individual. Moreover, exercise associations may exist at both subjective and psychophysiological levels. Expressive language regarding one's perception of exercise would constitute the subjective level of association. Brain responses, heart rate activity, and skin conductance response reflect psychophysiological processes.

Establishing that emotional and motivational differences exist between regular exercisers and sedentary individuals allows researchers to concentrate on the variables that change motivation directly. More specifically, if motivational differences occur at both subjective and psychophysiological levels, then experimenters would need to discern which variables affect subjective processes and which factors influence psychophysiologocal processes. This distinction becomes extremely important within the realm of exercise interventions. If researchers are targeting only subjective, and not psychophysiological, levels, then they may be overlooking a key component of exercise behavior change.

Theoretically, psychophysiological and subjective aspects of motivation need to be examined differentially. A self-report measure would not be sufficient in assessing motivation or emotion outside of conscious awareness. Questionnaires, such as the Stages of Change Questionnaire (Reed et al., 1997) and the Exercise Motivation Scale (Li, 1999) are better measures of overt, subjective levels of motivation than psychophysiological responses. Psychophysiological reactions (e.g., brain activity, skin conductance response, and heart rate) can be used for two purposes: (1) to assess covert, psychophysiological levels of motivation and emotion and (2) to compare the consistency between subjective and psychophysiological emotions.

Limitations

Failure to find between-group differences may indicate that the contents of the imagery scripts were not salient enough to elicit either strong feelings or images associated with the scripts. Additionally, it is possible that participants do not image what they are instructed to image. Post-experiment questionnaires will include questions that assess the degree to which the participants followed the imagery instructions and attended to the pictures from the IAPS.

Delimitations

The study will be delimited to:

1. Sixteen right-handed women, aged 21 to 30, who have no history of neurological or psychological disorders.

2. A purposive sample of individuals who do not enjoy running and individuals who enjoy running.

3. The use of the Leisure-Time Exercise Questionnaire (LTEQ) to measure physical activity.

4. The use of the Exercise Motivation Scale (EMS) to assess reasons for exercising.

5. The use of pictures from the International Assessment of Picture System (IAPS) to elicit emotions related to threat, erotica, mutilation, and household objects.

6. The use of pictures related to running and positive, negative, neutral, and running imagery scripts to evoke reactions associated with running, positive, negative, and neutral situations.

CHAPTER 2
REVIEW OF LITERATURE

The ever increasing number of obese and overweight individuals has reached epidemic magnitude in North America, and, more specifically, in the United States. Data from both the National Health and Nutrition Examination Survey (NHANES) 1999-2000 and the Behavior Risk Factors Surveillance System (BFRSS) 1991-2001 have documented recent trends in the occurrence of overweight, obesity, and extreme obesity. These data indicate that the prevalence of obesity and overweight continues to **increase** at a steady rate in the United States, despite awareness of and efforts to combat this disconcerting problem. In examining and documenting rates of obesity, most researchers consider adults with a Body Mass Index (BMI) greater than 25 to be overweight, greater than 30 to be obese, and greater than 40 to have extreme obesity (Flegal, Carroll, Ogden, & Johnson, 2002; Mack & Ahluwalia, 2003; Skyler & Oddo, 2002).

Mack & Ahluwalia (2003) reported a 9% increase in the prevalence of obesity *among women* from 12.4% in 1991 to 21.5% in 2001, according to BFRSS data. They also noted that percentage of female smokers decreased while the percentage of women engaging in exercise has remained unchanged for the past decade. However, the data from the BFRSS is based on self-report. Given the propensity to underreport weight and overreport height, the BFRSS rates of obesity may have **underestimated** the percentage of the population that qualifies as obese. As such, the researchers concluded that the "dramatic increase in obesity foretells similar increases in obesity-related chronic conditions unless public health efforts are successful in stemming this tide. Prevention programs must, therefore, become a priority" (Mack & Ahluwalia, 2003).

Flegal et al. (2002) identified similar obesity rates in the United States adult population. They compared data from the third NHANES (1988-1994) to that from the NHANES 1999-2000. Using a mobile examination center, investigators from the NHANES measured the height and weight of 4415 men and women to calculate their BMI. While the prevalence of obesity remained relatively stable from 1960 to 1980, Flegal et al. (2002) detailed rate increases from 15% in the second NHANES (1976-1980) to the 23.3% in third NHANES to approximately 30.9% in NHANES 1999-2000. The prevalence of people who are overweight also increased from 55.9% in the third NHANES to 64.5% in NHANES 1999-2000.

According to Flegal et al. (2002),"Obesity is a risk factor for many chronic conditions including diabetes, hypertension, hypercholesterolemia, stroke, heart disease, certain cancers, and arthritis" (p.1726). Diabetes and obesity may share the closest relationship: the rate of diabetes has increased consistently with the rate of obesity (Skyler & Oddo, 2002). Unfortunately, people with type 2 diabetes have the highest incidence of having multiple ailments (e.g., dyslipidemia and hypertension). Skyler & Oddo (2002) predict that diabetes will continue to plague the United States as a result of the growing rates of obesity and increasingly sedentary lifestyles. One in three children born today is projected to develop diabetes.

Given the ubiquitous nature of obesity and overweight in the United States, reversing these trends will most likely be difficult. However, the potential health benefits of reducing obesity and overweight warrant public consideration and future research (Flegal et al, 2002).

Body Weight and Exercise

A sample of current studies involving health, exercise, and obesity trends (Jeffery et al., 2003; Koh-Banerjee et al, 2003; Centers for Disease Control and Prevention (CDC), 2003e) have demonstrated the robust relationship between physical inactivity and obesity. Weight gain occurs when energy intake exceeds energy expenditure. Results from recent studies involving overweight and obese individuals provide further support for the role of physical inactivity in obesity. Jeffery, Wing, Sherwood, and Tate (2003) compared the effects of two different exercise prescriptions on long-term weight loss in men and women who were overweight. Participants in the high physical activity (HPA) group were given the goal energy expenditure of 2500 kcal per week compared to a 1000 kcal recommendation for the standard behavior therapy group (SBT). Treatment for both groups involved weekly meetings for the first six months, biweekly meetings for the second six months, and monthly meetings the last six months with trained interventionists. In addition to this intervention, participants in the HPA were encouraged to recruit exercise partners, received advice from an exercise coach, and were given small monetary rewards for meeting weekly goals.

Results indicated that individuals in the HPA group maintained higher mean levels of physical activity at six, twelve, and eighteen months post-intervention. Members of the HPA group also displayed higher mean cumulative weight loss at six, twelve, and eighteen months. The findings suggest that exercise prescriptions impact future physical activity behavior and ensuing weight loss. Recommending and indeed implementing programs that warrant higher levels of physical activity for overweight and obese individuals may facilitate exercise behavior changes and weight loss.

In another study, researchers analyzed the effects of dietary intake, physical activity, alcohol consumption, and smoking on waist gain over the course of nine years. Data revealed positive relationships between gaining weight in the waist area and trans fat intake, television watching, and smoking cessation. Physical activity and fiber intake, on the other hand, were associated with decreases in waist gain (Koh-Banerjee et al., 2003).

Other researchers have evaluated the influence of exercise on appetite and food consumption. Tsofliou et al. (2003) conducted a study with 10 obese women to determine the effects of moderate physical activity, a snack, or a 30-minute resting period on feelings of satiety and subsequent food consumption. While the participants reported a decrease in appetite and increased feelings of satiety following the snack and exercise conditions, neither condition influenced subsequent food consumption. In summary, data support the inverse relationship between exercise and several preventable diseases.

The theories discussed in the following section have been proposed to account for variance in human behavior in the exercise domain. Many of the same constructs (e.g., self-efficacy, perceived barriers) appear in multiple theories and models. Previous research within these theories has not identified the causes of exercise behavior change successfully, but each, including their respective limitations, is summarized below.

Models and Theories of Exercise Behavior

Social-Cognitive Theory (SCT) (Bandura, 1986)

Bandura (1986) developed the social cognitive theory to facilitate the study and comprehension of human cognitions, motivations, actions, and other related emotions. The principle of **triadic reciprocal causation** is a central tenet of the social cognitive theory. Bandura stipulates that the interaction of cognition, environment, and behavior leads to causation. For example, the environment may affect cognition, cognition may influence behavior. This behavior may then impact the selection of future environments.

SCT assumes that humans possess the abilities to symbolize, to analyze their own thoughts and feelings, to self-regulate, and to learn vicariously through others. Human forethought contributes to the goal-directed nature of human behavior. An individual's sense of mastery, according to Bandura's self-efficacy theory, affects his or her psychology and behavior.

Within SCT, Bandura (1977) identifies self-efficacy, outcome expectations, cognized goals, and impediments as four determinants of human behavior. Of the social psychological and health behavior theories, Bandura (1995) maintains that SCT is the most comprehensive. To test this interactional theory of behavior experimentally, Bandura recommends investigating "segments" of interaction within the causal processes. In a review of physical activity studies, Barnowski et al. (1998) found self-efficacy to be the most reliable predictor of exercise in studies based upon SCT. Pinto et al. (2002) examined the impact of an entirely automated, telephone-based intervention on physical activity levels among sedentary individuals. Participants were assigned to receive information encouraging either physical activity or healthy eating through telephone-linked communication (TLC). Telephone-based counseling programs provide one alternative to expensive, and often inconvenient, face-to-face counseling. In this study, participants in both the TLC-Physical Activity (TLC-PA) and TLC-eat groups were asked to call the system weekly for the first three months and biweekly for the subsequent three months.

In the TLC-PA group, participants received advice based upon both the Transtheoretical Model and Social-Cognitive Theory (Pinto et al., 2002). For example, participants could choose to listen to the benefits (pros) of exercise or how to overcome barriers (cons) to physical activity. Participants' levels of physical activity and stages of exercise behavior changes dictated the strategies recommended by the TLC-PA. For instance, the telephone counseling system emphasized cognitive processes for participants classified as precontemplators or contemplators. The TLC system classified participants based upon their reported levels of moderate-intensity physical activity.

Using a 7-day physical activity recall, the researchers (Pinto et al., 2002) assessed physical activity level at baseline, three months, and six months. Participants in the TLC-PA group were hypothesized to demonstrate higher levels of physical activity than those in the TLC-eat group at three- and six-month assessments. While the researchers observed significant intervention effects at the three-month mark, there were no significant differences six months after initiation of the program. The dramatic drop in use of the TLC over the duration of the study, the reliance on individuals to call the system, or technical difficulties potentially could account for the lack of significant findings at six months. However, the study did provide support for **short-term effects** of TLC on physical activity levels.

In another study (Booth et al., 2000) involving SCT, researchers interviewed 449 Australians, over the age of 60, to determine the influence of social cognitive variables, perceptions of social and environmental influences, reported availability of facilities, and perceived reinforcement for physical activity on exercise behavior. Qualified Australian Bureau of Statistics interviewers conducted the interviews in-person after obtaining initial consent by telephone. The experimenters equated expectations, from the social cognitive theory (SCT), with attitudes from the theory of planned behavior (TPB) and expectancies (SCT) with outcome evaluations (TPB) (Booth et al., 2000).

Data indicated that, of all 12 attitude measures, only health benefits of physical activity, significantly correlated with physical activity participation. High exercise self-efficacy, perceived opportunities to walk locally, and social support from family and friends were associated with participation in physical activity. The results also suggested that men were more physically active than women. This finding highlights the need for research regarding determinants of physical activity for women. The cross-sectional nature of the study prevents inferences of causality. In addition, the small sample size did not permit stratified analysis.

To examine the mediating effects of social-cognitive constructs on physical activity behavior, Lewis et al. (2002) reviewed 12 intervention studies that used appropriate statistical methods. Behavior processes of change, cognitive processes of change, self-efficacy, decisional balance, social support, and enjoyment were the most frequently assessed mediators of physical activity change. Consistent with Baron and Kenney (1986), Lewis et al. (2002) defined a mediator variable as an intervening, causal variable that is necessary to complete a cause-effect pathway between an intervention and physical activity. If a positive relationship between the intervention and an outcome variable is attenuated or assuaged after controlling for the mediator, then a variable is considered to have mediating effects. Baranowski, Anderson, and Carmack (1998) suggest first, identifying the targeted mediators, next, determining if these mediators are changed through the intervention, and then assessing if changes in mediating variables predicted change in exercise.

The results of Lewis et al. (2002) suggested that most intervention studies increased the use of behavioral processes and that this increase was associated with increases in exercise. However, support for cognitive processes of change, self-efficacy, decisional balance, social support, and enjoyment of physical activity are mixed. Lewis et al. (2002) concluded that “because previous studies indicate that mediators account for a small percentage of the variance, **it will be especially important to examine new theories** to improve our understanding of physical activity behavior change” (p.34). Furthermore, research on social cognitive theory within the physical activity literature has failed to test and operationalize SCT and its constructs consistently (Culos-Reed, Gyurcsik, & Brawley, 2001).

In one review (Marcus et al., 1998) of physical activity intervention studies, the effectiveness of SCT interventions in changing exercise behavior varied. Given the complex causal relationships hypothesized in Bandura’s SCT, experimenters struggled to test SCT in its entirety. Culos-Reed et al. (2001) suggested that researchers conduct longitudinal and prospective studies using SCT to examine the time lag inherit in reciprocal triadic interaction. While researchers could and should examine pieces of the

SCT, agencies, such as NIH, have stressed the scientific value of and need for testing it and alternative whole theories.

Health Belief Model (HBM) (Rosenstock, 1990)

The Health Behavior Model (HBM) was introduced in the 1950's to explain why individuals failed to engage in disease prevention when aware of the benefits of preventive actions. Influenced by both the Stimulus-Response Theory (Thorndike, 1898) and the Cognitive Theory (Kohler, 1925; etc.), the HBM emphasizes the significant influence of **intrapsychological** beliefs on health-related behavior.

According to the HBM, four key belief variables affect health behavior: (1) perceived susceptibility of acquiring a health condition, (2) perceived severity of the consequences of a health condition, (3) perceived benefits of engaging in actions to eliminate the threat, and (4) perceived barriers or negative components of the actions required to combat the threat. Perceived threat may result from the union of perceived susceptibility and perceived severity.

Demographic, sociopsychological, and structural variables are hypothesized to affect health behavior indirectly by influencing individual perceptions. Outcome expectations, the perception that a specific behavior will lead to a particular outcome, also influence individual beliefs. Proponents of the HBM later recognized the relevance of Bandura's (1977) self-efficacy concept to the model. Bandura (1977) defined self-efficacy as an individual belief that he or she possesses the skills to perform a behavior required for the desired outcome. In summary, the HBM states that "for behavior change to succeed, people must feel threatened by their current behavior patterns (perceived susceptibility and severity) and believe that change of a specific kind will be beneficial by resulting in a valued outcome at acceptable cost, but they must also feel themselves competent (self-efficacious) to implement that change" (Rosenstock, 1990, p. 45).

One major criticism of the Health Belief Model (HBM) is that a direct belief-relationship has never been established empirically. Unsuccessful attempts to modify beliefs require the development of alternative approaches. Other criticisms include the failure to account for socioenvironmental influences (e.g., physical and natural environment) on behavior, to quantify HBM variables, or to establish relationships between the variables. Also, HBM may encourage victim-blaming by focusing on intrapsychological variables.

Transtheoretical Model (TTM) (Prochaska, DiClemente, & Norcross, 1992)

Prochaska et al. (1992) stipulated that five constructs combine to influence behavior: **stages of change, decisional balance, processes of change, self-efficacy, and temptation**. According to the model, individuals progress and regress through six different stages of behavior: precontemplation, contemplation, preparation, action, maintenance, and termination. Each stage includes criteria concerning thoughts and actions about a specific behavior. For example, to be classified in the termination stage, an individual must have engaged in a behavior for more than five years and have no threat of relapse.

Prochaska et al. (1992) conceptualized the transtheoretical model to explain smoking cessation. Researchers have since adopted the model to describe exercise behavior. Decisional balance refers to the perceived advantages compared to the perceived disadvantages of engaging in a particular behavior. Similar to stages of change, processes of change involve the actual process or cognitions, behaviors, and emotions that individuals experience when changing a behavior. Prochaska et al. (1992)

borrowed the term, self-efficacy, from Bandura's (1977, 1986) social cognitive theory. Bandura (1977, 1986) defined self-efficacy as an individual's confidence in his or her possession of certain skills required to perform a behavior. Self-efficacy increases as an individual progresses through the various stages of change. In other words, a linear relationship is hypothesized to exist between self-efficacy and the stages of change. The last construct in the model, temptation, is considered to be a predictor of the likelihood of relapse.

Sarkin et al. (2001) investigated the extent to which the Transtheoretical Model's stages of change construct served as an indicator of readiness to engage in regular moderate exercise, in an overweight population. Participants completed questionnaires that assessed stages of change, decisional balance, situational confidence or temptation, processes of change, and behavior indicators with regard to regular moderate exercise, calorie reduction, dietary fat reduction, and emotional stress management.

Participants in precontemplation reported significantly lower pros of regular moderate exercise than any other stage, significantly higher cons than those in the maintenance, and significantly less confidence than any other stage (Sarkin et al., 2001). Contemplators reported significantly fewer pros than participants in the preparation and action stages and more cons than those in the action and maintenance stages. Individuals in the preparation stage reported significantly higher pros than participants in precontemplation, contemplation, and maintenance and more cons than those in precontemplation and contemplation. Action-stage participants reported significantly higher pros than those in maintenance, but no more cons. In addition, they were significantly more confident than those in precontemplation and contemplation.

Participants in the maintenance stage were significantly more confident than participants in precontemplation, contemplation, and preparation.

The data (Sarkin et al., 2001) provided support for the application of the TTM with regular moderate exercise in an overweight population. Earlier stages, such as precontemplation and contemplation, appeared to be differentiated by the perceived benefits (pros) of physical activity. Consistent with previous research, situational self-efficacy increased linearly from precontemplation to maintenance.

The strong and weak principles of progress principle states that progression from precontemplation to action involves, approximately, a one standard deviation increase in pros and a .5 standard deviation decrease in cons. Sarkin et al. (2001) replicated the findings that the reported pros for action were one standard deviation above the pros reported by precontemplators. In addition, the cons reported by participants in action were half of a standard deviation below the cons reported by precontemplators.

Although there were no significant differences between participants in action and maintenance stages with regard to strenuous physical activity, participants in these two stages (action and maintenance) reported significantly more strenuous activity than participants in the precontemplation, contemplation, and preparation stages. **The pattern of reported pros and cons suggests that exercise may be more automatic and less influenced by decisional balance in the maintenance stage** (Sarkin et al, 2001).

Another construct within the TTM, processes of change, are the methods by which individuals change behavior. The understudied processes of change construct includes both experiential and behavior processes. *Experiential processes* consist of consciousness-raising, dramatic relief, environmental reevaluation, social liberation, and self-evaluation and are hypothesized to dominate pre-action stages. *Behavioral processes* involve counterconditioning, helping relationships, reinforcement management, stimulus control, and self-liberation and are considered integral to the action and maintenance stages. In theory, stage progression and processes of change are positively related, while stage regression and processes of change are negatively related. Individuals who remain in their stage neither increase nor decrease their implementation of the processes of change (Plotnikoff, Hotz, Birkett, and Courneya, 2001).

Plotnikoff et al., (2001) tested the predictive validity of the TTM, with 683 Canadian adults, over two consecutive time periods. The researchers hypothesized that higher scores on self-efficacy, pros, **experiential** and **behavioral processes**, and lower scores on cons, would predict forward movement across the stages of change.

The researchers defined regular physical activity as engaging in at least three bouts of physical activity for a minimum of 20 minutes. Responses to the TTM constructs at time 1 were used to predict transitions from time 1 to time 2; time 2 constructs were used to predict transitions from time 2 to time 3. The researchers classified the participants as having progressed, regressed, or remained within the TTM's stages of change (Plotnikoff et al., 2001).

The results from the study (Plotnikoff et al., 2001) provided partial support for the internal validity of the TTM for exercise behavior. Consistent with previous findings, self-efficacy served as a moderate-to-strong predictor of forward stage movement. Surprisingly, perceived benefits (pros) of physical activity outnumbered the perceived barriers (cons) for exercise in the precontemplation stage. In contrast to findings from the Sarkin et al. (2001) study, the results did not support the strong and weak principles of progress. However, participants in the action and maintenance stages reported a significantly higher number of pros and lower number of cons than individuals in precontemplation (Plotnikoff et al., 2001). Mean scores for pros and cons were in the hypothesized directions for the majority of the stages. However, most of the predictions for pros and cons failed to reach levels of statistical significance. The researchers stipulated that **emphasizing the use of behavioral processes**, as opposed to experiential processes, **may benefit individuals who have yet to become physically active** (Plotnikoff et al., 2001).

Plotnikoff et al. (2001) emphasized the inappropriateness of cross-sectional studies in assessing a dynamic model, such as the TTM. In addition, they stressed the value of testing the entire TTM using a longitudinal design. However, the use of a short-form assessment of experiential and behavioral processes, the moderate response rate, and the potential impact of the seasonal variation in Canada on the results, limited the findings of this longitudinal study. According to the authors, future studies need to use longitudinal approaches, to integrate additional social-cognitive constructs, and to assess moderate levels of physical activity. In addition, Plotnikoff et al. (2001) questioned the appropriateness of the TTM in predicting exercise behavior change, based on the two counterintuitive results concerning the experiential and behavioral processes in the preparation stage.

Temptation, defined as the magnitude of an individual's desire to engage in a particular behavior in a stressful situation, is a key construct within the Transtheoretical Model. However, few studies have examined the temptation construct within the exercise domain. Hausenblas et al. (2001) conducted two studies to develop and validate the Temptation to Not Exercise Scale.

In the first study (Hausenblas et al., 2001), 345 participants completed a 50-item Temptation to Not Exercise Scale, as part of the scale development. Two factors emerged following principal component analysis: **affect** and competing demands. In the second study, 309 participants completed a 10-item Temptation to Not Exercise Scale, the Stages of Change Questionnaire (SCQ), and the Self-efficacy Questionnaire. Prior to the second study, Hausenblas et al. (2001) hypothesized that (1) temptation to not exercise would decrease as an individual progressed across the stages of change and (2) a negative relationship existed between temptation to not exercise and barrier self-efficacy. As expected, temptation to not exercise decreased as individuals progressed across stages of change and proved more significant in later stages of change. However, temptation was present in all stages of change. The Temptation to Not Exercise Scale provides a measure by which to differentiate, predict, and investigate stages of change.

Researchers (e.g, Calfas et al., 1996; Marcus, Goldstein, et al., 1997; Lombard et al., 1995) have implemented several constructs from both the Social Cognitive Theory (SCT) (Bandura, 1986) and the TTM (Prochaska et al., 1992) and tested their efficacy in a variety of exercise interventions. Marcus et al. (1998) reviewed 28 articles to examine the effects of different mediums of communication on exercise behavior change. Early community-based campaigns appeared influential in increasing awareness and interest in exercise, but not effective in changing physical activity **behavior**. Many of the 21 clinical trials that used either print media or telephone reported **short term** increases in physical activity behavior. The results provided support for the use of telephone interaction in eliciting short-term exercise behavior change. Interventions based upon flexible media approaches, that enabled the individuals to implement the information at their own pace, proved more effective than structured programs. Of the studies that incorporated the TTM and SCT, all reported significant changes in progression towards higher stages of motivational readiness and five reported increased levels of exercise. Unfortunately, the absence of control and comparison groups within these studies limited detailed conclusions concerning the specific messages, methods, and populations (Marcus et al., 1998).

In their review, Marcus et al. (1998) also found mixed support for interventions that targeted specific demographics. They noted that motivation-matched interventions were useful in media-based interventions. However, intervention comparisons were complicated by the various measurement techniques and intervention materials.

Marcus et al. (1998) recognized that physical activity decreases with increasing age, decreasing social support, and decreasing socioeconomic status. The researchers espoused the need for future research to discriminate the specific components of the media-based interventions that result in the greatest increase in physical activity. According to the researchers, "When attempting to design interventions to increase physical activity behavior, it is important to realize that the majority of the population is sedentary and unmotivated to exercise…**Theories that recognize the differing levels of motivation**, such as the Transtheoretical Model, **may help to guide the design of more-effective interventions tailored to the appropriate level of motivation**" (Marcus et al., 1998, p. 374).

Theory of Reasoned Action (TRA) (Ajzen & Fishbein, 1980; Fishbein & Ajzen, 1975)

According to the theory of reasoned action, **intention** has the largest influence on behavior. As the intention becomes stronger, so too does the likelihood that the behavior will occur. Conversely, as the length of time increases between the intention and behavior, the greater is the probability that the behavior will not occur. Ajzen & Fishbein (1980) identify **attitude** and **subjective norm** as two factors that influence intention. Subjective norm is defined as the perceived social pressure to engage in a particular behavior.

Theory of Planned Behavior (TPB)

The theory of planned behavior (Ajzen, 1991) is a modified version of the theory of reasoned action. Intention remains the central construct affecting behavior. However, Ajzen (1991) proposes that perceived behavioral control influences intention in addition to attitude and subjective norm. **Perceived behavioral control**, the "perceived ease or difficulty of performing a behavior," can influence both behavior and intention directly. For example, a cyclist could intend fully to cycle in the afternoon, but the presence of a tropical storm might prevent the individual from engaging in his or her planned activity.

According to Ajzen's (2002a) extended TPB, **two** specific sub-components combine to form each construct in the TPB. Attitude consists of both affective and instrumental evaluations toward a behavior, while perceived behavior control consists of self-efficacy and controllability. Traditional injunctive and descriptive components are integral to subjective norm. In one study, Rhodes & Courneya (2003) used the extended TPB (Ajzen, 2002a) and the Five Factor Model (FFM) of personality to explore the relationship between personality traits and exercise behavior. Rhodes & Courneya

(2003) defined personality traits as “generalized dimensions of individual differences in tendencies to show consistent patterns of thoughts, feelings, and action.” Within the FFM, **each** personality trait, neuroticism (N), extraversion (E), openness (O), agreeable (A), and conscientiousness (C), can be broken down into facets. Examples of the activity facet of extraversion include rapid talk, vigorous action, energetic and forceful individuals, and individuals who keep busy. Within an extended TPB model, Rhodes & Courneya (2003) hypothesized that the activity facet of extraversion would have a direct impact on physical activity.

In the first of two studies (Rhodes & Courneya, 2003), 303 undergraduate students simultaneously attended group sessions, completed questionnaires involving the TPB, and filled out measures of leisure time physical activity. In the second study, 302 cancer survivors completed the same questionnaire, but did not attend any meetings or sessions. Rhodes and Courneya (2003) defined regular exercise for each group as “activities performed at a vigorous intensity three or more times per week for 30 minutes” and “activities performed at a moderate intensity for 3 or more times per week for at least 20 minutes” for college students and cancer survivors, respectively.

In both studies (Rhodes & Courneya, 2003), **intention** to exercise had the greatest significant effect on physical activity levels and self-efficacy had the largest significant effect on intention. The data indicated that the FFM is a poor fit for explaining exercise behavior: only extraversion had a significant effect on exercise. Consistent with their hypothesis, however, only the activity facet of extraversion had an effect on exercise behavior when intention, controllability, and self-efficacy were controlled. The results suggest that the extended TPB model is unable to mediate the relationship between personality and exercise behavior.

Carron et al. (2003) cited four weaknesses of the theories of reasoned action and planned behavior. First, these theories failed to consider the influence of demographic variables, personality, and previous physical activity behavior on future exercise behavior. Second, the nebulous definition of perceived behavior control created measurement issues. Third, the theories failed to account for the influence of the length of time between the intention and behavior on the probability of completion of that behavior. Fourth, research indicated that subjective norm is not a strong predictor of exercise behavior. Attitude and perceived behavioral control tended to account for more variance in exercise behavior than subjective norm does.

Self-Determination Theory (SDT) (Deci & Ryan, 1985)

Unlike other theories related to exercise behavior change, self-determination theory (Deci & Ryan, 1985, 2000) considers various types of **motivation** as well as their interaction with behavior. Deci & Ryan (1985, 2000) emphasized the joint roles of causal orientation of the individual and his or her basic organismic needs of autonomy, competence, and relatedness on motivation and behavior. Causal orientation is defined as a person's motivational orientation in relation to events and goals. Autonomy orientation refers to individuals who prefer environments with choice and flexibility. People who are oriented in this way are considered to be highly self-determined. Individuals who are control-oriented tend to act in response to stimuli in the environment. While they still perceive their behavior to be a choice, it is in response to external events. Impersonally oriented individuals believe that they are unable to govern their behavior in a way that will affect outcomes (Deci & Ryan, 1985).

Because the **consequences of motivation**, such as persistence and direction, are highly valued, **antecedents of motivation** are equally significant within SDT. Deci & Ryan (2000) stipulated that feelings of **competence** and **autonomy**, with regard to behavior, are **both** necessary for possessing intrinsic motivation. They also maintained that pressured evaluations and imposed goals reduce intrinsic motivation. Deci and Ryan's (1985) concept of competence parallels Bandura's self-efficacy construct.

Deci & Ryan (2000) emphasized the importance of understanding non-intrinsically motivated behavior in affecting motivation and action. Extrinsic motivation refers to the motivation to act or respond based on some external stimuli or outcome and accounts for the majority of motivation. Extrinsic motivation affects four different types of regulation ranging from least to most autonomous: external, introjected, identified, and internal. As an individual begins to value a behavior as his or her own, regulation of that behavior becomes more internal than external. As such, he or she enjoys more autonomy or choice related to behavior (Deci & Ryan, 2000).

Understanding how to increase autonomous regulation of extrinsically- motivated behavior becomes critical to implementing a long-term behavioral change, such as exercise adherence. Deci & Ryan (2000) conceptualized organismic integration theory, a sub-component of self-determination theory, to explain extrinsic motivation and the conditions required for internalization and regulation of behavior. Environments that provide rationales, support choice, and encourage competence should lead to internalization and regulation of behavior. Conversely, situations lacking these characteristics will result in alienation (Deci & Ryan, 2000).

Although SDT considers the impact of motivation on behavior, it has received relatively little attention within the exercise psychology domain. One study (Biddle, Soos, and Chatzisarantis (1999) investigated the physical activity behavior of Hungarian youth, ages 12 – 18, within the frameworks of the Self Determination Theory (SDT) and Achievement Goal Orientations. The researchers hypothesized that goal orientations would be mediated by behavioral regulations, such as perceived level of autonomy. Perceived competence was hypothesized to influence behavioral regulations.

The findings suggested that perceived competence mediated the effects of ego orientation. Self-determined forms of behavior were the strongest predictors of intention. However, social-psychological variables predicted less than one-fifth (18.8%) of the variance in intention. The researchers attributed the amount of explained variance to the high scores on intention to exercise. Physical activity intentions were assessed by a one-item questionnaire that asked the participants the extent to which they intended to engage in sports at least once per week, over the next few months. The researchers recommended using stricter measures of intention in future studies.

Additional research will be needed to determine the accuracy of the SDT in predicting and changing exercise behavior. While the SDT considers motivation as a central factor that influences behavior, it does not allow for predictions involving psychophysiological responses.

Ecological Models (EM)

In contrast to most models and theories of exercise behavior, ecological models underscore the significant effect of an individual's **natural, physical, and social environment** on his or her probability of engaging in physical activity. Sallis and Owen (1999, 1997) emphasized the interaction of individuals' characteristics with their

external environments. Within EM, *ecology* is defined as the "interrelation between organisms and their environment," (Sallis & Owen, 1997, p.403) while the adjective, *ecological*, describes models, frameworks, or perspectives.

According to the model, particular environments can facilitate some behaviors while impeding others (Sallis & Owen, 1997). For example, recent legislation in the state of Florida has prohibited smoking in restaurants, preventing patrons from smoking indoors. Similarly, several colleges have limited or restricted vehicle access on campus, forcing people to use alternate modes of transportation.

Moos (1980) stated that the following four sets of environmental variables should be considered in health studies: physical setting, organizational, human aggregate, and social climate. The five principles of health behavior change, according to the EM, are the (1) numerous dimensions of influence on behavior, (2) interaction of these influences across dimensions, (3) various levels of environmental influences, (4) direct influence of the environment on behavior, and (5) behavior-specific ecological models (Sallis & Owen, 1997).

EM advocates maintain that the principles of EM can be applied to physical activity interventions. First, understanding the **influence of natural environment variables on physical activity behavior may help explain exercise participation**. Physical activity interventions may not account for environmental influences on behavior. Thus, behavior change may not occur because environmental variables are still present. Second, environmental influences may interact to impact behavior. For example, Sallis and Owen (1997) discussed how individuals who live in high crime neighborhoods may fear exercising outside and may lack the resources to join a private health club. As a result, these individuals may not exercise. However, these issues may be relevant **only** if the individual **intends** to exercise. Third, the physical layout of a community (e.g., number of bicycle lanes, rails to trails programs, stores within walking distance) may affect physical activity levels. Fourth, research has demonstrated that objective measures of facility convenience are associated with exercise status. Objective measures and perceived estimates, in this study, were unrelated (Sallis et al., 1990). Finally, behavior-specific ecological models should examine the effects of behavior settings (e.g., parks, schools, malls), organizations, and legislature on physical activity behavior.

Investigators have conducted insufficient amounts of research using ecological approaches to validate the central tenets of the model. Sallis and Owen (1997) admit that the application of the ecological model has grown more quickly than the research supporting this model. Another limitation of an ecological approach is the impracticality of changing certain environments. Large scale and organized movements, such as lobbying for nutritional information displays, may be necessary to change some environmental influences on behavior. These lofty demands create problems concerning the feasibility of conducting research on large environmental influences.

Altering physical environments may prevent or facilitate certain behaviors within that environment. However, individuals may not necessarily engage in the same behaviors outside of these “controlled” environments. Finally, people may find ways of circumventing the alteration of the environment. For example, colleges may restrict the use of automobiles, but individuals may choose to use motorized scooters or motorized bicycles to travel around campus.

Personal Investment Theory

The personal investment theory states that when people have multiple options, the decisions that they make represent the significance they assign to the action or activity. Based upon an interaction approach, the personal investment theory takes into account both **individual and environmental influences on behavior**. According to the theory, sense of self, perceived options, and personal incentives jointly define meaning. Motivation, within this theory, reflects the "selectivity, intensity, and persistence of a behavior." Therefore, an individual who engages in physical activity has some incentive to exercise, perceives exercise as possible, and considers it related to his or her identity. (Carron, Hausenblas, & Eastabrooks, 2003)

Limitations

Numerous limitations of current theoretical models within the exercise domain indicate the need for additional research with alternative theories. For instance, in their review of 12 intervention studies using SCT mediators, Lewis et al. (2002) found that the mediators accounted for little variance in behavior. They also emphasized the need for testing new theories. The 2001 meta-analysis conducted by Culos-Reed et al. revealed that many studies struggled to (1) test SCT in its entirety and (2) operationalize its constructs consistently. While Marcus et al.'s (1998) review of TTM interventions provided support for an increase in awareness in, interest of, and short-term participation in exercise, they found limited evidence for the effectiveness of interventions that targeted specific demographics. In addition, the TTM does not explain or describe what causes changes in decisional balance, self-efficacy, stages of change, or processes of change. Furthermore, not all of the constructs within the TPB have been reliably tested and supported in the literature: little evidence exists for subjective norm and the multiple definitions of perceived behavior control complicate comparative findings (Carron et al, 2003). Finally, the paucity of exercise research involving either the SDT or EM prevents investigators from making inferences concerning exercise behavior using these theories.

Investigators need to determine, first, that differences in **motivation** account for disparities in behavior before expecting that changes in motivation result in exercise behavior change, and secondly, the mechanisms that underlie these potential motivational differences. Many theories (e.g., Theory of Planned Behavior, Social Cognitive Theory, etc.) designed or adapted to explain exercise behavior do not consider motivation directly as a variable that influences behavior (Ajzen, 1991; Bandura, 1986). However, theories that do include motivation as a central construct (e.g., Self-determination Theory), do **not** allow for the measurement of the psychophysiological properties of emotion or motivation. Given the non-volitional and objective nature of psychophysiology, the use of psychophysiological measurement in conjunction with self-report is invaluable.

Physiological measures are necessary to verify the consistency between subjective, behavioral, and psychophysiological responses. Individuals could respond to the same situation differently on subjective and physiological levels. In other words, an inconsistency could exist between subjective and physiological responses to the same stimuli. For example, a person might report his or her enjoyment of exercise while physiological and behavioral responses would indicate otherwise.

In one study (Patrick, Bradley, & Lang, 1993), incarcerated psychopaths rated unpleasant pictures similarly to other prisoners and college controls. However, psychophysiological measurements clearly contrasted their verbal reports, indicating that unpleasant pictures motivated physiological responses that closely approximated those typical when viewing pleasant content. Coupled with self-report and brain activity assessments, psychophysiological measurements provide quantitative and qualitative methods of testing the influence of emotion and motivation on behavior.

Within the exercise psychology domain, no known studies have examined the psychophysiological **and** self-report aspects of motivation, in combination with fMRI technology, to compare and contrast regular exercisers and sedentary individuals. Lang's (1985) biphasic theory of emotion and bio-informational theory of emotional imagery (1979) permit/encourage the use of multiple methods of assessment motivation and emotion.

Biphasic Theory of Emotion

Lang (1985) proposed that affective expression or emotion varies along two continuums: valence (from unpleasant to pleasant) and arousal (from low to high). According to Bradley and Lang (2000), "**emotions** are defined as **activation** in a **motive** system and are indexed by the consequent actions. Stimuli have affective significance to the extent that they prompt a defensive or appetitive pattern" (p.249). Lang, Bradley, and Cuthbert (1999) developed the International Affective Picture System (IAPS), a set of over 700 photographs designed to elicit a broad range of measurable psychological and physiological reactions. These pictures differ in both valence and arousal and include pictures of mutilation, household scenes, cities, babies, food, erotica, nature and sporting events.

Researchers can measure individual psychological reactions to picture stimuli using the Self-Assessment Manikin (SAM). Developed by Lang (1980), the SAM is a *nonverbal* rating scale of arousal and valence that features an array of facial expressions. According to Lang's theory, subjective ratings of the pictures should correspond to physiological responses as measured by skin conductance, heart rate, and EEG, among others.

Bradley & Lang (2000) posited that emotion can and should be measured by three output systems: overt acts, emotional language, and physiological reactions. "Assuming that emotion is organized by the brain's motivational systems, physiological and behavioral reactions to affective stimuli should also reflect this organization, covarying significantly with judgments of affective valence and/or arousal" (p.254).

Empirical findings from multiple studies (Lang, Bradley, Fitzsimmons, Cuthbert, Scott, Moulder, & Nangia, 1998; Lang, 2000; Lane, Reiman, Bradley, Lang, Ahern, Davidson, & Scwartz, 1997; Lane, Chua, & Dolan, 1999) suggest that emotional pictures (assigned either pleasant or unpleasant ratings) from the International Affective Picture System (IAPS) elicited different patterns of brain activity compared to neutrally-rated pictures. These results lend support to the notion that pleasant and unpleasant emotions fall on a continuum and that the appetitive and aversive motivational systems involve similar regions of the brain. However, the specific areas of the brain displaying activation associated with emotional and neutral stimuli vary somewhat, depending upon the experiment and task.

Using functional Magnetic Resonance Imaging (fMRI), Lang et al. (1998) investigated activation of the visual cortex in response to pictures from the IAPS. The study revealed significantly more activation in the **right** hemisphere, occipital region, and in the posterior region than in the left hemisphere, occipitoparietal or dorsal-ventral regions, and the anterior or anterior-posterior regions respectively. Hemispheric differences were more prominent in the posterior than anterior regions. Lang et al.

(1998) also found more overall brain activity in response to "**emotionally** arousing" stimuli (either pleasant or unpleasant). This effect was stronger in the posterior compared to the anterior region, but significant for both regions.

Results from the study (Lang et al., 1998), indicated differential hemispheric activation for women and men. Women displayed significantly greater activity in the right hemisphere when viewing unpleasant pictures compared to pleasant pictures. Men did not show this same trend. Women also demonstrated more activity in the occipito-parietal region than men.

With regard to voxel number, Lang et al. (1998) found more voxels in the active clusters for emotional (both *pleasant and unpleasant*) compared to neutral stimuli. The primary visual cortex (V1) contained the largest clusters in response to picture stimuli. The posterior portion of secondary visual cortex (V2) was also active during the presentation of pictures (compared to checkerboard stimuli).

Lang et al. (1998) reported additional trends in cluster activity relative to emotional, unpleasant, and pleasant stimuli. The right fusiform gyrus, the right inferior and superior parietal lobules, Brodmann's Area 19, and the oribital gyrus displayed activation in response to emotional compared to neutral stimuli. Unpleasant pictures (compared to pleasant) elicited greater reactivity in the right fusiform gyrus, a portion of Brodmann's Area 18 on the right side, and a right hemisphere cluster anterior and centrally located. Conversely, pleasant pictures resulted in activation of the left fusiform gyrus, the right lingual gyrus, and a portion of Brodmann's Area 19 in the right hemisphere not seen in response to neutral or unpleasant stimuli.

The researchers recommended examining the cingulate and amygdala in the future with regard to attention and emotion. Lang et al. (1998) also underscored the significance of physiological measurements, such as skin conductance, in conjunction with self-report measurements.

In Lang's (2000) theoretical article, he cited multiple studies that provide support for the role of the amygdala in the aversive motivation system. Previous research indicated that the amygdala mediates the acquisition and expression of fear. Based upon previous fMRI research within the Lang laboratory (Lang et al., 1998), Lang suggested that the limbic-striatal-pallidal system and, possibly, the nucleus accumbens are involved in appetitive behavior.

Using PET methodology, Lane et al. (1997) observed increased cerebral blood flow in the medial prefrontal cortex, thalamus, hypothalamus, and midbrain when 12 women viewed emotional compared to neutral stimuli from the IAPS. Bilateral occipito-temporal activation increased for unpleasant pictures relative to pleasant and neutral. In addition, activation increased in the head of the left caudate nucleus when participants viewed pleasant compared to neutral pictures.

More recently, Lane et al. (1999) examined brain activity and the effects of performing a dual task, involving picture processing, on emotional processing. In response to pleasant (compared to neutral) pictures, participants demonstrated increased activation in the putamen, medial prefrontal cortex, right anterior temporal cortex, and left extrastriate visual cortex. Conversely, unpleasant stimuli (compared to neutral) were associated with activity in the right extrastriate visual cortex. Both pleasant and unpleasant (valenced) emotional stimuli correlated with activation of the bilateral extrastriate visual cortex,and the right anterior temporal region.

Exercise Imagery

Previous research (Hausenblas, Hall, Rodgers, & Munroe, 1999) indicated that imagery, in the context of exercise, may be used for energy-, appearance-, and technique-related reasons or to increase self-efficacy and outcome expectancy. Using a qualitative approach, Giacobbi, Hausenblas, Fallon, and Hall (2003) interviewed 16 women to investigate the content and function of exercise imagery. Exercise imagery use was positively related to exercise behavior. Half of the participants reported using exercise imagery when not exercising, nearly 30% used exercise imagery during their workouts, and around 20% used exercise imagery both within and outside the context of exercise (Giacobbi et al, 2003).

Consistent with previous research, Giacobbi et al. (2003) found that regular exercisers benefited from the use of, and the confidence associated with, exercise imagery in various contexts for a variety of reasons. Verbal accounts of imagery use in this study indicated that exercise imagery may facilitate increased motivation and confidence levels. However, the researchers recommended the use of “neuroscientific” techniques to investigate the non-conscious processes involved in imagery.

Bio-Informational Theory of Emotional Imagery

Lang (1979) proposed a theory of imagery in which psycho physiological responses serve as indices of emotional responses to imagery. Consistent with Pylyshyn (1973, 1978, 1984, 1989) and Kieras (1978), Lang adopted a propositional approach to information processing and imagery experiences. Propositions consist of logical relationships between concepts that represent semantic and abstract knowledge. Within a propositional framework, images result from abstract, language-like representations (propositional information) recovered from memory. In contrast, the analog account of imagery stipulates that images result from the initial picture perceived (analog codes).

The propositional network includes modality specific and response information related to an image. Because images are active response processes and not merely stimuli to which individuals respond, they are accompanied by “efferent” activity relevant to the image content, according to Lang (1979). Response propositions related to the image dictate the “efferent outflow.” Therefore, imagery scripts that contain **both** stimulus and response propositions theoretically result in greater physiological responses than scripts lacking stimulus and response propositions. For example, a description of a scorching sauna accompanied by phrases such as, ‘you sweat great buckets’ and ‘your heart pounds wildly,’ result in greater physiological responses. Within Lang’s (1979) bio-informational theory of emotional imagery, researchers can study emotional responses to imagery via physiological responses that occur during imagery (Lang, 1979).

Collins and Hale (1996) in their review of Bakker, Boschker, and Chong’s (1996) imagery study, advocated the use of Lang’s bio-informational theory of emotional imagery within the context of sport psychology. They also noted the importance of carefully implementing response and stimulus propositions in imagery scripts to test Lang’s (1979) theory adequately. Another astute criticism that Collins and Hale (1996) reported was the failure by Bakker et al. (1996) to ensure that all participants reached a baseline state prior to and in between conditions. Finally, Collins and Hale chastised Bakker et al. (1996) for their failure to confirm the effectiveness of their imagery manipulation (i.e., participant use of response and stimulus propositions). Collins and Hale concluded,

> Ideally, future research will attempt to measure the frequency, duration, and amplitude of imagery concomitants through a variety of psychophsyiological techniques (e.g., EMG, EEG) and measures of cerebral blood flow or CAT scan technology (Decety & Ingvar, 1990) while simultaneously examining the effects of image efference on motor learning and performance. (p.211)

In a review of Slade, Landers, and Martin's (2002) article concerning inflow explanations of imagery, Hale, Holmes, Smith, Fowler, and Collins (2003) also stressed the significance of conducting a manipulation check. They suggested the use of either interviews or diaries to check the efficacy of an imagery manipulation. In addition, Hale et al. (2003) recommended the use of rich and valid imagery scripts that Slade et al. (2002) failed to incorporate.

Areas of the Brain Implicated in Punishment and Reward

Areas of the brain that could potentially demonstrate activity in response to rewarding or punishing stimuli (be they picturial or imagined) include the orbitofrontral cortex, the anterior cingulate cortex, and the amygdala. Differences in regular exercisers' and sedentary individuals' brain activity in response to non-exercise and exercise-related pictures might reflect differences in the appraisal, interpretation, association, or representation of the stimulus. Within Lang's biphasic theory of emotion, one would hypothesize that pictures that elicit emotional responses (positive or negative) should correlate with areas of the brain involved in punishment and reward, such as the orbitofrontal cortex.

Orbitofrontal Cortex (OFC)

Recent research suggested the role of OFC in "decoding and representing" certain primary reinforcers, in "learning and reversing" associations of stimuli, and in managing reward- and punishment-related behavior (Rolls, 2000, p. 284). The involvement of the OFC in the processing of reward and punishment, and the ensuing emotional responses, may also extend to exercise-related reward or punishment. Therefore, the following discussion will focus on the OFC and brain regions that interact with the OFC, such as the amygdala, the anterior cingulate cortex, and the basal ganglia. These regions may constitute a brain circuitry that functions with different tasks or stimuli. Various modules may form reflecting brain functions (i.e., functional modules, see He et al, 2003 for the definition) related to exercise behavior.

Shin, McNally, Kosslyn, et al. (1999) conducted a PET study comparing responses of women with posttraumatic stress disorder (PTSD) and those without PTSD to neutral and traumatic imagery scripts. Both groups of women had been sexually abused as children. Results indicated that the traumatic imagery scripts were associated with regional cerebral blood flow (CBF) in the **orbitofrontal cortex** and anterior temporal poles for both groups. However, the PTSD group demonstrated greater increases in regional CBF in these paralimbic regions relative to the control group. Conversely, the control group displayed greater increases in the anterior cingulate gyrus. The results provided support for the hypothesis that the OFC is involved in processing negative or punishing stimuli during imagery.

The basal ganglia receive projections directly from the lateral and medial OFC. These projections influence loops connecting the OFC, striatum, globus pallidus, and thalamus. The limbic and paralimbic regions, including the basolateral nucleus of the amygdala, and the anterior cingulate direct projections to the ventral striatum. The ventral striatum includes the nucleus accumbens and the extreme edge of the ventral caudate. The interaction between the OFC and ventral striatum may affect motivation-related functions. For example, several studies suggested that the ventral striatum (particularly the nucleus accumbens) may function as a brain-reward mechanism and be activated by habit-forming drugs, other **reinforcers**, and behavior targeted to gain the **reinforcers** (Zald & Kim, 2000).

Two significant reward functions of the OFC include (1) distinct representations of rewarding stimuli (olfactory, taste, visual, and texture) and (2) continual updates of the reward value of each stimulus. Ensembles of neurons in primate OFC appear to provide information about the reward value of a stimulus. **In humans, the OFC is involved in correcting stimulus-reinforcer associations and readjusting the reinforcement values of visual stimuli**. This second function could be extremely important concerning the processing of emotion and emotional stimuli (Rolls, 2000).

Amygdala

The amygdala, an area of the brain involved with the processing of affective (especially negative) stimuli, is involved in OFC-related functions. For example, the amygdala projects to the agranular band in the posterior OFC. The basolateral nuculeus of the amygdala is largely responsible for the amygdalar fibers that reach the OFC. After receiving information from the sensory/response interface zones of the amygdala, the OFC returns "prominent projections back to the basolateral and basal accessory nuclei of the amygdala…However, the caudal OFC projects directly to the central nucleus of the amygdala, providing a route through which the OFC may exert a direct influence on the amygdala's output" (Zald & Kim, 2001, p.43).

Both the lateral and medial OFC send information to the basal ganglia. However, the medial OFC loop projects information to a more "extreme ventromedial segment of the caudate extending into adjacent portions of the putamen and other aspects of the ventral striatum" (Zald & Kim, 2001, p.46). Research suggests the involvement of the nucleus accumbens, a part of the ventral striatum, in brain-reward mechanisms, reinforcers, and behavior required for reinforcement. The striosomes of the ventral striatum appear to send information directly to the "dopamine-containing cells of the substantia nigra" (Zald & Kim, 2001, p.46). The posterior agranular OFC projects to these striosomes. This projection could enable the posterior OFC to modulate the dopamine projections to the basal ganglia.

Anterior Cingulate Cortex (ACC)

Allman, Hakeem, Erwin, Nimchinsky, and Hop (2001) posited that the anterior cingulate cortex (ACC) is a specialization of neocortex involved in activities such as emotional self-control, focused problem solving, and adaptive response. Spindle-shaped neurons present in the ACC may contribute to individual ability to concentrate on difficult problems through their vast connections to various parts of the brain. These spindle cells are only found in humans and apes, suggesting an advanced evolutionary specialization. Enriched or depleted environments can serve to either increase or decrease spindle cell density, possibly affecting emotional and cognitive functioning.

The ACC is one of the richest recipients of dopaminergic inputs in the human brain. Research indicate that the **dopaminergic input received by the ACC may be reward-related**. In the absence of an expected reward, the dopaminergic neurons fail to fire. Dopaminergic projections to the ACC may be associated with rewards. Allman et al. (2001) cited a study (Kuenig et al., 1999) revealing that patients with Parkinson's disease, when presented with monetary rewards, failed to demonstrate brain activity in the ACC. Under the same condition, the ACC was activated for participants without

Parkinson's disease. Parkinson's disease annihilates dopaminergic neurons, suggesting that these neurons play a vital role in responding to rewards. The ACC also receives input from the amygdala, an area of the brain associated with affect. Results from various studies provided evidence for the involvement of the ACC in cognition and emotion (Allman et al., 2001).

In conclusion, findings from previous studies reflect the need for additional research concerning the nature and effect of exercise motivation on exercise behavior. Support for the efficacy of theory-based interventions is equivocal. Additional research needs to target the differences, between regular exercisers and sedentary people, which account for contrasting exercise behavior patterns. Lang's Biphasic Theory of Emotion (1985) and Bio-Informational Theory of Emotional Imagery (1979) are promising, yet underutilized, theoretical frameworks within which to forward future research efforts. As such, these theories will serve as the foundation for the proposed study, in which psychophysiological, neuroimaging, and self-report measures will be used to compare and contrast regular exercisers' and sedentary individuals' responses to exercise-related stimuli.

CHAPTER 3
MATERIALS AND METHODS

Participants

Initially, criteria for inclusion into both the regular exercise (RE) and sedentary individual (SI) groups were based, in part, upon definitions of the termination and precontemplation stages, respectively, of the Transtheoretical Model (TTM; Prochaska, DiClemente, & Norcross, 1992). However, inclusion criteria for both groups were relaxed given the difficulty in finding participants who met **all** inclusion and exclusion criteria. For example, the researchers considered a total of 30 participants for the study. Yet, of those 30, eight participants never returned phone calls, four were ineligible due to age, mental history, exercise habits, or dental work, four were too busy, and two opted not to participate.

In total, ten healthy, right-handed women, aged 21 to 30 (*M* = 25.8, *SD* = 3.2), who lacked medical, cardiovascular, endocrinological, neurological, and psychiatric diseases, DSM-IV Substance Use Disorders, previous surgeries that increase risk of the MRI procedure, and who were not pregnant, were recruited to participate in one of two groups. The regular exercise (RE) group included 5 women, aged 21 to 29 (*M* = 25.8, *SD* = 3.3) all of whom report **running** for at least 30 minutes on an average 5 five days per week (ACSM guidelines), for a minimum of 3 months, and who expressed an enjoyment for running (as measured by the Exercise Motivation Scale). Five women, aged 21 to 30 (*M* = 25.8, *SD* = 3.4) who were currently **not** engaging in ***any*** type of regular exercise (at the time of the experiment) and **disliked** running (as measured by the demographic questionnaire) were selected to represent the sedentary individual (SI) group. Women of child-bearing potential were given the option of taking a pregnancy test prior to participation in the scanning portion of the study.

To prevent menopause from confounding the results, only women between the ages of 21 and 30 were included in the study. Research from the Lang laboratory suggests that women perceive negative stimuli (e.g., threat) as more aversive than men while men rate positive stimuli (e.g., erotica) as more pleasant than women. Therefore, women were selected for the study given the expected contrast between group perceptions of exercise stimuli. To further examine the largest potential difference between group responses to exercise stimuli, the researchers chose to compare responses of women who enjoyed running to those of women who disliked running. Because most people have engaged in running at some point in their life, running was chosen as the primary mode of exercise.

Measures

Self-Report Measures

Exercise Motivation Scale (EMS)

Deci and Ryan (2000) argue that motivation varies in both amount and nature. Based upon the self-determination theory (Deci & Ryan, 1985), the EMS includes 31 items (see Appendix A). Using a 6-point Likert-type scale anchored by “strongly disagree” and “strongly agree,” the instrument assesses eight different aspects of exercise motivation. The types of exercise motivation, as posited by Deci and Ryan (1985, 2000), range from amotivation to intrinsic motivation, and include amotivation, external regulation, introjected regulation, identified regulation, integrated regulation, intrinsic motivation to learn, intrinsic motivation to experience sensations. “The EMS is designed to assess motivational tendencies in the exercise context and, therefore, is intended to be used as a contextual scale in substantive research" (Li, 1999, p.99).

The 31 items on the scale consist of answers to the main question, "Why are you currently participating in this activity?". Regular exercisers rated the answers according to their agreement with the answer. For example, participants indicated the extent to which they agreed to the response, "For the pleasure that it gives me to experience positive sensations from the activity" and "Because I would feel guilty if I did not take the time to do it." The EMS has been validated within the college-aged population. The scale has demonstrated acceptable to good reliability.

Li (1999) examined differences in frequent exercisers' (more than twice per week) and non-exercisers' (1 bout or less per week) scores on the EMS. He found that frequent exercisers displayed higher levels of (1) intrinsic motivation to learn, (2) intrinsic motivation to experience sensations, (3) integreated regulation, (4) indentified regulation. Consistent with Li's findings, the investigator expected regular exercisers' scores to resemble frequent exercisers, and sedentary individuals to rate the items similarly to non-frequent exercisers.

Stages of Exercise Change Questionnaire

The purpose of the Stages of Exercise Change Questionnaire was to determine an individual's stage of change within Prochaska, et al. (1992) TTM. After reading descriptions of the precontemplation, contemplation, preparation, action, and maintenance stages as defined by Reed, Velicer, Prochaska, Rossi, and Marcus (1997), participants marked the stage that best described their physical activity attitudes or behaviors (see Appendix B for original). One statement was added to the Exercise

Staging Algorithm to describe the termination stage (participation in exercise for more than five years) (see Appendix C).

The exercise staging algorithm has shown reliability and validity with adult populations. After conducting a meta-analysis involving physical activity, Marshall and Biddle (2001) concluded, “There now are sufficient data to confirm that stage membership is associated with different levels of physical activity, self-efficacy, pros and cons, and processes of change” (p.229). Participants in the termination, maintenance, and action stages were assigned to the regular exercise group. The sedentary individual group consisted of women who were either precontemplators or contemplaters.

Leisure Time Exercise Questionnaire (LTEQ)

The Leisure-Time Exercise Questionnaire consists of descriptions of mild, moderate, and strenuous types of exercise. Participants recorded the number of times, in a given week, that they engaged in the specified mode of physical activity. Researchers can calculate MET scores by multiplying the number of reported mild, moderate, and vigorous exercise bouts by 3, 6, and 9, respectively, and then summing the total scores from each type of exercise. The LTEQ allows researchers to estimate participants’ type, mode, frequency, and intensity of physical activity, quickly and accurately. In addition, the measure has demonstrated reliability and validity with adults (see Appendix D; Godin & Shephard, 1985). Participants must report having engaged in the equivalent of five 30-minute bouts of exercise weekly to be included in the RE group. Conversely, to be eligible for the SI group, individuals could not have reported engaging regular moderate or strenuous types of exercise. Examples of mild exercise include bowling and fishing, and is defined as requiring “minimal effort, no sweating. Therefore, participants who reported engaging in mild exercise were considered for the study.

Temptation Not to Exercise Scale (TNES)

The TNES contains 10 items that question the extent to which a participant feels tempted to not engage in exercise in specific situations (see Appendix E). Participants were instructed to rate how tempted they are to NOT exercise, in the described contexts, on a scale ranging from 0% (not at all tempted) to 100% (extremely tempted). Regular exercisers were expected to rate most items extremely low. Theoretically, the scale should not be applicable to precontemplators' and contemplators' current habits, who, by definition, are not exercising. However, sedentary individuals completed the TNES based upon past attempts to exercise.

Hausenblas et al. (2001), in their development and validation study of the TNES, found a dramatic decrease in temptation to not exercise in the action and maintenance stages of change. They advocated the use of the TNES, in future intervention studies, to measure temptation levels, and thus, potential relapse. This scale served as an additional measure by which to differentiate regular exercisers and sedentary individuals. Consistent with TTM, regular exercisers should experience and report significantly less temptation to not exercise than sedentary individuals. The TNES has demonstrated discriminant validity, adequate internal consistency, and adequate psychometric properties within a sample of college students (Hausenblas et al., 2001).

Movement Imagery Questionnaire–Revised (MIQ-R)

Individual ability to image was measured using the MIQ-R. Participants first performed one of eight movements from the instrument then rated their ability, on a seven-point Likert scale, to image that specific motion. Of the eight items, four consist of visual imagery and four involve kinesthetic imagery (see Appendix F; MIQ-R; Hall & Martin, 1997). Higher ratings indicate greater ease in imagining the task. Recent studies involving mental imagery have used the MIQ-

R to assess participants' imagery ability (Smith et al., 2001; Lutz, 2003). Differences in imagery ability could influence psychophysiological and brain responses to imagery scripts. Measuring imagery ability allowed the researchers to control for differences in imagery ability.

State-Trait Anxiety Inventory (STAI)

Speilberger's (1977) STAI is a 40-question measure of state and trait forms of anxiety (see Appendix G). The items are rated on a four-point Likert scale that ranges from very much so (1) to not at all (4). Example items include "I feel calm," "I feel nervous," and "I feel jittery." Using this inventory enabled the researchers to assess **both** state and trait anxiety levels and to control for possible confounds.

NEO Five-Factor Inventory

The short form of Costa and McCrae's NEO Personality Inventory provided a means by which to examine the Five Factor Model (FFM) of personality (see Appendix H; Costa & McCrae, 1992). Researchers in the field of personality psychology (see McCrae, 2002, for review) have demonstrated the stability and longevity of personality traits, despite major life experiences. Personality is associated with psychological well-being and mental health. As such, the FFM of personality has received attention within the domain of exercise psychology (Courneya & Hellsten, 1998; Rhodes, Courneya, & Bobick, 2001).

Given the nature of personality and its influence on behavior, this study considered the levels of Neuroticism, Extraversion, Openness, Agreeableness, and Conscientiousness within and between groups. Participants' scores on the NEO were examined for potential covariates.

Behavior Inhibition System-Behavior Activation System Scale (BIS-BAS). The BIS-BAS is a measure of dispositional inhibition and activation developed by Carver and

White (1994). The scale is based on the premise that behavioral inhibition and behavioral activation systems govern behavior and affect. The behavioral activation subscale measures three types of activation termed, “reward responsiveness,” “drive,” and “fun seeking.” Participants rated items along four point scale from “very true to me” to “very false for me.” The BIS-BAS includes questions such as “When I want something I usually go all-out to get it” and “I feel worried when I think I have done poorly at something” to assess behavioral activation and behavioral inhibition tendencies (see Appendix I). The scale has demonstrated both convergent and discriminant validity. Dispositional propensity to engage in or avoid behaviors could influence physical activity behavior. The BIS-BAS allowed the experimenters to analyze dispositional inhibition and activation.

Beck Depression Inventory-II (BDI-II)

The BDI-II is a 21-item questionnaire that assesses the extent to which someone is experiencing symptoms associated with depression. Participants rated questions on a scale from 0 to 3 that best described their feelings over the previous two weeks, including the day they completed the questionnaire (see Appendix J; Beck, Steer, & Brown, 1996). The ratings from the 21 items were then summed to determine participants’ scores. The magnitude of depression is interpreted as follows: zero to 13 is minimal, 14 to 19 is mild, 20 to 28 is moderate, and 29 to 63 is severe.

Demographic Questionnaire

This questionnaire consisted of 17 items designed to gather background information and to determine group inclusion and exclusion. Individuals were instructed to answer as honestly and completely as possible. Questions involved age, sex, ethnicity, sexual orientation and exercise habits (see Appendix L)

Post-experiment Questionnaire

Questions regarding the degree to which participants imagined the scripts and attended to the pictures were included in this questionnaire to asses the degree to which participants followed instructions. Items concerning the purpose and nature of the study are also on this instrument (see Appendix M). The experimenter verbally asked participants the questions from the post-experiment questionnaire following the neuroimaging portion of the study.

Physiological Measures

Within Lang's (1985, 2000) biphasic theory of emotion, the brain's motivational systems (appetitive and aversive) mediate emotional response. Consequently, physiological, behavioral, and verbal responses to affective stimuli were expected to parallel brain activity (Bradley & Lang, 2000).

Skin conductance

Skin conductance, or electrodermal activity, is a common psychophysiological measure used to index arousal within the IAPS paradigm. Skin conductance response increases as the arousal rating of the stimulus increases. The experimenter ascertained measures of electrodermal activity via a Contract Precision Instruments Psylab stand-alone skin-conductance recorder (PsyLab SAM; Cambridge, MA). To assess electrodermal activity, the experimenter placed leads from the skin-conductance recorder, on the heel of the left hand, below the pinky finger of the participant [Contract Precision Instruments Psylab].

Heart rate

Researchers have consistently found specific heart rate patterns in response to affective picture stimuli: unpleasant pictures prompt greater initial deceleration while pleasant pictures elicit greater peak acceleration (Bradley & Lang, 2000). Cardiac patterns tend to vary as a function of the mental task. Previous research indicates that heart rate initially accelerates during aversive mental imagery tasks relative to neutral imagery (Lang, et al., 1990). Heart rate was assessed using an MRI Monitor heart recorder (MRI Monitor, 3155 (M); Orlando, FL).

Materials

In the experiment, **all** participants viewed the same set of 40 pictures and listened to 12 identical imagery scripts. The experimenters chose positive, negative, and neutral stimuli with which to compare participants' reactions to running-related pictures and scripts.

Picture-Viewing Paradigm

Participants viewed a total of 40 pictures, including five from each of the following four categories from the International Affective Picture System: threat, conntamination, erotica, and household objects (IAPS; Center for the Study of Emotion and Attention, 1999). Pictures from these categories (threat, contamination, erotica, and household objects) were included to depict highly arousing negative, highly arousing positive, and neutral events, respectively. Participants saw pictures of both threat and contamination as previous studies (Wright et al., 2003) have indicated that differences exist between reactions to these two highly arousing, negative categories.

Data indicate that participant reactivity varies as a function of picture content. For example, pictures reflecting threat resulted in the greatest potentiation of the startle reflex, independent of gender (Bradley et al., 2001). Research on gender differences revealed that **women** rate the most unpleasant pictures as more arousing than men. In contrast, **men** display greater reactivity for pictures containing erotica. Physiological responses (facial EMG activity, cardiac responses, and reflex modulation) further support differences in picture ratings.

The remaining 20 pictures were related to running. The researchers selected pictures of exercise behavior that allowed for multiple interpretations. Pictures of running that could be perceived negatively by sedentary individuals, but positively by regular exercisers, were included intentionally. For example, the experimenters chose pictures that depicted women engaging in seemingly difficult, fatiguing workouts. Pictures that involved elite and recreational runners were taken by Jim Rhoades, from Coolrunning.com, during different major marathons. To control for body image issues, participants viewed five pictures of elite runners, five pictures of recreational runners, five pictures of muscular (athletic) women not engaged in sport, and five pictures of neutral women who were sedentary and of normal body weight. Pictures that contained women sweating and not smiling were selected to reflect potentially difficult workouts (see Appendix Q).

Exercise-related pictures involved active participation in **running**. The investigators chose running to match the physical activity in which participants from the RE group primarily engaged. Images of running should elicit a greater amount of positive reactivity relative to other exercise-related pictures for these regular runners. Conversely, the same running-related pictures should evoke negative responses or lack positive responses from participants in the sedentary group, given their reported disdain for that specific form of exercise. Participants viewed each picture for the duration of five seconds, with a one-second interval in between pictures. The inter-category interval lasted for 30 seconds with a cross-hair at the center of the screen. The pictures were presented in a time locked-block design and were counterbalanced across participants.

Auditory (Imagery) Paradigm

The purpose of the imagery condition was to examine the effects of physical activity enjoyment on physiological measures in response to twelve different scripts. These imagery scripts, written by members of the Lang laboratory, included both response and stimulus propositions, and delineated pleasant, unpleasant, neutral and exercise scenarios (see Appendix N). The experimenter attempted to assess changes in heart rate, skin conductance, and brain activity during the imagery condition. Individual and group responses to 12 different imagery scripts were examined within Lang's bio-informational theory of emotional imagery.

Procedure

After obtaining approval from the University of Florida's Institutional Review Board, the investigators recruited participants via verbal and written advertisements. During the recruitment phase of the experiment, the researcher asked potential participants a list of prescreening questions concerning age, sex, ethnicity, sexuality, mental health status and history, exercise habits and intentions, height, weight, handedness, and fMRI safety. Prior to participation in the neuroimaging part of the study, participants completed a questionnaire packet (see Appendix O). The purpose of the packet was to obtain participants who met all of the inclusion criteria for one of the two groups and to ensure or control for variables affecting (1) homogeneity between groups with regard to mental health, social desirability, and imaging ability and (2) heterogeneity concerning running habits and attitudes. Any pregnant individuals were excluded from the study, given the potential risk to the fetus. The experimenter explained that participation was voluntary and that the participant had the right to withdraw from that the study at any time for any reason. After reading the consent form, potential participants had the opportunity to ask questions. Once the researcher obtained consent, participants completed all of the self-report measures except the post-experiment questionnaire.

Prior to start of MR scanning, a post-doctorate fMRI specialist positioned the participant correctly in the Siemens 3.0 T "head-dedicated" scanner (MAGNETOM Allegra, Siemens Medical Solutions; Malvern, PA). During MR scanning, each participant rested horizontally on a padded table with her head resting on a padded holder. Only the head and the upper shoulder of the participant were inside the MR magnet. To minimize motion artifacts, the head was restrained in an individually molded mask (a facial mask placed over the face to hold the head still). The experimenter conveyed the importance of minimizing all body and head movements during the scan. In addition, the experiment included MRI scans of the brain in the absence of stimuli as well as in the presence of visual and auditory stimuli.

During the study, participants received both verbal and visual instructions for each condition prior to the start of the scan. The investigator and participants were able to communicate via a microphone/headset in the scanner. An example of instructions given prior to a task is as follows, "Now we will be performing the functional scan, please watch the screen as we will be displaying some pictures on the screen. Please do not move your head or speak during the scanning. If you experience distress, please push the intercom button to inform us to stop the scan."

During the imagery condition, the experimenter instructed the participants to close their eyes prior to each scan, listen to each script carefully, image the described event as vividly as possible, and imagine each event as if they were actually participating in the event (Shin et al., 1999). The imagery scripts were presented auditorily via the computer. The order of script presentation was counterbalanced across participants.

In the picture condition, participants viewed a total of 40 pictures using a mirror-apparatus inside the scanner. The participants saw the pictures in a time-locked block design. For example, the participants viewed all five pictures, individually, from the threat category, then all five pictures from the contamination category, and so forth, until they had viewed all of the pictures. Participants were asked to focus on each picture for five seconds and on the cross-hair image presented in between the pictures for one second. The order of pictures presented within each category was randomized over the eight trials. In addition, the order of the picture category and of the conditions (visual and auditory) was counterbalanced across participants.

At the conclusion of the visual and auditory conditions, participants exited the scanner and viewed each picture and listened to each script again. They were asked to rate each picture on three dimensions, valence, arousal, and dominance using the Self-Assessment Manikin (SAM; Bradley & Lang, 1994) (See Appendix P). The SAM is a scale that contains graphic representations that correlate with valence (from positive to negative) and arousal (from high to low) dimensions.

After rating the stimuli, participants were asked questions from a post-experiment questionnaire (see Appendix M). Consistent the recommendations of Hale et al. (2003), the questions involved the extent to which participants focused on the pictures and imaged the scripts. Hale et al. (2003), in their critique of Slade, Landers, and Martin (2002), emphasized the importance of conducting manipulation checks following studies in which the task is not directly observable (e.g., imagery).

At the end of the experiment, the researcher debriefed the participants as to the purpose of the study. In addition, the participants were compensated monetarily for their participation. The SAM ratings were used to compare groups' affective reports, as well as to determine the covariation in BOLD response as a function of affective ratings. The researchers expected to obtain higher ratings of unpleasantness and arousal when sedentary individuals viewed exercise-related scenes relative to regular exercisers.

fMRI Techniques

This study incorporated an fMRI model to explore neuronal activation. MRI data were collected using the short-bore 3T Siemens Allegra system, fitted with a standard head coil. The Siemens Syngo software includes a package of standard pulse sequences. The standard pulse sequences was used to collect BOLD-sensitive echo planar imaging (EPI) data, in plane anatomical images and 3D anatomical images. EPI data was motion corrected, coregistered with 3D anatomical data, and normalized into Talairach space. Areas of functional activation were estimated using general linear modeling with BrainVoyager Software.

Optimization of fMRI Procedures and Resolution

The fMRI procedures were optimized for the current project by reducing the MR susceptibility effect (Mao et al, 2000), [pockets of air in head, created by the absence of blood and water, that can create dark space and obscure parts of the cortex] which is critical to the imaging of orbitofrontal cortex (OFC). In addition, the investigators have developed effective pre- and post-scan motion correction methods. A device that restrains head movement effectively was used to reduce and eliminate participant head movement. To reduce pulsation effects during the cardiac cycle, various motion correction strategies, including the navigator-echo technique and phase imaging methods developed to do the phase correction in the k-space (Liu et al., 1999a), have been used. The researchers set strict motion detection criteria for excluding participants' scans from the analysis (Liu et al, 1999a). Strict criteria were established based upon the significant impact of motion artifact on the results from an fMRI scan. Conventional block designs require a longer amount of time to conduct than event-related fMRI. As the duration of time inside the scanner increases, so too does the probablility of significant activation resulting from head movement increases. In sum, the experimenters used the best available techniques to deal with motion problems and to minimize motion artifacts.

To achieve a better spatial resolution of fMRI images, a critical aspect of localizing the small regions at subcortical structures (e.g., amygdala), the researchers have tested their MRI scanners with different field strengths (e.g., a 1.5 T GE scanner, two 3.0Ts, a GE Signa and a Siemens Allegra). In particular, the MRI techniques for imaging the red nucleus have been tested. High spatial resolution (0.5 mm^2) for the red nucleus has been achieved in a human 3T MRI scanner. This resolution is critical to obtaining functional signals in relatively small nuclei. The 3.0 T Siemens head dedicated high-field scanner will be used in the current project. The experimenters have achieved a current in-plane resolution of less than 1 mm^2 with a temporal resolution at 8.6 sec. This in-plane resolution is suitable for imaging slowly-induced emotion effects, but is highly time-dependant with regard to activation in the amygdala (usually has larger distortion on the PET images).

Spatial Reference System

The protocol for anatomical scanning has already been established in previous experiments in the researchers' lab. (see Liu, 1999b; James, 2001). The 3D spatial reference system (previously utilized for mapping the hypothalamus) was used for mapping small subcortical nuclei, including the red nucleus, the dentate nucleus, the internal globus pallidus and amygdala. The methods for calculating the centers of mass of the activated areas and the intensity weighted active brain volume were calculated after both the functional and anatomical images were coregistered to a reference image under the standard Talairach space (Talaraich & Tournoux, 1998). This reference system is based on the functional volume modeling method (Fox et al., 1999), in which the actual sites of interest are determined by the functional activation (or deactivation) signal with reference to the standard brain space using the Talairach coordinates.

Scanner and MRI procedures: For each experiment, MR images was acquired on a newly upgraded 3.0 T "head-dedicated" scanner (Siemens/Allegra System: updated from Syngo platform to Numaris 3.5 platform) located at the University of Florida McKnight Brain Institute. Both standard Siemens head coil and a dome-shaped head coil, developed at University of Florida, were used for radio-frequency transmission and reception of the MR signal. Both T1- and T2-weighted anatomical MRI images were acquired before functional scans for localization of the regions of interest (including subcortical nuclei, which have clear boundaries on the T2 images due to their intrinsic MRI susceptibility effects).

The Allegra is a head-dedicated high field MRI scanner, which is used both as a research system in cognitive neuroscience and clinical investigations. Designed for advanced neural MRI studies, the field of view (22 cm) is optimized to the requirements of brain imaging. Both the magnetic field homogeneity (0.3ppm) and the gradient power (40mT/m Amplitude; 100 microsec Rise Time; 400 T/m/s Slew Rate) are focused on the brain imaging volume. This benefits MR imaging studies of the brain that require high temporal/spatial resolution. The high 3T magnetic field serves to enhance imaging performance in advanced brain studies based on susceptibility weighted contrast (perfusion or diffusion weighted images and functional MRI) and chemical shift (spectroscopy).

The compact magnet design of the MRI system provides open access to human participants. In addition, it also accommodates headphones and eyeglass devices that are required in stimulation-based functional MR imaging studies. The 3.0 T field strength of the magnet will increase signal-to-noise ratio and BOLD effect. The development environment for protocols and pulse sequences is fully integrated. It allowe not only for development, but also for simulating, testing and debugging of protocols and pulse sequences.

The dedicated Allegra is based on the clinical 1.5T Symphony product platform. The operation is very similar to that of other MAGNETOM systems. Wherever possible, the Allegra uses standard MAGNETOM hardware, software, and service components. Unique components of the head scanner are the magnet, the patient table, the gradient and shim coils, a CP head coil, 123 MHz RF electronics, and a 123 MHz RF power amplifier. This scanner has also been used in the recent preliminary study discussed above (Wright et al, 2003).

Siemens Allegra provides the following pulse sequences and protocols: a basic set of pulse sequences and protocols including the standard T1-, T2-, T2*-, and proton density weighted imaging with the system. The EPI pulse sequence, diffusion-weighted EPI (with all the diffusion gradients, 1st and 2nd order, enabled), and perfusion-weighted EPI pulse sequence are included in the software package.

Siemens provides the sequence development environment (not included in standard package). Technical personnel (Dr. He) develop a home-made pulse sequence or modify sequences existed to meet research specific requirement. It also can be used for simulating, testing and debugging of protocols and pulse sequences.

Functional sequences. A gradient-echo EPI (EPI-RT on the GE scanner according the current update) pulse sequence were used with the following scan parameters: TR/TE/FA = 2.0s/25ms/90o, FOV = 240mm, matrix size = 64X64 with an in-plane resolution of 3.75 x 3.75 mm^2 and 32 slices (3.75 mm thick) without gap covering the whole brain (note in this proposal, we use an isometric cubic voxel size for a better functional signal). In addition, the cerebellar, basal ganglia, and amygdala regions were focused with a high in-plane resolution (~= 0.5 mm^2) using a FLASH sequence which has been used previously (Liu et al, 2000b) but with a higher spatial resolution under the 3T system [a conventional T2*-weighted gradient-echo pulse sequence (TR/TE/Flip Angle = 45ms/25ms/200; slice thickness = 10 mm; FOV = 20 cm x 20 cm; matrix size=384 x 192; pixel size = 0.5 mm x 1 mm, giving a in-plane resolution of 0.5mm2 and temporal resolution of 8.6 sec], to reduce the distortion, for example, at the amygdala.

Data Analysis

Self-Report Measures

Valence and arousal ratings were not expected to be significantly different between groups for the pictures containing contamination, threat, erotica, or household objects. However, according to the hypotheses, we expect a significant main effect for **running** pictures as a function of physical activity level. Regular exercisers were expected to report significantly higher arousal and valence ratings for exercise-related pictures compared to neutral pictures (household objects). Independent sample t-tests were performed to determine if both groups (regular exercisers and sedentary individuals) reported significantly different arousal, valence, or dominance ratings for each **picture** category. Picture categories include (1) threat, (2) contamination, (3) household objects, (4) heterosexual erotica, (5) elite female runners, (6) recreational female runners, (7) neutral-looking women, and (8) athletic (muscular) women. Additionally, independent sample t-tests were conducted to assess differences between arousal, valence, and dominance ratings of each **imagery** scripts. The imagery scripts included six different types of scripts: (1) erotica, (2) pleasant, (3) neutral, (4) contamination, (5) threat, and (6) running. Additional analyses examined whether significant differences exist between groups on scores on the LTEQ, TNES, MIQ-R, STAI, NEO, BIS-BAS, BDI, and post-experiment questionnaire. Furthermore, brain activation patterns in the proposed circuitry, consisting of the AMG, OFC, Ventral Striatum, and ACC, were assessed.

Heart Rate

Independent samples t-tests were used to examine between-group differences for average heart rate for **picture** stimuli. In the **imagery** condition, regular exercisers were expected to demonstrate a significantly different heart rate pattern than sedentary individuals for the running script. To determine if any significant differences existed between groups with regard imagery scripts, an independent samples t-test was used. No difference was anticipated between regular exercisers' HR responses between the positive and running script.

Skin Conductance

Researchers intended to use independent samples t-tests to examine differences in electrodermal activity for regular exercisers and sedentary individuals in response to **pictures**. Differences in electrodermal activity were expected to occur for running compared to household pictures for both groups.

In addition, independent samples t-test to assess differences in electrodermal activity for regular exercisers compared to sedentary individuals in response to imagery scripts. A lack of difference between groups in skin conductance would reflect similar arousal levels. However, differences in heart rate and self-report responses would indicate significant valence differences. In other words, the arousal levels may be similar, but valence ratings should differ by group.

Neuroimaging

Data analysis was focused on first, the comparisons between the patterns of brain activation by running-relevant vs non-running pictures, and second, on differences both within and between groups, according to the stated hypotheses. Analysis was undertaken using BrainVoyager v.4.9.6 (Brain Innovations, Maastricht, Holland). The fMRI images were co-registered with a high-quality 3D scan and standardized into Talairach space (Talaraich & Tournoux, 1988). Preprocessing included motion correction, slice scan time correction, linear trend removal and both spatial and temporal smoothing. The fMRI response was determined individually by voxel-wise general linear modeling, using the experimental time-course of each condition convolved with a standardized hemodynamic response equation as predictors (Boynton et al. 1996). Voxel-wise t-values were determined using a two-level random effects analysis in which the first level determines beta weights for each predictor using partial least squares. The second level determines statistically consistent activation across all participants using a simple t-test on the beta weight for each participant. The resulting statistical map was created a threshold using a t value of 4.00 (unless otherwise stated) and a minimum cluster size of 50. The image processing was performed on SUN Ultra60 workstations installed in Dr Liu's lab using BrainVoyager software packages and in-house programs, including corrections for head motion and global MRI signal shift. For each participant, the pixel-wise MRI signal intensity during each block $S_{block}(t)$ was normalized to a resting baseline s_0 to obtain the fMRI time series $S_{block}(t)$ using the following equation [a revised temporal normalization procedure has been proposed (He, 2001) and will be used as an alternative method]:

$$S_{block}(t) = [s_{block}(t) - s_0]/s_0 \qquad (t = 1, 2, 3 \ldots N),$$

in which N is the number of images acquired within a block and s_0 is the mean of the resting MRI signal averaged on the number of images acquired during all resting blocks. The task-induced activation was then determined by comparing the mean of the time series during the task, $S_t(t)$ and that during the control, $S_c(t)$, using group t tests. The resultant t-maps and their corresponding T2* images will then be co-registered with the T1 anatomical images using a spatial normalization procedure.

The ROIs selected in the analysis were determined based upon activation maps generated using statistical parametric images and the normalized or not normalized t-score image. The pre-selected anatomical regions include the amygdala, the NAc, and the OFC, which have been strongly implicated in reward and punishment processing. The functional relevance of these regions has been discussed in the Background and Significance Section in Chapter 2. The anatomical localization of these regions were performed by a standard spatial normalization procedure.

The researchers took the time series during neutral, $S_r(t)$, and the difference between time series, $\Delta S(t) = S_t(t) - S_r(t)$, for analysis of the interregional covariance. The fMRI signal change, $\Delta S(t)$, was calculated by paired subtraction at each image time in a block. This process eliminates the linear drift of MRI signal intensity and also reduces the physiological noises that may come from the respiratory and cardiac cycles. The time course in an active ROI (the functional cluster defined on the activation map, see above) was obtained by averaging $\Delta S(t)$ or $S_r(t)$ on the number of voxels in the ROI. The resultant mean values of $\Delta S(t)$ or Sr(t) in the ROIs (e.g., Amg or NAc) were then used for region-to-region covariance analysis across both trials and participants. The covariance maps were generated on a voxel-by-voxel basis by correlating the time series $\Delta S(t)$, in a reference ROI (e.g., an active region in the AMG), with those in the voxels throughout the image(s). The cross correlation (r) was calculated using the method from a previous report of fMRI time course. In the current study, the investigators used only the time series within the period of a block. The time series averaged on an active region served as the reference function. This method is independent of the blocked paradigm. The significance of r (versus zero) was determined by one-tail paired t tests ($n = 10$) in our study.

Functional clusters, defined on the averaged functional maps, were quantified further for between-group comparisons. The statistical significance of the difference in the activation magnitudes in these clusters between different groups was determined based on individual data with a threshold at the same P level ($p < 0.05$).

Scenario for Imaginary Task

The researchers did not anticipate significant between-group differences in physiological responses (as measured by skin conductance and heart rate) to pleasant, unpleasant, and neutral imagery scripts and IAPS pictures. The experimenters hypothesized that physiological reactions differ between groups in both exercise-related conditions (imagery and pictures). Both the imagery scripts and pictures should have elicited positive reactions in the RE group and negative responses in the SI group. Consistent with Lang's bio-informational theory of emotional imagery (1979), the researchers expected increased physiological or "efferent" output as the perceived emotionality of the stimulus (imagery script) increases.

More specifically, the running-related scripts and pictures should have activated areas of the brain associated with positive reward (e.g., the orbitofrontal cortex—medial or lateral is not clear now, nucleus accumbens, ventral striatum), as opposed to punishment, for regular exercisers. Conversely, increased activity was expected in the areas of the brain involved in punishment and decreased activity was anticipated in the areas of the brain associated with reward (orbitofrontal cortex, nucleus accumbens, and ventral striatum) for sedentary individuals. Overall, both groups were expected to demonstrate similar activity in the areas of the brain hypothesized to be involved in visual imagery and visual processing.

CHAPTER 4
RESULTS

Self-Report Measures

Exercise-Related Questionnaires

Leisure-Time Exercise Questionnaire (LTEQ)

Regular exercisers (RE) reported engaging in approximately 6.30 bouts of strenuous, 3.84 bouts of moderate, and 5.10 bouts of mild exercise. In comparison, the sedentary individual (SI) group did not report participating in any strenuous types of physical activity. Because one sedentary individual reported one moderate bout of physical activity, participants in the SI group averaged 0.20 bouts of moderate exercise. The mean number of mild bouts of physical activity for the SI was 1.60 (see Figure 4 – 1). RE and SI mean scores on strenuous, moderate, and mild scales of the LTEQ were significantly different ($t(8) = 6.27$, $p < .01$; $t(8) = 2.94$, $p < .02$, $t(8) = 2.71$, $p < .05$).

Body Mass Index

The mean body mass of the regular exercise group ($M = 21.7$, $SD = 1.90$) was less than the sedentary individual group ($M = 22.5$, SD = 3.12). However, the difference between the groups was not statistically significant ($t(8) = .311$, $p > .05$).

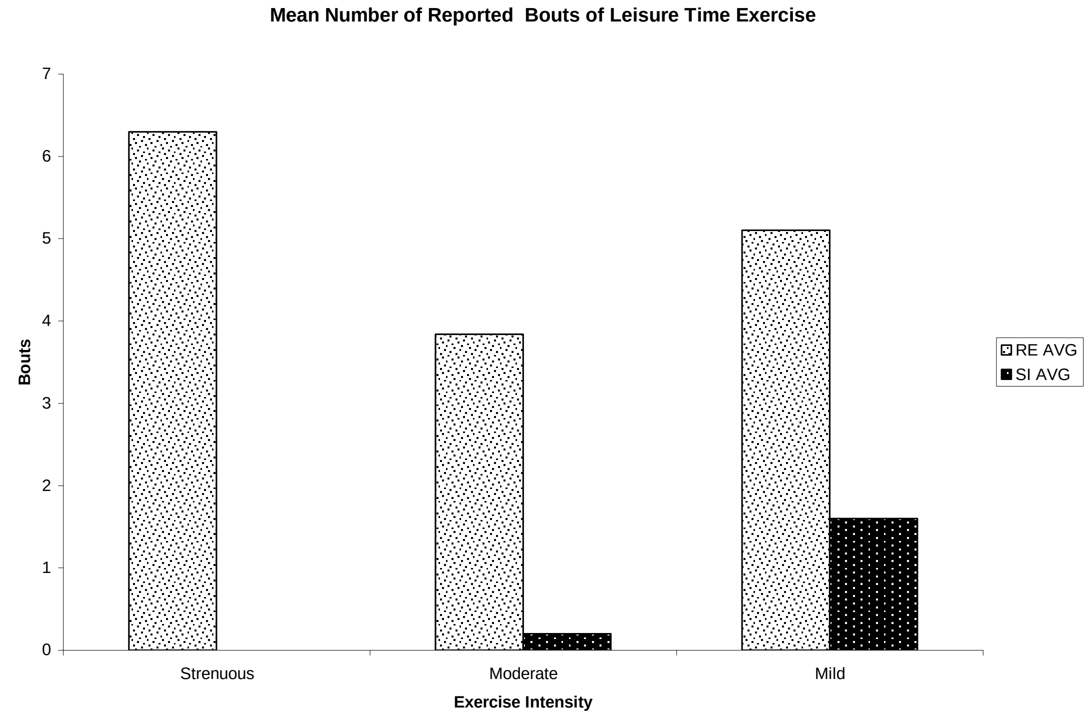


Figure 4-1. LTEQ reported 20-minute bouts of exercise by intensity.

Stages of Exercise Change Questionnaire (SCQ)

The regular exercise group consisted of four *terminators*, who, by definition, had been running for more than 5 years, and one individual in the action stage who had been exercising regularly for less than 6 months. In contrast, three participants in the SI group intended to exercise in the coming 6 months (definition of the *contemplation* stage) and two reported the intention of *initiating* an exercise program within 30 days.

Exercise Motivation Scale (EMS). The researchers analyzed only regular exercisers' responses to the following scales of the EMS: amotivation, external regulation, introjected regulation, identified regulation, integrated regulation, intrinsic motivation to learn, intrinsic motivation to accomplish things, and intrinsic motivation to experience sensations. On average, regular exercisers scored higher on the intrinsic motivation scales (M = 4.35, SD = 1.17) than the amotivation and extrinsic motivation scales (*M* = 3.47, *SD* = 1.76). With the exception of the scale reflecting intrinsic motivation to learn, participants' scores tended to increase with the number of questions reflecting intrinsic motivation.

Temptation Not to Exercise Scale (TNES)

Results indicate discriminate findings between members of the regular exercise and sedentary individual groups with regard to their levels of temptation to avoid exercise in given situations. In response to every question, sedentary individuals were much more likely to be tempted to not engage in exercise. See Table 4-1 for the mean responses of the groups to each question on the TNES. There were significant differences ($t(8) = 5.16$ $p < .01$) between regular exercisers' and sedentary individuals' scores on the TNES.

Table 4-1. Regular Exercisers' versus Sedentary Individuals' Mean Responses to Questions from Temptation Not to Exercise Scale

	Regular Exercisers (n = 5)	Sedentary Individuals (n = 5)
Question	%	%
1. When I am angry	0	82
2. When I feel lazy	52	84
3. When I feel satisfied	12	64
4. When I feel that I don't have time	48	84
5. When I am alone	0	74
6. When family events or situations interfere	38	78
7. When I am stressed	10	70
8. When I am busy	40	90
9. When I am out of shape	22	86
10. When I have work to do	53	86

Note: Percentage of time participants felt tempted not to exercise in the given situations.

Background Questionnaires

Movement Imagery Questionnaire- Revised (MIQ-R). Participants' ability to employ both kinesthetic and visual imagery did not appear to differ between groups. Compared to regular exercisers' mean score on the kinesthetic scale of 22.8, (*SD* = 6.1), sedentary individuals averaged 22.0 (*SD* = 9.0) on a 28-point scale. Additionally, regular exercisers' mean score on the imagery scales was 24.8 (*SD* = 2.8), compared to sedentary individuals' means score of 24.6 (*SD* = 3.4). There were no significant differences between groups on either the kinesthetic ($t(8) = .164$ $p > .05$) or visual ($t(8) = .101$ $p > .05$) imagery scale.

State-Trait Anxiety Inventory (STAI)

Results revealed that regular exercisers did not differ greatly from sedentary individuals with respect to scores on state (RE: $M = 1.98$, $SD = .51$; SI: $M = 1.92$, $SD = .37$) and trait (RE: $M = 1.74$, $SD = .58$; SI: $M = 1.77$, $SD = .36$) levels of anxiety, as measured by the STAI. There were no significant differences between groups on either the state ($t(8) = .282$, $p < .05$) or trait ($t(8) = .098$, $p > .05$) scales.

NEO Five Factor Inventory (NEO)

The only significant difference between groups occurred concerning agreeableness ($t(8) = 2.37$, $p < .05$). See Table 4-2 for mean scores.

Behavior Inhibition System-Behavior Activation System Scale (BIS-BAS)

For means and standard deviations, see Table 4-3. There were no significant differences between groups on any scale of the BIS-BAS: BAS drive ($t(8) = 1.09$, $p > .05$), BAS Fun seeking ($t(8) = .55$, $p > .05$), BAS Reward ($t(8) = 1.0$, $p > .05$), and BIS ($t(8) = 1.42$, $p > .05$).

Table 4-2. Regular Exercisers' versus Sedentary Individuals; Levels of Neurotic, Extroversion, Agreeableness, Openness, and Consciousness Scales of the NEO

Scale	Regular Exercisers (n = 5)		Sedentary Individuals (n = 5)	
	Score			
	M	*SD*	*M*	*SD*
Neuroticism	15.2	10.1	17.8	6.8
Extraversion	32.4	7.4	31.4	5.7
Openness	34.0	2.7	37.6	6.5
Agreeableness	32.6	3.4	38.6	4.5
Consciousness	35.0	6.0	32.8	6.9

Table 4-3. Regular Exercisers' versus Sedentary Individuals' Degree of Behavioral Inhibition and Behavior Activation

Scale	Regular Exercisers (n = 5)		Sedentary Individuals (n = 5)	
	Score			
	M	*SD*	*M*	*SD*
BAS Drive	10.4	2.2	9.0	1.9
BAS Fun Seeking	11.6	2.3	12.2	0.8
BAS Reward	16.6	2.1	18.0	2.3
BIS	15.8	3.6	18.8	3.1

Beck Depression Inventory (BDI-II)

The score of one participant in the regular exercise group fell 2.67 standard deviations from the mean; thus, it was considered an outlier. When controlling for the outlier, regular exercisers and sedentary individuals display similar mean scores on the BDI-II, (RE: $M = 2.0$, $SD = 1.6$; SI: $M = 3.4$, $SD = 3.1$). However, there were no significant differences between groups when the outlier was included ($t(8) = .39$, $p > .05$).

Post-Experiment Questionnaire

There were no significant differences between the RE and SI groups with regard to degree to which they watched the picture ($t(8) = .48$, $p > .05$) or the extent to which they listened to the imagery scripts ($t(8) = .63$, $p > .05$)

SAM picture ratings

Participants from the RE group rated pictures of elite runners significantly higher ($t(8) = 3.61$, $p < .01$) and pictures of threat ($t(8) = 2.73$, $p < .05$) than participants from the SI group. There were no significant differences between groups with regard to ratings on the valence, arousal, or dominance dimensions of any other picture category.

SAM script ratings

The only significant difference between groups concerning imagery script ratings on the valence, arousal, and dominance levels, was on the valence dimension for pleasant scripts ($t(8) = 2.36$, $p < .05$).

Table 4-4. Regular Exercisers' (RE) and Sedentary Individuals' (SI) Mean SAM Ratings for Pictures

	RE[1]		SI[2]		RE[1]		SI[2]		RE[1]		SI[2]	
	Valence				Arousal				Dominance			
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Erotica	5.7	1.9	6.2	1.4	5.3	1.7	6.1	1.4	5.0	1.7	6.6	1.8
Threat	0.2	0.4	1.4	1.8	6.4	1.5	4.4	3.1	2.6	1.8	4.1	2.7
Contamination	0.7	0.4	1.0	0.7	4.7	0.5	4.4	2.6	4.4	0.8	4.6	2.6
Neutral (IAPS)	4.1	0.4	4.3	0.5	1.4	1.3	1.7	1.9	6.7	2.2	7.6	1.6
Neutral Women	5.1	0.8	5.2	1.4	1.8	1.8	1.4	1.6	7.1	2.3	7.6	1.6
Athletic Women	4.7	1.9	5.6	1.5	3.0	1.8	2.3	1.8	6.0	1.8	6.6	1.5
Elite Runners	6.1	0.9	4.6	0.9	4.4	1.2	2.7	3.2	6.4	1.9	6.6	1.8
Recreational Runners	5.3	0.8	4.5	0.9	3.2	1.5	2.2	2.6	7.3	1.6	6.8	1.8

Note: 1 represents low, 9 high; [1] n = 5; [2] n = 5

Table 4-5. Regular Exercisers' and Sedentary Individuals' Mean SAM Ratings for Imagery Scripts

	Valence				Arousal				Dominance			
	RE[1]		SI[2]		RE[1]		SI[2]		RE[1]		SI[2]	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Erotica	7.0	0.71	7.5	0.96	5.5	1.27	6.9	0.74	7.0	2.00	6.8	3.03
Threat	0.9	0.65	0.7	0.84	6.9	1.02	4.1	2.88	3.0	2.09	3.2	2.16
Contamination	0.8	0.76	0.9	0.61	6.0	1.32	4.4	2.63	3.3	1.60	4.1	3.35
Neutral	4.7	0.84	4.9	0.82	1.6	1.47	1.4	1.56	7.9	1.43	7.2	2.01
Pleasant	7.4	0.42	7.9	0.22	6.4	0.65	5.4	3.11	8.0	1.41	6.4	3.44
Running	6.2	1.15	5.5	2.17	6.6	0.89	3.8	3.42	7.2	1.30	6.4	3.44

Note: 1 represents low, 9 high
[1]n = 5, [2]n = 5

Psychophysiological Data

Heart Rate Response

Because the heart rate data were unable to be recorded on-line (i.e., the computer recorded raw numbers as opposed to heart rate trends), the researchers opted not to analyze it. Heart rate data collected in the Lang laboratory is examined with regard to initial and subsequent patterns of accelerations or decelerations. Heart rate data needed to first be averaged, every three seconds, and then compared within and between groups. Given the abundance of other psychophysiological data (e.g., cortical activity), heart rates were not averaged for the purpose of reporting.

Skin Conductance Response

Inconsistent functioning of the skin conductance machine inside the scanner prevented the researchers from collecting consistent electrodermal responses throughout the scan. As a result, the skin conductance data was not analyzed for either condition.

fMRI Data

Prior to analysis, each brain had to be co-registered separately in Brain Voyager. Co-registration involves the localization, normalization, and standardization of each brain into Talairach space, as described in the Methods section of chapter 3. After co-registering each brain, a team of researchers performed several analyses involving both between- and across-group comparisons. These analyses were conducted based upon 1) findings from previous literature and 2) hypotheses from Chapter 3. After each analysis the time courses of significant clusters of brain activation were surveyed to determine if the activation seemed legitimate, or if it appeared to be a byproduct of motion artifact. A total of five whole-group analyses were performed, while nine between-group comparisons were conducted. In addition, 182 clusters were surveyed resulting from between-group analyses, and 91 clusters were evaluated from whole-group analyses. Clusters are defined as areas of activation in the brain in which the blood oxygenation level (BOLD) changes significantly ($t > 4$, $p < .001$) in response to the presentation of a stimulus or task. Further analysis involved examining relevant clusters of activation within specific brain regions of interest. Results will be discussed within each condition (pictures and imagery scripts) by brain region of interest.

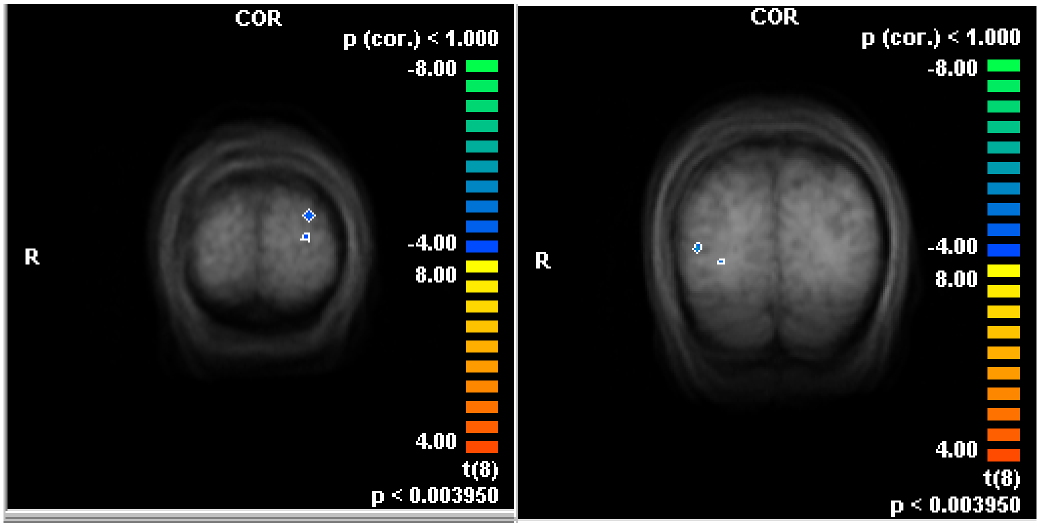
Voxel-wise t-values were determined using a two-level random effects analysis with general linear modeling (GLM) in which the first level determines beta weights for each predictor using partial least squares. The second level determines statistically consistent activation across subjects using a simple t-test on the beta weights for each subject. The resulting statistical map shows clusters of activation within the brain in which the threshold for activation was set at a t value of 4.00 (unless otherwise stated) and a minimum cluster size of 50.

Cortical Activity

Visual Stimuli (Pictures)

Occipital cortex

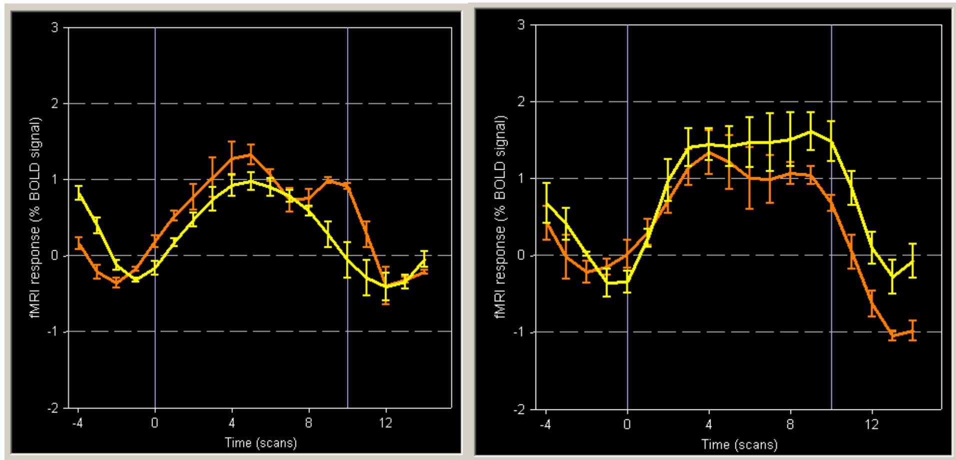
A whole-group analysis contrasting pictures of elite runners and neutral pictures from the IAPS resulted in four clusters of significant activation within the occipital cortex. These clusters reveal significant differences between regular exercisers' and sedentary individuals' hemodynamic responses to pictures of elite runners. This differential response occurred in both left and right hemispheres (see Figure 4-2).



A B

Figure 4-2. The clusters of bilateral activation are outlined in both the left and right hemispheres and are shown from the coronal view. Each cluster represents significant differences in the signal change between groups. Talaraich coordinates are as follows: right: +33, -77, +3, left: -24, -90, +16. A) Left Occipital Cortex B) Right Occipital Cortex

As Figure 4-3 demonstrates, *regular exercisers* display a *stronger* response to pictures of elite runners than to neutral pictures. Conversely, the opposite pattern of activity occurs for sedentary individuals: stronger response to neutral pictures than to those of elite runners. The yellow line represents responses to pictures of neutral (IAPS) objects while the orange line denotes activity during the presentation of pictures of elite runners.



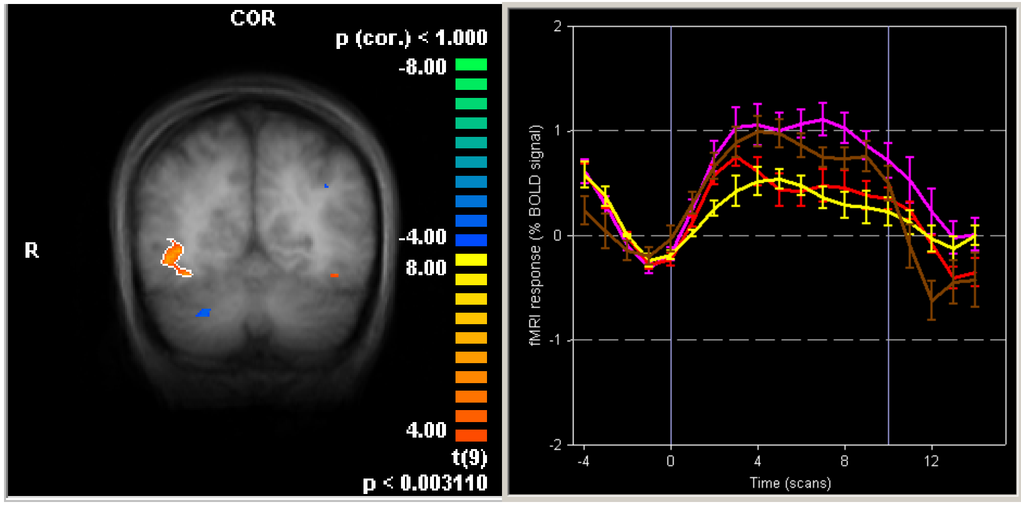
A B

Figure 4-3. The Percent Signal Change in the Responses of Regular Exercisers and Sedentary Individuals to Pictures of Elite Runners and Neutral Objects. A) Regular Exercisers B) Sedentary Individuals

Additional analyses in which the occipital cortex demonstrated activation during whole-group analyses included the following contrasts: between 1) all emotional vs. neutral pictures, 2) emotional IAPS pictures vs. neutral IAPS pictures, and 3) unpleasant vs. pleasant IAPS pictures. These patterns of activation did not differ between groups.

Fusiform Gyrus

Whole-group analyses revealed activation in both the right and left fusiform gyrus in response to emotional IAPS pictures compared to neutral IAPS pictures. In Figure 4-4, both the clusters of activation and time courses are shown for participant response to emotional and neutral IAPS pictures.



A B

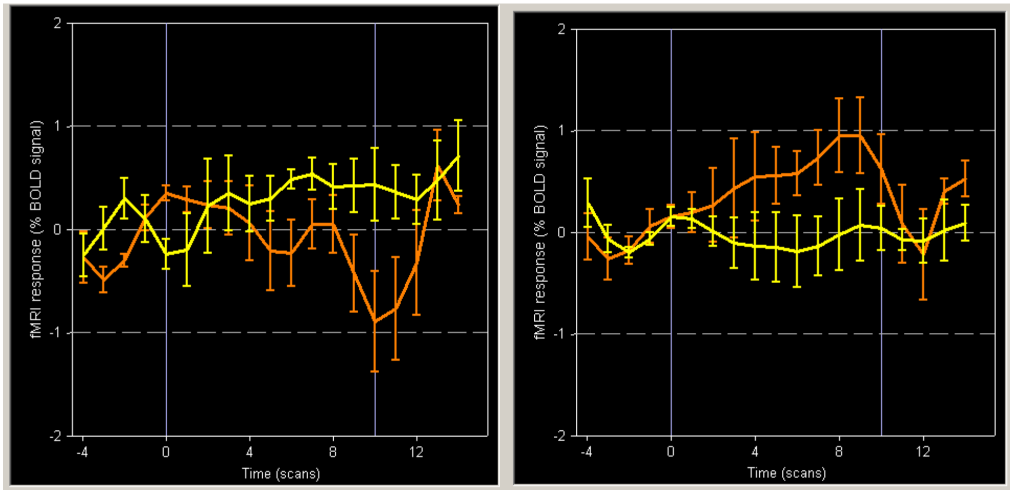
Figure 4-4. Activation in the right fusiform gyrus A) Talarach coordinates of the cluster in the right fusiform gyrus: +40,-56,-5. B) Time course for the significant cluster of activation in which pink represents erotica, brown threat, red contamination, and yellow neutral.

Prefrontal Cortex

In the medial dorsal prefrontal cortex, *sedentary individuals* displayed greater reactions to pictures of elite runners than neutral pictures (Talaraich: 0, 56, 30). In contrast, regular exercisers demonstrated no differences in their responses to elite runners and neutral pictures. Refer to Figure 4-5 for graphs of differential activation.

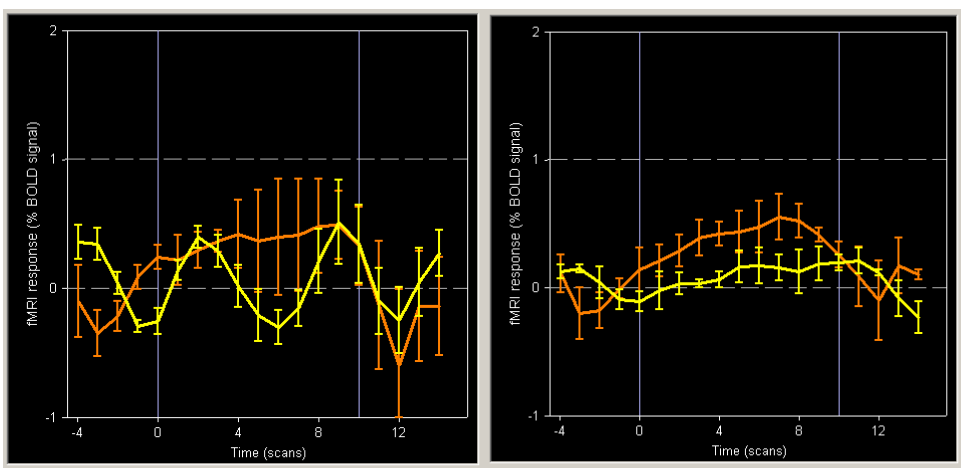
Amygdala

Pictures of **elite runners** elicited consistently greater responses in *sedentary individuals* than regular exercisers. For example, the time course of activation of *sedentary individuals*, compared to regular exercisers, indicates a greater response to elite pictures. See Figures 4-6 and 4-7 for more detail



A B

Figure 4-5. Time courses of group responses to elite runners and neutral pictures. Pictures of elite runners are depicted by the orange line, while yellow represent neutral pictures. A).Regular Exercisers . B). Sedentary Individuals



A B

Figure 4-6. The graphs represent the different time courses of percent signal change of regular exercisers and sedentary individuals in response to elite runners (orange). Note: The time course of neutral IAPS pictures (yellow) is included in the graph as a reference. A) Regular Exercisers B) Sedentary Individuals

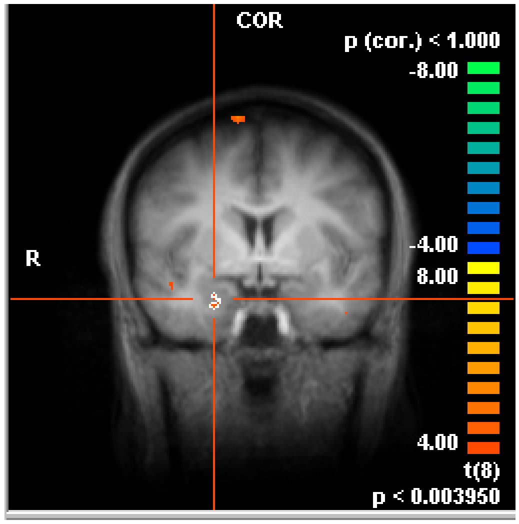
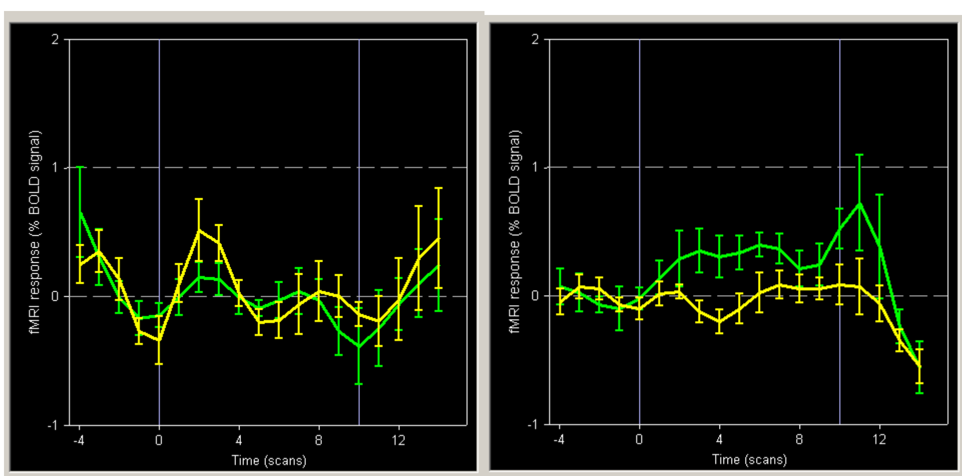


Figure 4-7. Activation of the right amygdala elicited by pictures of elite runners for sedentary individuals. Talaraich coordinates: 23, 0, -23.

Left Amygdala/Ventral Striatum

Sedentary individuals displayed greater activation in response to pictures of **athletic women** relative to neutral objects. In contrast, regular exercisers' pattern of reactivity, however, did not differ significantly between athletic women and neutral objects. Figure 4-8 illustrates the between-group differences.

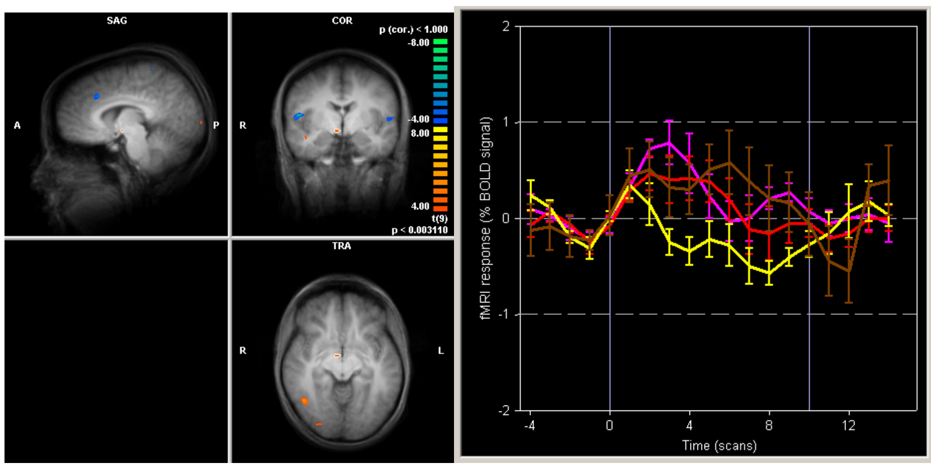


A B

Figure 4-8. Green represents the time course of pictures of athletic women while yellow refers to neutral objects. A) Regular Exercisers B) Sedentary Individuals

Ventral Striatum

A whole-group analysis revealed greater activation in response to emotional IAPS pictures compared to neutral IAPS pictures. No significant differences existed between regular exercisers and sedentary individuals with regard to the comparison between emotional and neutral pictures. Figure 4-9A shows activation clusters while Figure 4-9B displays the time course of all participants' responses to emotional and neutral IAPS pictures.



A B

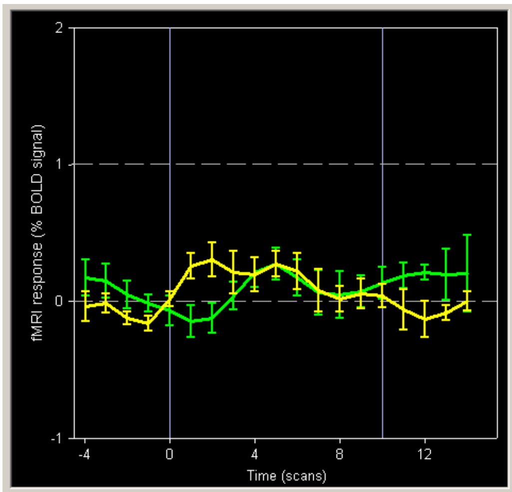
Figure 4-9. Response to emotional IAPS pictures compared to neutral IAPS pictures in the Ventral Striatum A) The orange cluster of activation inside the ventral striatum is outlined. B) In this time course involving pictures, yellow represents neutral, brown - threat, red - contamination, and pink - erotica.

Right Cerebellum

Compared to regular exercisers, *sedentary individuals* displayed greater activation to **athletic** pictures (see Figure 4-10 for more detail). Furthermore, pictures of **elite** runners elicited greater activation in multiple clusters in the cerebellum for sedentary individuals relative to regular exercisers.

Left Cerebellum

In the left, similar to the right, cerebellum, *sedentary individuals* displayed greater overall levels of activity to all pictures. Pictures of **elite runners** elicited greater activity for *sedentary individuals* compared to regular exercisers. Overall, pictures evoked less responsiveness in the cerebellum for regular exercisers.



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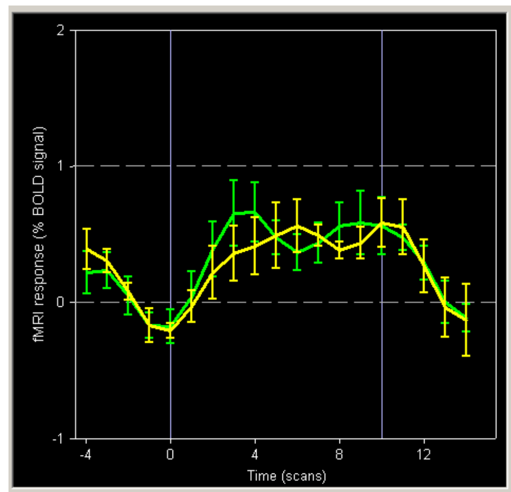


B

Figure 4-10. Time courses of athletic (green) and neutral (yellow) pictures. A) Regular Exercisers B) Sedentary Individuals

Midline Cerebellum

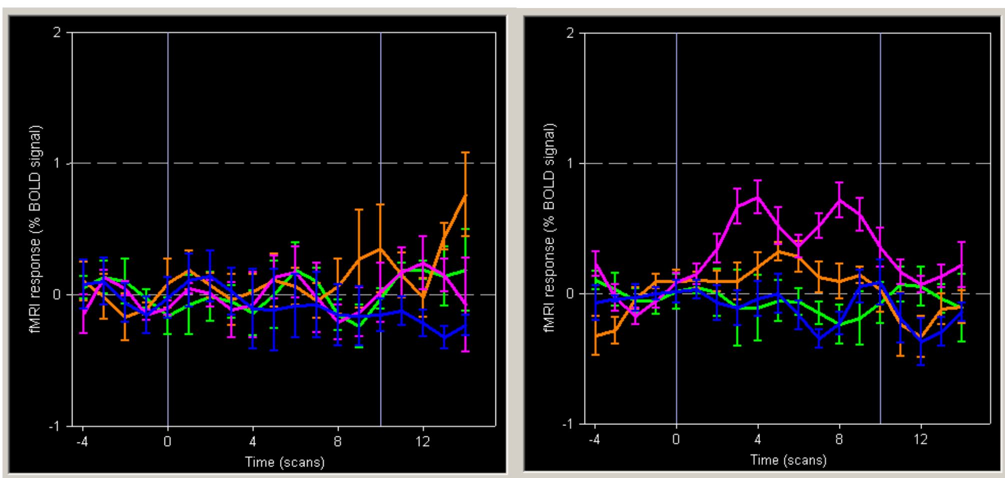
Between-group analyses revealed greater responses to **pictures** of erotica than pictures of athletic women, recreational runners, and elite runners for *sedentary individuals* only. Regular exercisers did not demonstrate differential activation to the aforementioned pictures (refer to Figure 4-11).

Cortical Activity

Auditory Stimuli (Imagery Scripts)

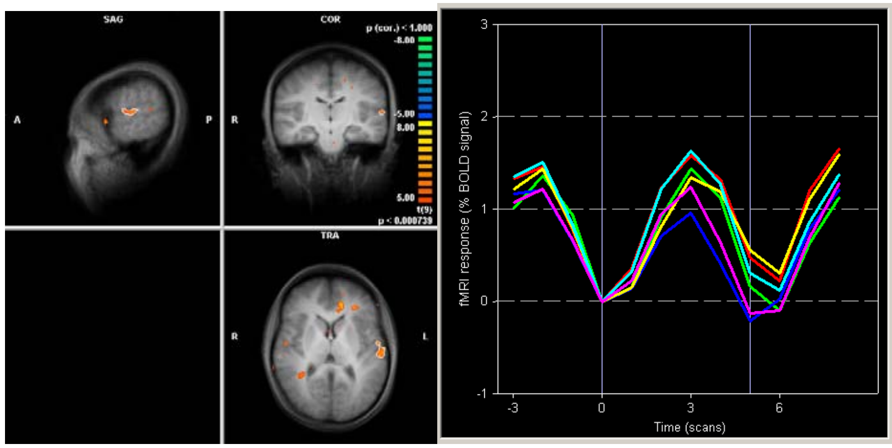
Primary Auditory Cortex

Significant activation was found in the primary auditory cortex in response to all **emotional** compared to **neutral** imagery scripts during whole-group analyses. Figure 4-12 shows both the significant cluster in the left hemisphere and its time course of activity. ***NOTE***: The colors used to depict patterns of activation during the auditory paradigm are NOT the same as the colors implemented in the visual paradigm.



A B

Figure 4-11. Time course of celebellar activity in response to athletic, elite runners, and recreational runner pictures compared to erotica. In this time course involving pictures, pink represents erotica, green – athletic women, orange – elite runners, and blue – recreational runners. A) Regular Exercisers B) Sedentary Individuals



A B

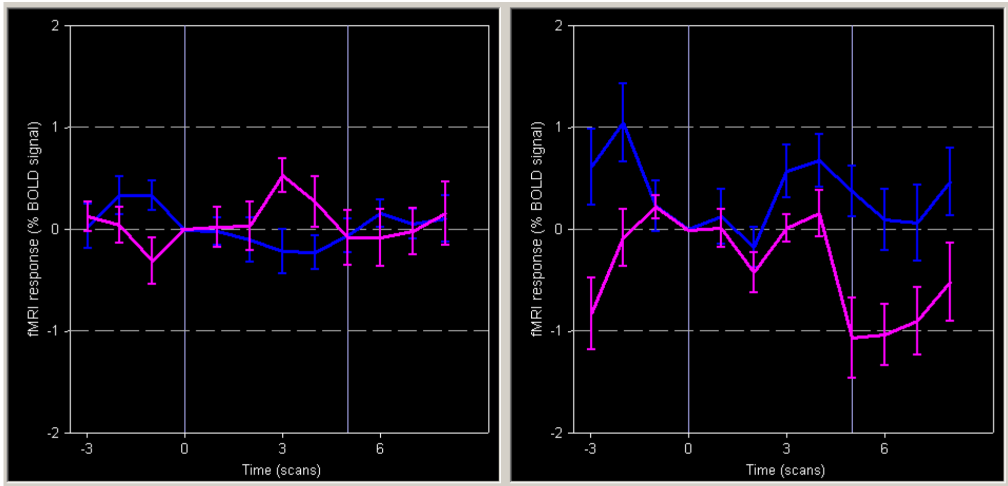
Figure 4-12. Activation in the primary auditory cortex. A) Clusters of Activation B) Time course of percent change in hemodynamic response. The following colors correspond with the following imagery scripts: blue corresponds with neutral, yellow with erotica, green with threat, pink with running, cyan with pleasant, and red with contamination.

Ventrolateral Prefrontal Cortex (VLPFC)

The second between-group analysis that demonstrated differential hemodynamic in the VLPFC involved imagery scripts. Regular **exercisers** demonstrated *greater* activity to imagery scripts involving **running** than those involving neutral situations. In contrast, sedentary individuals' activation did not differ significantly between running and neutral imagery scripts (see Figure 4-13).

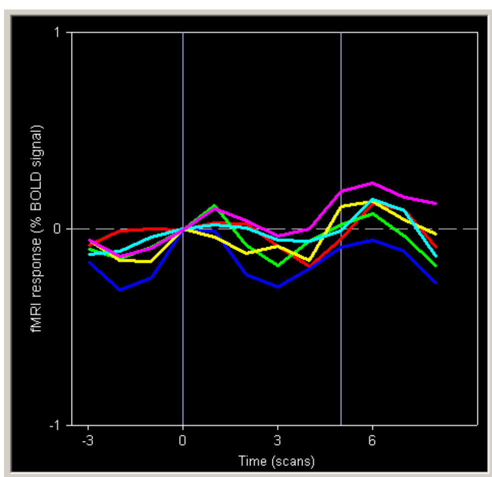
Anterior Cingulate Cortex (ACC)

Participants, across groups, demonstrated deactivation in the ACC for all emotional imagery scripts compared to neutral scripts. Figure 4-14 denotes the time course of signal change in response to all imagery scripts.



A B

Figure 4-13. Time courses of regular exercisers' and sedentary individuals' responses in the Ventrolateral Prefrontal Cortex to running and neutral imagery scripts. The blue line represents neutral imagery scripts while the pink line denotes imagery scripts related to running. A) Regular Exercisers B) Sedentary Individuals



Blue = neutral
Yellow = erotica
Green = threat
Pink = running
Cyan = pleasant
Red = contamination

Figure 4-14. Time course of percent signal change of the hemodymanic activity in response to all imagery scripts. Again, different colors are used with imagery scripts in comparison to pictures (e.g., yellow represents erotica in this graph).

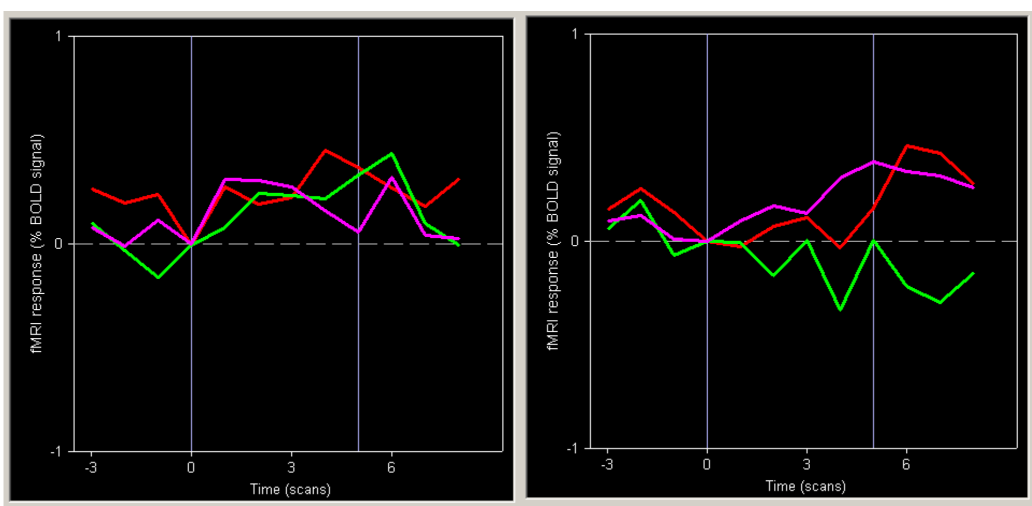
Right Cerebellum

Consistent with pictures, *sedentary individuals* also displayed greater brain activity to **running** and **neutral** scripts than did regular exercisers, during the imagery condition.

In addition, when the running scripts were compared to unpleasant (threat, contamination) scripts, sedentary individuals' responses indicated a deactivation for threat scripts and an increase in activation for running and contamination scripts. Conversely, regular exercisers' reactions did not vary significantly between threat, contamination, and running (see Figure 4-15 for the time courses and Figure 4-16a for the area of activation in the brain).

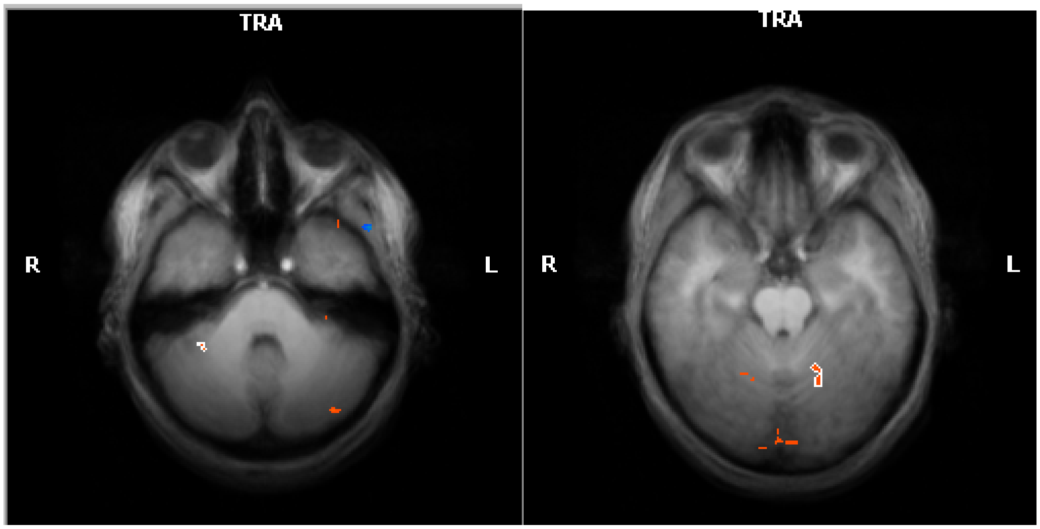
Left Cerebellum

Sedentary individuals demonstrated a differential response to imagery scripts involving running compared to those consisting of unpleasant scripts. In contrast, regular exercisers' responses did not differ between running and unpleasant imagery scripts (see Figure 4-16b for the area of activation).



A B

Figure 4-15. Time courses of running (pink), contamination (red), and threat (green) imagery scripts. A) Regular Exercisers B) Sedentary Individuals



A B

Figure 4-16. Areas of activation in the cerebellum A) right cerebellum B) left cerebellum.

CHAPTER 5
DISCUSSION

The purpose of this study was to assess regular exercisers' and sedentary individuals' responses (psychophysiological, subjective) to various running-related stimuli using both fMRI and self-report measures. The findings were analyzed and interpreted relative to previous findings and within the framework of Lang's Biphasic Theory of Emotion. Possible explanations for each finding are offered and then fruitful areas of future research are suggested. As such, results will be organized and examined first, by response (psychophysiological or self-report), then by condition, and finally, according to each brain region of interest. Self-report data (e.g., background and exercise-related questionnaires) will be discussed prior to the psychophysiological data.

Self-Report Measures

Exercise-Related Questionnaires

Leisure-Time Exercise Questionnaire (LTEQ)

Consistent with the operationalized definitions of regular exercisers and sedentary individuals (see Chapter 3), regular exercisers (RE) reported engaging in a greater number of strenuous, moderate, and mild bouts of physical activity. More specifically, zero participants in the sedentary individual group reported engaging in *any* activities that resulted in the rapid beating of the heart for more than 20 minutes during a typical *week* (definition of strenuous physical activity). Because one sedentary individual reported one moderate bout of physical activity, participants in the SI group averaged 0.20 bouts of moderate exercise. Relative to regular exercisers, sedentary individuals still reported fewer bouts of mild activity (see Figure 4 – 1). Overall, regular exercisers were more physically active than sedentary individuals, independent of the intensity of exercise (e.g., mild, moderate, or strenuous). Results from the LTEQ provide strong support for a distinct delineation between participants in the regular exercise group and those in the sedentary individual group.

Stages of Exercise Change Questionnaire (SCQ)

While only individuals whose physical activity habits were consistent with either the definition for precontemplation or termination stages were recruited initially, the small number of people who met *all* inclusion criteria for either group (see Participants, Chapter 3) caused the researcher to relax the criteria. While intention to engage in future physical activity may have excluded sedentary individuals from categorization into the precontemplation stage of exercise change, their *current* exercise habits were indicative of sedentary people. Moreover, participants in the sedentary individual group, because they reported their intentions to exercise regularly in the *future*, may actually represent a greater proportion of the population than women who express no intention of exercising in the future.

Exercise Motivation Scale (EMS)

Because the EMS is concerned with reasons for participation in exercise, only scores for regular exercisers were examined. Three sedentary individuals completed the scale as if they were exercising. However, because the scale was intended for use with physically active people only, sedentary individuals' scores were excluded. Regular exercisers' scores on the scales of intrinsic motivation supports the notion that having intrinsic motivation to exercise facilitates long-term exercise behavior.

Temptation Not to Exercise Scale (TNES)

Results from the TNES offered additional support for the clear differentiation between individuals who engaged in regular physical activity and those who did not. Not surprisingly, the SI group reported greater feelings (higher percentages) of temptation not to exercise in response to every situation presented on the TNES.

SAM Picture Ratings

Regular exercisers appraised pictures of elite runners more positively than did sedentary individuals. Given the habits of the RE group, this finding is not surprising. However, there were no other significant differences between groups with regard to any SAM dimension of exercise-related stimuli. Regular exercisers may perceive higher levels of fitness more positively than sedentary individuals.

SAM Script Ratings

The significant difference between groups on the valence dimension for pleasant imagery scripts was unexpected. The researchers have no reason to believe that this trend would continue with a larger group of participants. However, future studies examining differences between regular exercisers' and sedentary individuals' responses to pleasant stimuli could elucidate these findings.

Background Questionnaires

Movement Imagery Questionnaire-

Results indicate that imagery ability, on both kinesthetic and visual scales, did not differ significantly between groups. As such, differences in patterns of brain activation, during the imagery condition, cannot be attributed to differences in imagery ability.

State-Trait Anxiety Inventory (STAI)

No significant differences were found between regular exercisers' and sedentary individuals' levels of state and trait anxiety. The purpose of this scale was to confirm homogeneity between groups with regard to anxiety levels.

NEO Five Factor Inventory (NEO)

Sedentary individuals scored significantly higher than regular exercisers on the agreeableness scale of the NEO. No other significant differences were found. Additional analyses, with larger sample sizes, would be needed to replicate this finding, prior to interpretation.

Behavior Inhibition System-Behavior Activation System

Participants did not differ between groups with regard to their scores on inhibition and activation scales. Therefore differences concerning reward and punishment can not be attributed to differences in inhibition or activation tendencies.

Beck Depression Inventory (BDI-II)

Regular exercisers and sedentary individuals display similar mean scores on the BDI-II, when controlling for the outlier in the regular exerciser group. Because the regular exercise outlier barely scored high enough to qualify for the mild depression categorization, she was included in the fMRI analyses. In addition, no significant differences existed between groups with the inclusion of the outlier.

Post-Experiment Questionnaire

Results from the post-experiment questionnaire indicate that both groups watched and listened to the picture and imagery stimuli, respectively. Researchers can conclude, from this finding, that between-group differences in pscyhophysiological or subjective data could not be attributed to differential levels of attention.

Psychophysiological Results

As expected, areas of the brain associated with basic visual and auditory processing, such as the occipital cortex and primary auditory cortex, respectively, demonstrated activation during the picture and imagery script conditions. These findings provide evidence for the effectiveness of both visual and auditory paradigms. In addition, data offer support for the general hypotheses that participants, independent of group, responded similarly for pleasant, unpleasant, and neutral stimuli (excluding running-related stimuli). For example, patterns of brain activity did not differ between groups in the occipital cortex for emotional relative to neutral pictures. General hypotheses concerning the processing of visual and auditory stimuli, as well as emotional and neutral stimuli, were supported.

Given the large number of clusters of activation observed in response to both visual and auditory stimuli, 7 primary brain regions of interest were analyzed further: 1) primary visual cortex (fusiform gyrus and occipital cortex), 2) primary auditory cortex, 3) orbital frontal cortex (medial and prefrontal cortices), 4) amygdala, 5) anterior cingulate gyrus, 6) ventral striatum, and 7) cerebellum. With the exception of the cerebellum, the researchers focused on the aforementioned brain regions of interest given the main hypotheses of this study. The plethora of clusters of activation present in the right, left, and midline cerebellum, for both picture and imagery script conditions, prompted the additional analysis of the cerebellum.

With regard to *self-report* measures, the multitude of data (both subjective and psychophysiological), collected in this study, impelled the researchers to conduct between-group analyses only. In other words, only independent sample t-tests were used to determine significant differences between mean scores on each questionnaire.

Overall, participants did not vary significantly between groups with regard to measures of mental health, behavioral inhibition/activation, and imagery ability. These findings greatly decrease the probability of a confounding variable accounting for different patterns of brain activity.

Cortical Activity

Visual Stimuli (Pictures)

Occipital Cortex

Patterns of brain activation in response to 1) emotional and neutral pictures, 2) emotional and neutral pictures from the IAPS, and 3) unpleasant and pleasant pictures did not differ significantly across groups in the occipital cortex. In other words, regular exercisers and sedentary individuals demonstrated similar patterns of activity in the occipital cortex for emotional compared to neutral pictures, as well as unpleasant versus pleasant pictures. No between-group differences were hypothesized to occur in response to pleasant, neutral, or unpleasant pictures, based upon previous IAPS literature (Lang, Bradley, & Cuthbert, 1999). These results provide further support for the homogeneity of the two groups included in the study, in response to general stimuli (e.g., pleasant, unpleasant, etc.). Additionally, based upon the three aforementioned patterns of brain activity, the occipital lobe appears to be encoding the arousal properties of the stimuli.

Data did reveal significant differences in runners' and non-runners' responses to pictures of elite runners in the *occipital cortex*. Relative to neutral pictures, regular exercisers demonstrated a greater amount of activation for pictures of elite runners. Sedentary individuals, however, displayed greater activity for neutral pictures compared to pictures of elite runners. Interestingly, different trends emerged between groups, for pictures of elite runners and athletic women, in other areas of the brain to be discussed.

Fusiform Gyrus (part of the ventral surface of the temporal lobe)

Emotional IAPS pictures, compared to neutral IAPS pictures, resulted in bilateral activation of the fusiform gyrus across participants. The fusiform gyrus has been associated with the processing of complex visual stimuli, such as faces and emotion. Consistent with previous research (Lang et al., 1998), the results revealed differential activation for emotional compared to neutral pictures from the IAPS. However, all pictures elicited a similar time course trend concerning the amount and duration of percent signal change. Similar to the primary auditory cortex, data from the fusiform gyrus confirmed the effectiveness of the pictures in eliciting normal responses in areas associated with processing visual stimuli.

Prefrontal Cortex

Pictures of elite runners evoked different patterns of brain activity for regular exercisers compared to sedentary individuals in the medial dorsal prefrontal cortex (MDPFC). Unlike running-related imagery scripts though, sedentary individuals showed *greater* activation in response to pictures of elite runners, when compared to neutral pictures. Conversely, regular exercisers showed greater activity to neutral, compared to running pictures. Previous research (Stein, Liu, Shapira, & Goodman, 2001) has shown less activation in the prefrontal cortex in response to pictures of contamination for people with obsessive-compulsive disorder (OCD), compared to controls. Results suggest that OCD patients were unable to inhibit responses to contamination. This finding implicates the involvement of the MDPFC in inhibition processes. Perhaps, at an implicit level, sedentary individuals inhibit the processing of pictures of elite runners, but express appreciation of these pictures, at an explicit level. In other words, greater activation in the prefrontal cortex may indicate that sedentary individuals consciously perceive pictures of physical activity positively, but attempt to inhibit the processing of the same pictures at the cortical level.

Amygdala

Previous research (Zald & Kim, 2001) has suggested the involvement of the amygdala in processing emotional, especially negatively valued, stimuli. The response of the sedentary group to pictures of elite runners resulted in a clear trend of brain activity: pictures of elite runners elicited greater activation in the amygdala for the SI group compared to regular exercisers. The time course of reactivity for regular exercisers was not nearly as consistent and included quite large variability for pictures of elite runners. While the data from the regular exercisers are harder to interpret, it would appear that pictures of elite runners result in greater emotional (most likely negative) responses from non-exercisers compared to exercisers. Pictures of competitive running may be represented negatively in the amygdala for physically inactive people

Left Amygdala/Ventral Striatum

Pictures of athletic women seemed to result in similar trends of activation as pictures of elite runners. Although regular exercisers' reactions to visual stimuli did not vary significantly between athletic women and neutral pictures, pictures of athletic women elicited a significantly greater response from sedentary individuals than did neutral pictures. This distinct pattern of activation for sedentary individuals, in which responses to pictures of athletic women correlated to activation in the left amygdala and ventral striatum, further provides evidence for the notion that exercise-related (elite runners and athletic women) pictures are associated with emotional responses for sedentary people.

Ventral Striatum

As hypothesized, emotional pictures from the IAPS (contamination, threat, and erotica) resulted in greater brain activity relative to neutral IAPS pictures *across participants*. These results confirm that IAPS pictures containing contamination, threat, and erotica elicit emotional responses, independent of group.

Cerebellum

The unexpected activation of the cerebellum deserves reporting. However, interpreting the greater overall activity in the cerebellum for non-exercisers compared to exercisers proves extremely difficult. Recent findings (Gottwald,Wilde, Mihajlovic, & Mehdorn, 2004; Lazeron, Rombouts, Scheltens, Polman, & Barkhof, 2004) suggest the involvement of the cerebellum in cognitive activities, such as planning and executive processes, in addition to motor functioning. In light of these new developments, the researchers speculate that sedentary individuals may require additional cerebellar resources when planning or pondering physical activities. Conversely, regular exercisers, given their current physical activity *habits*, may process exercise-related stimuli more efficiently, thus demanding fewer resources.

Sedentary individuals displayed more activity in both the right and left cerebellum, relative to regular exercisers, when viewing pictures of athletic women and elite runners, respectively. Gottwald et al. (2004) found greater decrements in performance on verbal tasks with patients who suffered from right cerebellar lesions. In contrast, left cerebellar lesions were associated with non-verbal deficits. These findings further complicate interpretation of the activation of the cerebellum. Additional studies that include the cerebellum as an ROI are needed to elucidate these findings.

Auditory Stimuli (Imagery Scripts)

Primary Auditory Cortex

Activity in the primary auditory cortex is usually elicited by sounds or language. The experimenters expected activation in the primary auditory cortex in response to the imagery scripts that were presented auditorily, given its involvement in sound and language. In this study, the primary auditory cortex served as a control or means by which to confirm the successful implementation of the auditory paradigm (imagery scripts). The results indicated that, across participants, primary auditory cortex in the left hemisphere, displayed consistent activity in response to the imagery scripts. Although neutral imagery scripts did not evoke as much activation as emotional scripts, the pattern of activation for all scripts was similar (see Figure 4-3B).

Ventrolateral Dorsal Prefrontal Cortex (VLPFC)

The prefrontal cortex has been implicated in the processing of reward (Ramnani & Miall, 2003). Perhaps, imaging running scenarios elicits a greater response from regular exercisers, relative to sedentary individuals, in the VLPFC because of their greater familiarity with and *enjoyment* of running. If running is associated with positive reinforcement for regular exercisers, then thoughts of running may activate areas of the brain involved in reward, such as the VLPFC. By contrast, sedentary individuals demonstrate an approximately inverse pattern of brain activity in response to running-related imagery scripts. The negative trend displayed by sedentary individuals in response to running scripts, coupled with their greater response to neutral scripts, may signify a lack of reward associated with thoughts related to running.

These findings are consistent with the hypothesis that running and thoughts of running are perceived to be more rewarding for regular exercisers than for sedentary individuals. In contrast, non-exercisers may lack the same positive associations with running and thoughts of running.

Anterior Cingulate Cortex (ACC)

All imagery scripts resulted in similar activation in the ACC across groups. As expected, emotional scripts were associated with greater reactivity than neutral scripts. However, the lack of activation of the ACC in response to pictures may indicate that none of the stimuli was perceived to be rewarding enough by either group to trigger the release of dopaminergic neurons in the ACC. This finding may also be consistent with the equivocal findings in previous literature concerning the dopaminergic theory of "runners high."

Cerebellum

Involvement of the cerebellum during the processing of imagery scripts remains challenging to interpret. Similar to the discussion involving visual stimuli, regular exercisers may process imagery scripts more efficiently than sedentary individuals. As a result, *sedentary individuals* may need additional cerebellar resources to image running-related scenarios. Perhaps running regularly facilitates the planning and processing of running-related behavior.

Conclusion

Between-group differences in exercise patterns were confirmed by responses to the LTEQ and SCQ: regular exercisers engaged in physical activity regularly, sedentary individuals did not. While all participants in the sedentary group expressed intentions to begin exercising regularly, none, at the time of the study, was physically active. These findings provide evidence for behavioral differences between groups. Explanations for differences in patterns of physical activity and emotion related to exercise are discussed within Lang's Biphasic Theory of Emotion.

Areas of the brain associated with positive and negative affect (e.g., ventral striatum, amygdala) demonstrated differential activation between groups. For example, *sedentary individuals* displayed greater brain activation in the amygdala in response to pictures of elite runners and in the left amygdala/ventral striatum in response to pictures of athletic women. Additionally, differences in patterns of activation were found in the prefrontal cortex (MDPFC and VLPFC). For instance, pictures of elite runners elicited greater activation from *sedentary individuals* than regular exercisers. Conversely, regular exercisers demonstrated significantly greater activation in the VLPFC while imaging running-related scripts. S*edentary individuals* consistently displayed greater brain activation in both hemispheres of the cerebellum for pictures of athletic women and elite runners. Finally, overall activation of the cerebellum for emotional pictures and imagery scripts was significantly greater for *sedentary individuals.*

Consistent with the hypotheses, these findings suggest that differences in the emotional perception of exercise exist between groups, as measured by cortical patterns of activation. While additional research is needed to replicate and extend these findings, results from this study offer rudimentary support for differences between regular exercisers' and sedentary individuals' cortical representations of physical activity.

Statement of Limitations

The small number of participants included in the study (n = 10) could be cited as a potential limitation. While a larger number of participants is usually desirable, both financial and temporal constraints prevented the inclusion of additional participants. However, the investigators took extreme measures to ensure the homogeneity of the groups with regard to every measure *but* **exercise habits**. For example, each participant completed a total of **11** self-report questionnaires. Scores from the instrument were then averaged within groups and analyzed for significant between-group differences.

Secondly, the data do not allow researchers to make causal inferences or to identify causal pathways related to exercise behavior. Given the use of a new approach to examine exercise behavior and exercise behavior change, additional studies are needed to corroborate and elucidate findings from this experiment. While this limitation is not unique to this particular study of physical activity behavior, future studies that implement this paradigm may be able to better identify neural pathways in the brain related to exerciser behavior change.

Third, given the number of times (greater than 20) the researcher implemented independent sample t-tests, the data may reflect a highly inflated type I error rate. Additionally, the researchers' interpretations of the results rely solely upon contemporary understanding of the functions of the brain. As the knowledge about the brain and it structures improves, so too should the strength of the interpretations. Finally, the results may be difficult to generalize to individuals who do not share the same characteristics of the sample of women included in the study.

Future Research

Given the importance of establishing the exercise habits and psychological health of all participants, future studies need to continue to include measures of current exercise behavior and mental health status. However, the number of self-report questionnaires included in future studies could be reduced to lesson the time requirements of both the participants and experimenters. For example, the LTEQ and TNES could be used to determine current physical activity habits, the NEO could reveal information associated with psychological disorders, and a background questionnaire could provide general information regarding both mental health status and demographic variables.

While this study provided a novel method for the analysis of psychophysiological and subjective similarities and differences related to exercise behavior, additional research with alternative populations is necessary to extend these findings. Studies involving men, older women, overweight individuals, or comparisons between various groups could provide valuable information regarding exercise behavior.

If exercise-related stimuli consistently elicit differential responses from regular exercisers and sedentary individuals, as demonstrated in this study, then determining the relationship between these differences and exercise behavior is needed to further these findings. In addition to offering support for the researchers' hypotheses, results from this study raise many significant questions. For example, does greater activation in the VLPFC, in response to running-related scripts, correlate with a positive perception of exercise? Or, are runners simply able to image running-related scripts more vividly, given their exercise routines? Could positively imaging exercise-related behavior lead to increased or prolonged patterns of physical activity? Would researchers find positive changes in VLPFC activity as exercise behavior increases? Does cerebellar activity decrease, in response to exercise stimuli, as physical activity behavior increases? Would flooding sedentary individuals with exercise-related stimuli decrease cortical activity associated with processing negative stimuli?

To answer some of these questions, future studies could investigate differences in participants' brain activation both prior to and following initiation of regular exercise programs. Researchers could compare and contrast cortical activation, in response to exercise-related stimuli, of individuals who maintained regular exercise habits and those who did not. Another possible line of research could involve the examination of injured exercisers. How would their patterns of brain activity compare to regular exercisers' and sedentary individuals' responses? Findings from this study present evidence for the effectiveness of fMRI in examining exercise-related behavior. Future studies could successfully adopt similar paradigms, with different populations, to investigate changes in physical activity behavior and to examine patterns of exercise-related behavior.

APPENDIX A
EXERCISE MOTIVATION SCALE

WHY ARE YOU CURRENTLY PARTICIPATING IN THIS ACTIVITY?

Direction: Please read each of the statements listed below and indicate how strongly you agree or disagree with each statement by circling the appropriate response to the right of the statement. Use the following response categories:

Strongly disagree (SD) 1	Disagree (D) 2	Moderately disagree (MD) 3	Moderately agree (MA) 4	Agree (A) 5	Strongly agree (SA) 6

	SD	D	MD	MA	A	SA
1. For the pleasure it gives me to experience positive sensations from the activity.	1	2	3	4	5	6
2. For the satisfaction it gives me to increase my knowledge about this activity.	1	2	3	4	5	6
3. Because other people believe that it’s a good idea for me to exercise.	1	2	3	4	5	6
4. Because I must exercise to feel good about myself.	1	2	3	4	5	6
5. Because I believe that regular exercise is a good way to enhance my overall development.	1	2	3	4	5	6
6. Because it is consistent with what I value.	1	2	3	4	5	6
7. I can’t understand why I am doing this.	1	2	3	4	5	6
8. Because I feel pressure from others to participate.	1	2	3	4	5	6
9. Because I think that exercise allows me to feel better about myself.	1	2	3	4	5	6
10. For the pleasure I experience while learning about this activity.	1	2	3	4	5	6
11. For the satisfaction I feel when I get into the flow of this activity.	1	2	3	4	5	6
12. Because I feel I have to do it.	1	2	3	4	5	6

WHY ARE YOU CURRENTLY PARTICIPATING IN THIS ACTIVITY?

	SD	D	MD	MA	A	SA
13. To satisfy people who want me to exercise.	1	2	3	4	5	6
14. Because exercising is an important aspect of how I perceive myself.	1	2	3	4	5	6
15. For the pleasure of understanding this activity.	1	2	3	4	5	6
16. I have no idea.	1	2	3	4	5	6
17. For the pleasure of mastering this activity.	1	2	3	4	5	6
18. Because I think it is a good thing for my personal growth.	1	2	3	4	5	6
19. For the pleasure I experience when I feel completely absorbed in the activity.	1	2	3	4	5	6
20. For the satisfaction I feel while I try to achieve my personal goals during the course of this activity.	1	2	3	4	5	6
21. Because I would feel guilty if I did not take the time to do it.	1	2	3	4	5	6
22. Because I value the way exercise allows me to make changes in my life.	1	2	3	4	5	6
23. It is not clear to me anymore.	1	2	3	4	5	6
24. Because I think exercise contributes to my health.	1	2	3	4	5	6
25. To comply with expectations of others (e.g., friends).	1	2	3	4	5	6
26. For the enjoyment that comes from how good it feels to do the activity.	1	2	3	4	5	6
27. Because I enjoy the feelings of discovering more about this activity.	1	2	3	4	5	6
28. Because I enjoy the feelings of improving through participating in this activity.	1	2	3	4	5	6

WHY ARE YOU CURRENTLY PARTICIPATING IN THIS ACTIVITY?

	SD	D	MD	MA	A	SA
29. Because I feel that changes that are taking place through exercise are becoming part of me.	1	2	3	4	5	6
30. For the pleasure I experience while trying to become the person I want to be.	1	2	3	4	5	6
31. Because I would feel ashamed if I was not doing anything to improve my current situation.	1	2	3	4	5	6

Factor Scoring
Amotivation = Items of 7, 16, 23
External regulation = Items of 3, 8, 13, 25
Introjected regulation = Items of 4, 12, 21, 31
Identified regulation = Items of 5, 9, 18, 24
Integrated regulation = Items of 6, 14, 22, 29
IM to learn = Item of 2, 10, 15, 27
IM to accomplish things = Items of 17, 20, 28, 30
IM to experience sensations = Items of 1, 11, 19, 26

APPENDIX B
EXERCISE STAGING ALGORITHM

Regular exercise is any planned voluntary physical activity (e.g., brisk walking, aerobics, jogging, bicycling, swimming, basketball, etc.) performed to increase physical fitness. Such activity should be performed 3 to 5 times per week for a minimum of 20 minutes per session. Exercise does not have to be painful to be effective, but should be done at a level that increases your breathing rate and causes you to break a sweat.

Do you exercise regularly according to the definition above? Place an "X" beside ONE statement that applies to you.

______ Yes, I have been exercising for more than 6 months.
______ Yes, I have been exercising, but for less than 6 months.
______ No, but I intend to begin exercising regularly in the next 30 days.
______ No, but I intend to begin exercising in the next 6 months.
______ No, and I do not intend to begin exercising in the next 6 months.

APPENDIX C
EXERCISE STAGING ALGORITHM WITH TERMINATION STAGE

Regular exercise is any planned voluntary physical activity (e.g., brisk walking, aerobics, jogging, bicycling, swimming, basketball, etc.) performed to increase physical fitness. Such activity should be performed 3 to 5 times per week for a minimum of 20 minutes per session. Exercise does not have to be painful to be effective, but should be done at a level that increases your breathing rate and causes you to break a sweat.

Do you exercise regularly according to the definition above? Place an "X" beside ONE statement that applies to you.

______ Yes, I have been exercising for more than 5 years.
______ Yes, I have been exercising for more than 6 months.
______ Yes, I have been exercising, but for less than 6 months.
______ No, but I intend to begin exercising regularly in the next 30 days.
______ No, but I intend to begin exercising in the next 6 months.
______ No, and I do not intend to begin exercising in the next 6 months.

APPENDIX D
LEISURE-TIME EXERCISE QUESTIONNAIRE

Instructions. This is a scale which measures your leisure-time exercise (i.e., exercise that was done during your free time such as intramural sports–NOT your physical education class). Considering a typical week, please indicate how often (on average) you have engaged in strenuous, moderate, and mild exercise more that 20 minutes during your free time?

1. Strenuous exercise: heart beats rapidly (e.g., running, basketball, jogging, hockey, squash, judo, roller skating, vigorous swimming, vigorous long distance bicycling, vigorous aerobic dance classes, heavy weight training)
How many times per typical week do you perform strenuous exercise for 20 minutes or longer?

______

2. Moderate exercise: not exhausting, light sweating (e.g., fast walking, baseball, tennis, easy bicycling, volleyball, badminton, easy swimming, popular and folk dancing)
How many times per typical week do you perform moderate exercise for 20 minutes or longer?

____

3. Mild exercise: minimal effort, no sweating (e.g., easy walking, yoga, archery, fishing, bowling, lawn bowling, shuffleboard, horseshoes, golf)
How many times per typical week do you perform mild exercise for 20 minutes or longer?

____

Scoring. A total exercise index (weekly metabolic equivalents - METS) is calculated by weighing the frequency of each intensity and summing for a total score using the following formula: 3(mild) + 5(moderate) +9(strenuous).

Reference. Godin, G., Jobin, J., & Bouillon, J. (1986). Assessment of leisure time exercise behavior by self-report: A concurrent validity study. Canadian Journal of Public Health, 77, 359-361.

APPENDIX E
TEMPTATION NOT TO EXERCISE SCALE

Using the scale below, please indicate how **TEMPTED** you are **NOT** to exercise in the following situations:

0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
Not Tempted at All					Somewhat Tempted					Extremely Tempted

For example, if you feel extremely tempted to **not** exercise when you are stressed, you would write in 100%. However, if you are **not** tempted at all when you are stressed, you would write in 0%.

______% 1. When I am angry.
______% 2. When I feel lazy.
______% 3. When I feel satisfied.
______% 4. When I feel that I don't have the time.
______% 5. When I am alone.
______% 6. When family events/situations interfere.
______% 7. When I am stressed.
______% 8. When I am busy.
______% 9.When I am out of shape.
______% 10. When I have work to do.

____

Scoring. Affect Subscale = 1, 3, 5, 7, 9
Excuse Making = 2, 4, 6, 8, 10

Reference. Hausenblas, H. A., Nigg, C. R., Dannecker, E. A., Symons, D. A., Ellis, S. R., Fallon, E. A., Focht, B. C., & Loving, M. G. (in review). The Missing Piece of the Transtheoretical Model Applied to Exercise: Development and Validation of the Exercise Temptation Scale. Psychology and Health.

APPENDIX F
MOVEMENT IMAGERY QUESTIONNAIRE-REVISED

Instructions

This questionnaire concerns two ways of mentally performing movements which are used by some people more than by others, and are more applicable to some types of movements than others. The first is attempting to form a visual image or picture of a movement in your mind. The second is attempting to feel what performing a movement is like without actually doing the movement. You are requested to do both of these mental tasks for a variety of movements in this questionnaire, and then rate how easy/difficult you found the tasks to be. The ratings that you give are not designed to assess the goodness or badness of the way you perform these mental tasks. They are attempts to discover the capacity individuals show for performing these tasks for different movements. There are no right or wrong ratings that are better than others.

Each of the following statements describes a particular action or movement. Read each statement carefully and then actually perform the movement as described. Only perform the movement a single time. Return to the starting position for the movement just as if you were going to perform the action a second time. Then depending on which of the following you are asked to do, either (1) form as clear and vivid a visual image as possible of the movement just performed, or (2) attempt to feel yourself making the movement just performed without actually doing it.

After you have completed the mental task required, rate the ease/difficulty with which you were able to do the task. Take your rating from the following scale. Be as accurate as possible and take as long as you feel necessary to arrive at the proper rating for each movement. You may choose the same rating for any number of movements "seen" or "felt" and it is not necessary to utilize the entire length of the scale.

RATING SCALES

Visual Imagery Scale

7	6	5	4	3	2	1
Very easy to see	Easy to see	Somewhat easy to see	Neutral (not easy not hard)	Somewhat hard to see	Hard to see	Very hard to see

Kinesthetic Imagery Scale

7	6	5	4	3	2	1
Very easy to feel	Easy to feel	Somewhat easy to feel	Neutral (not easy not hard)	Somewhat hard to feel	Hard to feel	Very hard to feel

Scoring instructions:

Odds numbered items represent Kinesthetic imagery, evens Visual imagery. Both are scored out of a total of 7 x 4 = 28. Higher the score = the better the ability.

1. *STARTING POSITION*: Stand with your feet and legs together and your arms at your sides.

***ACTION*:** Raise your knee as high as possible so that you are standing on your left leg with your right leg flexed (bent) at the knee. Now lower your right leg so that you are again standing on two feet. Perform these actions slowly.

***MENTAL TASK*:** Assume the starting position. Attempt to feel yourself making the movement just performed without actually doing it. Now rate the ease/difficulty with which you were able to do this mental task.

***RATING*:** _____________

2. *STARTING POSITION*: Stand with your feet slightly apart and your hands at your sides.

***ACTION*:** Bend down low and then jump straight up in the air as high as possible with both arms extended above your head. Land with your feet apart and lower your arms to your sides.

***MENTAL TASK*:** Assume the starting position. Attempt to see yourself making the movement just performed with as clear and vivid a visual image as possible. Now rate the ease/difficulty with which you were able to do this mental task.

***RATING*:** _____________

3. *STARTING POSITION*: Extend your arm of your nondominant hand straight out to your so that it is parallel to the ground, palm down.

***ACTION*:** Move your arm forward until it is directly in front of your body (still parallel to the ground). Keep your arm extended during the movement and make the movement slowly.

***MENTAL TASK*:** Assume the starting position. Attempt to feel yourself making the movement just performed without actually doing it. Now rate the ease/difficulty with which you were able to do this mental task.

***RATING*:** _____________

4. ***STARTING POSITION*****:** Stand with your feet slightly apart and your arms fully extended above your head.

ACTION**:** Slowly bend forward at the waist and try and touch your toes with your fingertips (or if possible, touch the floor with your fingertips or hands). Now return to the starting position, standing erect with your arms extended above your head..

MENTAL TASK**:** Assume the starting position. Attempt to see yourself making the movement just performed with as clear and vivid a visual image as possible. Now rate the ease/difficulty with which you were able to do this mental task.

RATING**:** _____________

5. ***STARTING POSITION*****:** Stand with your feet slightly apart and your hands at your sides.

ACTION**:** Bend down low and then jump straight up in the air as high as possible with both arms extended above your head. Land with your feet apart and lower your arms to your sides.

MENTAL TASK**:** Assume the starting position. Attempt to feel yourself making the movement just performed without actually doing it. Now rate the ease/difficulty with which you were able to do this mental task.

RATING**:** _____________

6. ***STARTING POSITION*****:** Stand with your feet and legs together and your arms at your sides.

ACTION**:** Raise your knee as high as possible so that you are standing on your left leg with your right leg flexed (bent) at the knee. Now lower your right leg so that you are again standing on two feet. Perform these actions slowly.

MENTAL TASK**:** Assume the starting position. Attempt to see yourself making the movement just performed with as clear and vivid a visual image as possible. Now rate the ease/difficulty with which you were able to do this mental task.

RATING**:** _____________

7. ***STARTING POSITION*****:** Stand with your feet slightly apart and your arms fully extended above your head.

ACTION**:** Slowly bend forward at the waist and try and touch your toes with your fingertips (or if possible, touch the floor with your fingertips or hands). Now return to the starting position, standing erect with your arms extended above your head..

MENTAL TASK**:** Assume the starting position. Attempt to feel yourself making the movement just performed without actually doing it. Now rate the ease/difficulty with which you were able to do this mental task.

RATING**:** _____________

8. ***STARTING POSITION*****:** Extend your arm of your nondominant hand straight out to your so that it is parallel to the ground, palm down.

ACTION**:** Move your arm forward until it is directly in front of your body (still parallel to the ground). Keep your arm extended during the movement and make the movement slowly.

MENTAL TASK**:** Assume the starting position. Attempt to see yourself making the movement just performed with as clear and vivid a visual image as possible. Now rate the ease/difficulty with which you were able to do this mental task.

RATING**:** _____________

APPENDIX G
STATE-TRAIT ANXIETY INVENTORY

SELF-EVALUATION QUESTIONNAIRE

Please provide the following information:

Name_______________________________________Date_____________S_________

Age_________________ Gender (*Circle*) M F T_________

DIRECTIONS

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

(1 = almost never, 2 = sometimes, 3 = often, 4 = almost always)

1. I feel calm ……………………………………………………….…..1 2 3 4
2. I feel secure……………………………………………………….…..1 2 3 4
3. I am tense………………………………………………………………1 2 3 4
4. I feel strained……………………………………………………………1 2 3 4
5. I feel at ease…………………………………………………………...1 2 3 4
6. I feel upset………………………………………………………………1 2 3 4
7. I am presently worrying over possible misfortunes……………………..1 2 3 4
8. I feel satisfied……………………………………………………………1 2 3 4
9. I feel frightened………………………………………………………...1 2 3 4
10. I feel comfortable……………………………………………………...1 2 3 4
11. I feel self-confident………………………………………………………1 2 3 4

(1 = almost never, 2 = sometimes, 3 = often, 4 = almost always)

12. I feel nervous…………………………………………………………..1 2 3 4

13. I am jittery…………………………………………………………..1 2 3 4

14. I feel indecisive………………………………………………………..1 2 3 4

15. I am relaxed…………………………………………………………1 2 3 4

16. I feel content…………………………………………………………..1 2 3 4

17. I am worried………………………………………………………1 2 3 4

18. I feel confused……………….…………………………………………1 2 3 4

19. I feel steady…………………..………………………………………....1 2 3 4

20. I feel pleasant………………..…………………………………........1 2 3 4

DIRECTIONS

A number of statements which people have used to describe themselves are given below. Read each statement and then circle the appropriate number to the right of the statement to indicate how you generally feel. There are no right or wrong answers. Do not spend too much time on any one statement but give the answer which seems to describe how you generally feel.

(1 = almost never, 2 = sometimes, 3 = often, 4 = almost always)

21. I feel pleasant…………………………………………………………1 2 3 4

22. I feel nervous and restless……………………………………………….1 2 3 4

23. I feel satisfied with myself……..……………………………………….1 2 3 4

24. I wish I could be as happy as others seem to be…………………………1 2 3 4

25. I feel like a failure……………………………………………………….1 2 3 4

26. I feel rested………………………………………………………………….1 2 3 4

27. I am “calm, cool, and collected”……………………………………...1 2 3 4

28. I feel that difficulties are piling up so that I cannot overcome them…….1 2 3 4
(1 = almost never, 2 = sometimes, 3 = often, 4 = almost always)

29. I worry too much over something that really doesn't matter…………….1 2 3 4

30. I am happy…………………………………………………………..…….1 2 3 4

31. I have disturbing thoughts…………………………………………..….1 2 3 4

32. I lack self-confidence……………………………………………………1 2 3 4

33. I feel secure……………………………………………………………….1 2 3 4

34. I make decisions easily……………..…………………………………….1 2 3 4

35. I feel inadequate………………………………………………………….1 2 3 4

36. I am content……………………………………………………………….1 2 3 4

37. Some unimportant thought runs through my mind and bothers me…….1 2 3 4

38. I take disappointments so keenly that I can't put them out of my mind...1 2 3 4

39. I am a steady person……………………………………………………..1 2 3 4

40. I get in a state of tension or turmoil as I think over my recent concerns and interests…………………………………………………………………...1 2 3 4

APPENDIX H
NEO FIVE FACTOR MODEL – PERSONALITY INVENTORY

Instructions

Write only where indicated in this booklet. Carefully read all of the instructions before beginning. This questionnaire contains 60 statements. Read each statement carefully. For each statement fill in the circle with the response that best represents your opinion. Make sure that your answer is in the correct box.

Fill in SD if you *strongly disagree* or the statement is definitely false.

Fill in D if you *disagree* or the statement is mostly false.

Fill in N if you are *neutral* on the statement, if you cannot decide, or if the statement is about equally true and false.

Fill in A if you *agree* or the statement is mostly true.

Fill in SA if you *strongly agree* or the statement is definitely true.

For example, if you strongly disagree or believe that a statement is definitely false, you would fill in SD for that statement.

Fill in only one response for each statement. Respond to all of the statements, making sure that you fill in the correct response. **DO NOT ERASE**! If you need to change an answer, make an "X" though the incorrect response and then fill in the correct response.

Note that the responses are numbered in *rows*. Before responding to the statements, turn to the inside of the booklet and enter your name, age, gender, and today's date.

1. I am not a worrier.
2. I like to have a lot of people around me.
3. I don't like to waste my time daydreaming.
4. I try to be courteous to everyone I meet.
5. I keep my belongings neat and clean.

6. I often feel inferior to others.
7. I laugh easily.
8. Once I find the right way to do something, I stick to it.

9. I often get into arguments with my family and co-workers.
10. I'm pretty good about pacing myself so as to get things done on time.

11. When I'm under a great deal of stress, sometimes I feel like I'm going to pieces.
12. I don't consider myself especially "light-hearted."
13. I am intrigued by the patterns I find in art and nature.
14. Some people think I'm selfish and egotistical.
15. I am not a very methodical person.

16. I rarely feel lonely or blue.
17. I really enjoy talking to people.
18. I believe letting students hear controversial speakers can only confuse and mislead them.
19. I would rather cooperate with others than compete with them.
20. I try to perform all the tasks assigned to me conscientiously.

21. I often feel tense and jittery.
22. I like to be where the action is.
23. Poetry has little or no effect on me.
24. I tend to be cynical and skeptical of others' intentions.
25. I have a clear set of goals and work toward them in an orderly fashion.

26. Sometimes I feel fearful or anxious.
27. I usually prefer to do things alone.
28. I often try new and foreign foods.
29. I believe that most people will take advantage of you if you let them.
30. I waste a lot of time before settling down to work.

31. I rarely feel fearful or anxious.
32. I often feel as if I'm bursting with energy.
33. I seldom notice the moods or feelings that different environments produce.
34. Most people I know like me.
35. I work hard to accomplish my goals.

36. I often get angry at the way people treat me.
37. I am a cheerful, high-spirited person.
38. I believe we should look to our religious authorities for decisions on moral issues.
39. Some people think of me as cool and calculating.
40. When I make a commitment, I can always be counted on to follow through.

41. Too often, when things go wrong, I get discouraged and feel like giving up.
42. I am not a cheerful optimist.
43. Sometimes when I am reading poetry or looking at a work of art, I feel a chill or wave of excitement.
44. I'm hard-headed and tough-minded in my attitudes.
45. Sometimes I'm not as dependable or reliable as I should be.

46. I am seldom sad or depressed.
47. My life is fast-paced.
48. I have little interest in speculating on the nature of the universe or the human condition.
49. I generally try to be thoughtful and considerate.
50. I am a productive person who always gets the job done.

51. I often feel helpless and want someone else to solve my problems.
52. I am a very active person.
53. I have a lot of intellectual curiosity.
54. If I don't like people, I let them know it.
55. I never seem to be able to get organized.

56. At times I have been so ashamed I just wanted to hide.
57. I would rather go my own way than be a leader of others.
58. I often enjoy playing with theories or abstract ideas.
59. If necessary, I am willing to manipulate people to get what I want.
60. I strive for excellence in everything I do.

Have you responded to all of the statements? _________Yes_________No

Have you entered your responses in the correct boxes?_______Yes_________No

Have you responded accurately and honestly? _________Yes_________No

APPENDIX I
BEHAVIOR INHIBITION SYSTEM/BEHAVIOR ACTIVATION SYSTEM SCALE

Participant #:____________________

Date: ___________________

BIS/BAS

Each item of this questionnaire is a statement that a person may either agree with or disagree with. For each item, indicate how much you agree or disagree with what the item says. Please respond to all of the items; do not leave any blank. Choose only one response to each statement. Please be as accurate and honest as you can be. Respond to each item as if it were the only item. That is, don't worry about being "consistent" in your responses. Choose from the following four response options:

1 = very true for me **2** = somewhat true for me **3** = somewhat false for me **4** = very false for me

1. ____ A person's family is the most important thing in life.
2. ____ Even if something bad is about to happen to me, I rarely experience fear or nervousness.
3. ____ I go out of my way to get things that I want.
4. ____ When I'm doing well at something I love to keep at it.
5. ____ I'm always willing to try something new if I think it will be fun.
6. ____ How I dress is important to me.
7. ____ When I get something I want, I feel excited and energized.
8. ____ Criticism or scolding hurts me quite a bit.
9. ____ When I want something I usually go all-out to get it.
10. ____ I will often do things for no other reason than that they might be fun.
11. ____ It's hard for me to find the time to do things such as get a haircut.
12. ____ If I see a chance to get something I want I move on it right away.

13. ____ I feel pretty worried or upset when I think or know somebody is angry at me.
14. ____ When I see an opportunity for something I like I get excited right away.
15. ____ I often act on the spur of the moment.
16. ____ If I think something unpleasant is going to happen I usually get pretty “worked up”.
17. ____ I often wonder why people act the way they do.
18. ____ When good things happen to me, it affects me strongly.
19. ____ I feel worried when I think I have done poorly at something important.
20. ____ I crave excitement and new sensations.
21. ____ When I go after something I use a “no holds barred” approach.
22. ____ I have very few fears compared to my friends.
23. ____ It would excite me to win a contest.
24. ____ I worry about making mistakes.

APPENDIX J
BECK DEPRESSION INVENTORY

Date: ____________________
Name: ____ Martial Status: ________ Age: ______ Sex:_____

Occupation:____ Education:___________________________________

This questionnaire consists of 21 groups of statements. After reading each group of statements carefully, circle the number (0,1,2,3) next to the one statement in each group which <u>best</u> describes the way you have been feeling the <u>past week, including today</u>. If several statements within a group seem to apply equally well, circle each one. <u>Be sure to read all the statements in each group before making your choice.</u>

1. O 0 I do not feel sad.
O 1 I feel sad.
O 2 I am sad all the time and I can't snap out of it.
O 3 I am so sad or unhappy that I can't stand it.

2. O 0 I am not particularly discouraged about the future
O 1 I feel discouraged about the future.
O 2 I feel I have nothing to look forward to.
O 3 I feel that the future is hopeless and that things can't improve.

3. O 0 I do not feel like a failure.
O 1 I feel I have failed more that the average person
O 2 As I look back on my life, all I can see is a lot of failures.
O 3 I feel I am a complete failure as a person.

4. O 0 I get as much satisfaction out of things as I used to
O 1 I don't enjoy things the way I used to.
O 2 I don't get real satisfaction out of anything anymore
O 3 I am dissatisfied or bored with everything.

5. O 0 I don't feel particularly guilty.
O 1 I feel guilty a good part of the time.
O 2 I feel quite guilty most of the time.
O 3 I feel guilty all of the time.

6. O 0 I don't feel I am being punished.
O 1 I feel I may be punished.
O 2 I expect to be punished.
O 3 I feel I am being punished.

7. O 0 I don't feel disappointed in myself.
O 1 I am disappointed in myself.
O 2 I am disgusted with myself.
O 3 I hate myself.

8. O 0 I don't feel I am any worse than anybody else
O 1 I am critical of myself for my weaknesses or mistakes.
O 2 I blame myself all the time for my faults.
O 3 I blame myself for everything bad that happens.

9. O 0 I don't have any thoughts of killing myself.
O 1 I have thoughts of killing myself, I would not carry them out.
O 2 I would like to kill myself.
O 3 I would kill myself if I had the chance.

10. O 0 I don't cry any more than usual.

O 1 I cry more now than I used to.
O 2 I cry all the time now.
O 3 I used to be able to cry, but now I can't cry even though I want to.

11. O 0 I am no more irritated now than I ever am.
O 1 I get annoyed or irritated more easily than I used to.
O 2 I feel irritated all the time now.
O 3 I don't get irritated at all by the things that used to irritate me.

SUBTOTAL PAGE 1________

12. O 0 I have not lost interest in other people.
O 1 I am less interested in other people than I used to be
O 2 I have lost most of my interest in other people.
O 3 I have lost all of my interest in other people.

13. O 0 I make decisions about as well as I ever could.
O 1 I put off making decisions more than I used to.
O 2 I have greater difficulty in making decisions than before.
O 3 I can't make decisions at all anymore.

14. O 0 I don't feel I look any worse than I used to.
O 1 I am worried that I am looking old or unattractive.
O 2 I feel that there are permanent changes in my appearance that make me look unattractive.
O 3 I believe that I look ugly.

15. O 0 I can work about as well as before
O 1 It takes an extra effort to get started at doing something.
O 2 I have to push myself very hard to do anything.
O 3 I can't do any work at all.

16. O 0 I can sleep as well as usual.
O 1 I don't sleep as well as I used to.
O 2 I wake up 1-2 hours earlier than usual and find it hard to get back to sleep.
O 3 I wake up several hours earlier than I used to and cannot get back to sleep.

17. O 0 I don't get more tired than usual.
O 1 I get tired more easily than I used to.
O 2 I get tired from doing almost anything.
O 3 I am too tired to do anything.

18. O 0 My appetite is no worse than usual.
O 1 My appetite is not as good as it used to be.
O 2 My appetite is much worse now.
O 3 I have no appetite at all anymore.

19. O 0 I haven't lost much weight, if any, lately.
O 1 I have lost more than 5 pounds.
O 2 I have lost more than 10 pounds
O 3 I have lost more than 15 pounds.

I am purposely trying to lose weight by eating less.
Yes__ No__

20. O 0 I am no more worried about my health than usual.
O 1 I am worried about physical problems such as aches and pains; or upset stomach; or constipation.
O 2 I am very worried about physical problems and it's hard to think of much else.
O 3 I am so worried about my physical problems that I can't think about anything else.

21. O 0 I have not noticed any recent change in my interest of sex.
O 1 I am less interested in sex than I used to be.
O 2 I am much less interested in sex now.
O 3 I have lost interest in sex completely.

SUBTOTAL PAGE 1.______
SUBTOTAL PAGE 2._______
TOTAL SCORE________

APPENDIX K
MARLOW-CROWNE SOCIAL DESIRABILITY SCALE (20)

Name________________________________ Date_________

Please indicate whether the question is true (T) or false (F) for you.

1. _____I never hesitate to go out of my way to help someone in trouble.
2. _____I have never intensely disliked anyone.
3. _____I sometimes feel resentful when I don’t get my way.
4. _____I like to gossip at times.
5. _____There have been times when I felt like rebelling against people in authority even though I knew they were right.
6. _____I can remember “playing sick” to get out of something.
7. _____I’m always willing to admit it when I make a mistake.
8. _____I always try to practice what I preach.
9. _____I sometimes try to get even rather than forgive and forget.
10. _____When I don’t know something I don’t at all mind admitting it.
11. _____I am always courteous, even to people who are disagreeable.
12. _____At times I have really insisted on having things my own way.
13. _____There have been occasions when I took advantage of someone.
14. _____There have been occasions when I felt like smashing things.
15. _____I would never thing of letting someone else be punished for my wrong doings.
16. _____I never resent being asked to return a favor.

17. _____I have never been irked when people expressed ideas very different from my own.

18. _____There have been times when I was quite jealous of the good fortune of others.

19. _____I am sometimes irritated by people who ask favors of me.

20. _____I have never deliberately said something that hurt someone's feelings.

APPENDIX L
DEMOGRAPHIC QUESTIONNAIRE

Please provide the requested information in the blanks provided. Where appropriate, please indicate your response by circling **one** of the answers provided.

1. Name____ Date__________

2. UF ID #______________________

3. Phone Number_______________________

4. Sex M F 5. Age____________ 6. D.O.B._____________

7. Ethnicity: Caucasian African-American Hispanic Other

8. Sexual Orientation: Heterosexual Homosexual Bisexual

9. Please indicate the number of years of education that you have **completed:**
< 12 12 13 14 15 16 17 18 19 20 Other____

10. Dominant Hand: Right Left Ambidexterous

11. Do you exercise regularly? Y N

12. If **not**, do you have any intention of beginning Y N

13. If you exercise, do you enjoy exercising?____________________________________

____

____

14. If you exercise, **why** do you exercise?_______________________________________

____

____

15. If you exercise, what is your primary mode of exercise (e.g, running, swimming, etc.)

____

16. Do you have any history of mental illness? Y N

17. Are you currently experiencing any mental illness or receiving treatment for any mental illness? Y N

APPENDIX M
POST-EXPERIMENT QUESTIONNAIRE

Participant_______ Date_______

On a scale from 1 to 7, 1 being not at all, 7 being very much:

1. How closely did you pay attention to the pictures? ____
2. Did you watch all of the pictures? ____
3. How carefully did you listen to the imagery scripts? ____
4. Did you image all of the scripts? ____

5. What did you think the purpose of the experiment was?

6. Was there anything that you noticed/stuck out/recall from the experiment?

7. Do you have any other questions?

APPENDIX N
IMAGERY SCRIPTS

CONTAMINATION

1C. You are leaving the concert. (when) A drunk, smelling of smoke and alcohol, stumbles into you and throws up on your jacket. You retch as vomit drips onto your hand.

2C. A vagrant, wino, approaches you, yellow teeth and scabs on his face, clothes smelling of mold and urine. You cringe as his hand touches your sleeve.

THREAT

1D. You're alone in the alley in a bad part of the city. A street gang slowly surrounds you, knives out, laughing with menace. Your heart pounds as they close in.

2D. As you ease the car onto the wooden bridge, it groans. In the headlights, a broken railing swings in the wind. A swift current rams against the pilings below.

NEUTRAL

1N. You are sitting at the kitchen table with yesterday's newspaper in front of you. You push back the chair when you hear the coffee maker slow to a stop.

2N. You run the comb through your hair, straighten your collar, smooth out the shirt's wrinkles. Water is running in the sink. You turn it off and leave.

PLEASANT

1P. The registered letter says that "You have just won ten million dollars!" It's amazing—You bought the winning ticket in the lottery. You cry, scream, jump with joy!

2P. It's a beautiful day and you're heading a new convertible to the beach. The CD player is blasting, and you're singing along at the top of your voice.

EROTICA

1E. You are both aroused, breathless. You fall together on the couch. Kisses on your neck, face-- warm hands fumbling with clothing, hearts pounding.

2E. You are lying together, legs over legs, arms around bodies--kisses deep and sweet. In love on a blanket, beneath a tree, on a warm summer day.

RUNNING

R1. Running sprints, you breathe hard and pump your arms. Your legs feel heavy and your hamstrings burn as your come to the finish line.

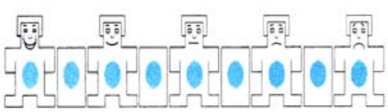
R2. Your heart pounds heavily in your chest and you begin running up the hill. You reach the top and continue running at a brisk pace for the next quarter mile.

Note: Imagery scripts were written by members of Peter Lang's laboratory at the University of Florida.

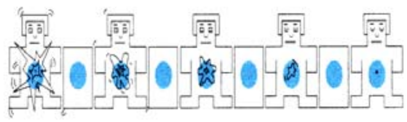
APPENDIX O
PRESCREENING QUESTIONNAIRE

Includes questions pertaining to (1) the stages of change questionnaire, (2) age, ethnicity, gender, sexual orientation, socioeconomic status, medical history, and mental illness and (3) the mode of exercise in which they engage (if they exercise).

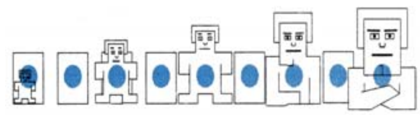
APPENDIX P
THE SELF-ASSESSMENT MANIKIN



Pleasure Scale

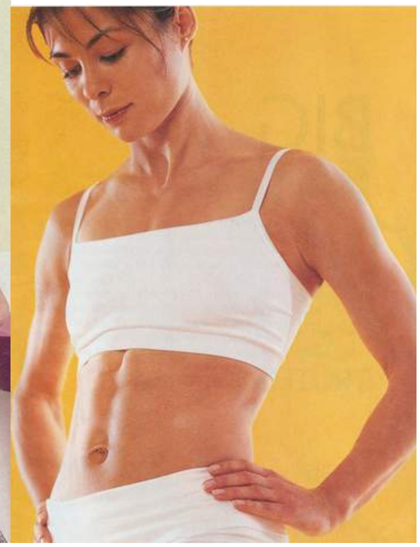


Arousal Scale



Dominance Scale

APPENDIX Q
RUNNING STIMULI

1. Neutral Woman 2. Athletic Woman

3. Elite Runner 4. Recreational Runner

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BIOGRAPHICAL SKETCH

Jaclyn Wetherington was born in St. Augustine, Florida, in 1980. She was raised, along with her older sister, Crista, by their devoted parents, Cathy and Jack, in Jacksonville, Florida. In 1998, she graduated from St. Johns Country Day School with a high school diploma. She obtained her Bachelor of Science degree in psychology from the University of Florida in December of 2001 and began her master's program in exercise and sport sciences at the University of Florida in August of 2002.